C.7: West Angelas Geochemical Characterisation

Rio Tinto Iron Ore

Pilbara Operations

2021 West Angelas Geochemical Characterisation

West Angelas

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RTIO-PDE-

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Executive Summary

As part of its mining operations within the Pilbara region of Western Australia, Rio Tinto Iron Ore are required to undertake geochemical characterisation of disturbed material. The purpose of the characterisation is to provide guidance for waste rock management with respect to limiting the potential for acid and metalliferous drainage.

Acid and metalliferous drainage (AMD) risks are associated with the disturbance and oxidation of rock units within the Pilbara. This geochemical characterisation report aims to identify West Angelas rock units that could pose AMD risks if disturbed. Acid base accounting and whole rock geochemistry analyses were undertaken on 99 rock samples from 18 different rock units. The characterisation covers Deposit H, Deposit F North, Mount East Ella and Western Hill deposits.

The results from the acid base accounting analyses found that the majority of rock types sampled were classified as Non – Acid Forming or Uncertain (AMIRA, 2002). Of these, 66 samples had a sulfide concentration less than 0.1 wt% and are considered barren of sulfur. Seven samples are classified as Potentially Acid Forming – Low capacity (PAF - LC) and 5 samples were classified as Potential Acid Forming (PAF). From the samples selected Potentially Acid Forming samples were sourced from Mount McRae Shale, Waste Dales Gorge Member and Immature Detrital. For most rock units encountered at West Angelas, the AMD risk is generally low. Future characterisation work should focus on quantifying acid generation from those rock units characterised as Potentially Acid Forming.

Geochemical data suggests a number of elements including Fe, Bi, Te, Sb, Mo, Re and S are enriched or elevated in a number of rock units. Enriched elements of Fe and Se and non-enriched elements including Al, As, Ce, Co, Cu, La, Na, Ni, Th, Tl and U typically display mobility under strongly oxidising conditions. Elements including Ca, Na, K, Nb, Sr and W display mobility under oxidised conditions and/or water, regardless of acidity. Given the mineralised nature of the Pilbara, elevated concentrations of metals are not unexpected, and it is considered likely that surrounding receptors have adapted to the naturally elevated concentrations.

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List of acronyms

mS/cm	Milli siemens per centimeter
ABA	Acid-base accounting
AF	Acid forming
ANC	Acid neutralising capacity
ANG	West Angela Member
AP	Acid potential
CarbNP	Carbonate neutralisation capacity
CLA	Clay
CRS	Chromium reducible sulfur
DET	Detrital
DG	Dales Gorge Member
DOR	Dolerite
EC	Electrical conductivity
FWZ	Footwall zone
GAI	Global Abundance Index
g/t	Grams per tonne
ICP-MS	Inductively coupled plasma mass spectrometry
ICP-OES	Inductively coupled plasma optical emission spectrometry
LDL	lower detection limit
MM	Marra Mamba Iron Formation
MCS	Mount McRae Shale
MPA	Maximum potential acidity
MTS	Mount Sylvia Formation
NAF	Non-acid forming
NAG	Net acid generation
NAPP	Net acid producing potential
NPR	Net potential ratio
NEW	Mount Newman Member
PAF	Potential acid forming
PAF - LC	Potential acid forming – Low Capacity
RTIO	Rio Tinto Iron Ore
TC	Total carbon
TIC	Total inorganic carbon
TOC	Total organic carbon
TS	Total sulfur
WS	Whaleback Shale
XRF	X-ray fluorescence

1. Introduction

As part of its mining operations within the Pilbara region of Western Australia, Rio Tinto Iron Ore are required to undertake characterisation of waste rock, including the assessment of risks associated with acid and metalliferous drainage (AMD). This report aims to assess potential acid generation, soluble metal/metalloids, and salt release from West Angelas rock units. It provides guidance for waste rock management and aids in mitigating acid and metalliferous drainage.

Acid and metalliferous drainage risk within the Pilbara is associated with disturbance and subsequent oxidation of certain mineral groups (i.e., sulfides/sulfates) known to be present within the Hamersley Group and overlying detrital sequences. This assessment includes the analysis of 99 samples from 18 rock units from West Angelas project area, which have been risk classified from acid base accounting and multi – element analyses.

2. Background

The West Angelas project area is located approximately 100 km west of Newman in Western Australia and includes sixteen discrete areas of mineralisation (RTIO, 2010). These deposits lie on the limbs of the east-west trending, west plunging Wonmunna Anticline located in the eastern part of the Ophthalmia Fold Belt. Mineralisation is found in limited quantities in the Macleod Member and the lower portion of the West Angela Member (RTIO, 2010). The West Angelas deposits, are comprised mainly of the Marra Mamba Iron Formation with mineralisation occurring in the Mt Newman Member (RTIO, 2010). Tertiary Detrital material derived from both the Marra Mamba and Brockman Iron Formations has also accumulated throughout the project area (RTIO, 2010). This study will focus on the geochemical characterisation of rock-types at Deposit H, Deposit F North, Mount East Ella, and Western Hill. No previous geochemical characterisation work has been conducted at these deposits.

Deposits H

Deposit H is the eastern most West Angelas deposit on the northern half of the Wonmunna Anticline. The 5.5 km long deposit is that is 9 km north-east of infrastructure at the West Angelas mine. Structurally, Deposit H is an asymmetric doubly plunging syncline of mineralised and unmineralised Marra Mamba Members. Bedded mineralisation is primarily observed in the upper Newman Members, with low grade material also found in the West Angela Shale and MacLeod Members. Detritals are primarily unmineralised.

Deposit F – North

The iron ore resource at Deposit F North is found within tertiary mature detritals that blanket the paleo-topography and in the E-W striking folded Marra Mamba Iron Formation. Mature detritals intermittently overlie hydrated bedded material that transitions into mineralised Mount Newman Member and sometimes the Macleod Member. Immature detrital, clay and quaternary alluvial material overlies the mineralised zone with thicknesses from 2 to 80 metres.

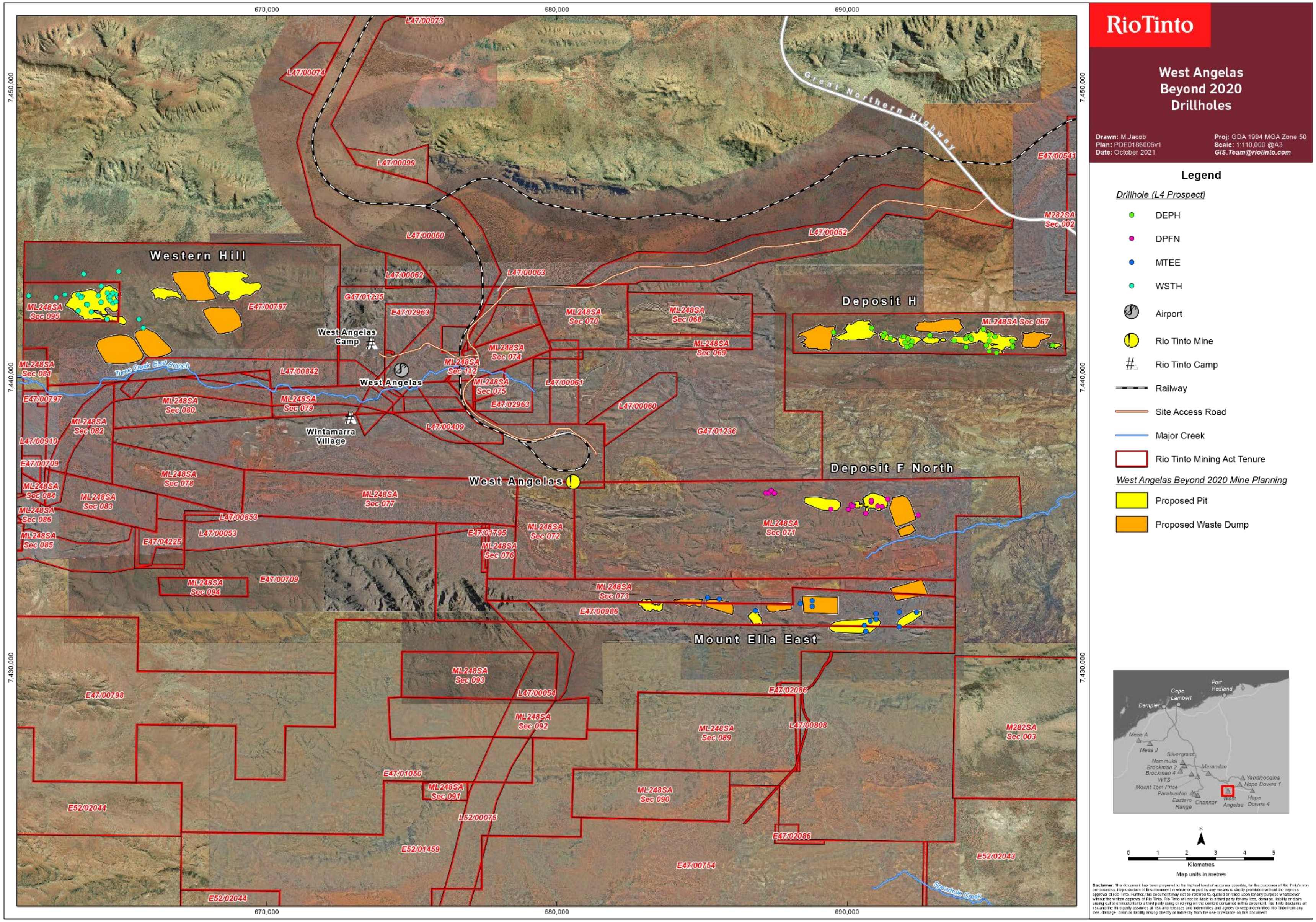
Mount Ella East

Mount Ella East (MTEE) is predominantly a detrital deposit. It is a mostly concealed deposit with some altered Brockman iron formation mapped in the hills to the south. Mineralisation occurs in layers of variably pisolitic/magnetic detritals, hematite-rich with siliceous clay matrix, overlying a distinctly limonitic/goethitic detrital sequence. There are some pods of general mature detritals, pisolitic waste, and internal or basal clay

Western Hill

Western Hill lies along the northern limb of the Wonmunna Anticline, and consists predominantly of lower Brockman Iron Formation rocks, flanked by secondary detrital deposits. The deposit is located approximately 110 km west-northwest of Newman in the East Pilbara region of Western Australia

Figure 1: Map showing the location of ABA samples



3. Sampling and Analysis Program

3.1 Sample Selection

A total of 99 samples were selected from across the WANG project area, including Deposit H (33 samples), Deposit F North (19 samples), Mount East Ella (16 samples) and Western Hill (31 samples) (Figure 1). Samples were sourced from a variety of rock units including Clay (CLA), Detritals (DET), Dolerite (DOR), Whaleback Shale (WS), Dales Gorge Member (DG), Footwall zone (FWZ), Mount McRae Shale (MCS), Mount Sylvia, West Angela (ANG), Mount Newman (NEW), Undifferentiated Marra Mamba Iron Formation (MM).

Samples were selected by RTIO and included diamond drill core and reverse circulation chips drilled during 2020 and 2021. Samples were selected based on their location within the project area (ensuring vertical and lateral coverage) and considering the sulfur concentration. Samples with elevated sulfur are considered a higher risk in terms of propensity to produce AMD and therefore selectively targeted within the sampling program.

Table 1: Number of samples by rock units and deposit.

Rock Unit	Deposit			
	DEPH	DPFN	MTEE	WSTH
ANG - Ore	2			
ANG - Waste	7			
CLA	5		1	2
DG - Ore			1	4
DG - Waste			4	6
DI	2	4	3	4
DM	1	2	2	2
DOR		1		4
FWZ - Waste			1	1
MAC - Waste	2	3		
MCS - Waste			3	3
MM - Ore	2	2		
MTS - Waste			1	1
NAM - Waste	4	1		
NEW - Ore	2	1		
NEW - Waste	6	5		
WS - Ore				2
WS - Waste				2
Total	33	19	16	31

3.2 Testing Program

The samples were sent to Intertek-Genalysis in Perth for sample preparation and analysis using a range of geochemical test. A full description of each analytical technique is provided in Appendix A. A summary of the test program carried out is provided below:

- Paste pH1:5 and electrical conductivity (EC) 1:5 solid to liquid ratio;
- Sulfur speciation (Chromium Reducible and Sulfate Sulfur);
- Carbon speciation (Total C, total organic carbon (TOC), total inorganic carbon (TIC);
- Acid neutralising capacity (ANC);
- Single addition net acid generation (NAG) test;
- Multi-Element Four Acid Digest with ICP-MS/OS; and,
- Multi Element NAG Digestion with ICP-MS/OS.

4. Results

4.1 Acid Base Accounting

The results of acid base accounting (ABA) analysis undertaken as part of this assessment are presented in Appendix B, Table B-1. Results are summarised in the following sections.

4.1.1 Paste pH

The paste pH test can give an indication of readily soluble oxidation products. An alkaline (pH >7) may indicate the presence of neutralising minerals and an acidic pH (pH <5) could indicate the presence of acidic reaction products generated by sulfide oxidation.

The paste pH values range from pH 2.6 (acidic) to 8.0 pH (slightly basic) (Figure 2). A total of 39% of samples recorded a circum neutral pH between 6 to 8 pH, 30.6% of samples reported a 5-6 pH and 30.6% of samples reported an acidic paste pH (<5 pH).

MCS- Waste, DG – Waste, FWZ – Ore and MM – Ore all have median paste pH values in the acidic range. Additionally, the majority of MCS – Waste samples are classified as acidic (Figure 2). There is a correlation between increasing sulfur concentration and decreasing pH. This is particularly evident in the MCS-Waste samples and is reflective of a higher acid production potential due to sulfur enrichment (Figure 3). Not all samples have a strong correlation between total sulfur concentration and paste pH, this could indicate that some samples have not been completely oxidised, with the full acid load not released.

Figure 2: Paste pH range according to rock unit

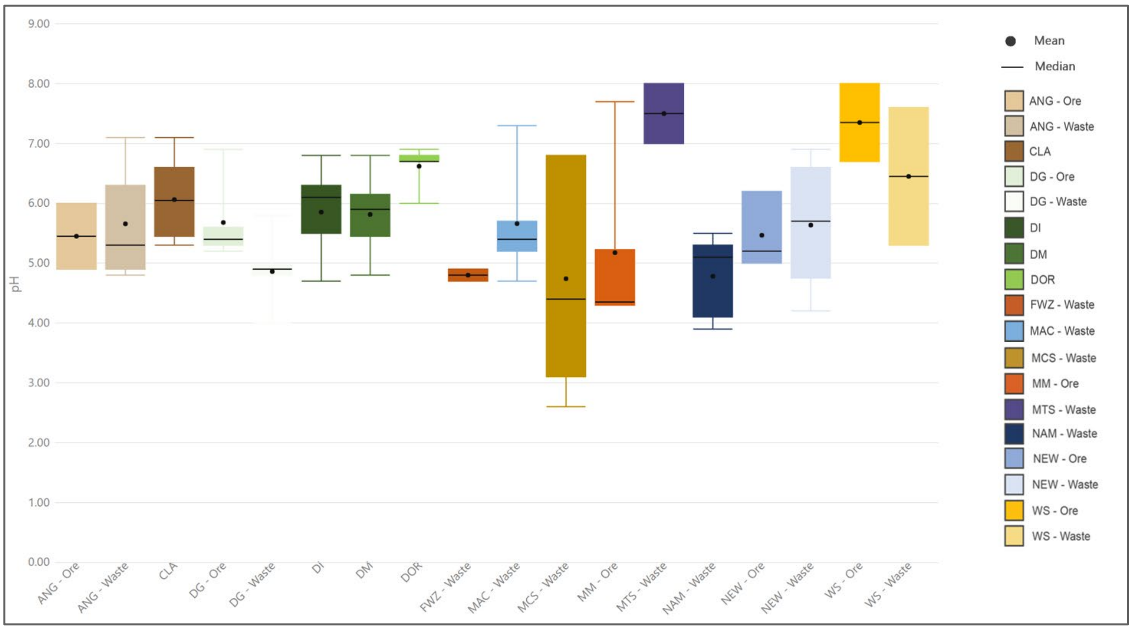
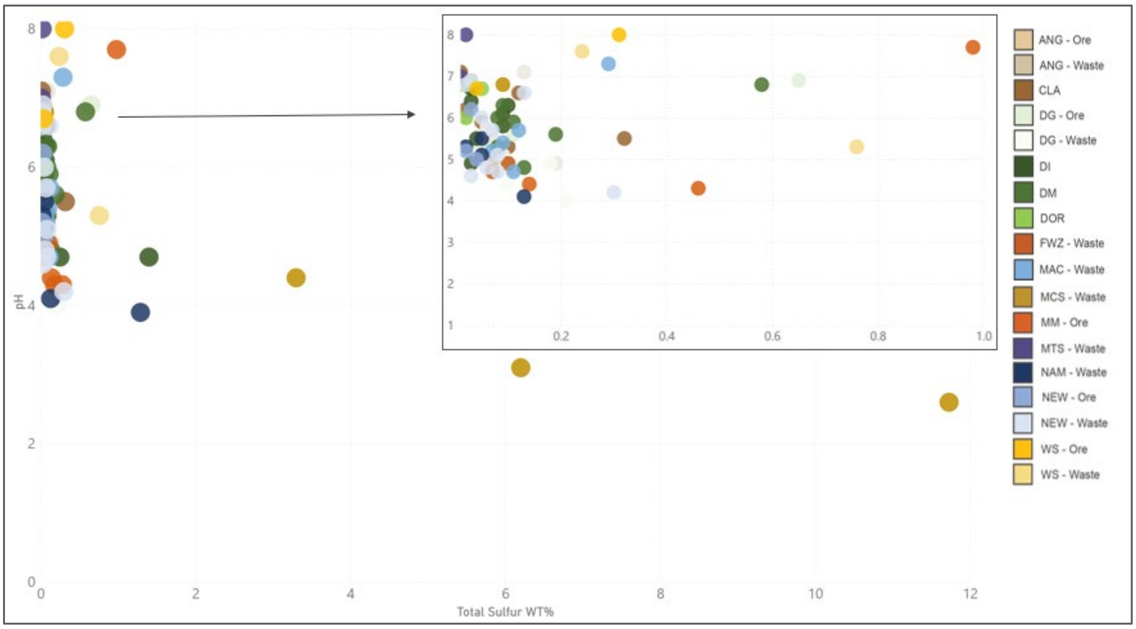


Figure 3: Paste pH versus total sulfur according to rock unit



4.1.2 Paste EC

Paste EC provides an indication of the state of oxidation/weathering, where higher EC values usually suggest more advanced state of oxidation/weathering. If the sample is however from a saline environment an elevated EC may indicate residual salt rather than in indication as to the oxidation state.

The paste EC of the 99 samples ranges from 0.05 to 4.34 mS/cm with a paste dilution of 1:5 solid to liquid ratio (Figure 4 and 5). The median and average paste EC are 0.2 and 0.4 mS/cm respectively (Figure 4). The EC values vary significantly between the rock units. MCS - Waste registers an outlier of 4.34 mS/cm and shows the greatest range in paste EC values (Figure 4).

Figure 4: Paste EC range according to rock unit

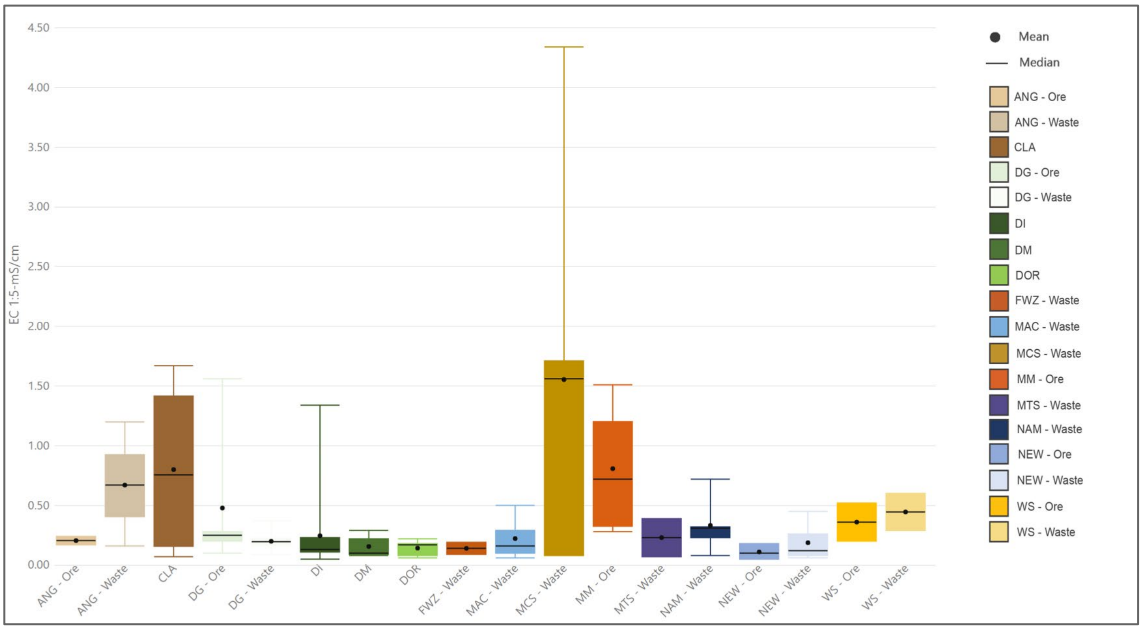
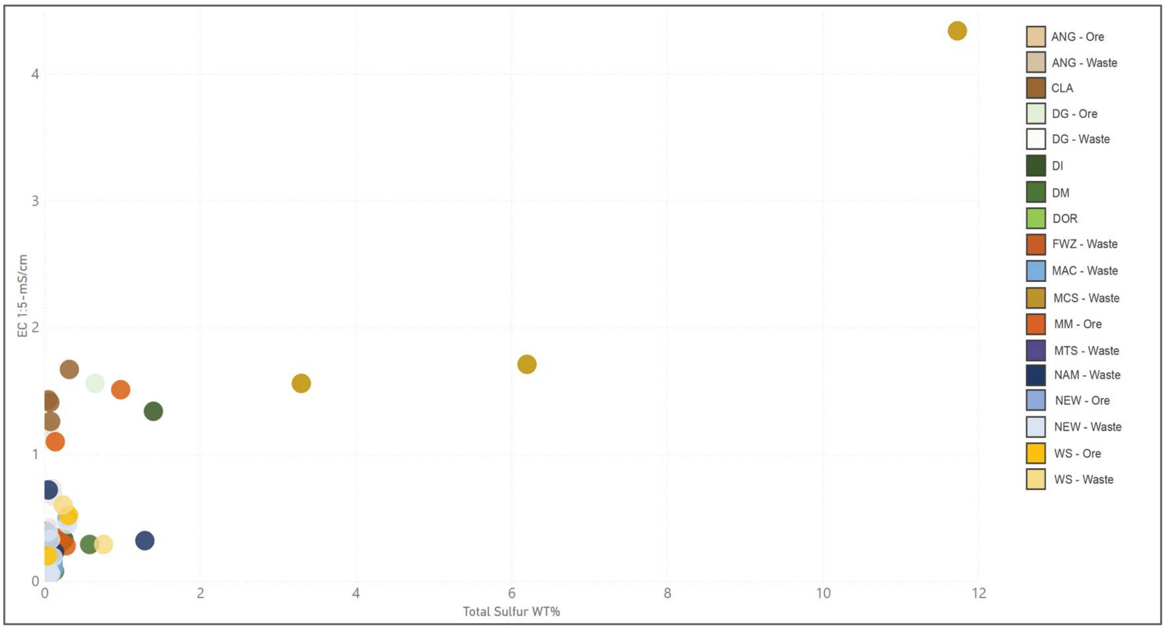


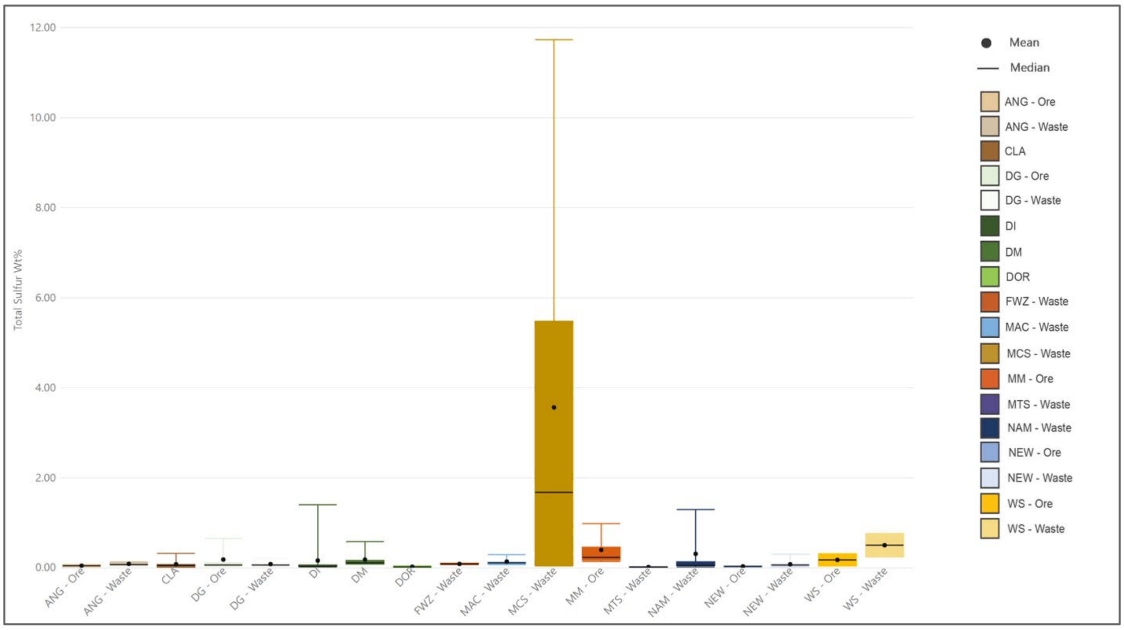
Figure 5: Paste EC versus total sulfur according to rock unit



4.1.3 Sulfur Speciation

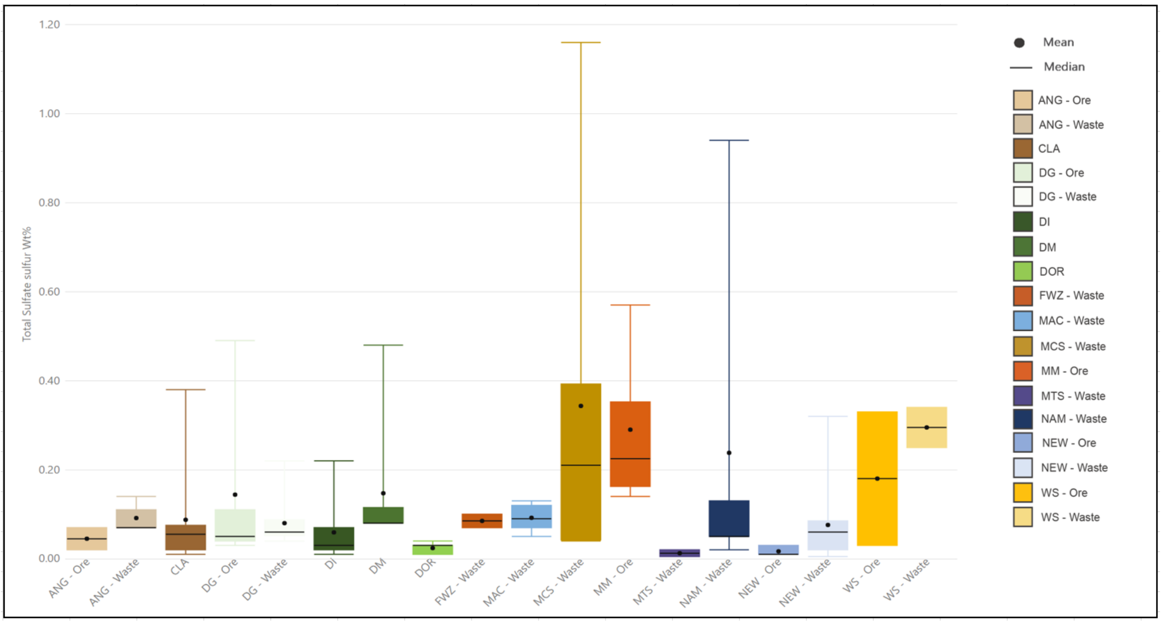
The results of the sulfur speciation test-work are shown in Figure 6 and Figure 7. The total sulfur (TS) content of the West Angelas samples range from 0.01 wt% S (Lower detection Limit - LDL) to 11.73 wt% S (MCS- Waste). The median and average are 0.06 and 0.34 wt% S respectively (Figure 6). Materials with TS content equal to or less than 0.1 wt% S are classified as barren of sulfur and have negligible capacity to generate additional acidity. There are thirty-two (32) samples which have sulfur concentrations exceeding 0.1 wt% S. Additionally, 1.5% of samples have TS greater than 0.3 wt% S.

Figure 6: Total sulfur values according to rock unit



The sulfate sulfur method measures the oxidised non-acid forming portion of sulfur. The sulfate sulfur concentration ranges from <0.01 (LDL) to 1.16 wt% S (MCS - Waste) (Figure 7). Sulfate sulfur is the dominant sulfur species in all lithologies except for MCS – Waste. This could suggest that apart from MCS-waste, all other units have undergone sufficient oxidation to convert the majority of sulfides to sulfates.

Figure 7: Total sulfate sulfur values according to rock unit:



The chromium reducible sulfur (CRS) method measures the sulfide sulfur content or un-oxidised portion of sulfur (pyrite and marcasite). The chromium reducible concentration ranges from <0.005 (LDL) to 8 wt% S (MCS - Waste) (Figure 8). Samples from, DET- Immature, MAC – Waste and

MCS – Waste all have CRS sulfur concentrations greater than 0.1 wt % S. Only four of these samples have more than 50% sulfur in a sulfide form. Three of these are from the MCS – Waste and one from Detrital- Immature (Figure 8). This indicates that not all samples are completely oxidised with some rock units having significant concentrations of sulfur in sulfide bearing minerals (pyrite or marcasite) that could be a source of acidity (Figure 8 and 9). These samples are barren of sulfur and have negligible ability to produce acid.

Figure 8: Total sulfur versus sulfide sulfur according to rock unit

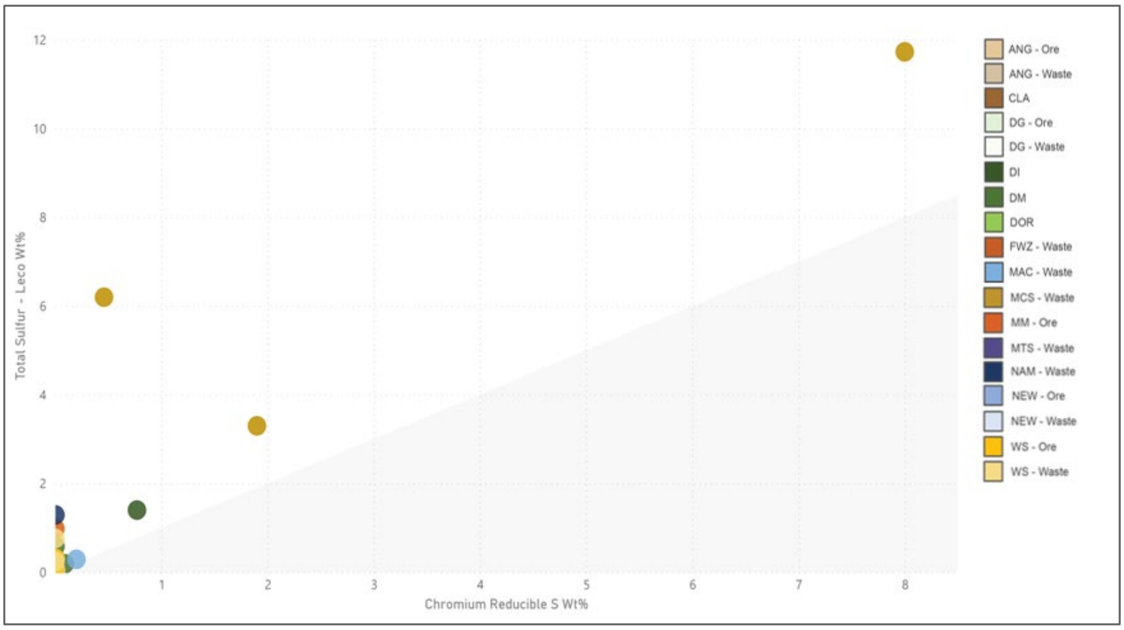
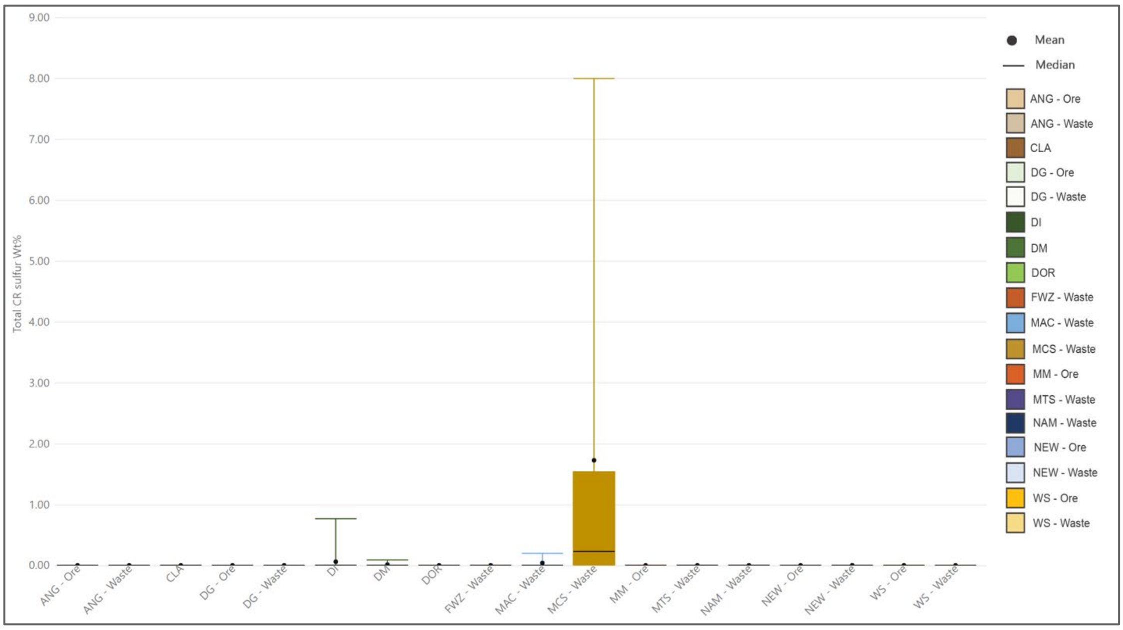
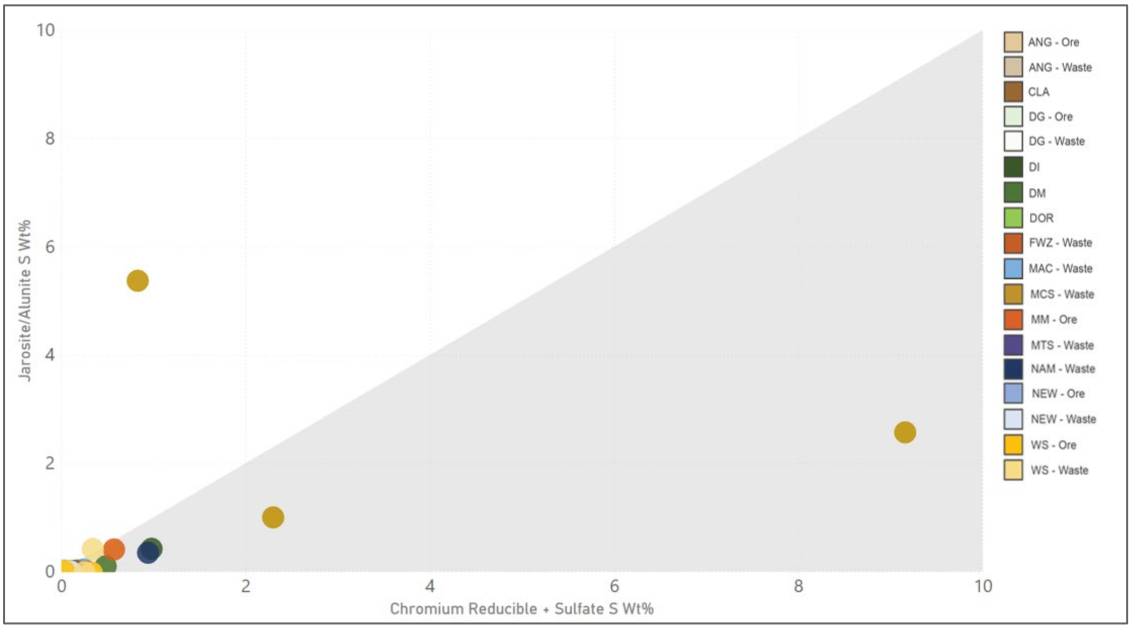


Figure 9: Total chromium reducible sulfur according to rock unit



Jarosite and alunite have the capability to generate acid through dissolution, if coincident with precipitation of iron and aluminium hydroxide minerals (SRK, 2013). The concentration of hydroxysulfates is calculated by subtracting sulfate sulfur and sulfide sulfur from total sulfur – Leco. Jarosite and Alunite sulfur has been plotted against chromium reducible and sulfate sulfur. The majority of samples plot near of below the line of equivalence indicating that sulfur is contributed to sulfates or sulfides. A single MCS- Waste sample plots above the line indicating that hydroxysulfates are the dominant sulfur speciation.

Figure 10: Total Jarosite/Alunite sulfur plotted against sulfide and sulfate S according to rock unit



4.1.4 Carbon Speciation

Carbon can occur as both inorganic carbon (in carbonate minerals) or as organic carbon (in organic matter). Inorganic carbon can contribute neutralisation capacity if carbonate minerals are present. Elevated organic carbon can signify shale bands which are commonly associated with sulfide mineralogy in Hamersley Group. The total carbon (TC) content ranges from 0.02 wt% to 23.68 wt%, with median and average values of 0.11 wt% and 0.59 wt% (Figure 11).

The total inorganic carbon (TIC) content ranges from <0.01 (LDL) to 5.8 wt % C, with median and average values of 0.02 wt% and 0.14 wt% respectively (Figure 12). The median and average TIC concentrations across all rock units was below 1 wt% C. The detrital rock unit reported a wide range of TIC concentrations (0.03 – 5.8 wt %) which suggests heterogeneity in the distribution of carbonate minerals.

Total organic carbon (TOC) content ranges from 0.01 wt% to 18.06 wt% C, with median and average values of 0.08 wt% and 0.46 wt% C respectively (Figure 13). It is noted that organic carbon is elevated in MCS – Waste, with a median and average values of 2.48 wt% and 2.58 wt% (respectively). Furthermore, MCS- waste samples have a positive correlation between sulfur and TOC, this suggests an association between carbonaceous shale and elevated sulfur. The Detrital rock units reported a wide range of TOC concentrations (0.04 to 18.06 wt% C). This variability in TOC concentrations is reflective of the heterogenous makeup of the detrital unit.

Figure 11: Total carbon according to rock unit

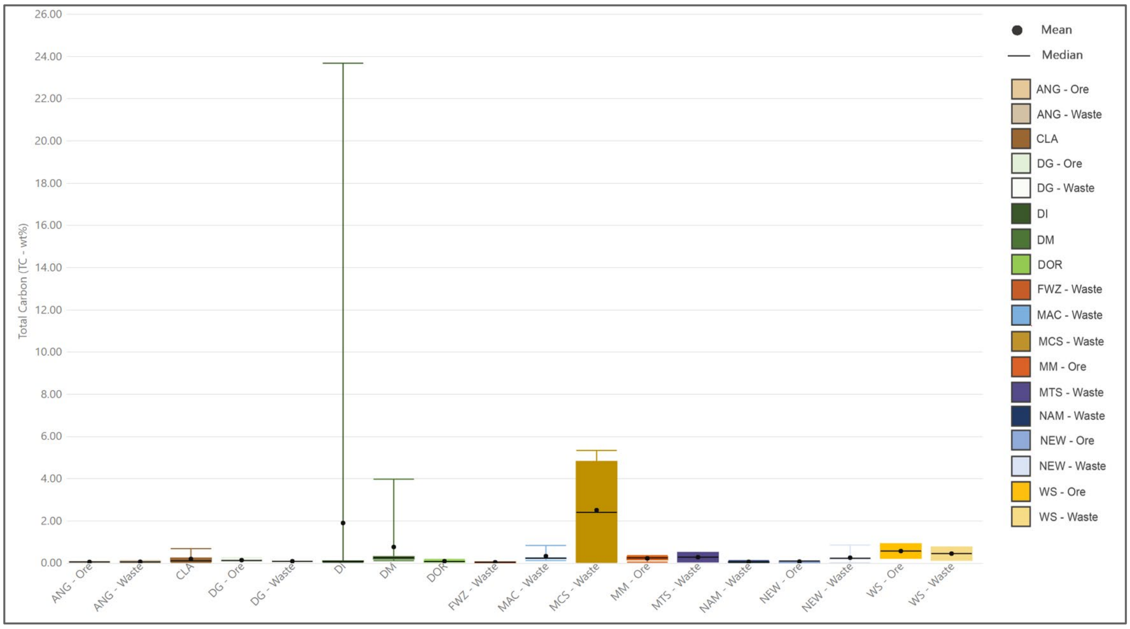


Figure 12: Total inorganic carbon according to rock unit

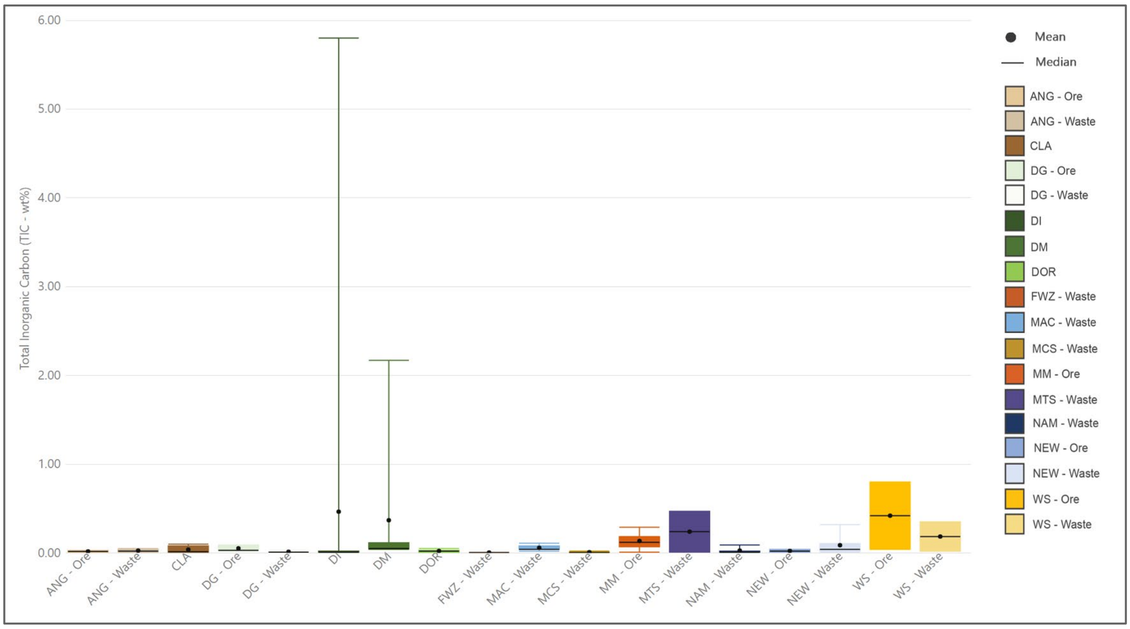
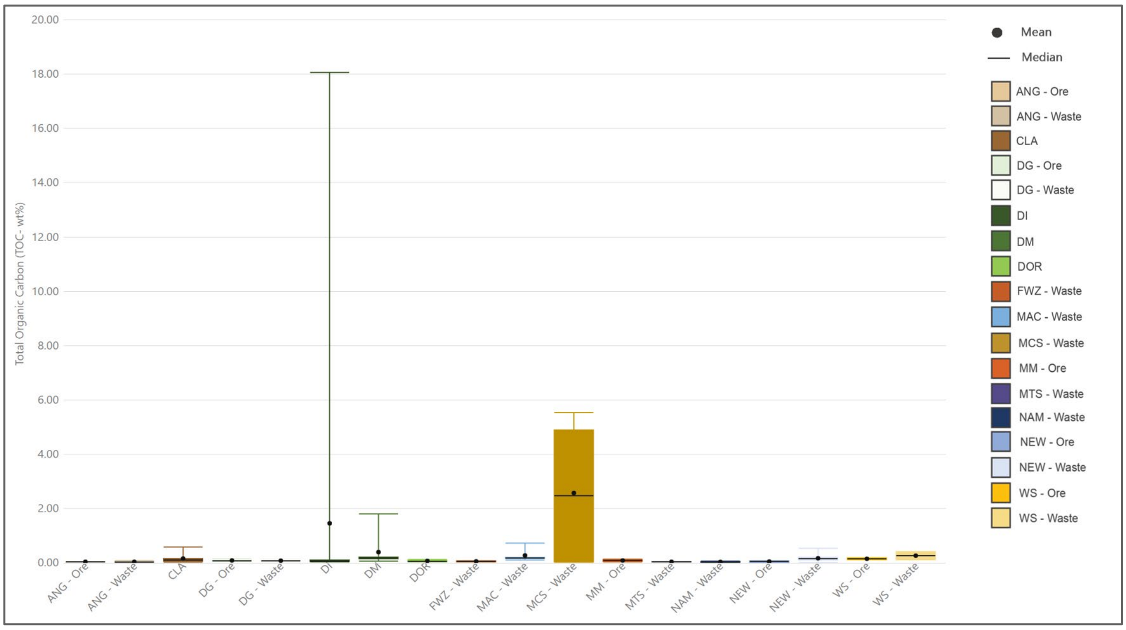


Figure 13: Total organic carbon according to rock unit



4.1.5 Acid Generation potential

In order to assess acid generation potential, the maximum potential acidity (MPA) and the acid potential (AP) were calculated. The maximum potential acidity uses total sulfur (TS) and assumes all TS has acid producing potential in the form of pyrite. The calculated MPA values for all samples ranged from 0.5 to 359 kg H_2SO_4/t with a median and average value of 2 and 10.56 kg H_2SO_4/t respectively (Table 2). Acid potential (AP) is calculated using estimates of the portion TS that is present as oxidisable sulfur (using chromium reducible sulfur (CRS)) and in the form of Jarosite and/or Alunite. The AP ranges from 0.08 – 303.65 kg H_2SO_4/t, with a median and average value of 0.08 and 6.17 kg H_2SO_4/t respectively (Table 2). The MPA is higher than the AP as it considers that all sulfur is in the form of pyrite when a significant portion of this is likely to be present in oxidised minerals and will not produce acid.

Table 2: Summary table of acid generation potential and maximum potential acidity

Rock unit	Average MPA– kg H_2SO_4/t	Average AP – kg H_2SO_4/t	Median MPA- Kg H_2SO_4/t	Median AP- kg H_2SO_4/t	Max MPA – kg H_2SO_4/t	Max AP – kg H_2SO_4/t	Min MPA – kg H_2SO_4/t	Min AP– kg H_2SO_4/t
ANG - Ore	1.25	0.08	1.25	0.08	2.00	0.08	0.50	0.08
ANG - Waste	2.57	0.08	2.00	0.08	4.00	0.08	2.00	0.08
CLA	2.44	0.08	2.00	0.08	10.00	0.08	0.50	0.08
DG - Ore	5.60	0.91	2.00	0.25	20.00	3.68	1.00	0.08
DG - Waste	2.60	0.11	2.00	0.08	7.00	0.25	1.00	0.08
DI	4.81	2.82	1.00	0.25	43.00	33.18	0.50	0.08
DM	5.71	0.89	3.00	0.25	18.00	3.21	3.00	0.08
DOR	0.70	0.08	0.50	0.08	1.00	0.08	0.50	0.08
FWZ - Waste	2.50	0.08	2.50	0.08	3.00	0.08	2.00	0.08
MAC - Waste	4.40	1.47	4.00	0.08	9.00	7.04	2.00	0.08
MCS - Waste	109.00	87.02	51.50	40.64	359.00	303.65	1.00	0.08
MM - Ore	11.75	2.45	6.50	0.16	30.00	9.41	4.00	0.08
MTS - Waste	0.50	0.11	0.50	0.11	0.50	0.13	0.50	0.08
NAM - Waste	9.70	1.67	2.00	0.08	40.00	8.03	0.50	0.08
NEW - Ore	0.67	0.32	0.50	0.25	1.00	0.48	0.50	0.25
NEW - Waste	2.27	0.17	2.00	0.15	9.00	0.38	0.50	0.08
WS - Ore	5.50	0.16	5.50	0.16	10.00	0.25	1.00	0.08
WS - Waste	15.00	4.86	15.00	4.86	23.00	9.64	7.00	0.08

4.1.6 Acid Neutralising Capacity (ANC)

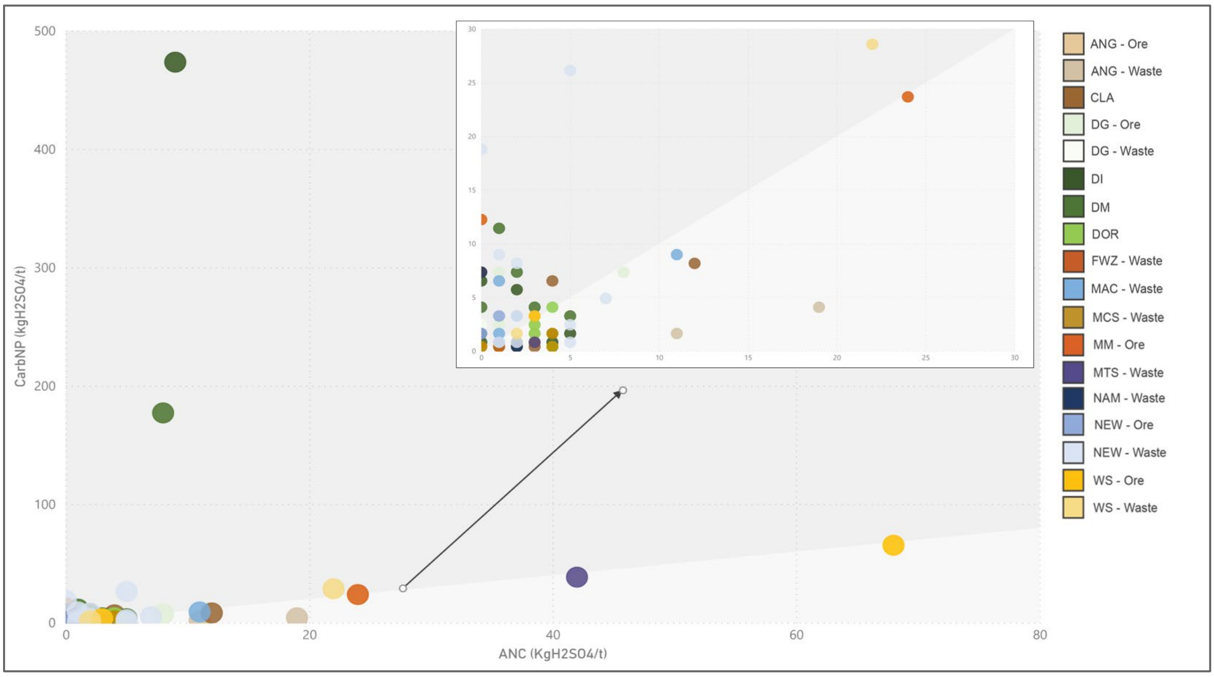
Some minerals have the capacity to neutralise acidity and whilst many may contribute to the ANC, the calcium and magnesium carbonate minerals (e.g. calcite and dolomite) are of greatest importance in terms of neutralising acidity as they react rapidly and buffer at near neutral pH. It should be noted that not all carbonate minerals contribute to the ANC. Some carbonates may be unreactive or present in forms that do not yield an equivalent neutralisation capacity. This includes minerals such as siderite ($FeCO_3$). Whilst dissolution of the carbonate consumes acidity, the ferrous iron contained in siderite has the potential to oxidise to ferric iron and to precipitate as $Fe(OH)_3$ releasing an equivalent amount of acidity to that consumed. Thus under oxidising conditions siderite does not provide effective neutralisation capacity.

The ANC of the samples range between 0 kgH_2SO_4/t and 68 kgH_2SO_4/t and is generally low with, 92% of samples having less than kgH_2SO_4/t.

The total inorganic carbon (TIC) concentration can be used to infer information about the carbonate mineral content and estimate the carbonate neutralisation potential (CarbNP). The CarbNP is calculated assuming all the carbon is present in the form of calcite. The calculated CarbNP values range from 0.4 - 473.35 kg H_2SO_4/t.

A plot of the calculated CarbNP as a function of measured ANC is shown in Figure 14. Samples plotted along the line have equal CarbNP to the ANC. Samples that plot above the line of equivalence (where CarbNP = ANC) have an excess of CarbNP over ANC, suggesting that carbonate minerals are present in a form that does not contribute to neutralising reactions (such as siderite, FeCO3). For samples plotting below the line of equivalence the CarbNP is less than ANC which suggests the ANC is associated with slower reacting silicate minerals. The majority of samples plot near the line of equivalence indicating low to no concentration of calcite. DET – Mature has two samples that plot significantly above the line indicating the presence of iron carbonates.

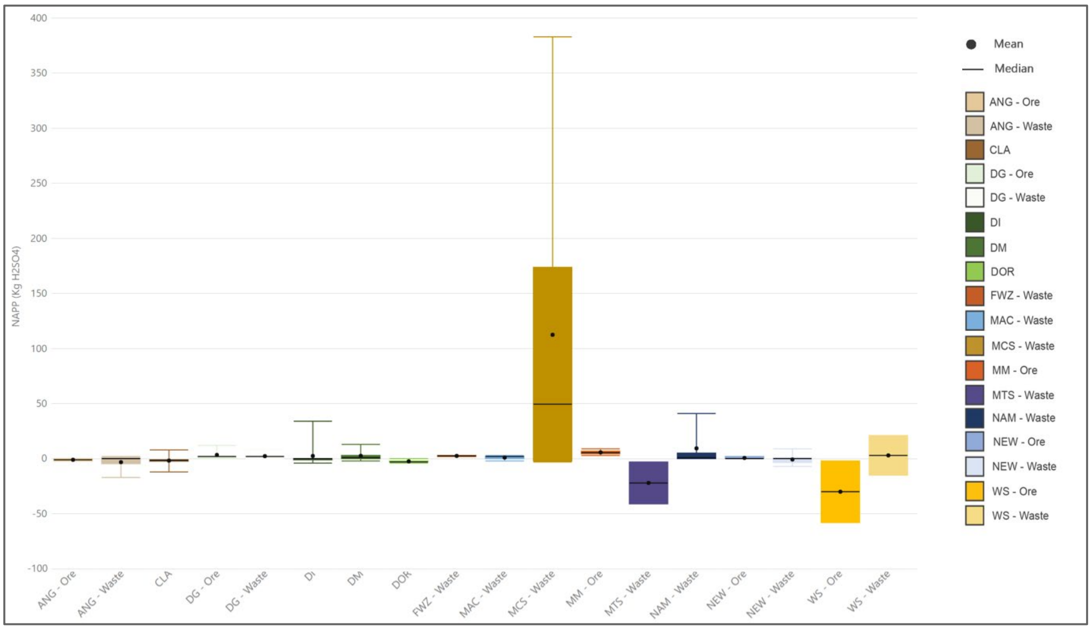
Figure 14: Carbonate plotted as a function of ANC according to rock unit



4.1.7 Net Acid Producing Potential (NAPP)

The NAPP of the samples is a balance of MPA and ANC (ie NAPP = MPA – ANC). A negative NAPP indicates an overall excess of neutralising capacity, whilst a positive NAPP indicates an excess of acidity (Figure 15). Calculated NAPP values range from -58 to 383 kgH_2SO_4 with 34 likely possessing neutralising capacity and eight samples plotting with high positive NAPP suggesting excess acidity (>10 kgH_2SO_4). Samples plotting with a positive NAPP were sourced form MCS- Waste, DG – Ore, DI, DM, WS – Waste and NAM – Waste.

Figure 15: NAPP ranges according to rock unit

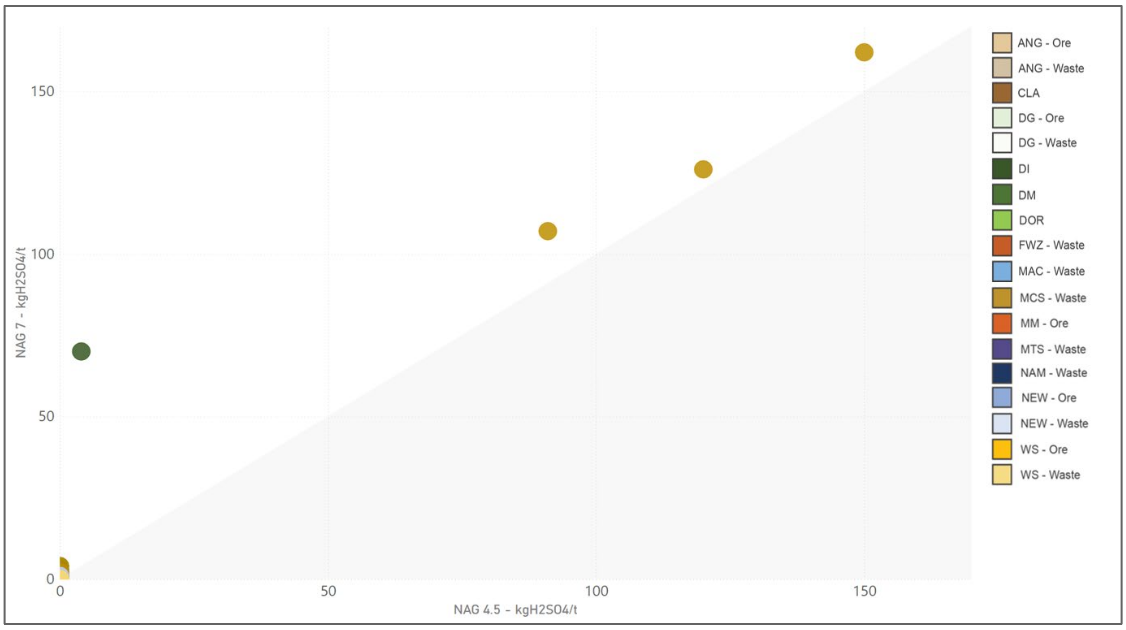


4.1.1 Single Addition NAG Tests

During the NAG test, the samples are contacted with the strong oxidant (hydrogen peroxide) to oxidise sulfide minerals contained in the sample. Concurrently, neutralising minerals present in the sample consume the acidity generated until either the ANC or sulfide is depleted. Should the ANC be depleted first, excess acidity is generated, and the sample pH would decrease. Following a predetermined contact time, the solution pH (NAG pH) is recorded, and the acidity of the samples is quantified by titration with a base (sodium hydroxide). The acidity generated at pH 4.5 and below is generally attributed to free sulfuric acid and ferric irons. Acidity generated between pH 4.5 and 7 includes a contribution from metals such as copper which are soluble at 4.5 pH but insoluble at 7 pH.

Single addition NAG tests were conducted on all samples to assess the net amount of acid generated. Acid pH values were recorded, and acidity was generated for all samples, with only four producing significant quantities of acid. Three of the samples are from the MCS - Waste and one from the DI. The MCS - Waste samples generated similar quantities of acid at below 4.5 pH (between 46 to 49 %) and between 4.5 to 7 pH (between 51 to 54 %) (Figure 16). The acid load of the DI sample was predominately generated between 4.5 to 7 pH (Figure 16). All other samples generated an acid load less than 5 kg H_2SO_4/t and had 100% of acid generated between 4.5 to 7 pH.

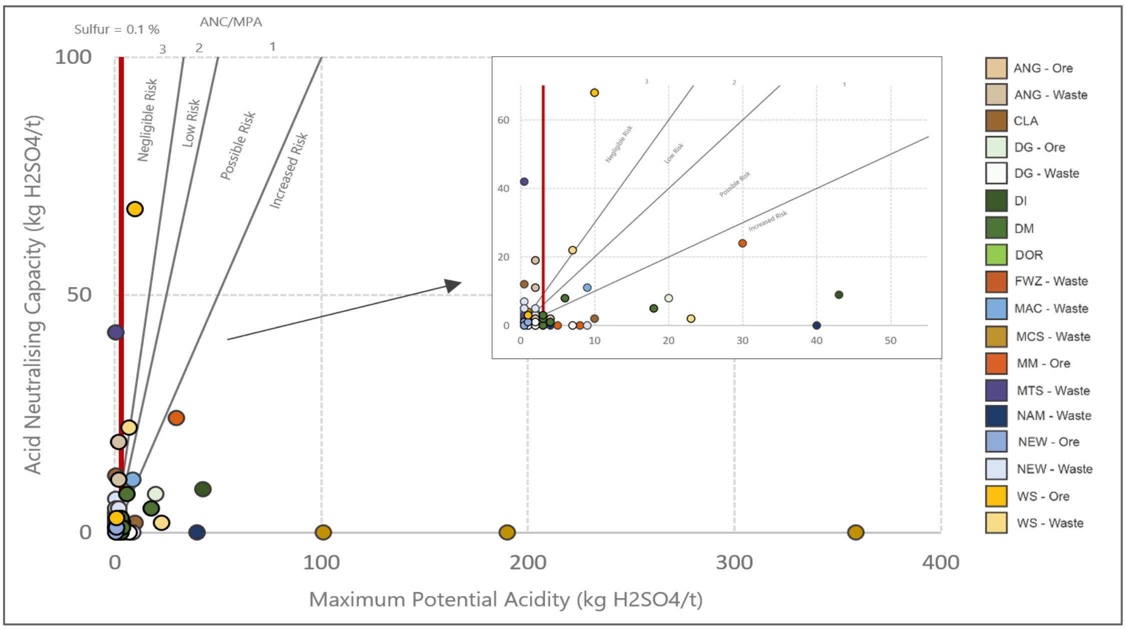
Figure 16: NAG 7 versus NAG 4.5



4.1.2 Net Potential Ratio (NPR)

The ratio of ANC to MPA (Net Potential Ratio – NPR), ranges from 0 to 84, with a median and average value of 1.0 and 3.1, respectively. Generally, those samples with a sulfur content <0.1% or have an NPR greater than 2 have a low to negligible risk of generating acid (COA, 2016; INAP, 2009). There are 69 samples that fit into this classification (Figure 17). Six samples are a possible risk with an NPR between 1-2 and 28 samples have an increased risk with an NPR less than 1 (Figure 17).

Figure 17: Net Potential Ratio according to rock type



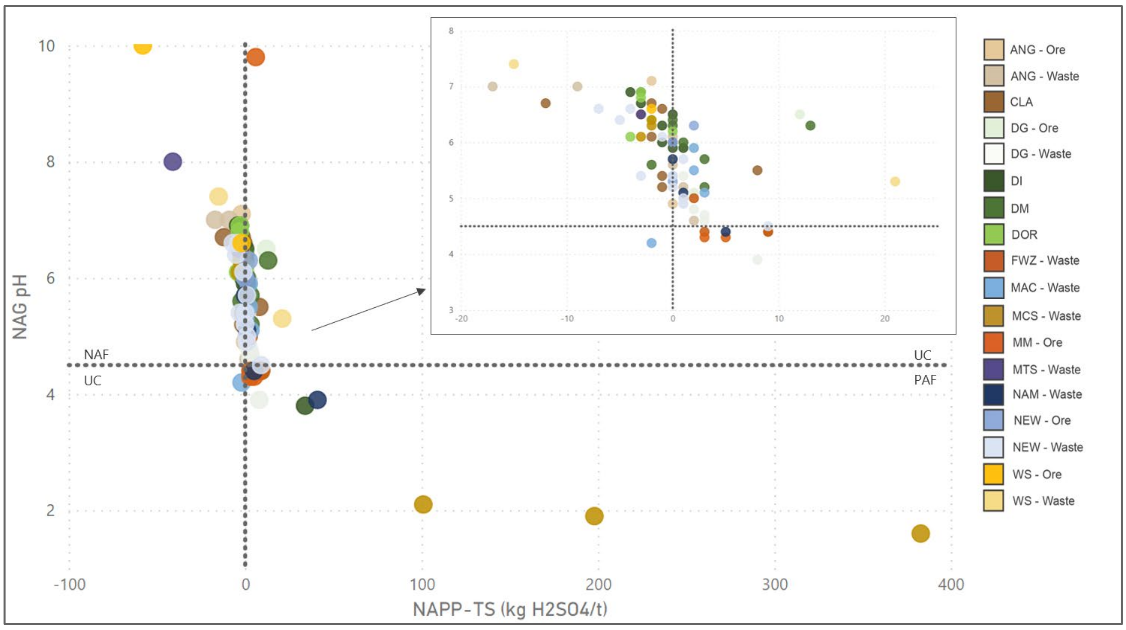
4.1.3 Sample Classification

Samples have been classified using the AMIRA (2002) classification scheme (Table 3, Figure 18). More than half of samples (55%) plot within the Uncertain classification, 33 are classified as Non-Acid Forming (NAF) and 12 as Potential Acid Forming (PAF) (Figure 18). Samples that are classified as PAF were sourced from the MCS - Waste (n3), MM - Ore (n3), NAM - Waste (n2), DI (n2), DG (n 1), and FWZ (n 1) rock units.

Table 3: Summary table of AMIRA classification scheme.

Class	Sub - Class	Description
NAF	NAF	Samples with a negative NAPP value and a NAG pH of ≥ 4.5
PAF	PAF	Samples with a positive NAPP value and a NAG pH of < 4.5
	PAF- LC	PAF materials associated with low NAG acidities (NAG pH 4.5 <5 kgH_2SO_4/t)
Uncertain	UC (PAF)	Samples with a negative NAPP but giving NAG pH values <4.5
	UC (NAF)	Samples with positive NAPP but giving NAG pH values ≥ 4.5. For these samples' acidity is likely attributed to metal acidity

Figure 18 NAG pH vs NAPP according to rock unit



4.2 Multi-Element Chemical Assays

Whole rock geochemistry of the 99 samples was determined by using ICP-MS or ICP-OES with a four-acid digestion and NAG oxidation. The four-acid digest method quantified the mass balance of the major, minor and trace elements in the samples and the NAG method was used to determine the mobility of major, minor and trace elements under strongly oxidising conditions.

4.2.1 Geochemical Abundance

Total metal/metalloid concentrations in samples can be compared to average crustal abundance for unmineralised soils. The extent of enrichment is reported as the Geochemical Abundance index (GAI), which relates the actual concentration in a sample with a median (or average) crustal abundance on a $\log_{10}$ scale (Bowen, 1979). GAI is expressed as an integer increments from 0 to 6, where a GAI value equal to or less than 0 indicates that the elements are equal to or less than the crustal abundance. A GAI value of 6 indicates a 100-fold enrichment above the crustal abundance.

Table 4: Geochemical Abundance Index (GAI) values and enrichment factors

GAI	Enrichment Factor
0	Less than 3-fold enrichment
1	3-6-fold enrichment
2	6-12 fold enrichment
3	12-24 fold enrichment
4	24-48 fold enrichment
5	48-96 fold enrichment
6	Greater than 96 fold enrichment

Metals/metalloids identified as enriched may not necessarily be a concern to vegetation, drainage water quality or public health, but their significance should still be evaluated. The GAI only provides an indication of metal/metalloids that are enriched relative to the global average crustal abundance. Things to consider are:

- If a sample is shown to be enriched relative to the average crustal abundance, there is no direct correlation that the sample will also leach metals/metalloids at elevated concentrations. The mobility of metals/metalloids is dependent on mineralogy, adsorption/desorption, and the chemical environment in which it occurs.

- Although there are a number of metals/metalloids elevated relative to the median crustal abundance, the nature of an ore deposit means the background levels are always higher than expected to be elevated. For instance, tellurium is found to be naturally occurring at higher GAI factors from volcaniclastic sandstone in the Pilbara Region.

Additionally, because metals/metalloids are not enriched does not mean they are not of environmental concern. Solubility of elements is of importance, i.e elements such as Al, Cu, Cd, Fe and Zn are mobile under low pH conditions.

The GAI was calculated using four acid-digest ICP-MS/OES results for the 99 samples. The following elements were analysed, Fe, S, Zn, Pb, Ca, Cu, Ba, Bi, V, Cr, As, Ag Ni, Co, Sn, Sr, Zr, Ag, Be, Cd, Ce, Cs, Ga, Ge, Hf, In, K, La, Li, Mg, Mn, Mo, Na, Nb, P, Rb, Re, Sb, Sc, Se, Ta, Te, Th, Tl, U, W, Y. The majority of these elements have median GAI values below the crustal abundances. Those that are elevated or enriched are displayed in Table 5.

The GAI results indicate that the metals/metalloids of Fe, Bi, Te, Sb and Se are enriched or elevated across the majority of rock units. Additionally, Mo, Re are enriched in the MCS – Waste. Sulfur is enriched in WS - Waste and MCS - Waste.

Table 5: GAI values above the elevation and enrichment factors by lithology

Rock Type	Median of GAI_Bi	Median of GAI_Fe	Median of GAI_In	Median of GAI_Mn	Median of GAI_Mo	Median of GAI_Pb	Median of GAI_Re	Median of GAI_S	Median of GAI_Sb	Median of GAI_Se	Median of GAI_Te	Median of GAI_W	Median of GAI_Zn
ANG - Ore	2	2					1		2	3	4		
ANG - Waste	2	2		2			1	1	3	3	4		
CLA	3	2					1		4	3	4		1
DG - Ore	1	3					1	1	2	3	4		
DG - Waste	2	3					1	1	2	2	4		
DI	1	3					1		3	5	4		
DM	2	3					1	1	3	5	4	1	
DOR	3	2					1		2	3	4		
FWZ - Waste	2	3			1		1	1	3	2	5	1	
MAC - Waste	1	3					1	1	3	5	4		
MCS - Waste	5		1		3	2	3	3	6	6	6	1	
MM - Ore	1	3					1	2	2	4	4		
MTS - Waste	4	1	1		1		1		4	4	6		
NAM - Waste		2					1	1	1	2	4		
NEW - Ore		3					1			2	4		
NEW - Waste		3					1		2	5	4		
WS - Ore	1	3					1	1	3	3	4		
WS - Waste	4	2	1		1	2	1	3	5	4	6	1	

4.2.2 NAG - Multi-Element analysis

ICP-MS/OES results for the NAG and Four acid digest methods have been plotted against each other, graphs are presented in Appendix B. Results indicate variability in mobility between elements and rock units. MCS - Waste samples and a single DI sample showed the greatest mobility of elements under oxidised conditions for Al, As, Ce, Co, Cu, Fe, La, Na, Ni, Se, Th, Tl and U. These samples all have S concentrations greater than 1 wt % with low Nag pH values (ranging from 1.6 to 3.8). This indicates that the elements are mobile under strongly oxidising and therefore acidic conditions.

Elements including Ca, K, Nb, Sr and W, have a widespread scatter. This suggest that the elements are mobile under oxidised conditions and/or water, regardless of acidity. Additionally, Na displayed a strong positive correlation which reflects its water solubility.

5. Conclusions and Recommendations

The geochemical characterisation of the West Angelas mine deposits has been undertaken to assess potential rock units that could pose a geochemical risk at Rio Tinto's future mining operations. The characterisation has analysed ABA and geochemical data to identify enriched concentrations of elements which may pose an environmental risk.

A total of 99 samples were analysed of which 54 were classified as Uncertain, 33 were classified as Non-Acid Forming, 7 were classified as Potential Acid Forming- Low capacity and 5 were classified as Potential Acid Forming. Of the samples classified as Uncertain or Non-Acid forming 66 have less than 0.1 wt% S and are considered barren of sulfur with a negligible ability to produce acid. Rock units with samples identified as PAF- Low Capacity are from Detrital – immature, Footwall Zone – waste, Nammuldi – waste and Marra Mamba – Ore. Three Mount McRae Shale - waste samples are classified as Potentially Acid Forming, as well as a sample from Dales Gorge Member - waste and Detrital – immature. It is likely that the Detritals immature Potentially Acid Forming sample (IXU692) has been miss identified and is likely to be a lignite. This will be investigated in future work.

Future characterisation work should focus on the PAF rock units from the Mount McRae Shale, Detrital – immature and Nammuldi – waste rock units which exhibited strong acid NAGpH values (<4 pH).

The GAI results indicate that the metals/metalloids of Fe, Bi, Te, Sb and Se are enriched or elevated across the majority of rock units. Additionally, Mo, Re are enriched in MCS – Waste samples, while sulfur is enriched in WS and MCS - Waste. The mobility of the enriched elements is typically low, where strongly oxidising conditions did not yield an acidic pH. Under strongly oxidising conditions, enriched elements of Fe and Se and non-enriched elements including Al, As, Ce, Co, Cu, La, Na, Ni, Th, Tl and U display mobility. Elements including Ca, Na, K, Nb, Sr and W, display mobility under oxidised conditions and/or water, regardless of acidity. Enriched and mobile elements should be considered in any source-path-receptor modelling related.

6. Bibliography

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Appendix A: Test Methods and Calculations

The tests carried out as part of the geochemical characterisation programme and calculations used to assist in evaluating the acid base accounting parameters of the samples are shown in Table A-1 and A-2 respectively.

Table A-1: Parameters measured and description of methods

Parameter	Description
Paste pH (1:5)	pH measurements are performed on a 1:5 solid/water extract
Paste EC (1:5)	Electrical conductivity measurements are performed on a 1:5 solid/water extract
Acid Neutralising Capacity (ANC)	Determined by adding hydrochloric acid (HCl) to the sample, heating it, and then backtitrating the mixture with (NaOH) in order to determine the amount of HCL that remains on completion of the reaction. The amount of acid consumed in the initial reactions is calculated and expressed as the ANC.
Total Carbon/Sulfur	The sample is combusted in oxygen in a leco furnace at 1350° C. Carbon/sulfur present in the sample is evolved as carbon dioxide/sulfur dioxide and swept to a measurement cell for quantification by infrared detection.
Acid Extractable Sulfur SO4-S	Determined by adding HCL to the sample. Soluble sulfates dissolved in the HCL and are detected/quantified by ICP.
Chromium Reducible Sulfur	Chromium reducible sulfur (CRS) method measures the sulfide sulfur content or un-oxidised portion of
Total Organic Carbon	Inorganic carbon (carbonates, bicarbonates) is removed by reaction with dilute HCL. After drying the remaining sample is combusted in Oxygen in a Leco furnace at 1350° C. Any organic carbon in the sample presents organic matter or graphite is evolved as carbon dioxide and swept to a cell for quantification by infrared detection.
Single addition net acid generation (NAG) test	The NAG test involves addition of hydrogen peroxide (H_2O_2) to prepare samples (to oxidised any reactive sulfides). The NAG pH of the final solution. The resultant acidity is then titrated (using NaOH) to pH 4.5 and then to pH 7. Details of the procedure are outlined in the AMIRA international ARD Test Handbook (AMIRA, 2002)
Four acid digest multi element chemical assay	Involves the near total dissolution of most elements using a variety of digestion techniques (nitric, perchloric, hydrofluoric acid and hydrochloric acid). Analytical techniques are ICP-MS and ICP-OES dependant on the element
Net acid generation extraction multi element chemical assay	Acid extraction using H_2O_2. Analytical techniques are ICP-MS and ICP-OES dependant on the element

Table A-2: Calculated data

Parameter	Description
Sulfur Concentration Jarosite and Alunite (wt%)	Calculated by taking away total sulfur from Chromium reducible sulfur and sulfate sulfur
Maximum potential acidity (MPA)	Calculated by multiplying the total sulfur content (wt%) by 30.6. Approach assumes that all sulfur is present as pyrite.
Acidity potential (AP)	Calculated by multiplying the chromium reducible sulfur (wt%) by 30.6 and adding alunite/jarosite sulfur (wt%) multiplied by 22.9
Sulfide - Sulfur	Difference between total sulfur and sulfate sulfur
Net acid producing potential (NAPP)	NAPP is the difference between the MPA of the sample and the ANC. NAPP = MPA - ANC
Net potential Ratio (NPR)	NPR is the ratio of the MPA and the ANC: NPR = ANC/MPA
Total inorganic carbon (TIC)	Total inorganic carbon content was calculated as the difference between the total carbon content and total organic carbon content of the sample.
Carbonate-based neutralisation potential (CarbNP)	Calculated by multiplying the total inorganic carbon content (wt%) by 81.63.
Global abundance index	The GAI value provides a direct comparison of the measured average abundance of elements in the earth's crust. $GAI = Int\left[log_2\left(\frac{Measured\ Concentration}{1.5\ x\ Average\ Abundance}\right)\right]$

Appendix B: Test Results

Table B-1: ABA data analysis

Sample ID	Rock unit	From	To	Interval	pH	EC	Total S	SO_4	Scr	MPA	AP	ANC	NAPP	NPR	NAGpH	NAG Capacity (pH 4.5)	NAG Capacity (pH 7)	Total Carbon (TC)	Total Organic Carbon (TOC)	Total Inorganic Carbon (TIC)	CarbNP	Sample Classification
		m				(mS/cm)	(%)	(%)	(%)	kg H_2SO_4/t	kg H_2SO_4/t			ANC:MPA Ratio		kg H_2SO_4/t		(%)				
ISR998	ANG - Ore	10	12	2	4.9	0.24	0.07	0.07	<0.005	2.0	0.1	2	0.0	1	4.9	0	1	0.05	0.05	<0.01	0.41	UC
KDK997	ANG - Ore	20	22	2	6	0.17	0.02	0.02	<0.005	<1	0.1	3	-2.0	6	7.1	0	0	0.07	0.04	0.03	2.45	NAF
IKT735	ANG - Waste	22	24	2	7.1	1.12	0.06	0.07	<0.005	2.0	0.1	19	-17.0	9.5	7	0	0	0.08	0.03	0.05	4.08	NAF
IQI015	ANG - Waste	26	28	2	7.1	1.2	0.07	0.07	<0.005	2.0	0.1	11	-9.0	5.5	7	0	0	0.05	0.03	0.02	1.63	NAF
IQI264	ANG - Waste	12	14	2	4.9	0.39	0.13	0.14	<0.005	4.0	0.1	2	2.0	0.5	4.6	0	1	0.12	0.09	0.04	3.27	UC
IQI357	ANG - Waste	14	16	2	5.3	0.73	0.1	0.1	<0.005	3.0	0.1	2	1.0	0.7	5.2	0	0	0.1	0.06	0.04	3.27	UC
ISQ933	ANG - Waste	6	8	2	4.9	0.16	0.06	0.07	<0.005	2.0	0.1	1	1.0	0.5	5	0	1	0.03	0.03	<0.01	0.41	UC
KBU112	ANG - Waste	10	12	2	5.5	0.42	0.07	0.07	<0.005	2.0	0.1	2	0.0	1	6.1	0	0	0.04	0.03	0.01	0.82	UC
KDB643	ANG - Waste	12	14	2	4.8	0.67	0.11	0.12	<0.005	3.0	0.1	3	0.0	1	5.6	0	0	0.06	0.04	0.02	1.63	UC
IKC060	CLA	12	14	2	6.6	1.41	0.07	0.07	<0.005	2.0	0.1	3	-1.0	1.5	6.6	0	0	0.14	0.13	0.01	0.82	NAF
IKC062	CLA	16	18	2	6.6	1.43	0.05	0.06	<0.005	2.0	0.1	4	-2.0	2	6.7	0	0	0.08	0.06	0.02	1.63	NAF
IKD414	CLA	8	10	2	5.3	1.26	0.08	0.09	<0.005	2.0	0.1	3	-1.0	1.5	5.2	0	3	0.09	0.09	<0.01	0.41	NAF
ISA287	CLA	8	10	2	5.3	0.07	0.02	0.02	<0.005	<1	0.1	2	-1.0	4	5.4	0	2	0.07	0.07	<0.01	0.41	NAF
ISR689	CLA	20	22	2	7.1	0.25	0.01	0.01	<0.005	<1	0.1	12	-12.0	24	6.7	0	0	0.69	0.59	0.1	8.16	NAF
IWV832	CLA	60	62	2	5.9	0.15	0.05	0.05	<0.005	2.0	0.1	4	-2.0	2	6.1	0	0	0.26	0.18	0.08	6.53	NAF
KBP675	CLA	12	14	2	6.2	0.16	0.02	0.02	<0.005	<1	0.1	4	-3.0	8	6.5	0	0	0.24	0.16	0.08	6.53	NAF
KDW888	CLA	8	10	2	5.5	1.67	0.32	0.38	<0.005	10.0	0.1	2	8.0	0.2	5.5	0	1	0.04	0.03	0.01	0.82	UC
IKE803	DG - Ore	34	36	2	5.4	0.25	0.04	0.03	<0.005	1.0	0.2	1	0.0	1	6	0	0	0.1	0.08	0.02	1.63	UC
IQH700	DG - Ore	30	32	2	5.3	0.1	0.06	0.04	<0.005	2.0	0.5	0	2.0	0	5.1	0	0	0.09	0.06	0.03	2.45	UC
IQH843	DG - Ore	44	46	2	5.2	0.2	0.05	0.05	<0.005	2.0	0.1	1	1.0	0.5	5.9	0	0	0.13	0.1	0.03	2.45	UC
IQK216	DG - Ore	6	8	2	5.6	0.28	0.11	0.11	<0.005	3.0	0.1	1	2.0	0.3	5.9	0	0	0.25	0.16	0.09	7.35	UC
KDY617	DG - Ore	6	8	2	6.9	1.56	0.65	0.49	<0.005	20.0	3.7	8	12.0	0.4	6.5	0	0	0.16	0.07	0.09	7.35	UC
IKS295	DG - Waste	10	12	2	5.8	0.16	0.06	0.06	<0.005	2.0	0.1	1	1.0	0.5	5.9	0	0	0.15	0.14	0.01	0.82	UC
ISB458	DG - Waste	28	30	2	4.8	0.21	0.06	0.06	<0.005	2.0	0.1	1	1.0	0.5	5.4	0	0	0.1	0.08	0.02	1.63	UC
IXP068	DG - Waste	44	46	2	4.9	0.27	0.09	0.09	<0.005	3.0	0.1	1	2.0	0.3	4.8	0	1	0.06	0.05	0.01	0.82	UC
KAA196	DG - Waste	26	28	2	5.1	0.09	0.09	0.08	<0.005	3.0	0.2	1	2.0	0.3	5	0	2	0.07	0.08	<0.01	0.41	UC
KAA560	DG - Waste	86	88	2	4.9	0.09	0.04	0.04	<0.005	1.0	0.1	1	0.0	1	5.2	0	0	0.06	0.07	<0.01	0.41	UC
KBS379	DG - Waste	22	24	2	4	0.37	0.21	0.22	<0.005	7.0	0.1	0	8.0	0	3.9	0	2	0.19	0.17	0.02	1.63	PAF
KBS842	DG - Waste	12	14	2	4.4	0.23	0.1	0.1	<0.005	3.0	0.1	0	3.0	0	4.6	0	0	0.13	0.1	0.03	2.45	UC
KBS861	DG - Waste	48	50	2	5	0.19	0.05	0.05	<0.005	1.0	0.1	0	1.0	0	4.9	0	3	0.1	0.08	0.02	1.63	UC
KDY374	DG - Waste	102	104	2	4.8	0.2	0.06	0.06	<0.005	2.0	0.1	0	2.0	0	4.8	0	1	0.05	0.06	<0.01	0.41	UC
KJK834	DG - Waste	24	26	2	4.9	0.18	0.05	0.04	<0.005	2.0	0.2	0	3.0	0	4.7	0	0	0.03	0.02	0.01	0.82	UC
IKT635	DI	10	12	2	4.9	0.16	0.03	0.02	<0.005	<1	0.2	5	-4.0	10	6.9	0	0	0.09	0.07	0.02	1.63	NAF
IPX289	DI	12	14	2	6.8	0.13	0.02	0.02	<0.005	<1	0.1	4	-3.0	8	6.9	0	0	0.11	0.12	<0.01	0.41	NAF
IQJ569	DI	26	28	2	5.5	0.11	0.04	0.03	<0.005	1.0	0.2	0	1.0	0	5.9	0	0	0.09	0.07	0.08	6.53	UC
IXO621	DI	8	10	2	6.4	0.25	0.03	0.03	<0.005	1.0	0.1	4	-3.0	4	6.7	0	0	0.08	0.07	0.01	0.82	NAF
IXU692	DI	130	132	2	4.7	1.34	1.4	0.21	0.77	43.0	33.2	9	34.0	0.2	3.8	4	70	23.68	18.06	5.8	473.45	PAF
KBS302	DI	22	24	2	6.1	0.18	0.03	0.02	<0.005	<1	0.2	1	0.0	2	5.9	0	4	0.06	0.06	<0.01	0.41	UC
KDY571	DI	20	22	2	6.3	0.05	0.03	0.01	<0.005	<1	0.5	2	-1.0	4	6	0	3	0.07	0.08	<0.01	0.41	NAF
KJK611	DI	14	16	2	6.1	0.12	0.06	0.05	<0.005	2.0	0.2	2	0.0	1	5.9	0	2	0.07	0.06	0.01	0.82	UC

Table B-1: ABA data analysis

Sample ID	Rock unit	From	To	Interval	pH	EC	Total S	SO_4	Scr	MPA	AP	ANC	NAPP	NPR	NAGpH	NAG Capacity (pH 4.5)	NAG Capacity (pH 7)	Total Carbon (TC)	Total Organic Carbon (TOC)	Total Inorganic Carbon (TIC)	CarbNP	Sample Classification
		m				(mS/cm)	(%)	(%)	(%)	(%)	kg H_2SO_4/t			ANC:MPA Ratio		kg H_2SO_4/t		(%)				
KJV431	DI	12	14	2	6.3	0.13	0.07	0.07	<0.005	2.0	0.1	2	0.0	1	6.5	0	0	0.21	0.14	0.07	5.71	UC
KKA680	DI	14	16	2	4.7	0.33	0.25	0.22	<0.005	8.0	0.7	0	9.0	0	4.4	0	2	0.06	0.05	0.01	0.82	PAF -LC
KKK174	DI	24	26	2	6.7	0.08	0.03	0.01	<0.005	<1	0.5	2	-1.0	4	6.3	0	1	0.07	0.06	0.01	0.82	NAF
KKW509	DI	12	14	2	5.8	0.23	0.03	0.01	0.006	1.0	0.5	1	0.0	1	6	0	1	0.05	0.04	0.01	0.82	UC
KNE680	DI	10	12	2	5.8	0.08	0.06	0.07	<0.005	2.0	0.1	2	0.0	1	6	0	1	0.12	0.11	0.01	0.82	UC
ISQ383	DM	0	2	2	6.3	0.1	0.09	0.08	<0.005	3.0	0.2	3	0.0	1	6.3	0	0	0.12	0.07	0.05	4.08	UC
IWV729	DM	34	36	2	5.9	0.15	0.11	0.11	<0.005	3.0	0.1	2	1.0	0.7	6	0	0	0.3	0.21	0.09	7.35	UC
IWV732	DM	38	40	2	6	0.09	0.08	0.08	<0.005	3.0	0.1	3	0.0	1	6.4	0	0	0.26	0.22	0.04	3.27	UC
IXU682	DM	114	116	2	5.6	0.29	0.19	0.08	0.09	6.0	3.2	8	-2.0	1.3	5.6	0	0	3.98	1.81	2.17	177.14	NAF
KAF556	DM	28	30	2	6.8	0.29	0.58	0.48	<0.005	18.0	2.3	5	13.0	0.3	6.3	0	2	0.19	0.15	0.04	3.27	UC
KKA384	DM	8	10	2	4.8	0.08	0.13	0.12	<0.005	4.0	0.2	1	3.0	0.3	5.2	0	0	0.32	0.18	0.14	11.43	UC
KKA527	DM	4	6	2	5.3	0.09	0.08	0.08	<0.005	3.0	0.1	0	3.0	0	5.7	0	0	0.21	0.16	0.05	4.08	UC
IPX089	DOR	70	72	2	6.7	0.18	0.01	0.01	<0.005	<1	0.1	4	-4.0	8	6.1	0	0	0.18	0.13	0.05	4.08	NAF
IPX094	DOR	78	80	2	6.8	0.22	0.01	0.01	<0.005	<1	0.1	3	-3.0	6	6.8	0	0	0.12	0.09	0.03	2.45	NAF
IXU931	DOR	232	234	2	6	0.08	0.02	0.03	<0.005	<1	0.1	1	0.0	2	6.2	0	0	0.05	0.05	<0.01	0.41	UC
IXU939	DOR	246	248	2	6.7	0.17	0.04	0.04	<0.005	1.0	0.1	3	-2.0	3	6.4	0	0	0.08	0.06	0.02	1.63	NAF
KNE128	DOR	68	70	2	6.9	0.06	0.03	0.03	<0.005	1.0	0.1	4	-3.0	4	6.9	0	0	0.05	0.05	<0.01	0.41	NAF
ISB681	FWZ - Waste	38	40	2	4.9	0.19	0.1	0.1	<0.005	3.0	0.1	1	2.0	0.3	5	0	0	0.06	0.08	<0.01	0.41	UC
KBS203	FWZ - Waste	66	68	2	4.7	0.09	0.07	0.07	<0.005	2.0	0.1	0	3.0	0	4.4	0	2	0.03	0.04	<0.01	0.41	PAF - LC
IPR635	MAC - Waste	6	8	2	5.4	0.06	0.09	0.09	<0.005	3.0	0.1	1	2.0	0.3	5.5	0	1	0.13	0.11	0.02	1.63	UC
KJE033	MAC - Waste	14	16	2	5.2	0.29	0.07	0.07	<0.005	2.0	0.1	2	0.0	1	5.4	0	0	0.24	0.2	0.04	3.27	UC
KJV904	MAC - Waste	4	6	2	5.7	0.1	0.12	0.13	<0.005	4.0	0.1	2	2.0	0.5	5.9	0	0	0.22	0.18	0.04	3.27	UC
KKA519	MAC - Waste	32	34	2	4.7	0.16	0.11	0.12	<0.005	4.0	0.1	1	3.0	0.3	5.1	0	0	0.25	0.17	0.08	6.53	UC
KNE828	MAC - Waste	84	86	2	7.3	0.5	0.29	0.05	0.2	9.0	7.0	11	-2.0	1.2	4.2	0	1	0.84	0.73	0.11	8.98	UC
KDY612	MCS - Waste	42	44	2	I/S	I/S	0.05	0.37	<0.005	2.0	0.1	4	-2.0	2	6.4	0	2	0.05	0.03	0.02	1.63	NAF
IPX549	MCS - Waste	94	96	2	3.1	1.71	6.2	0.4	0.46	190.0	137.0	0	198.0	0	1.9	120	126	5.34	5.54	<0.01	0.41	PAF
IQC742	MCS - Waste	66	68	2	4.4	1.56	3.3	1.16	1.9	101.0	81.0	0	101.0	0	2.1	150	162	4.77	4.9	<0.01	0.41	PAF
IQC744	MCS - Waste	70	72	2	2.6	4.34	11.73	0.05	8	359	303.7	0	383	0	1.6	91	107	4.84	4.89	<0.01	0.41	PAF
KJE387	MCS - Waste	28	30	2	6.8	0.08	0.04	0.04	<0.005	1.0	0.1	4	-3.0	4	6.1	0	4	0.04	0.06	<0.01	0.41	NAF
KJE711	MCS - Waste	116	118	2	6.8	0.08	0.05	0.04	<0.005	1.0	0.2	3	-2.0	3	6.3	0	1	0.05	0.04	0.01	0.82	NAF
IPR791	MM - Ore	4	6	2	7.7	1.51	0.98	0.57	<0.005	30.0	9.4	24	6.0	0.8	9.8	0	0	0.36	0.07	0.29	23.67	UC
KDK056	MM - Ore	10	12	2	4.4	1.1	0.14	0.14	<0.005	4.0	0.1	1	3.0	0.3	4.3	0	1	0.05	0.04	0.01	0.82	PAF - LC
KKA684	MM - Ore	20	22	2	4.3	0.34	0.18	0.17	<0.005	5.0	0.2	0	5.0	0	4.3	0	1	0.29	0.14	0.15	12.24	PAF - LC
KKA686	MM - Ore	24	26	2	4.3	0.28	0.28	0.28	<0.005	8.0	0.1	0	9.0	0	4.4	0	1	0.21	0.12	0.09	7.35	PAF - LC
ISB416	MTS - Waste	14	16	2	8	0.39	0.02	0.02	<0.005	<1	0.1	42	-41.0	84	8	0	0	0.51	0.04	0.47	38.37	NAF
KJE524	MTS - Waste	134	136	2	7	0.07	0.01	<0.01	<0.005	<1	0.1	3	-3.0	6	6.5	0	1	0.06	0.05	0.01	0.82	NAF
IKT373	NAM - Waste	14	16	2	5.5	0.31	0.05	0.05	<0.005	2.0	0.1	2	0.0	1	5.7	0	0	0.07	0.07	<0.01	0.41	UC
IPW007	NAM - Waste	18	20	2	3.9	0.32	1.29	0.94	<0.005	40.0	8.0	0	41.0	0	3.9	0	1	0.12	0.03	0.09	7.35	PAF - LC
KDK147	NAM - Waste	22	24	2	5.1	0.72	0.05	0.05	<0.005	2.0	0.1	1	1.0	0.5	5.1	0	1	0.04	0.03	0.01	0.82	UC

Table B-1: ABA data analysis

Sample ID	Rock unit	From	To	Interval	pH	EC	Total S	SO4	Scr	MPA	AP	ANC	NAPP	NPR	NAGpH	NAG Capacity (pH 4.5)	NAG Capacity (pH 7)	Total Carbon (TC)	Total Organic Carbon (TOC)	Total Inorganic Carbon (TIC)	CarbNP	Sample Classification
		m				(mS/cm)	(%)	(%)	(%)	kg H2SO4/t	kg H2SO4/t			ANC:MPA Ratio		kg H2SO4/t		(%)				
KJK122	NAM - Waste	28	30	2	4.1	0.23	0.13	0.13	<0.005	4.0	0.1	0	5.0	0	4.4	0	0	0.05	0.03	0.02	1.63	PAF - LC
KNF277	NAM - Waste	20	22	2	5.3	0.08	0.02	0.02	<0.005	<1	0.1	1	0.0	2	6	0	0	0.05	0.04	0.01	0.82	UC
ISQ526	NEW - Ore	28	30	2	5.2	0.1	0.02	0.01	<0.005	<1	0.2	1	0.0	2	6	0	0	0.03	0.02	0.01	0.82	UC
KJK432	NEW - Ore	14	16	2	5	0.18	0.04	0.03	<0.005	1.0	0.2	1	0.0	1	5.3	0	0	0.1	0.06	0.04	3.27	UC
KKW195	NEW - Ore	16	18	2	6.2	0.05	0.03	0.01	<0.005	<1	0.5	0	2.0	0	6.3	0	0	0.1	0.08	0.02	1.63	UC
IPW047	NEW - Waste	10	12	2	4.7	0.33	0.08	0.09	<0.005	3.0	0.1	2	1.0	0.7	4.9	0	0	0.23	0.13	0.1	8.16	UC
IPW060	NEW - Waste	6	8	2	5.1	0.06	0.08	0.08	<0.005	2.0	0.1	2	0.0	1	5.4	0	0	0.2	0.16	0.04	3.27	UC
ISQ854	NEW - Waste	32	34	2	4.6	0.12	0.03	0.02	<0.005	<1	0.2	1	0.0	2	5.2	0	0	0.03	0.02	0.01	0.82	UC
KDS668	NEW - Waste	10	12	2	5.7	0.07	0.07	0.07	<0.005	2.0	0.1	3	-1.0	1.5	6.1	0	0	0.26	0.22	0.04	3.27	NAF
KDS722	NEW - Waste	6	8	2	6.6	0.19	0.11	0.11	<0.005	3.0	0.1	2	1.0	0.7	5	0	1	0.02	0.01	0.01	0.82	UC
KDU367	NEW - Waste	16	18	2	6	0.39	0.05	0.05	<0.005	2.0	0.1	5	-3.0	2.5	5.4	0	1	0.86	0.54	0.32	26.12	NAF
KIS260	NEW - Waste	30	32	2	6.6	0.18	0.02	<0.01	<0.005	<1	0.2	5	-5.0	10	6.4	0	1	0.23	0.2	0.03	2.45	NAF
KIS196	NEW - Waste	18	20	2	6.8	0.09	0.02	0.02	0.005	<1	0.4	7	-7.0	14	6.6	0	0	0.24	0.18	0.06	4.90	NAF
KIS257	NEW - Waste	24	26	2	6.9	0.12	0.03	0.01	0.009	<1	0.3	5	-4.0	10	6.6	0	1	0.25	0.24	0.01	0.82	NAF
KJW683	NEW - Waste	16	18	2	4.8	0.06	0.06	0.06	0.005	2.0	0.2	1	1.0	0.5	5.7	0	0	0.2	0.09	0.11	8.98	UC
KKA687	NEW - Waste	26	28	2	4.2	0.45	0.3	0.32	0.005	9.0	0.2	0	9.0	0	4.5	0	1	0.36	0.13	0.23	18.77	UC
IMU159A	WS - Ore	106	108	2	6.7	0.2	0.04	0.03	<0.005	1.0	0.2	3	-2.0	3	6.6	0	0	0.23	0.19	0.04	3.27	NAF
IQL134	WS - Ore	4	6	2	8	0.52	0.31	0.33	<0.005	10.0	0.1	68	-58.0	6.8	10	0	0	0.92	0.12	0.8	65.30	NAF
IQL024	WS - Waste	14	16	2	7.6	0.6	0.24	0.25	<0.005	7.0	0.1	22	-15.0	3.1	7.4	0	0	0.77	0.42	0.35	28.57	NAF
KBP703	WS - Waste	12	14	2	5.3	0.29	0.76	0.34	<0.005	23.0	9.6	2	21.0	0.1	5.3	0	0	0.14	0.12	0.02	1.63	UC
Average					5.64	0.40	0.34	0.12	0.12	10.6	6.2	4.03	6.98	3.1	5.68	3.69	5.26	0.59	0.46	0.14	11.05	-
Median					5.50	0.20	0.06	0.07	0.00	2.0	0.08	2.00	0.00	1.00	5.90	0.00	0.00	0.11	0.08	0.02	1.63	-
Minimum					2.60	0.05	0.01	0.01	0.00	0.5	0.08	0	-58.00	0	1.60	0.00	0.00	0.02	0.01	0.01	0.41	-
Maximum					8.00	4.34	11.73	1.16	8.00	359.	303.7	68.00	383.00	84.00	10.00	150.00	162.00	23.68	18.06	5.80	473.45	-

Table B-2: Global crustal abundance data

Parameters	ANG - Ore	ANG - Waste	CLA	DG - Ore	WS - Waste	DG - Waste	DI	DM	DOR	FWZ - Waste	MAC - Waste	MCS - Waste	MM - Ore	MTS - Waste	NAM - Waste	NEW - Ore	NEW - Waste	WS - Ore
Count of GAI_Al	2	7	8	5	2	10	13	7	5	2	5	6	4	2	5	3	11	2
Average of GAI_Al	-2	-2	-1	-3	0	-3	-2	-2	0	-2	-2	-1	-2	-1	-4	-5	-2	-3
Median of GAI_Al	-2	-2	-1	-3	0	-2	-2	-2	0	-2	-2	-1	-2	-1	-3	-5	-2	-3
Max of GAI_Al	-2	-1	0	-3	0	0	-1	-2	0	-2	-1	0	-2	0	-2	-4	-1	-2
Min of GAI_Al	-2	-2	-1	-4	0	-6	-3	-4	-1	-2	-3	-2	-3	-2	-6	-5	-6	-3
Count of GAI_Ag	2	7	8	5	2	10	13	7	5	2	5	6	4	2	5	3	11	2
Average of GAI_Ag	-2	-1	-1	-2	-2	-1	-1	-1	-2	-2	-1	1	-2	-1	-1	-1	-1	-2
Median of GAI_Ag	-2	-2	-2	-2	-2	-1	-2	-2	-2	-2	-2	0	-2	-1	-1	-1	-1	-2
Max of GAI_Ag	-1	1	0	-1	-2	1	0	0	0	-2	0	2	-1	0	-1	0	0	-2
Min of GAI_Ag	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	0	-2	-2	-2	-2	-2	-2
Count of GAI_Ba	2	7	8	5	2	10	13	7	5	2	5	6	4	2	5	3	11	2
Average of GAI_Ba	-6	-2	-3	-5	-3	-4	-3	-5	-5	-4	-4	-3	-6	-4	-5	-6	-5	-6
Median of GAI_Ba	-6	-2	-3	-6	-3	-5	-3	-3	-5	-4	-5	-3	-7	-4	-5	-6	-6	-6
Max of GAI_Ba	-4	2	0	-3	-2	-2	1	-2	-2	-1	-1	-1	-2	-3	-2	-5	-2	-3
Min of GAI_Ba	-7	-6	-6	-6	-4	-7	-8	-10	-7	-6	-6	-4	-7	-4	-7	-8	-8	-8
Count of GAI_Be	2	7	8	5	2	10	13	7	5	2	5	6	4	2	5	3	11	2
Average of GAI_Be	-1	-1	-1	-2	-2	-2	-2	-3	-1	-1	-2	-1	-2	-2	-1	-3	-3	-2
Median of GAI_Be	-1	-1	-1	-1	-2	-2	-2	-3	-1	-1	-2	-1	-2	-2	-2	-2	-3	-2
Max of GAI_Be	-1	2	0	-1	-1	-1	0	-2	0	-1	-2	-1	-1	-1	0	-2	-1	0
Min of GAI_Be	-1	-2	-3	-3	-2	-3	-4	-4	-3	-1	-3	-2	-3	-2	-2	-3	-4	-3
Count of GAI_Bi	2	7	8	5	2	10	13	7	5	2	5	6	4	2	5	3	11	2
Average of GAI_Bi	2	2	3	1	4	2	2	2	1	2	1	5	1	4	-1	-1	0	1
Median of GAI_Bi	2	2	3	1	4	2	1	2	3	2	1	5	1	4	0	-1	0	1
Max of GAI_Bi	2	3	5	2	4	5	2	3	4	2	2	5	1	4	0	0	2	3
Min of GAI_Bi	2	1	2	-1	4	-4	1	1	-1	2	1	4	0	3	-4	-1	-4	0
Count of GAI_Ca	2	7	8	5	2	10	13	7	5	2	5	6	4	2	5	3	11	2
Average of GAI_Ca	-9	-8	-8	-9	-6	-9	-7	-8	-8	-9	-8	-7	-8	-5	-11	-10	-8	-5
Median of GAI_Ca	-9	-9	-8	-9	-6	-9	-7	-7	-8	-9	-8	-8	-10	-5	-11	-10	-8	-5
Max of GAI_Ca	-9	-4	-4	-5	-3	-7	-5	-6	-7	-9	-5	-5	-3	-3	-9	-9	-3	-1
Min of GAI_Ca	-10	-10	-9	-11	-8	-11	-10	-11	-9	-9	-11	-9	-11	-7	-11	-10	-11	-9
Count of GAI_Cd	2	7	8	5	2	10	13	7	5	2	5	6	4	2	5	3	11	2
Average of GAI_Cd	-1	-1	-2	-4	-5	-4	-3	-6	-1	-1	-5	0	-3	-4	-5	-4	-5	-7
Median of GAI_Cd	-1	-1	-1	-2	-5	-5	-2	-7	0	-1	-7	-1	-2	-4	-7	-2	-7	-7
Max of GAI_Cd	-1	5	1	0	-2	1	2	-2	0	-1	0	2	1	-1	0	-2	0	-7
Min of GAI_Cd	-2	-7	-7	-7	-7	-7	-7	-7	-2	-1	-7	-1	-7	-7	-7	-7	-7	-7
Count of GAI_Ce	2	7	8	5	2	10	13	7	5	2	5	6	4	2	5	3	11	2
Average of GAI_Ce	-2	-1	-1	-2	-1	-2	-3	-4	-3	-1	-4	-1	-4	-2	-4	-3	-4	-2
Median of GAI_Ce	-2	-1	-1	-2	-1	-2	-4	-4	-3	-1	-4	0	-4	-2	-4	-4	-4	-2
Max of GAI_Ce	-2	0	0	-1	0	1	1	-2	-1	-1	-2	0	-3	-1	-2	-2	0	-2
Min of GAI_Ce	-2	-3	-2	-4	-1	-4	-5	-6	-4	-2	-5	-3	-5	-2	-5	-4	-5	-3
Count of GAI_Co	2	7	8	5	2	10	13	7	5	2	5	6	4	2	5	3	11	2
Average of GAI_Co	-2	0	0	-4	-3	-4	-2	-3	-2	-3	-3	-2	-2	-3	-2	-3	-3	-5
Median of GAI_Co	-2	0	0	-4	-3	-4	-3	-4	-2	-3	-3	-2	-2	-3	-2	-3	-3	-5
Max of GAI_Co	-1	2	1	-2	-2	-1	2	1	0	-2	-2	0	-2	-3	0	-2	0	-4
Min of GAI_Co	-2	-2	-3	-5	-3	-5	-5	-5	-4	-3	-4	-3	-3	-4	-4	-3	-5	-5
Count of GAI_Cr	2	7	8	5	2	10	13	7	5	2	5	6	4	2	5	3	11	2
Average of GAI_Cr	-2	-2	0	-3	0	-3	-1	-1	-1	-1	-1	0	-2	-1	-3	-4	-2	-3
Median of GAI_Cr	-2	-2	0	-2	0	-3	-1	-1	-1	-1	-1	0	-1	-1	-3	-4	-2	-3
Max of GAI_Cr	-2	0	1	-2	1	-1	1	0	1	-1	0	0	-1	0	-2	-3	1	-2
Min of GAI_Cr	-2	-4	-1	-4	0	-5	-2	-3	-2	-2	-2	-1	-3	-1	-5	-5	-5	-4
Count of GAI_Cs	2	7	8	5	2	10	13	7	5	2	5	6	4	2	5	3	11	2
Average of GAI_Cs	-5	-5	-2	-7	-6	-7	-5	-6	-4	-6	-5	0	-7	-2	-7	-7	-7	-7
Median of GAI_Cs	-5	-4	-1	-7	-6	-7	-4	-6	-4	-6	-6	0	-7	-2	-7	-7	-7	-7
Max of GAI_Cs	-3	-2	0	-3	-5	-5	-2	-3	0	-5	-1	2	-6	-2	-6	-7	-4	-7
Min of GAI_Cs	-7	-6	-6	-7	-7	-7	-7	-7	-7	-6	-7	-1	-7	-2	-7	-7	-7	-7
Count of GAI_Cu	2	7	8	5	2	10	13	7	5	2	5	6	4	2	5	3	11	2
Average of GAI_Cu	-1	-1	0	-3	-1	-2	-2	-3	-1	-1	-1	0	-2	-1	-2	-3	-2	-3
Median of GAI_Cu	-1	-1	0	-3	-1	-2	-3	-3	-1	-1	-1	0	-2	-1	-2	-3	-1	-3
Max of GAI_Cu	0	0	1	-2	-1	-1	1	-1	1	-1	0	1	0	-1	-1	-3	1	-2
Min of GAI_Cu	-2	-2	-1	-5	-2	-4	-5	-4	-2	-2	-2	-1	-3	-1	-4	-4	-5	-4
Count of GAI_Fe	2	7	8	5	2	10	13	7	5	2	5	6	4	2	5	3	11	2
Average of GAI_Fe	2	2	2	3	2	2	3	3	2	3	3	1	3	1	3	3	3	3
Median of GAI_Fe	2	2	2	3	2	3	3	3	2	3	3	0	3	1	2	3	3	3
Max of GAI_Fe	3	3	3	3	2	3	3	3	3	3	3	2	3	3	3	3	3	3
Min of GAI_Fe	2	2	1	3	1	1	2	3	2	2	2	0	3	0	2	3	2	3
Count of GAI_Ga	2	7	8	5	2	10	13	7	5	2	5	6	4	2	5	3	11	2
Average of GAI_Ga	-1	-1	0	-2	0	-2	-1	-1	0	-1	-1	0	-1	-1	-2	-2	-2	-1
Median of GAI_Ga	-1	-1	0	-1	0	-2	-1	-1	0	-1	-1	0	-1	-1	-2	-2	-2	-1
Max of GAI_Ga	-1	0	1	-1	0	0	1	0	0	-1	-1	0	-1	0	-2	-2	0	-1
Min of GAI_Ga	-1	-2	-1	-2	0	-3	-2	-1	-1	-1	-2	-1	-2	-1	-3	-2	-3	-2
Count of GAI_Ge	2	7	8	5	2	10	13	7	5	2	5	6	4	2	5	3	11	2
Average of GAI_Ge	-1	-2	-3	-1	-2	-2	-2	-1	-2	-2	-1	-2	-1	-1	-1	-1	-1	-1
Median of GAI_Ge	-1	-2	-3	-1	-2	-2	-2	-1	-2	-2	-1	-3	-1	-1	-2	-1	-1	-1
Max of GAI_Ge	-1	0	-1	0	-2	-1	-1	-1	-2	-1	0	-2	-1	-1	0	-1	-1	-1
Min of GAI_Ge	-1	-2	-4	-2	-2	-3	-3	-2	-3	-3	-2	-3	-1	-2	-2	-1	-2	-1
Count of GAI_Hf	2	7	8	5	2	10	13	7	5	2	5	6	4	2	5	3	11	2
Average of GAI_Hf	-3	-2	-1	-4	0	-3	-2	-2	-1	-3	-3	-1	-4	-2	-5	-6	-4	-3
Median of GAI_Hf	-3	-2	-1	-3	0	-3	-2	-2	-1	-3	-3	-1	-3	-2	-4	-6	-3	-3
Max of GAI_Hf	-3	-2	0	-2	0	0	-1	-2	-1	-2	-2	0	-3	-1	-4	-4	-2	-2
Min of GAI_Hf	-3	-3	-3	-5	0	-6	-3	-4	-2	-3	-3	-1	-5	-3	-6	-7	-8	-4

Table B-2: Global crustal abundance data

Parameters	ANG - Ore	ANG - Waste	CLA	DG - Ore	WS - Waste	DG - Waste	DI	DM	DOR	FWZ - Waste	MAC - Waste	MCS - Waste	MM - Ore	MTS - Waste	NAM - Waste	NEW - Ore	NEW - Waste	WS - Ore
Count of GAI_In	2	7	8	5	2	10	13	7	5	2	5	6	4	2	5	3	11	2
Average of GAI_In	-2	-1	0	-2	1	-1	-1	-1	0	-1	0	1	-1	1	-2	-4	-2	-2
Median of GAI_In	-2	-1	0	-1	1	-2	-1	-1	0	-1	-1	1	-1	1	-3	-4	-1	-2
Max of GAI_In	-1	1	2	0	1	2	1	0	1	-1	0	2	0	2	0	-4	2	-1
Min of GAI_In	-2	-2	-1	-4	1	-4	-2	-2	-1	-1	-1	1	-3	0	-4	-4	-4	-4
Count of GAI_K	2	7	8	5	2	10	13	7	5	2	5	6	4	2	5	3	11	2
Average of GAI_K	-7	-5	-3	-8	-4	-8	-7	-7	-6	-8	-7	-1	-7	-4	-7	-10	-8	-7
Median of GAI_K	-7	-5	-2	-9	-4	-9	-7	-8	-8	-8	-8	-1	-8	-4	-9	-10	-8	-7
Max of GAI_K	-5	-2	0	-3	-3	-6	-3	-4	0	-8	-3	0	-3	-3	-2	-10	-5	-5
Min of GAI_K	-9	-9	-9	-10	-5	-9	-9	-12	-10	-9	-9	-2	-10	-4	-9	-10	-9	-10
Count of GAI_La	2	7	8	5	2	10	13	7	5	2	5	6	4	2	5	3	11	2
Average of GAI_La	-3	-1	0	-3	-1	-2	-3	-4	-3	-1	-4	-1	-5	-2	-4	-4	-4	-3
Median of GAI_La	-3	-2	-1	-2	-1	-2	-3	-4	-3	-1	-5	0	-5	-2	-4	-4	-5	-3
Max of GAI_La	-3	2	4	-1	-1	2	1	-2	-1	0	-2	0	-5	-1	-3	-3	-2	-3
Min of GAI_La	-3	-3	-2	-5	-1	-3	-6	-6	-5	-2	-6	-2	-5	-2	-6	-5	-6	-4
Count of GAI_Li	2	7	8	5	2	10	13	7	5	2	5	6	4	2	5	3	11	2
Average of GAI_Li	-3	-3	-2	-5	-2	-4	-3	-4	-4	-6	-3	0	-4	-2	-4	-5	-4	-4
Median of GAI_Li	-3	-3	-2	-6	-2	-4	-3	-4	-3	-6	-4	0	-4	-2	-4	-5	-4	-4
Max of GAI_Li	-3	-2	-1	-4	-1	-2	-1	-3	-2	-5	-2	1	-4	-2	-3	-5	-2	-2
Min of GAI_Li	-3	-4	-2	-6	-2	-5	-5	-7	-7	-6	-4	-1	-4	-2	-5	-6	-5	-5
Count of GAI_Mg	2	7	8	5	2	10	13	7	5	2	5	6	4	2	5	3	11	2
Average of GAI_Mg	-6	-5	-4	-7	-5	-7	-6	-7	-6	-7	-7	-3	-7	-4	-8	-7	-6	-5
Median of GAI_Mg	-6	-6	-3	-8	-5	-8	-6	-6	-6	-7	-7	-4	-7	-4	-8	-7	-7	-5
Max of GAI_Mg	-6	-3	-2	-5	-4	-6	-4	-6	-5	-6	-3	-2	-5	-3	-6	-7	-3	-4
Min of GAI_Mg	-6	-7	-6	-8	-6	-8	-8	-9	-6	-7	-9	-4	-8	-5	-9	-8	-9	-6
Count of GAI_Mn	2	7	8	5	2	10	13	7	5	2	5	6	4	2	5	3	11	2
Average of GAI_Mn	0	2	0	-3	-4	-3	-2	-3	-1	-1	-4	-4	-4	-4	-4	-2	-4	-2
Median of GAI_Mn	0	2	0	-3	-4	-3	-2	-4	-1	-1	-4	-4	-4	-4	-4	-2	-4	-2
Max of GAI_Mn	1	7	2	-2	-3	-1	4	1	1	-1	-3	-3	-3	-3	-2	-1	-1	-1
Min of GAI_Mn	-1	-4	-5	-4	-4	-6	-6	-5	-3	-1	-6	-5	-5	-5	-6	-3	-5	-3
Count of GAI_Mo	2	7	8	5	2	10	13	7	5	2	5	6	4	2	5	3	11	2
Average of GAI_Mo	-1	-1	-1	-1	1	-1	0	0	0	1	-1	3	-1	1	-3	-2	-1	-1
Median of GAI_Mo	-1	-1	-1	0	1	-1	0	0	0	1	-1	3	-1	1	-2	-2	-1	-1
Max of GAI_Mo	-1	-1	3	0	1	2	1	2	2	1	0	3	0	2	-2	-2	-1	0
Min of GAI_Mo	-1	-2	-2	-2	0	-2	-2	-1	-2	1	-1	2	-2	0	-3	-3	-3	-2
Count of GAI_Na	2	7	8	5	2	10	13	7	5	2	5	6	4	2	5	3	11	2
Average of GAI_Na	-7	-6	-6	-8	-5	-8	-7	-7	-7	-8	-7	-7	-7	-7	-7	-9	-7	-6
Median of GAI_Na	-7	-6	-5	-8	-5	-7	-7	-8	-7	-8	-8	-7	-7	-7	-6	-9	-7	-6
Max of GAI_Na	-7	-5	-5	-6	-5	-7	-6	-4	-6	-8	-6	-6	-5	-7	-6	-8	-4	-5
Min of GAI_Na	-7	-7	-8	-9	-6	-9	-8	-9	-8	-8	-8	-7	-8	-7	-9	-9	-10	-7
Count of GAI_Nb	2	7	8	5	2	10	13	7	5	2	5	6	4	2	5	3	11	2
Average of GAI_Nb	-4	-5	-4	-5	-2	-4	-4	-3	-3	-4	-4	-3	-4	-4	-6	-6	-5	-4
Median of GAI_Nb	-4	-4	-4	-4	-2	-5	-4	-4	-3	-4	-4	-3	-4	-4	-5	-7	-4	-4
Max of GAI_Nb	-4	-3	-2	-4	-2	-2	-2	-2	-3	-4	-4	-3	-4	-4	-5	-5	-3	-3
Min of GAI_Nb	-4	-6	-5	-6	-2	-7	-5	-4	-4	-4	-4	-4	-5	-4	-7	-7	-8	-5
Count of GAI_Ni	2	7	8	5	2	10	13	7	5	2	5	6	4	2	5	3	11	2
Average of GAI_Ni	-2	-1	0	-4	-2	-4	-3	-4	-2	-2	-3	-1	-2	-2	-3	-4	-3	-5
Median of GAI_Ni	-2	-1	0	-4	-2	-3	-3	-4	-2	-2	-3	-1	-3	-2	-3	-4	-3	-5
Max of GAI_Ni	-2	1	1	-2	-1	-1	1	-1	-1	-2	-2	0	-1	-1	-1	-3	-1	-4
Min of GAI_Ni	-2	-3	-3	-5	-3	-6	-4	-5	-4	-2	-4	-2	-3	-3	-4	-4	-6	-5
Count of GAI_P	2	7	8	5	2	10	13	7	5	2	5	6	4	2	5	3	11	2
Average of GAI_P	-2	-2	-2	-1	-2	-1	-2	-1	-1	0	-3	-3	-1	-3	-2	-2	-2	-1
Median of GAI_P	-2	-2	-2	-1	-2	-1	-1	-2	0	0	-2	-3	-1	-3	-2	-2	-2	-1
Max of GAI_P	-2	-1	-1	0	-1	0	-1	-1	0	0	-1	-2	-1	-2	-1	-1	-1	0
Min of GAI_P	-2	-3	-2	-1	-2	-2	-4	-2	-2	0	-6	-4	-2	-5	-4	-2	-3	-2
Count of GAI_Pb	2	7	8	5	2	10	13	7	5	2	5	6	4	2	5	3	11	2
Average of GAI_Pb	-1	-1	0	-1	2	-1	-1	-1	-1	0	-1	2	-1	0	-3	-3	-2	-2
Median of GAI_Pb	-1	-1	0	-1	2	-1	-1	-1	0	0	-2	2	-1	0	-3	-3	-1	-2
Max of GAI_Pb	-1	0	1	0	2	2	0	0	1	0	-1	2	-1	1	-1	-2	0	-1
Min of GAI_Pb	-1	-2	0	-4	2	-4	-2	-2	-2	0	-2	1	-1	0	-5	-5	-6	-2
Count of GAI_Rb	2	7	8	5	2	10	13	7	5	2	5	6	4	2	5	3	11	2
Average of GAI_Rb	-7	-6	-3	-9	-7	-8	-6	-7	-5	-8	-7	-1	-9	-3	-8	-10	-8	-9
Median of GAI_Rb	-7	-5	-1	-9	-7	-9	-7	-8	-7	-8	-8	-1	-9	-3	-8	-10	-8	-9
Max of GAI_Rb	-5	-3	-1	-4	-6	-7	-2	-3	-1	-8	-1	1	-6	-3	-7	-10	-5	-8
Min of GAI_Rb	-9	-8	-8	-10	-8	-10	-9	-11	-9	-8	-8	-1	-10	-3	-9	-10	-9	-10
Count of GAI_Re	2	7	8	5	2	10	13	7	5	2	5	6	4	2	5	3	11	2
Average of GAI_Re	1	1	1	1	1	1	1	1	1	1	1	3	1	1	1	1	1	1
Median of GAI_Re	1	1	1	1	1	1	1	1	1	1	1	3	1	1	1	1	1	1
Max of GAI_Re	1	1	1	1	1	2	1	4	1	1	2	6	1	1	1	1	1	1
Min of GAI_Re	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Count of GAI_S	2	7	8	5	2	10	13	7	5	2	5	6	4	2	5	3	11	2
Average of GAI_S	0	1	0	1	3	1	0	2	-1	1	2	3	3	-1	1	0	0	1
Median of GAI_S	0	1	0	1	3	1	0	1	-1	1	1	3	2	-1	1	-1	0	1
Max of GAI_S	1	2	3	4	4	2	5	3	-1	1	3	8	4	-1	5	0	3	3
Min of GAI_S	-1	1	-1	-1	2	0	-1	1	-1	1	1	-1	2	-1	-1	-1	-1	0

Table B-2: Global crustal abundance data

Parameters	ANG - Ore	ANG - Waste	CLA	DG - Ore	WS - Waste	DG - Waste	DI	DM	DOR	FWZ - Waste	MAC - Waste	MCS - Waste	MM - Ore	MTS - Waste	NAM - Waste	NEW - Ore	NEW - Waste	WS - Ore
Count of GAI_Sb	2	7	8	5	2	10	13	7	5	2	5	6	4	2	5	3	11	2
Average of GAI_Sb	2	3	4	2	5	2	3	3	3	3	3	6	2	4	2	0	1	3
Median of GAI_Sb	2	3	4	2	5	2	3	3	2	3	3	6	2	4	1	0	2	3
Max of GAI_Sb	2	4	7	3	6	5	5	4	6	3	3	6	2	5	3	1	3	3
Min of GAI_Sb	2	1	2	0	4	0	2	2	1	3	1	5	2	3	0	0	-2	2
Count of GAI_Sc	2	7	8	5	2	10	13	7	5	2	5	6	4	2	5	3	11	2
Average of GAI_Sc	-2	-1	0	-3	0	-2	-2	-2	0	-2	-1	0	-2	-1	-3	-4	-2	-2
Median of GAI_Sc	-2	-1	0	-3	0	-2	-2	-2	0	-2	-2	0	-2	-1	-2	-4	-2	-2
Max of GAI_Sc	-2	0	1	-2	0	-1	-1	-1	2	-1	0	0	-1	0	-1	-3	0	-2
Min of GAI_Sc	-2	-2	-1	-4	0	-5	-3	-4	-1	-2	-2	-1	-3	-2	-5	-5	-6	-3
Count of GAI_Se	2	7	8	5	2	10	13	7	5	2	5	6	4	2	5	3	11	2
Average of GAI_Se	3	3	3	3	4	3	4	5	3	2	5	6	4	4	3	2	4	3
Median of GAI_Se	3	3	3	3	4	2	5	5	3	2	5	6	4	4	2	2	5	3
Max of GAI_Se	4	4	5	5	5	5	6	7	5	3	6	7	5	4	5	3	6	4
Min of GAI_Se	2	2	2	2	3	2	2	3	2	2	3	5	2	3	2	2	2	2
Count of GAI_Sn	2	7	8	5	2	10	13	7	5	2	5	6	4	2	5	3	11	2
Average of GAI_Sn	-2	-2	0	-3	0	-2	-1	-1	-1	-2	-2	0	-2	-1	-3	-5	-3	-2
Median of GAI_Sn	-2	-2	0	-2	0	-2	-2	-1	-1	-2	-2	0	-2	-1	-3	-5	-2	-2
Max of GAI_Sn	-2	0	1	-2	0	0	0	0	0	-2	-1	1	-1	0	-1	-3	0	-1
Min of GAI_Sn	-2	-3	-1	-4	0	-5	-2	-2	-2	-2	-2	0	-3	-1	-4	-5	-5	-3
Count of GAI_Sr	2	7	8	5	2	10	13	7	5	2	5	6	4	2	5	3	11	2
Average of GAI_Sr	-8	-6	-5	-5	-2	-6	-5	-6	-6	-6	-7	-5	-6	-5	-8	-8	-7	-5
Median of GAI_Sr	-8	-7	-5	-5	-2	-6	-5	-6	-6	-6	-7	-5	-7	-5	-9	-8	-6	-5
Max of GAI_Sr	-7	-2	-2	-4	-2	-4	-3	-2	-5	-6	-6	-4	-3	-4	-4	-7	-4	-2
Min of GAI_Sr	-9	-8	-7	-7	-2	-8	-8	-10	-7	-6	-10	-7	-7	-6	-10	-8	-10	-8
Count of GAI_Ta	2	7	8	5	2	10	13	7	5	2	5	6	4	2	5	3	11	2
Average of GAI_Ta	-3	-4	-3	-4	-1	-4	-3	-3	-3	-3	-4	-2	-4	-3	-6	-6	-4	-4
Median of GAI_Ta	-3	-4	-3	-4	-1	-4	-3	-3	-3	-3	-4	-2	-4	-3	-5	-6	-4	-4
Max of GAI_Ta	-3	-2	-1	-3	-1	-2	-2	-2	-2	-3	-3	-2	-3	-3	-4	-5	-3	-2
Min of GAI_Ta	-3	-5	-4	-6	-1	-7	-4	-3	-3	-4	-4	-3	-5	-3	-7	-7	-7	-5
Count of GAI_Te	2	7	8	5	2	10	13	7	5	2	5	6	4	2	5	3	11	2
Average of GAI_Te	4	4	4	4	6	5	4	4	5	5	4	6	4	6	4	4	4	4
Median of GAI_Te	4	4	4	4	6	4	4	4	4	5	4	6	4	6	4	4	4	4
Max of GAI_Te	4	4	7	4	7	6	4	6	6	5	4	7	4	6	4	4	5	4
Min of GAI_Te	4	4	4	4	5	4	4	4	4	4	4	6	4	6	4	4	4	4
Count of GAI_Th	2	7	8	5	2	10	13	7	5	2	5	6	4	2	5	3	11	2
Average of GAI_Th	-2	-2	0	-3	1	-2	-2	-2	-2	-2	-2	0	-3	-1	-5	-5	-4	-2
Median of GAI_Th	-2	-2	0	-2	1	-2	-2	-2	-2	-2	-2	0	-3	-1	-4	-6	-3	-2
Max of GAI_Th	-2	-1	1	-2	1	1	-1	-1	0	-2	-2	1	-3	0	-4	-4	-2	-1
Min of GAI_Th	-2	-2	-2	-5	1	-6	-3	-4	-4	-2	-3	0	-4	-1	-6	-6	-7	-3
Count of GAI_Tl	2	7	8	5	2	10	13	7	5	2	5	6	4	2	5	3	11	2
Average of GAI_Tl	-4	-1	-3	-5	-6	-5	-4	-5	-4	-3	-5	0	-6	-3	-6	-6	-6	-6
Median of GAI_Tl	-4	-2	-2	-4	-6	-6	-4	-5	-3	-3	-5	0	-6	-3	-6	-6	-6	-6
Max of GAI_Tl	-3	2	-1	-2	-6	-1	2	-4	0	-3	-2	1	-5	-3	-3	-4	-2	-5
Min of GAI_Tl	-4	-5	-6	-6	-6	-6	-6	-6	-6	-3	-6	-1	-6	-3	-6	-6	-6	-6
Count of GAI_U	2	7	8	5	2	10	13	7	5	2	5	6	4	2	5	3	11	2
Average of GAI_U	-1	0	0	-2	0	-2	-1	-2	-1	-1	-2	0	-3	-1	-4	-3	-3	-1
Median of GAI_U	-1	0	0	-2	0	-1	-2	-2	-1	-1	-2	0	-3	-1	-4	-3	-3	-1
Max of GAI_U	-1	1	1	-1	0	1	0	-1	0	-1	0	1	-2	0	-3	-3	-1	-1
Min of GAI_U	-1	-2	-2	-3	0	-4	-3	-3	-2	-1	-3	-1	-4	-2	-4	-4	-6	-1
Count of GAI_V	2	7	8	5	2	10	13	7	5	2	5	6	4	2	5	3	11	2
Average of GAI_V	-3	-2	-1	-4	0	-3	-2	-2	0	-2	-2	-1	-2	-2	-4	-5	-3	-3
Median of GAI_V	-3	-2	-1	-3	0	-3	-2	-2	0	-2	-2	-1	-2	-2	-4	-6	-2	-3
Max of GAI_V	-3	-1	1	-2	0	-1	0	-1	1	-2	-2	-1	-2	-1	-3	-3	1	-2
Min of GAI_V	-3	-3	-3	-5	-1	-6	-3	-3	-2	-3	-2	-2	-4	-3	-6	-6	-7	-4
Count of GAI_W	2	7	8	5	2	10	13	7	5	2	5	6	4	2	5	3	11	2
Average of GAI_W	0	0	1	0	1	0	0	1	0	1	0	1	0	0	-1	0	0	0
Median of GAI_W	0	0	0	0	1	0	0	1	0	1	0	1	0	0	-1	-1	0	0
Max of GAI_W	0	1	2	1	1	1	2	2	1	1	0	2	0	0	0	1	1	1
Min of GAI_W	0	-1	0	0	1	0	-1	0	-2	1	-1	1	-1	0	-2	-1	-1	0
Count of GAI_Y	2	7	8	5	2	10	13	7	5	2	5	6	4	2	5	3	11	2
Average of GAI_Y	-2	0	-1	-3	-1	-3	-3	-4	-2	-2	-3	-1	-4	-2	-3	-3	-4	-3
Median of GAI_Y	-2	-1	-1	-3	-1	-3	-2	-4	-1	-2	-3	-1	-4	-2	-3	-3	-4	-3
Max of GAI_Y	-2	3	1	-2	-1	0	1	-2	-1	-2	-3	-1	-2	-1	-2	-3	-2	-3
Min of GAI_Y	-2	-2	-2	-5	-1	-4	-4	-5	-2	-2	-4	-2	-4	-2	-4	-4	-5	-3
Count of GAI_Zn	2	7	8	5	2	10	13	7	5	2	5	6	4	2	5	3	11	2
Average of GAI_Zn	0	0	1	-2	-1	-2	-2	-3	0	0	-3	-1	-2	-2	-2	-2	-2	-2
Median of GAI_Zn	0	0	1	-1	-1	-1	-2	-3	0	0	-3	-1	-2	-2	-2	-2	-2	-2
Max of GAI_Zn	0	2	4	0	0	1	1	-1	0	0	-1	1	1	0	0	-2	1	-2
Min of GAI_Zn	0	-1	-3	-3	-1	-4	-6	-5	-2	0	-4	-3	-4	-3	-3	-3	-5	-3
Count of GAI_Zr	2	7	8	5	2	10	13	7	5	2	5	6	4	2	5	3	11	2
Average of GAI_Zr	-3	-2	-1	-3	0	-3	-2	-2	-1	-2	-3	-1	-3	-2	-4	-6	-4	-3
Median of GAI_Zr	-3	-2	-1	-3	0	-3	-2	-2	-1	-2	-3	-1	-3	-2	-4	-6	-3	-3
Max of GAI_Zr	-3	-2	0	-2	0	0	-1	-2	-1	-2	-2	0	-3	-1	-3	-4	-2	-2
Min of GAI_Zr	-3	-3	-2	-5	0	-6	-3	-4	-2	-3	-3	-1	-4	-3	-6	-6	-7	-4

Figure B-1: NAG-ICP versus Four Acid ICP data – Ag, Al, As, Ba.

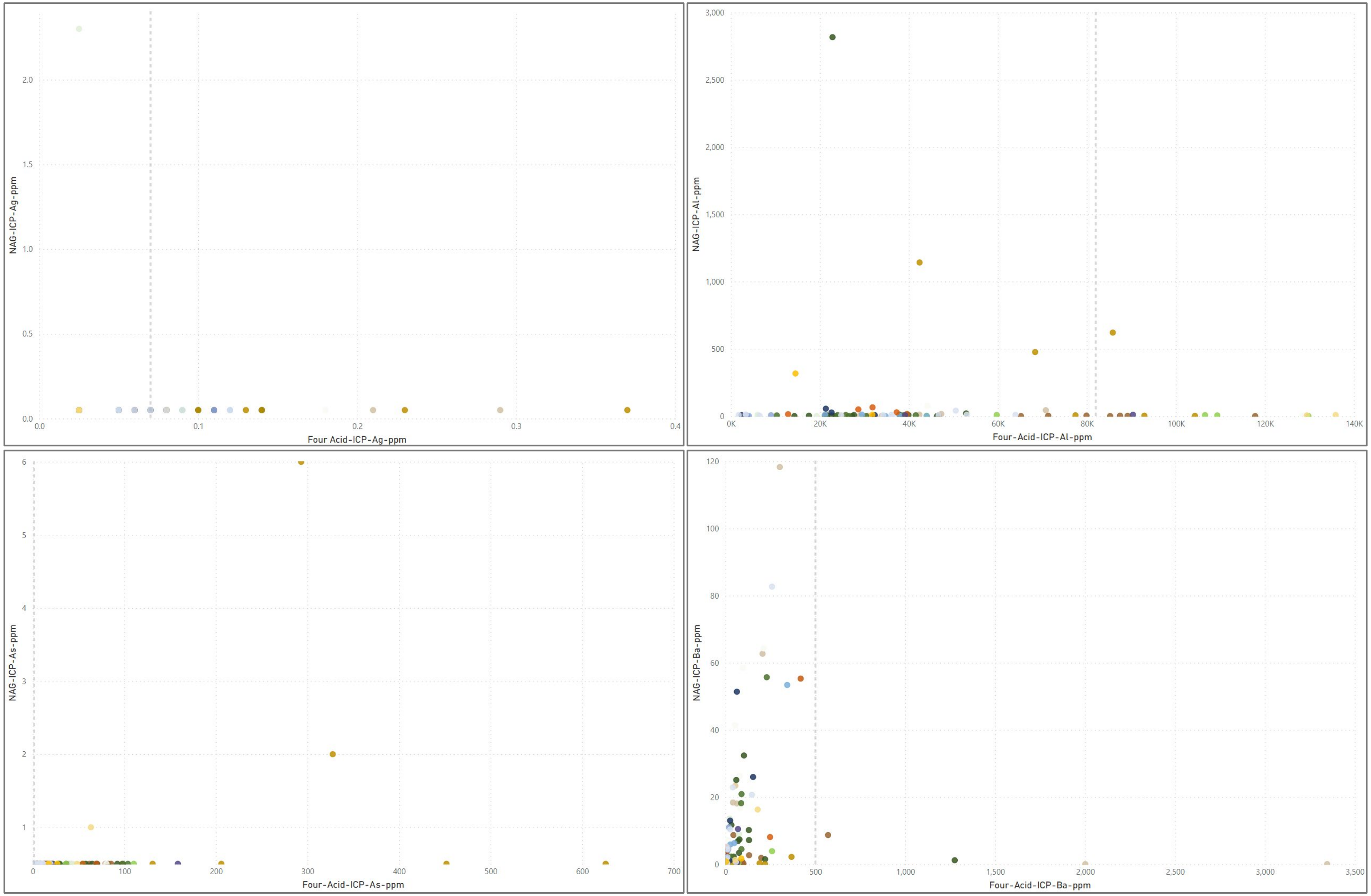


Figure B-1: NAG-ICP versus Four Acid ICP data – Bi, Ca, Cd, Ce

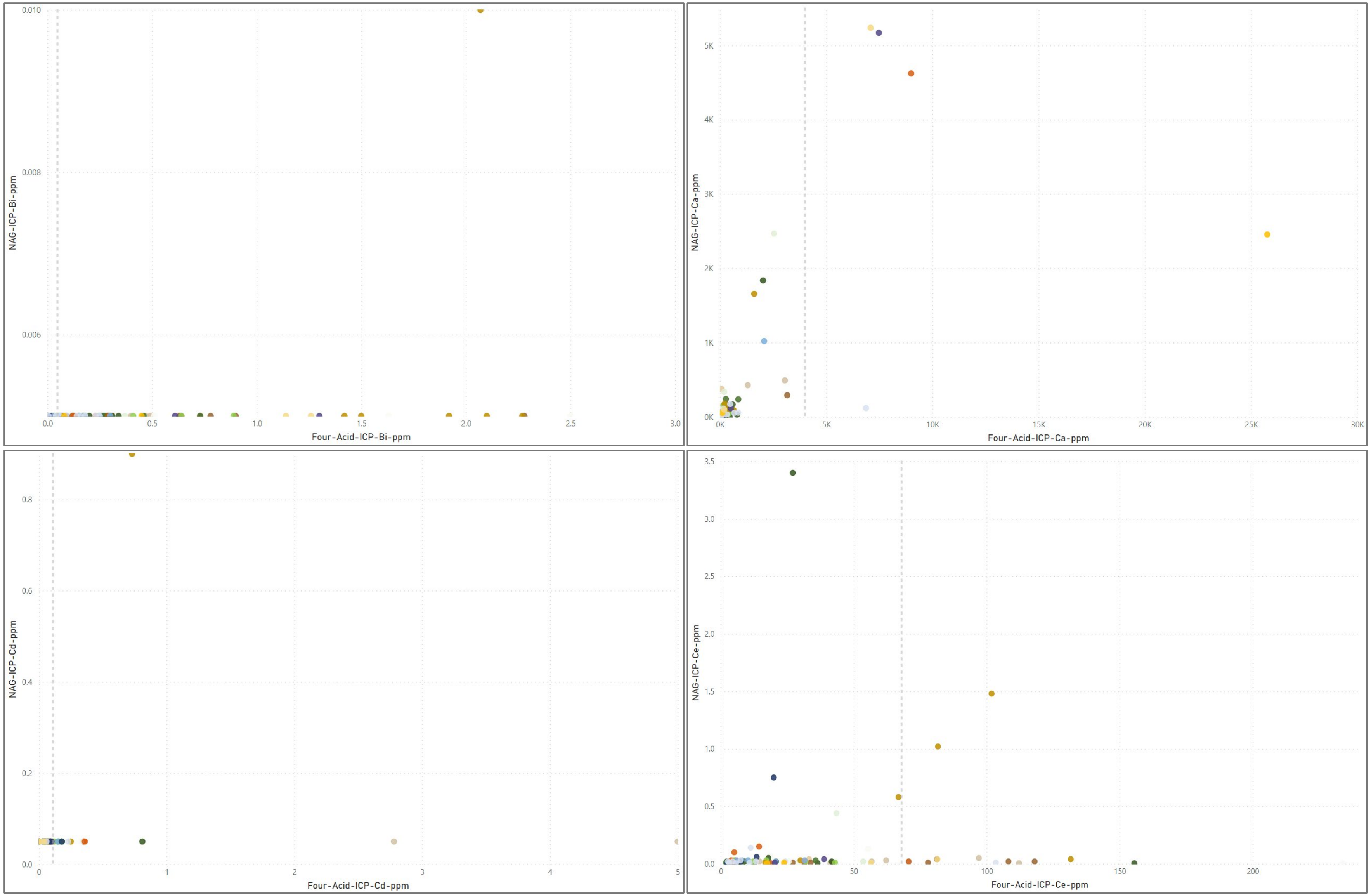


Figure B-1: NAG-ICP versus Four Acid ICP data – Co, Cr, Cs, Cu

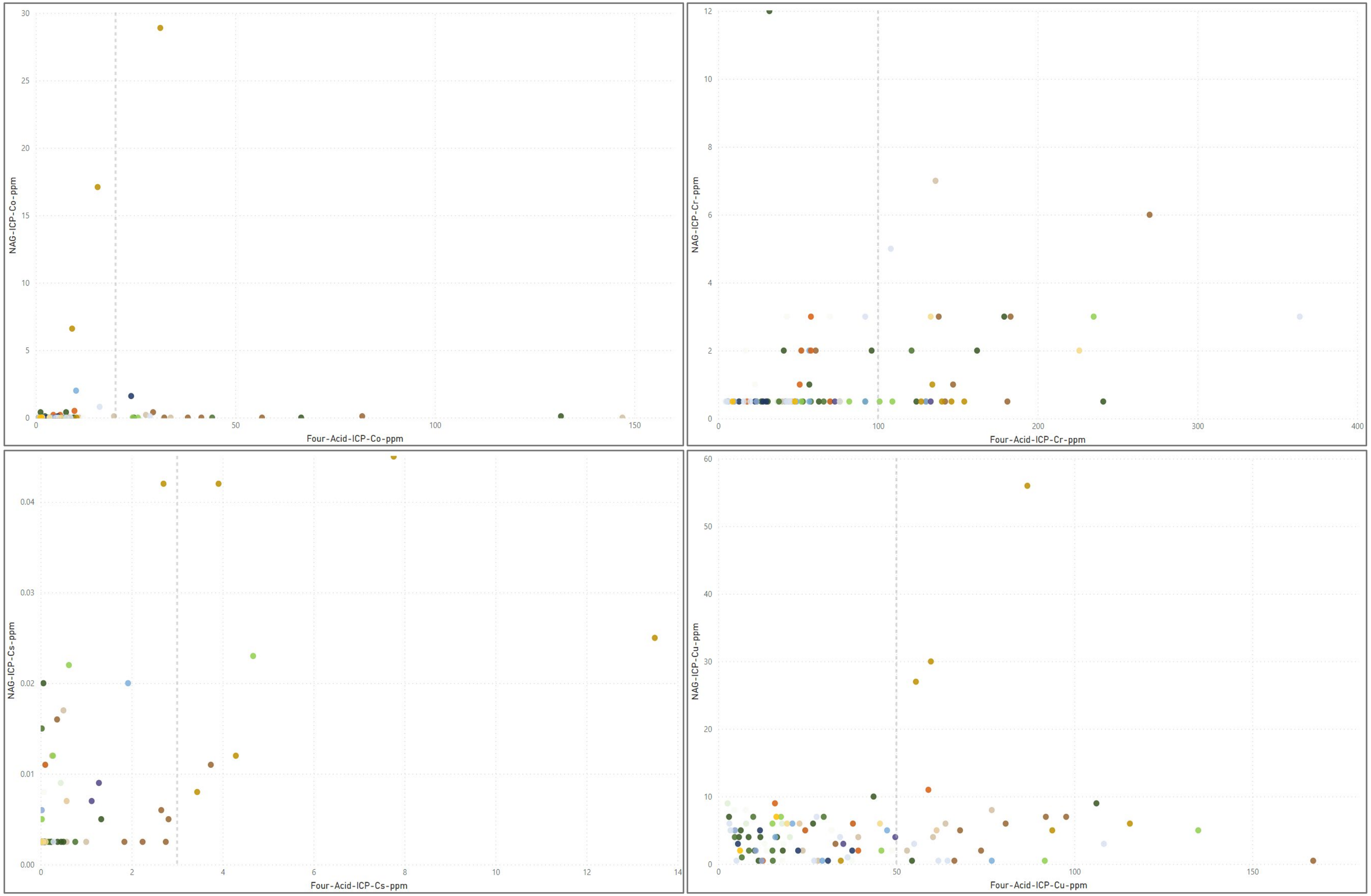


Figure B-1: NAG-ICP versus Four Acid ICP data – Fe, Ga, Ge, Hf

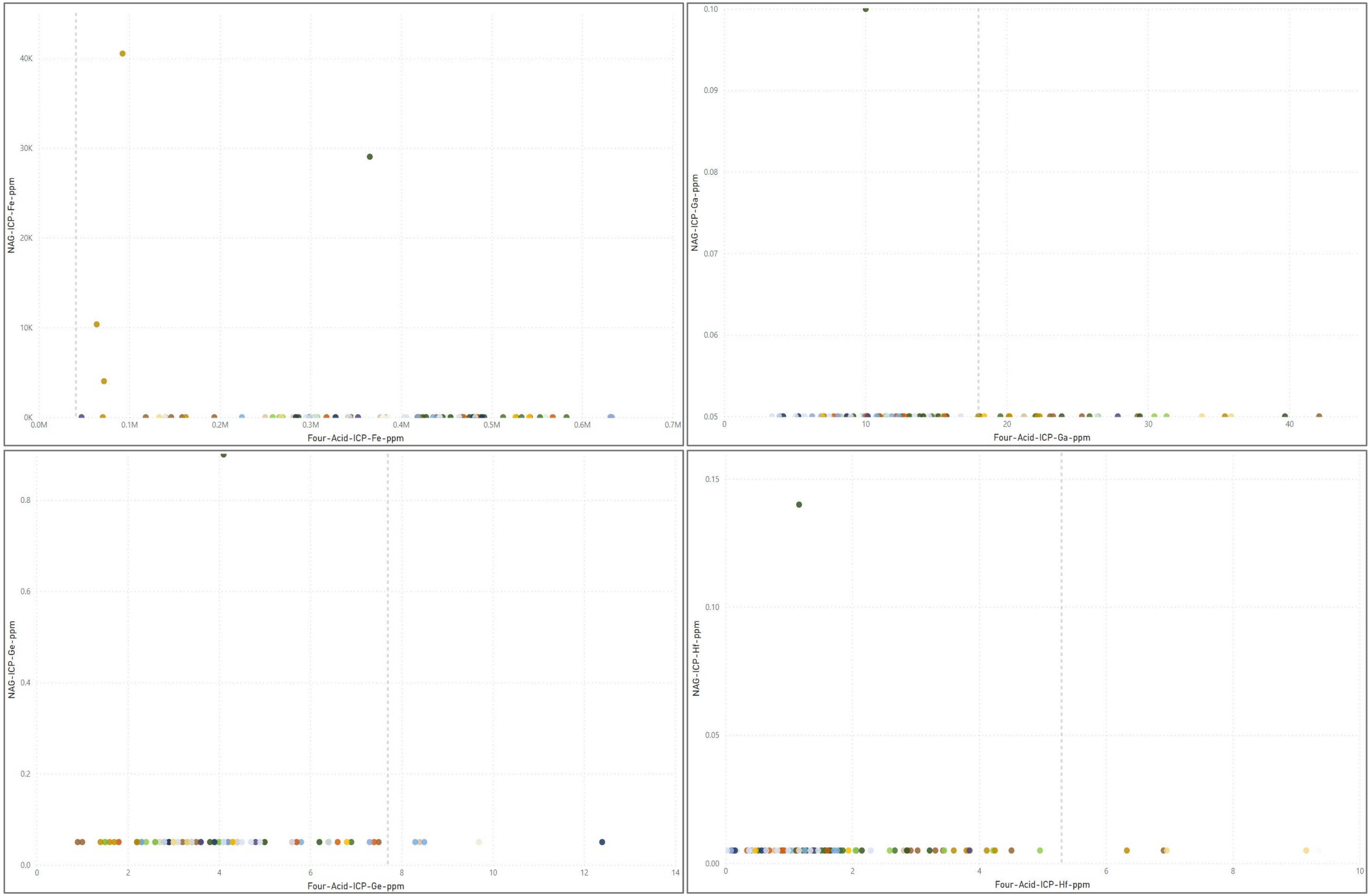


Figure B-1: NAG-ICP versus Four Acid ICP data – In, K, La, Li

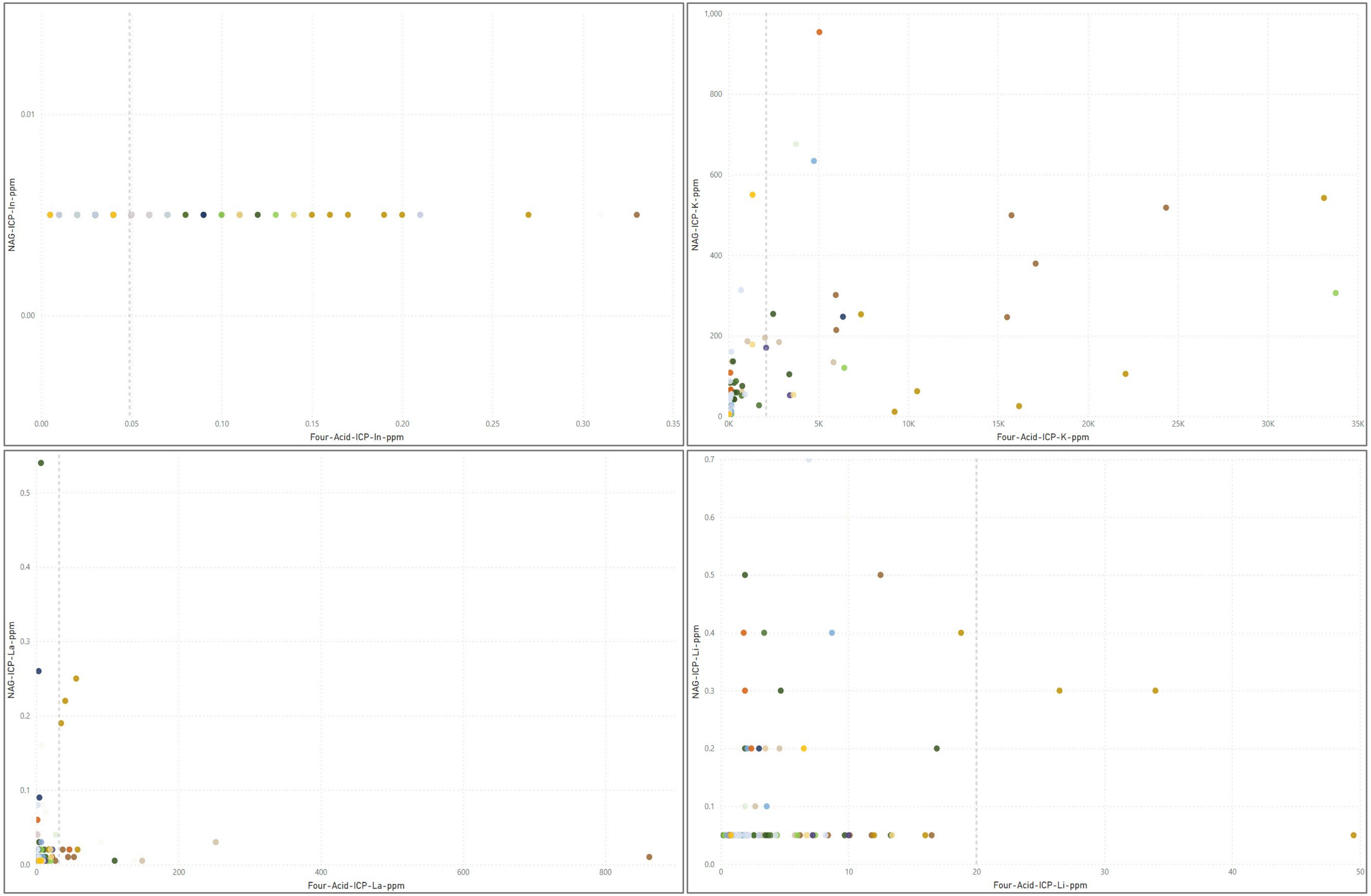


Figure B-1: NAG-ICP versus Four Acid ICP data – Mn, Mo, Na, Nb

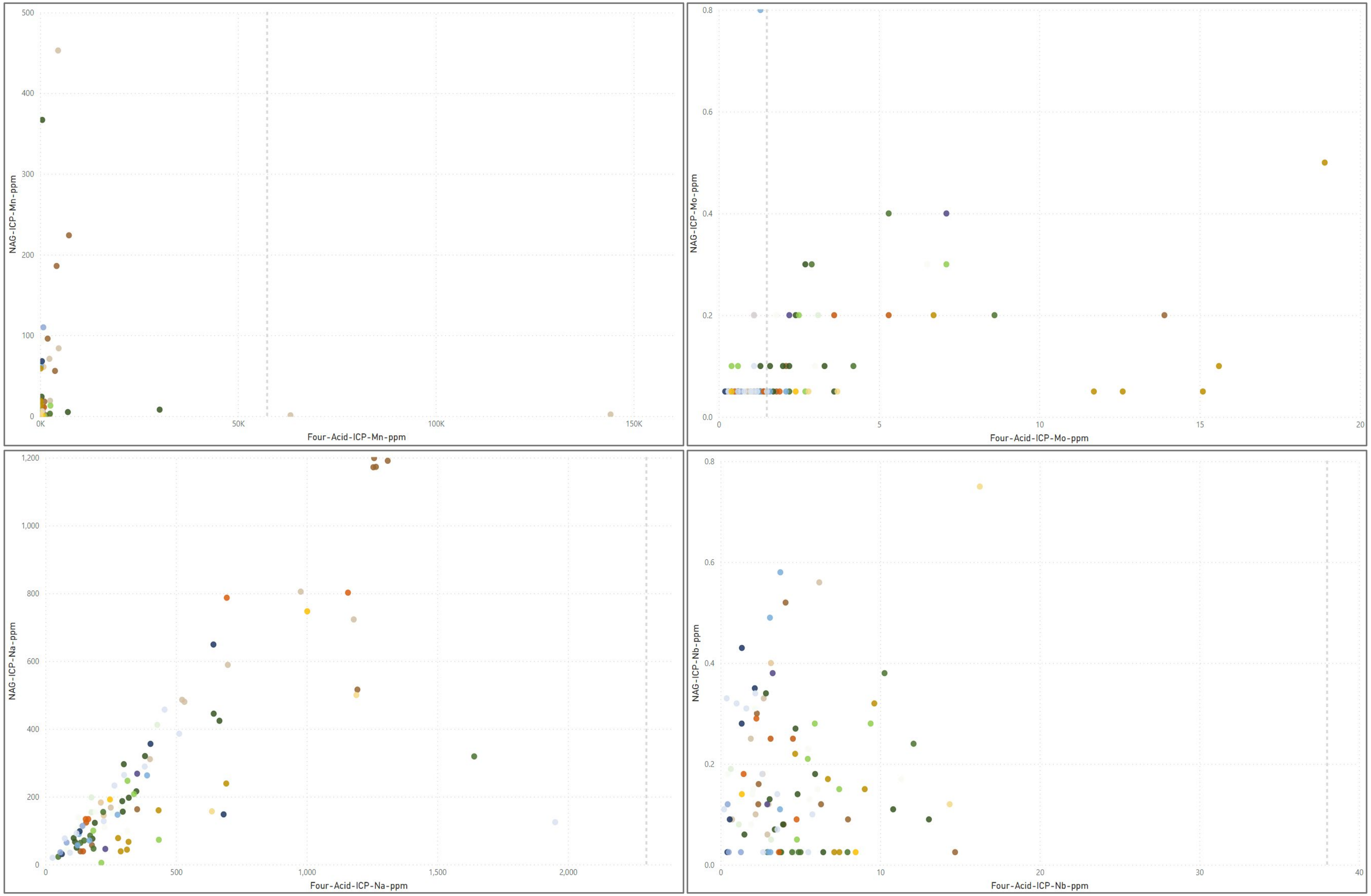


Figure B-1: NAG-ICP versus Four Acid ICP data – Ni, P, Sr, Ta

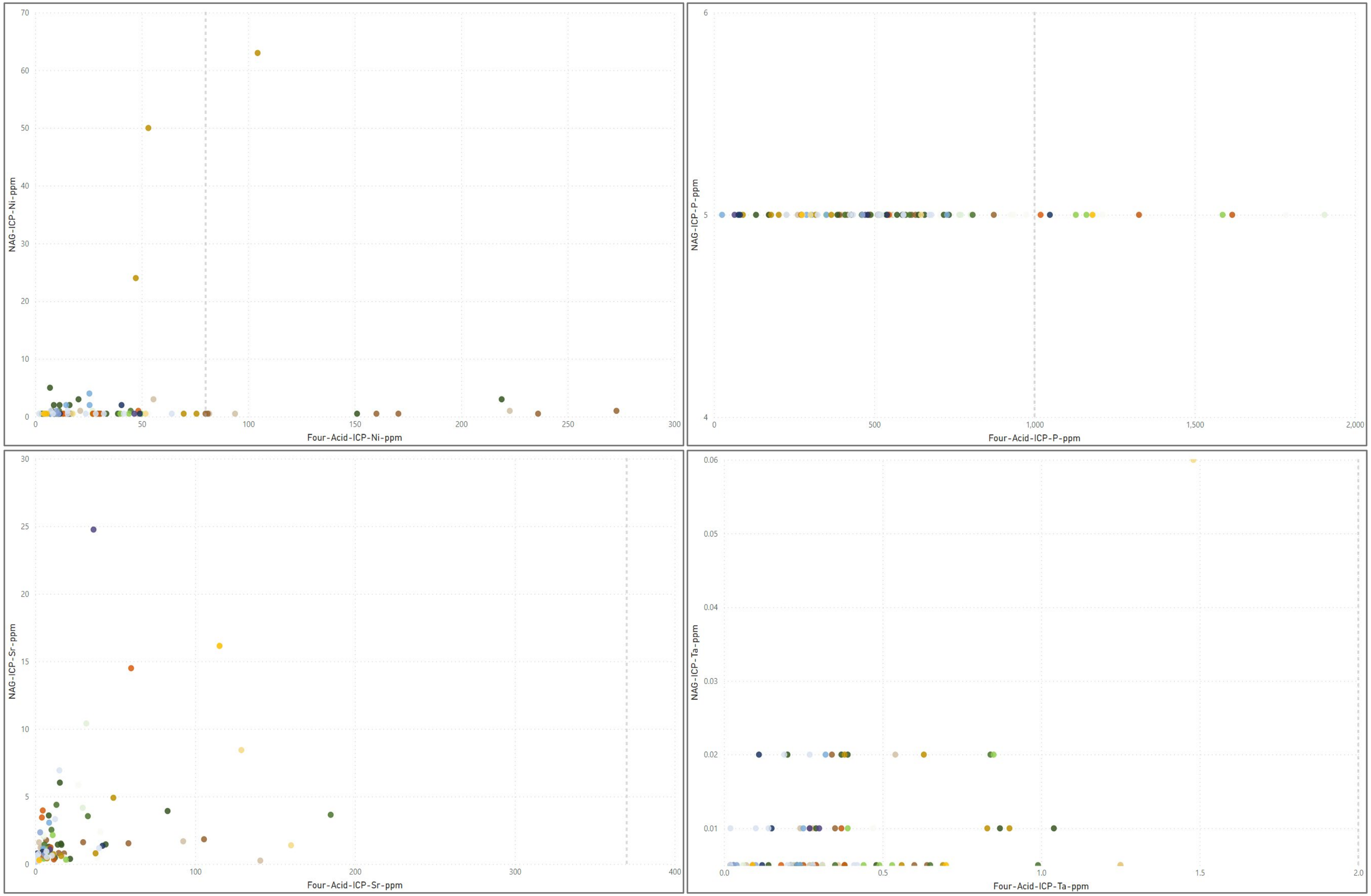


Figure B-1: NAG-ICP versus Four Acid ICP data – Te, Th, Ti, Tl

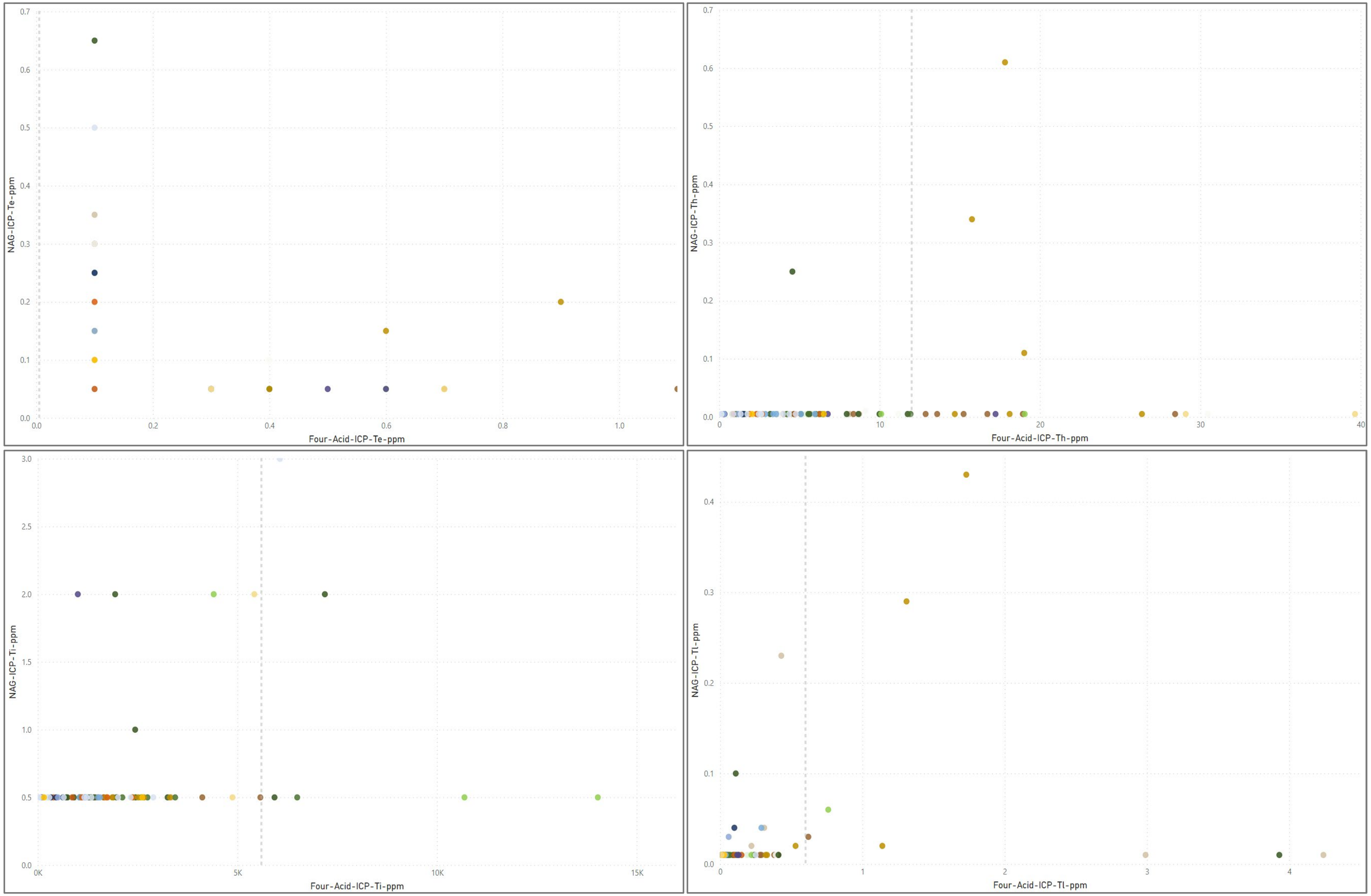


Figure B-1: NAG-ICP versus Four Acid ICP data – U, V, Y, W

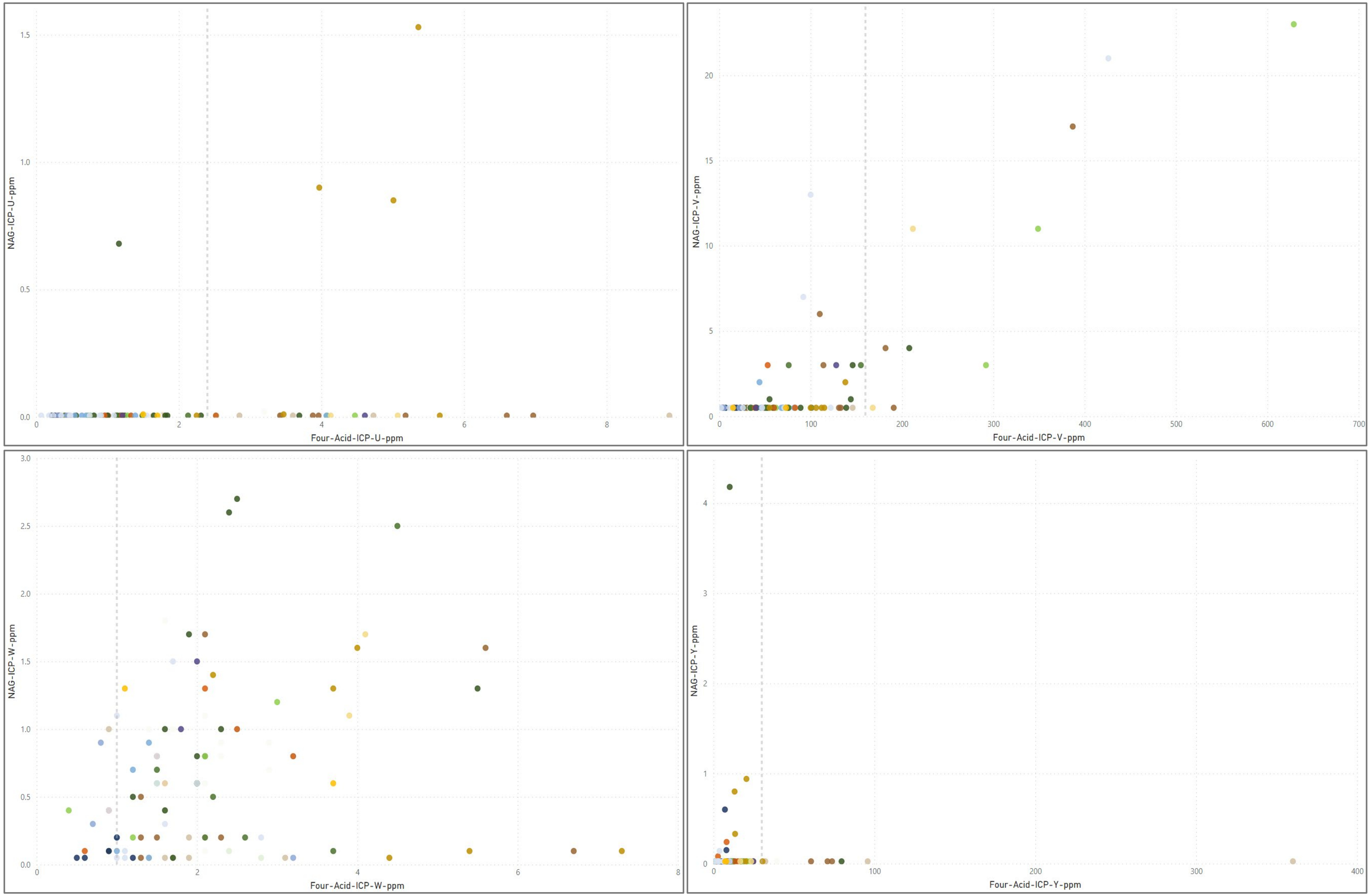
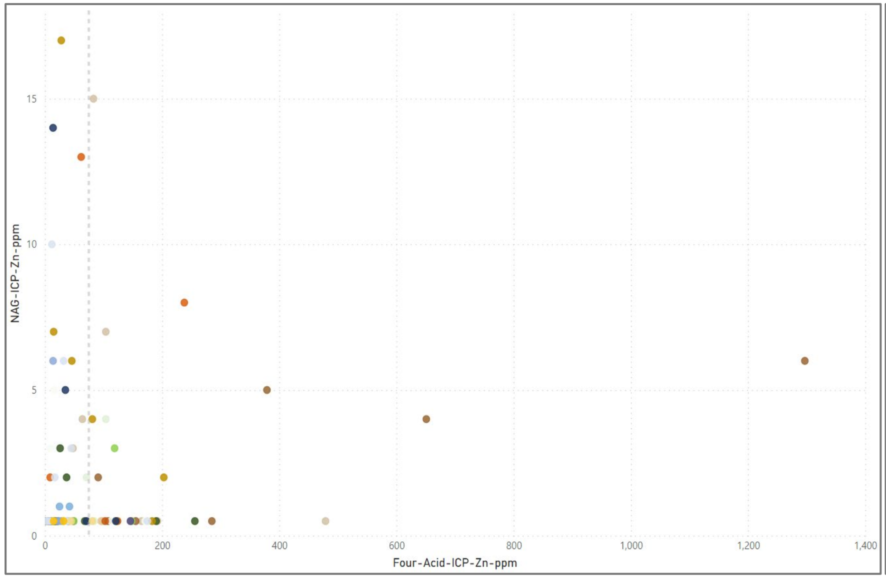
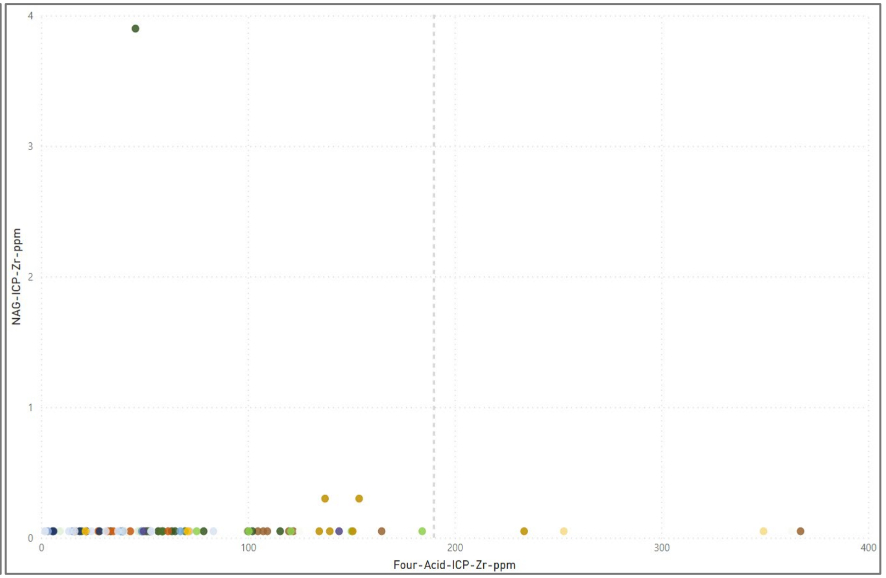


Figure B-1: NAG-ICP versus Four Acid ICP data – Zn, Zr.





Appendix C: Laboratory Reports

MINERALS
TEST REPORT

CLIENT	**PILBARA IRON COMPANY (SERVICES) PTY LIMITED**

JOB INFORMATION

JOB CODE	: 1804.0/2105393
NO. SAMPLES	: 99
NO. ELEMENTS	: 48
CLIENT ORDER NO.	: 3104437544 (Job 1 of 1)
SAMPLE SUBMISSION NO.	: WANG_WCht
PROJECT	: WANG
SAMPLE TYPE	: Pulp
DATE RECEIVED	: 29/03/2021
DATE TESTED	: 06/04/2021 - 08/04/2021
DATE REPORTED	: 09/04/2021
DATE PRINTED	: 09/04/2021

REPORT NOTES

1. Please note:
   1. The following sample was NOT received with this consignment:
   KAE622

TESTED BY

Intertek
15 Davison Street, Maddington 6109, Western Australia
PO Box 144, Gosnells 6990, Western Australia
Tel: +61 8 9263 0100
Email: min.aus.per@intertek.com

APPROVED SIGNATURE FOR

Craig RITCHIE
Operations Manager - Perth

SIGNIFICANT FIGURES

It is common practice to report data derived from analytical instrumentation to a maximum of two or three significant figures. Some data reported herein may show more figures than this. The reporting of more than two or three figures in no way implies that figures beyond the least significant digit have significance.

For more information on the uncertainty on individual reported values, please contact the laboratory.

MEASUREMENT OF UNCERTAINTY

Measurement of uncertainty estimates are available for most tests upon request.

SAMPLE STORAGE

All solid samples (assay pulps, bulk pulps and residues) will be stored for 60 days without charge. Following this samples will be stored at a daily rate until clients written advice regarding return, collection or disposal is received. If storage information is not supplied on the submission, or arranged with the laboratory in writing the default will be to store the samples with the applicable charges. Storage is charged at $4.00 per m3 per day, expenses related to the return or disposal of samples will be charged at cost. Current disposal cost is charged at $150.00 per m3.

Samples received as liquids, waters or solutions will be held for 60 days free of charge then disposed of, unless written advice fo return or collection is received.

LEGEND	X	= Less than Detection Limit	NA	= Not Analysed
	SNR	= Sample Not Received	UA	= Unable to Assay
	LNR	= Lab Not Received	>	= Value beyond Limit of Method
	DTF	= Result still to come	+	= Extra Sample Received Not Listed
	I/S	= Insufficient Sample for Analysis		

ELEMENTS	Fe	Mn	P	S	Zn	Pb	Cu	Ba	V	Cr
UNITS	%	ppm	ppm	%	ppm	ppm	ppm	ppm	ppm	ppm
DETECTION LIMIT	0.01	1	50	0.05	1	0.5	0.5	0.1	1	1
DIGEST	4A/	4A/	4A/	4A/	4A/	4A/	4A/	4A/	4A/	4A/
ANALYTICAL FINISH	MS	MS	MS	MS	MS	MS	MS	MS	MS	MS
SAMPLE NUMBERS										
0001 IPX549	6.39	35	90	5.33	28	88.6	86.8	34.1	100	154
0002 KNE128	30.75	2579	350	<0.05	119	23.7	15.2	258.7	70	109
0003 KNE828	22.43	211	<50	0.30	25	5.9	20.8	29.8	44	57
0004 IPR635	43.52	93	305	0.10	42	7.4	47.4	49.0	82	92
0005 IPR791	46.93	130	481	0.96	62	10.7	59.0	247.8	53	58
0006 IPW007	28.40	170	76	1.29	35	3.0	30.8	21.7	19	23
0007 IPW047	40.61	69	591	0.09	45	10.5	36.3	40.7	15	20
0008 IPW060	46.40	71	678	0.10	17	7.7	34.2	26.2	26	42
0009 IKC060	34.50	7257	617	0.10	651	24.5	167.1	93.8	131	142
0010 IKC062	19.38	3733	511	0.08	379	18.1	92.0	94.7	133	130
0011 IQI015	32.72	>5.00%	558	0.09	165	13.6	53.0	2001.2	60	31
0012 IQI264	38.46	73	171	0.17	48	22.1	63.8	41.5	146	136
0013 IQI357	38.34	2320	226	0.10	64	16.9	60.3	64.1	83	46
0014 ISA287	34.47	118	391	<0.05	91	25.3	73.8	44.2	30	61
0015 IKT373	47.97	23	480	0.08	14	2.1	37.6	153.2	16	30
0016 IKT635	47.85	6983	588	0.05	256	11.5	43.6	220.2	146	124
0017 IKT735	30.46	>5.00%	638	0.10	479	5.1	76.8	3346.2	48	13
0018 ISR998	46.48	844	398	0.10	96	8.3	22.8	54.7	40	44
0019 ISQ383	>50.00	2455	461	0.12	13	14.1	29.6	229.2	155	121
0020 ISQ526	>50.00	785	591	<0.05	14	0.8	4.7	19.5	5	6
0021 ISQ854	34.30	142	424	<0.05	12	<0.5	3.1	3.2	2	5
0022 ISQ933	28.11	2489	261	0.09	83	7.1	23.7	301.9	23	28
0023 KBU112	37.72	4657	515	0.08	192	11.4	28.0	206.0	31	30
0024 KDS668	44.29	115	276	0.08	32	8.6	61.8	146.8	71	45
0025 KDS722	30.04	127	226	0.12	13	<0.5	5.1	11.3	2	6
0026 KDU367	40.34	294	512	0.06	38	17.1	26.9	258.6	47	43
0027 KDK056	>50.00	83	1019	0.17	238	7.8	39.3	6.8	17	18
0028 KDB643	34.15	4506	407	0.10	104	14.7	39.3	15.7	58	40
0029 KDK147	48.93	37	1048	0.05	121	9.8	22.4	6.3	23	28
0030 KDK997	>50.00	2379	319	<0.05	98	14.3	61.3	8.1	27	27
0031 IXO621	44.59	3.02%	638	0.05	190	21.3	106.2	1274.8	51	27
0032 KDW888	14.62	4130	629	0.31	285	19.6	66.3	100.0	114	138
0033 KJK122	29.89	441	81	0.13	71	0.9	11.7	63.3	4	6
0034 KJK432	>50.00	198	463	0.06	27	4.6	12.2	3.7	3	10
0035 KJE033	41.85	64	727	0.08	11	12.0	76.8	343.1	70	130
0036 IPX089	25.83	609	517	<0.05	122	5.0	91.7	72.1	349	82
0037 IPX094	26.92	1000	1587	<0.05	49	5.0	134.8	30.8	629	101
0038 IPX289	42.76	351	571	<0.05	68	12.6	26.6	55.2	34	41
0039 IQH700	45.12	144	770	0.07	13	1.7	4.4	14.1	6	8
0040 IKE803	>50.00	217	801	<0.05	104	16.9	7.8	14.0	13	13

ELEMENTS	As	Ni	Co	Sn	Sr	Zr	Na	Ag	Al	Be
UNITS	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
DETECTION LIMIT	0.5	0.5	0.1	0.1	0.05	0.1	20	0.05	50	0.05
DIGEST	4A/	4A/	4A/	4A/	4A/	4A/	4A/	4A/	4A/	4A/
ANALYTICAL FINISH	MS	MS	MS	MS	MS	MS	MS	MS	MS	MS
SAMPLE NUMBERS										
0001 IPX549	327.6	104.4	31.2	4.6	5.55	153.8	288	0.14	8.58%	1.88
0002 KNE128	36.2	44.0	24.3	0.9	7.31	75.2	214	0.09	4.40%	5.40
0003 KNE828	4.9	25.4	10.1	0.8	8.64	38.5	123	0.08	2.11%	0.98
0004 IPR635	13.8	14.5	4.6	1.5	4.59	67.3	168	<0.05	3.79%	1.03
0005 IPR791	5.2	12.9	4.9	0.7	59.94	27.6	1158	<0.05	3.18%	0.54
0006 IPW007	1.7	11.0	5.5	0.4	42.08	18.6	682	<0.05	2.13%	0.89
0007 IPW047	6.3	8.3	3.4	0.2	2.04	16.2	301	0.06	2.48%	0.61
0008 IPW060	7.2	15.2	3.5	0.4	1.63	31.3	94	0.07	3.42%	0.74
0009 IKC060	82.5	272.9	81.8	2.2	6.79	107.4	1255	0.14	7.13%	3.19
0010 IKC062	85.5	236.1	56.7	2.6	4.86	119.8	1265	0.11	8.74%	2.98
0011 IQI015	55.9	81.7	33.8	1.2	92.53	56.7	977	0.29	4.24%	5.70
0012 IQI264	13.8	21.1	6.0	2.6	3.79	99.7	400	<0.05	7.08%	0.89
0013 IQI357	78.9	39.7	9.5	1.4	3.25	71.7	698	<0.05	4.73%	1.63
0014 ISA287	4.5	29.2	4.4	1.2	18.01	52.9	134	0.06	4.67%	0.98
0015 IKT373	5.5	11.6	2.9	1.4	4.56	21.9	402	<0.05	3.23%	0.84
0016 IKT635	92.2	219.0	66.5	1.9	21.80	58.8	644	0.07	2.72%	2.21
0017 IKT735	39.9	222.8	147.0	0.5	140.77	27.6	1180	0.21	3.39%	14.03
0018 ISR998	17.9	30.5	5.7	1.0	3.86	49.8	223	<0.05	3.08%	1.53
0019 ISQ383	9.0	44.8	44.2	3.2	32.89	69.6	184	<0.05	4.15%	0.84
0020 ISQ526	2.9	10.9	6.8	0.1	5.85	3.3	81	<0.05	4056	0.87
0021 ISQ854	1.9	7.3	1.5	0.1	0.45	1.9	74	0.08	1761	0.56
0022 ISQ933	27.7	55.5	19.6	0.8	1.88	39.3	250	<0.05	2.45%	1.07
0023 KBU112	36.2	93.8	24.3	0.8	3.96	41.3	523	<0.05	2.90%	3.92
0024 KDS668	11.0	28.4	5.7	0.7	6.94	24.2	223	0.05	3.63%	0.92
0025 KDS722	1.3	4.2	1.7	0.1	15.06	1.8	119	<0.05	3340	0.31
0026 KDU367	10.8	15.2	5.1	0.7	12.36	53.1	456	<0.05	5.30%	0.47
0027 KDK056	3.5	48.4	6.1	0.4	4.68	16.4	694	0.06	1.29%	2.10
0028 KDB643	42.1	48.0	27.6	0.8	2.33	57.8	532	<0.05	3.43%	2.00
0029 KDK147	7.6	49.1	6.1	0.6	0.91	28.2	643	0.07	2.26%	3.64
0030 KDK997	20.2	29.5	10.9	0.8	1.45	47.6	212	0.05	2.56%	1.39
0031 IXO621	64.9	151.1	131.6	0.9	44.05	48.7	666	0.14	3.79%	4.39
0032 KDW888	61.8	160.2	38.1	2.4	105.56	104.8	1310	<0.05	7.99%	2.57
0033 KJK122	0.9	40.5	23.9	0.2	1.20	6.0	131	0.05	3655	1.63
0034 KJK432	6.5	10.0	4.0	0.1	3.02	3.3	142	0.11	3510	0.79
0035 KJE033	11.6	25.5	8.6	1.1	3.24	67.3	389	<0.05	4.40%	0.89
0036 IPX089	4.7	26.9	7.4	1.1	4.57	120.8	339	<0.05	10.93%	0.58
0037 IPX094	13.6	49.8	25.6	1.5	5.26	150.1	314	<0.05	10.65%	1.70
0038 IPX289	69.7	33.4	24.6	0.8	12.29	39.5	348	0.10	2.16%	1.85
0039 IQH700	44.0	3.1	1.2	0.2	29.66	9.1	61	0.07	6018	0.81
0040 IKE803	6.7	6.0	1.8	0.2	11.47	17.4	176	<0.05	6037	1.43

ELEMENTS	Bi	Ca	Cd	Ce	Cs	Fe-Rp1	Ga	Ge	Hf	In
UNITS	ppm	ppm	ppm	ppm	ppm	%	ppm	ppm	ppm	ppm
DETECTION LIMIT	0.01	50	0.02	0.01	0.05	0.01	0.05	0.1	0.05	0.01
DIGEST	4A/	4A/	4A/	4A/	4A/	4AH/	4A/	4A/	4A/	4A/
ANALYTICAL FINISH	MS	MS	MS	MS	MS	OE	MS	MS	MS	MS
SAMPLE NUMBERS										
0001 IPX549	2.07	221	0.73	81.69	2.70		22.33	2.2	4.25	0.16
0002 KNE128	0.64	225	0.18	42.98	4.67		11.45	3.9	2.05	0.06
0003 KNE828	0.12	2081	0.15	20.70	1.92		8.01	2.3	0.93	0.03
0004 IPR635	0.25	205	0.02	4.25	0.08		12.36	5.7	1.76	0.09
0005 IPR791	0.09	8999	0.03	4.28	0.08		10.04	4.4	0.69	0.04
0006 IPW007	0.06	<50	<0.02	13.49	<0.05		5.25	2.9	0.42	0.01
0007 IPW047	0.06	62	<0.02	10.93	<0.05		5.69	4.1	0.43	0.01
0008 IPW060	0.09	66	<0.02	5.72	0.06		7.44	4.5	0.82	0.03
0009 IKC060	0.63	281	0.35	77.95	1.84		23.07	0.9	2.92	0.06
0010 IKC062	0.73	227	0.18	31.45	2.24		25.32	0.9	3.31	0.08
0011 IQI015	0.47	1307	5.00	112.17	0.57		14.07	3.1	1.52	0.04
0012 IQI264	0.49	65	0.02	41.24	0.50		21.22	8.4	2.81	0.11
0013 IQI357	0.47	54	0.02	23.74	1.00		15.03	2.8	2.04	0.05
0014 ISA287	0.25	101	0.03	108.21	0.08		11.01	7.5	1.38	0.04
0015 IKT373	0.09	129	<0.02	2.47	<0.05		7.06	3.9	0.57	0.09
0016 IKT635	0.31	453	0.15	41.71	0.20		23.89	1.5	1.64	0.06
0017 IKT735	0.14	3055	2.78	97.06	0.25		8.66	2.2	0.77	0.03
0018 ISR998	0.33	92	0.05	20.17	0.57		11.55	6.4	1.39	0.03
0019 ISQ383	0.29	434	<0.02	12.56	0.07	55.34	25.86	6.4	1.85	0.10
0020 ISQ526	0.03	52	<0.02	31.57	<0.05	63.18	6.23	4.1	0.08	<0.01
0021 ISQ854	<0.01	<50	0.02	3.26	0.05		3.89	3.4	<0.05	<0.01
0022 ISQ933	0.32	93	0.09	14.60	0.05		8.24	4.1	1.06	0.02
0023 KBU112	0.25	191	0.35	56.76	0.05		9.71	3.4	1.14	0.02
0024 KDS668	0.09	325	<0.02	7.42	<0.05		8.96	5.6	0.64	0.02
0025 KDS722	<0.01	170	<0.02	3.23	<0.05		3.38	2.8	<0.05	<0.01
0026 KDU367	0.25	481	<0.02	103.45	<0.05		11.50	4.4	1.46	0.04
0027 KDK056	0.13	94	0.36	5.09	<0.05	56.76	7.76	7.4	0.34	0.01
0028 KDB643	0.40	134	0.04	62.19	0.06		12.19	2.9	1.56	0.04
0029 KDK147	0.07	<50	0.18	6.98	<0.05		8.69	12.4	0.63	0.03
0030 KDK997	0.30	75	0.07	33.21	<0.05	55.89	11.05	5.0	1.26	0.02
0031 IXO621	0.29	255	0.81	155.50	0.50		14.10	2.2	1.28	0.04
0032 KDW888	0.64	185	0.11	42.07	2.81		22.10	1.0	2.87	0.05
0033 KJK122	<0.01	<50	0.09	19.95	<0.05		3.94	2.8	0.15	<0.01
0034 KJK432	0.03	52	0.03	6.13	<0.05	63.13	6.87	7.3	0.09	<0.01
0035 KJE033	0.30	96	0.08	10.32	0.07		11.86	8.3	1.71	0.05
0036 IPX089	0.03	407	0.16	5.05	0.62		26.46	2.6	3.45	0.10
0037 IPX094	0.04	350	0.12	12.20	0.27		30.45	1.5	4.22	0.14
0038 IPX289	0.17	805	0.09	36.42	0.37		9.14	3.8	1.11	0.04
0039 IQH700	0.04	<50	<0.02	29.17	<0.05		5.52	9.7	0.18	<0.01
0040 IKE803	0.04	87	0.03	43.52	<0.05	63.01	6.94	4.7	0.33	<0.01

ELEMENTS	K	La	Li	Mg	Mn-Rp1	Mo	Nb	Rb	Re	Sb
UNITS	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
DETECTION LIMIT	20	0.01	0.1	20	10	0.1	0.05	0.05	0.002	0.05
DIGEST	4A/	4A/	4A/	4A/	4AH/	4A/	4A/	4A/	4A/	4A/
ANALYTICAL FINISH	MS	MS	MS	MS	OE	MS	MS	MS	MS	MS
SAMPLE NUMBERS										
0001 IPX549	1.05%	40.67	26.5	2609		11.7	9.63	58.16	0.016	8.01
0002 KNE128	3.38%	20.34	4.4	497		2.5	5.46	90.82	<0.002	1.30
0003 KNE828	4757	9.52	2.1	4102		1.3	3.09	55.26	0.002	0.79
0004 IPR635	163	1.15	1.9	193		1.2	3.74	1.01	<0.002	2.10
0005 IPR791	5064	1.52	1.4	884		1.1	2.24	1.73	<0.002	1.38
0006 IPW007	6373	4.34	2.1	97		0.3	1.33	0.92	<0.002	0.80
0007 IPW047	102	2.02	1.0	180		0.6	1.00	0.49	<0.002	0.67
0008 IPW060	100	2.26	1.9	140		1.1	1.61	0.41	<0.002	0.92
0009 IKC060	1.55%	44.54	6.8	4371		1.8	2.38	52.19	<0.002	4.47
0010 IKC062	1.71%	22.31	8.4	4747		1.0	2.36	60.40	<0.002	4.54
0011 IQI015	2818	148.90	5.8	3640	6.33%	0.6	2.19	8.84	<0.002	4.26
0012 IQI264	1061	16.81	4.6	548		0.9	6.18	5.28	<0.002	4.19
0013 IQI357	5847	12.95	4.3	1877		0.9	1.89	23.62	<0.002	4.08
0014 ISA287	52	52.97	6.2	424		0.5	4.07	0.43	<0.002	1.01
0015 IKT373	110	0.74	0.8	252		0.6	1.32	0.46	<0.002	1.62
0016 IKT635	331	12.98	16.9	1196		1.2	4.82	1.47	<0.002	9.23
0017 IKT735	2035	252.37	3.3	3557	14.42%	1.3	0.72	5.73	<0.002	2.23
0018 ISR998	743	7.41	3.5	590		0.9	3.15	5.85	<0.002	1.26
0019 ISQ383	427	4.99	2.6	427		2.9	12.09	0.73	<0.002	2.62
0020 ISQ526	43	6.99	0.9	242		0.3	0.44	0.18	<0.002	0.39
0021 ISQ854	76	1.24	2.2	118		0.3	0.22	0.55	<0.002	0.25
0022 ISQ933	66	12.72	1.9	312		0.9	2.70	0.41	<0.002	0.64
0023 KBU112	198	18.48	2.0	597		1.4	3.00	0.80	<0.002	1.14
0024 KDS668	143	3.25	3.0	200		1.0	2.60	0.55	<0.002	1.15
0025 KDS722	707	0.63	1.4	274		0.3	0.38	0.40	<0.002	0.10
0026 KDU367	171	8.51	1.5	677		1.0	2.17	0.51	<0.002	1.08
0027 KDK056	74	1.63	1.8	496		0.5	1.44	0.11	<0.002	1.06
0028 KDB643	190	7.23	2.7	673		1.5	2.93	0.43	<0.002	1.95
0029 KDK147	66	2.61	3.0	455		0.4	2.14	0.21	<0.002	2.24
0030 KDK997	83	4.40	3.2	407		1.2	2.63	0.28	<0.002	0.90
0031 IXO621	2490	110.18	3.7	1709		0.6	1.49	7.52	<0.002	4.91
0032 KDW888	2.43%	26.76	10.1	6301		0.5	2.27	73.62	<0.002	6.62
0033 KJK122	72	3.29	3.0	152		0.2	0.57	0.64	<0.002	0.37
0034 KJK432	24	2.71	0.5	172		0.4	0.51	0.13	<0.002	0.27
0035 KJE033	173	3.90	8.7	459		2.1	3.72	0.60	<0.002	2.90
0036 IPX089	6447	1.71	7.4	688		0.4	5.90	32.24	<0.002	0.47
0037 IPX094	167	7.28	6.0	774		0.6	7.43	1.07	<0.002	0.79
0038 IPX289	324	17.59	2.6	1222		2.2	2.93	2.14	<0.002	1.17
0039 IQH700	243	10.96	0.4	100		0.7	0.64	0.12	<0.002	0.33
0040 IKE803	43	27.58	1.0	165		0.5	1.14	0.19	<0.002	0.42

ELEMENTS	Sc	Se	Ta	Te	Th	Ti	Tl	U	W	Y
UNITS	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
DETECTION LIMIT	0.1	0.5	0.01	0.2	0.01	5	0.02	0.01	0.1	0.05
DIGEST	4A/	4A/	4A/	4A/	4A/	4A/	4A/	4A/	4A/	4A/
ANALYTICAL FINISH	MS	MS	MS	MS	MS	MS	MS	MS	MS	MS
SAMPLE NUMBERS										
0001 IPX549	22.1	4.4	0.90	0.6	17.82	3311	0.53	5.01	7.3	20.46
0002 KNE128	13.3	<0.5	0.53	0.3	6.36	2580	0.76	1.51	1.2	20.92
0003 KNE828	6.7	0.7	0.25	<0.2	2.88	1223	0.29	0.64	1.4	7.40
0004 IPR635	8.0	3.9	0.32	<0.2	5.96	1508	0.04	0.54	1.0	4.33
0005 IPR791	13.3	2.6	0.18	<0.2	1.89	1104	0.02	0.32	0.9	2.08
0006 IPW007	5.9	<0.5	0.11	<0.2	1.45	461	<0.02	0.32	0.5	8.01
0007 IPW047	6.4	2.7	0.10	<0.2	1.34	289	<0.02	0.35	1.0	2.69
0008 IPW060	6.0	3.6	0.14	<0.2	2.61	652	<0.02	0.47	1.1	2.86
0009 IKC060	18.2	1.3	0.23	<0.2	12.87	1336	0.29	6.60	1.3	60.62
0010 IKC062	19.2	0.5	0.31	<0.2	15.24	1450	0.28	6.97	1.5	73.67
0011 IQI015	11.1	<0.5	0.22	<0.2	6.50	936	2.99	2.85	1.6	95.82
0012 IQI264	19.9	1.4	0.54	<0.2	8.13	3343	0.04	1.64	1.7	11.79
0013 IQI357	17.7	1.0	0.21	<0.2	8.73	860	0.22	3.44	0.9	20.50
0014 ISA287	13.6	0.9	0.34	<0.2	3.98	1887	<0.02	1.01	5.6	10.33
0015 IKT373	6.6	1.8	0.12	<0.2	1.55	327	<0.02	0.24	0.6	2.13
0016 IKT635	8.4	1.0	0.38	<0.2	5.57	2448	0.41	1.84	2.0	12.56
0017 IKT735	7.0	1.1	0.07	<0.2	3.56	249	4.24	8.88	3.1	360.10
0018 ISR998	5.1	1.1	0.28	<0.2	4.76	1182	0.11	1.76	2.1	10.60
0019 ISQ383	8.7	0.5	0.99	<0.2	4.22	6497	0.07	0.91	2.6	5.08
0020 ISQ526	0.8	<0.5	0.04	<0.2	0.29	106	0.06	0.30	0.7	6.14
0021 ISQ854	0.3	<0.5	0.02	<0.2	0.15	48	<0.02	0.18	2.8	2.96
0022 ISQ933	4.6	0.5	0.24	<0.2	3.52	1023	0.03	0.97	1.9	12.54
0023 KBU112	5.0	0.5	0.27	<0.2	3.62	1113	0.31	4.73	1.4	32.19
0024 KDS668	14.0	1.7	0.20	<0.2	1.75	1345	<0.02	0.48	1.1	6.44
0025 KDS722	0.3	<0.5	0.02	<0.2	0.13	40	<0.02	0.07	1.6	1.42
0026 KDU367	15.9	2.6	0.19	<0.2	4.77	1165	0.03	1.09	0.9	3.01
0027 KDK056	3.3	<0.5	0.09	<0.2	0.88	392	<0.02	0.30	0.6	8.12
0028 KDB643	8.6	<0.5	0.29	<0.2	5.77	1397	0.43	3.60	1.9	10.92
0029 KDK147	15.8	1.1	0.15	<0.2	1.48	633	<0.02	0.47	1.0	10.16
0030 KDK997	5.1	<0.5	0.36	<0.2	4.43	1020	0.05	1.78	1.6	8.42
0031 IXO621	12.8	<0.5	0.14	<0.2	5.63	711	3.93	3.69	0.9	79.58
0032 KDW888	18.0	<0.5	0.27	<0.2	13.59	1508	0.38	3.88	1.3	18.75
0033 KJK122	0.8	<0.5	0.03	<0.2	0.33	103	0.10	0.22	1.2	7.09
0034 KJK432	1.2	<0.5	0.03	<0.2	0.30	88	<0.02	0.34	3.2	5.94
0035 KJE033	22.0	2.3	0.29	<0.2	5.10	1560	0.02	4.07	1.4	5.96
0036 IPX089	51.0	<0.5	0.39	<0.2	1.39	1.07%	0.22	0.73	0.4	7.97
0037 IPX094	86.4	0.7	0.49	<0.2	1.60	1.40%	0.11	1.28	1.5	17.62
0038 IPX289	7.4	2.1	0.23	<0.2	4.66	903	0.04	2.31	1.6	17.02
0039 IQH700	1.5	1.2	0.04	<0.2	0.78	103	<0.02	0.37	1.6	3.41
0040 IKE803	1.9	<0.5	0.06	<0.2	1.03	239	<0.02	0.77	1.2	5.89

ELEMENTS	Fe	Mn	P	S	Zn	Pb	Cu	Ba	V	Cr
UNITS	%	ppm	ppm	%	ppm	ppm	ppm	ppm	ppm	ppm
DETECTION LIMIT	0.01	1	50	0.05	1	0.5	0.5	0.1	1	1
DIGEST	4A/	4A/	4A/	4A/	4A/	4A/	4A/	4A/	4A/	4A/
ANALYTICAL FINISH	MS	MS	MS	MS	MS	MS	MS	MS	MS	MS
SAMPLE NUMBERS										
0041 IQC742	7.20	114	366	2.45	46	61.7	59.7	367.0	106	146
0042 IQC744	9.25	41	202	8.86	15	56.7	55.5	219.8	55	76
0043 IQK216	>50.00	119	534	0.12	12	9.2	2.6	23.6	43	45
0044 IQH843	>50.00	260	1905	0.06	84	17.4	17.9	14.0	22	27
0045 IKS295	38.66	615	974	0.07	171	97.2	48.7	78.2	33	23
0046 ISB416	4.72	33	64	<0.05	10	22.1	35.1	69.6	40	73
0047 ISB458	25.73	49	565	0.06	49	4.4	13.6	5.9	33	26
0048 IQL024	13.31	67	301	0.24	81	61.3	45.4	54.7	212	226
0049 IQL134	>50.00	580	1181	0.29	32	5.3	6.1	88.1	15	9
0050 ISR689	13.96	1043	416	<0.05	155	18.0	97.7	131.0	182	181
0051 ISB681	41.99	967	1326	0.12	103	16.0	24.4	418.0	39	70
0052 KAA196	41.61	121	706	0.10	16	7.4	7.7	96.2	20	16
0053 KAA560	36.09	410	1196	0.06	62	4.3	18.0	13.5	19	17
0054 KAF556	48.50	81	598	0.45	22	20.7	4.6	88.7	76	53
0055 IQJ569	48.07	362	657	<0.05	16	7.6	5.8	32.8	27	31
0056 KBP675	11.81	1871	390	<0.05	1297	26.4	67.9	198.6	110	183
0057 KBP703	26.75	187	646	0.75	45	64.2	19.3	178.7	168	133
0058 IMU159A	>50.00	179	274	0.05	15	9.6	16.3	3.8	73	48
0059 IXU682	>50.00	153	409	0.20	14	8.4	8.6	2.9	50	38
0060 IXU692	36.55	507	733	1.27	26	7.2	11.8	3.3	41	32
0061 IXU931	26.56	175	1162	<0.05	148	35.0	45.8	10.4	292	235
0062 IXU939	47.95	196	1129	<0.05	31	18.0	17.6	5.1	62	52
0063 KJK611	46.76	116	385	0.06	8	9.3	3.0	69.2	40	48
0064 KJK834	37.99	81	934	0.05	9	1.1	4.5	16.2	3	4
0065 IXP068	45.53	569	1784	0.09	131	46.7	37.5	211.5	42	33
0066 KBS203	31.77	614	1617	0.07	124	16.3	37.8	13.1	60	52
0067 KBS302	28.68	157	428	<0.05	37	17.1	16.5	129.8	55	63
0068 KBS379	49.06	16	368	0.20	6	18.7	13.0	16.8	86	70
0069 KBS842	35.02	71	488	0.12	7	4.8	4.9	54.4	22	23
0070 KBS861	13.92	145	925	0.05	113	81.6	31.8	81.5	92	78
0071 KDY374	29.04	281	1212	0.05	54	16.0	18.3	21.9	41	43
0072 KDY571	41.82	185	462	<0.05	14	13.8	11.3	45.3	89	96
0073 KDY612	7.07	153	274	<0.05	183	67.1	115.6	189.8	115	127
0074 KDY617	48.08	379	765	0.54	71	5.6	20.1	74.5	35	37
0075 KJE387	16.23	52	178	0.05	81	35.3	34.4	66.0	112	134
0076 KJE524	35.25	193	472	<0.05	146	39.2	49.7	64.7	128	133
0077 KJE711	28.36	214	317	<0.05	203	93.2	93.8	62.1	138	140
0078 KKA384	>50.00	51	807	0.12	4	4.5	6.6	1.0	35	24
0079 KKA519	44.26	71	351	0.11	9	10.1	16.0	9.7	68	49
0080 KKA527	>50.00	91	611	0.09	10	6.0	15.3	87.0	75	66

ELEMENTS	As	Ni	Co	Sn	Sr	Zr	Na	Ag	Al	Be
UNITS	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
DETECTION LIMIT	0.5	0.5	0.1	0.1	0.05	0.1	20	0.05	50	0.05
DIGEST	4A/	4A/	4A/	4A/	4A/	4A/	4A/	4A/	4A/	4A/
ANALYTICAL FINISH	MS	MS	MS	MS	MS	MS	MS	MS	MS	MS
SAMPLE NUMBERS										
0041 IQC742	451.8	47.2	9.1	4.2	48.86	139.6	433	0.37	6.84%	1.45
0042 IQC744	293.1	53.1	15.5	3.7	37.69	137.3	278	0.23	4.24%	0.83
0043 IQK216	29.8	4.1	1.4	1.1	5.38	52.5	176	<0.05	1.93%	0.45
0044 IQH843	51.9	14.8	7.6	1.1	20.38	67.6	136	<0.05	2.09%	2.16
0045 IKS295	80.5	26.1	7.7	2.2	4.40	42.0	258	0.18	2.24%	2.09
0046 ISB416	21.0	15.8	2.3	1.2	36.43	49.5	351	0.11	3.91%	0.75
0047 ISB458	6.6	6.7	2.0	0.5	2.09	41.6	126	0.07	1.66%	0.42
0048 IQL024	63.4	51.8	6.3	3.9	128.91	252.8	1190	<0.05	13.59%	1.40
0049 IQL134	17.4	4.1	1.5	0.4	115.27	21.4	1002	<0.05	1.45%	3.39
0050 ISR689	18.2	79.9	29.4	2.4	29.93	109.4	1194	<0.05	8.91%	0.76
0051 ISB681	69.3	30.6	4.3	0.7	9.55	43.1	156	<0.05	3.20%	1.78
0052 KAA196	9.9	4.9	1.0	0.5	10.80	27.5	226	0.13	2.64%	0.68
0053 KAA560	10.0	18.3	6.9	0.4	6.33	21.7	56	0.08	1.06%	2.31
0054 KAF556	28.3	4.5	0.7	2.4	184.80	52.3	1641	<0.05	2.40%	0.32
0055 IQJ569	12.8	8.9	7.6	0.8	2.56	50.7	108	<0.05	1.43%	0.69
0056 KBP675	70.3	81.0	32.2	2.8	14.63	122.0	351	<0.05	8.52%	2.14
0057 KBP703	48.3	17.5	3.4	4.1	160.01	349.4	637	<0.05	12.94%	0.78
0058 IMU159A	26.7	5.4	1.1	2.1	2.47	70.8	247	<0.05	3.18%	0.44
0059 IXU682	16.1	3.7	1.1	1.3	10.11	58.5	134	<0.05	2.65%	0.34
0060 IXU692	15.0	6.9	1.2	1.3	8.42	45.6	300	<0.05	2.28%	0.54
0061 IXU931	110.3	39.9	6.8	3.1	19.20	184.3	434	<0.05	12.98%	2.49
0062 IXU939	54.5	10.5	2.3	1.2	10.88	100.5	183	<0.05	5.97%	1.83
0063 KJK611	21.6	9.9	3.5	1.1	82.76	64.8	189	<0.05	2.12%	0.54
0064 KJK834	5.5	2.3	0.7	0.1	26.85	5.4	81	<0.05	2534	0.89
0065 IXP068	53.1	17.0	4.4	1.4	40.72	77.7	313	0.06	4.08%	2.13
0066 KBS203	54.5	30.0	5.9	1.1	11.62	61.4	144	<0.05	3.96%	2.31
0067 KBS302	57.8	15.4	3.5	1.1	14.04	51.5	319	0.11	2.26%	0.96
0068 KBS379	49.7	8.5	1.1	1.6	5.60	124.9	289	<0.05	4.42%	0.73
0069 KBS842	9.1	2.8	0.9	0.5	1.55	37.8	191	<0.05	2.16%	0.53
0070 KBS861	50.1	53.0	11.9	4.0	38.64	363.0	313	<0.05	12.85%	1.47
0071 KDY374	15.9	15.2	2.5	1.4	18.25	70.7	122	<0.05	3.23%	1.63
0072 KDY571	29.3	8.7	1.8	1.5	9.32	78.6	180	<0.05	2.77%	0.54
0073 KDY612	130.8	69.7	10.2	3.6	16.19	150.7	318	0.13	9.29%	2.60
0074 KDY617	42.0	26.9	2.3	0.7	31.91	46.8	428	<0.05	2.09%	2.08
0075 KJE387	205.9	27.1	3.6	3.5	11.28	134.5	692	0.08	7.74%	0.76
0076 KJE524	158.4	46.5	4.8	2.8	9.19	144.1	229	<0.05	9.03%	1.76
0077 KJE711	625.7	75.7	8.3	4.9	7.32	233.6	312	0.10	10.43%	1.65
0078 KKA384	5.5	3.1	2.0	1.1	0.47	19.5	49	<0.05	1.03%	0.20
0079 KKA519	11.3	11.6	3.4	0.8	0.53	38.3	128	0.12	2.94%	0.49
0080 KKA527	7.3	6.9	2.5	1.4	5.70	69.6	171	0.08	2.58%	0.46

ELEMENTS	Bi	Ca	Cd	Ce	Cs	Fe-Rp1	Ga	Ge	Hf	In
UNITS	ppm	ppm	ppm	ppm	ppm	%	ppm	ppm	ppm	ppm
DETECTION LIMIT	0.01	50	0.02	0.01	0.05	0.01	0.05	0.1	0.05	0.01
DIGEST	4A/	4A/	4A/	4A/	4A/	4AH/	4A/	4A/	4A/	4A/
ANALYTICAL FINISH	MS	MS	MS	MS	MS	OE	MS	MS	MS	MS
SAMPLE NUMBERS										
0041 IQC742	1.92	1612	0.08	101.85	7.76		20.14	1.6	3.83	0.20
0042 IQC744	2.27	125	0.09	66.84	3.91		17.98	1.7	3.80	0.19
0043 IQK216	0.18	198	<0.02	4.60	<0.05	55.94	12.40	4.1	1.33	0.03
0044 IQH843	0.37	78	0.06	53.56	<0.05	56.56	10.05	4.9	1.71	0.06
0045 IKS295	2.50	191	0.33	25.61	<0.05		9.51	2.5	1.10	0.14
0046 ISB416	0.61	7482	<0.02	20.37	1.28		10.17	3.6	1.39	0.09
0047 ISB458	0.11	103	<0.02	7.54	<0.05		6.20	2.3	1.00	0.02
0048 IQL024	1.26	7093	0.04	56.51	0.11		33.81	3.3	6.96	0.11
0049 IQL134	0.08	2.58%	<0.02	17.41	<0.05	52.63	7.00	6.8	0.47	<0.01
0050 ISR689	0.30	3168	0.10	33.82	2.75		22.13	2.7	3.03	0.11
0051 ISB681	0.23	114	0.06	18.74	0.10		10.91	5.6	1.14	0.03
0052 KAA196	0.11	81	<0.02	29.29	0.07		7.37	2.6	0.67	0.01
0053 KAA560	0.06	97	0.08	23.37	<0.05		6.42	2.9	0.48	0.01
0054 KAF556	0.27	863	<0.02	4.54	<0.05		19.55	4.4	1.37	0.05
0055 IQJ569	0.15	174	<0.02	7.07	0.10		10.13	3.0	1.22	0.02
0056 KBP675	0.78	394	0.07	81.33	2.65		23.28	0.9	3.43	0.07
0057 KBP703	1.14	204	<0.02	81.49	<0.05		35.88	3.0	9.16	0.14
0058 IMU159A	0.45	109	<0.02	23.83	<0.05	54.14	18.41	4.3	1.94	0.04
0059 IXU682	0.27	279	0.05	35.70	<0.05	52.71	13.13	2.3	1.51	0.03
0060 IXU692	0.20	2028	0.07	27.10	0.06		10.02	4.1	1.16	0.02
0061 IXU931	0.89	173	0.04	31.90	0.10		31.31	2.4	4.96	0.13
0062 IXU939	0.41	147	0.03	17.12	<0.05		15.49	4.0	2.59	0.04
0063 KJK611	0.18	408	0.05	5.57	<0.05		12.61	3.3	1.66	0.04
0064 KJK834	<0.01	77	<0.02	18.42	<0.05		4.28	2.3	0.11	<0.01
0065 IXP068	0.41	133	0.07	132.09	0.05		12.19	2.8	2.04	0.07
0066 KBS203	0.29	148	0.09	70.68	0.06		12.17	1.8	1.61	0.05
0067 KBS302	0.31	196	<0.02	17.95	1.33		10.15	2.6	1.41	0.04
0068 KBS379	0.51	<50	0.02	19.73	<0.05		15.31	4.7	3.12	0.12
0069 KBS842	0.14	62	<0.02	5.24	<0.05		6.65	2.2	0.92	0.02
0070 KBS861	1.63	384	0.06	233.89	0.15		28.54	2.4	9.36	0.31
0071 KDY374	0.33	124	0.03	55.33	0.07		10.82	1.6	1.78	0.03
0072 KDY571	0.30	415	<0.02	8.93	0.45		15.74	2.9	2.15	0.05
0073 KDY612	1.42	257	0.25	131.62	13.50		22.17	3.4	4.12	0.15
0074 KDY617	0.14	2547	0.13	7.53	0.44		9.57	2.7	1.17	0.03
0075 KJE387	1.50	644	0.06	16.80	4.29		20.20	1.4	3.60	0.17
0076 KJE524	1.30	514	0.10	38.84	1.12		27.86	4.8	3.85	0.21
0077 KJE711	2.10	365	0.08	29.98	3.44		35.44	3.0	6.33	0.27
0078 KKA384	0.12	<50	<0.02	1.99	<0.05	58.27	11.43	6.9	0.52	0.02
0079 KKA519	0.15	<50	0.02	7.87	<0.05		9.94	5.8	1.02	0.05
0080 KKA527	0.28	186	<0.02	4.94	0.17	51.27	14.69	4.4	2.06	0.04

ELEMENTS	K	La	Li	Mg	Mn-Rp1	Mo	Nb	Rb	Re	Sb
UNITS	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
DETECTION LIMIT	20	0.01	0.1	20	10	0.1	0.05	0.05	0.002	0.05
DIGEST	4A/	4A/	4A/	4A/	4AH/	4A/	4A/	4A/	4A/	4A/
ANALYTICAL FINISH	MS	MS	MS	MS	OE	MS	MS	MS	MS	MS
SAMPLE NUMBERS										
0041 IQC742	2.21%	56.04	34.0	5167		15.1	7.44	133.31	0.030	17.21
0042 IQC744	1.62%	34.87	18.8	2299		12.6	7.12	76.94	0.039	9.36
0043 IQK216	57	2.10	0.6	267		2.2	4.63	0.27	<0.002	1.66
0044 IQH843	31	12.16	0.6	159		3.1	3.78	0.16	<0.002	1.81
0045 IKS295	139	6.26	2.3	624		0.7	1.98	0.52	<0.002	7.74
0046 ISB416	2101	12.55	7.2	5255		2.2	3.26	16.46	<0.002	2.81
0047 ISB458	54	9.94	0.9	148		1.0	2.05	0.27	<0.002	0.58
0048 IQL024	1333	20.78	13.4	2339		2.8	16.24	1.50	<0.002	22.31
0049 IQL134	1345	3.54	0.8	1814		0.4	1.33	0.62	<0.002	1.61
0050 ISR689	5974	15.95	16.5	6781		1.3	7.98	45.10	<0.002	1.45
0051 ISB681	135	12.20	0.7	214		5.3	3.13	0.61	<0.002	1.91
0052 KAA196	460	11.62	1.8	128		0.5	2.15	0.87	<0.002	0.65
0053 KAA560	50	6.62	1.5	149		1.5	1.55	0.25	<0.002	0.30
0054 KAF556	743	3.65	1.5	585		5.3	10.27	0.57	<0.002	3.37
0055 IQJ569	108	2.88	1.9	160		1.3	3.07	0.87	<0.002	1.44
0056 KBP675	1.57%	37.18	11.8	3119		2.1	6.29	65.08	<0.002	8.71
0057 KBP703	3620	19.91	6.7	619		3.7	14.35	0.55	<0.002	6.55
0058 IMU159A	33	7.18	6.5	398		2.4	8.46	0.12	<0.002	2.93
0059 IXU682	43	10.59	1.4	522		1.4	5.01	0.19	0.008	1.81
0060 IXU692	77	6.55	0.7	1359		1.3	3.73	0.32	<0.002	1.68
0061 IXU931	68	15.69	1.5	628		7.1	9.40	0.62	<0.002	20.51
0062 IXU939	41	4.86	0.3	563		2.7	4.78	0.21	<0.002	4.72
0063 KJK611	329	3.97	1.7	484		2.4	4.69	0.74	<0.002	1.57
0064 KJK834	188	7.46	0.7	157		0.4	0.46	0.18	<0.002	0.29
0065 IXP068	72	91.05	0.7	474		3.0	5.49	0.27	<0.002	2.83
0066 KBS203	86	46.55	0.6	403		3.6	4.53	0.46	<0.002	2.66
0067 KBS302	3389	10.90	9.7	952		2.7	2.84	28.40	<0.002	2.09
0068 KBS379	69	8.97	9.9	267		1.6	6.08	0.28	<0.002	4.19
0069 KBS842	50	4.58	1.6	150		0.7	1.92	0.23	<0.002	1.10
0070 KBS861	163	138.15	6.8	526		6.5	11.32	1.01	0.002	8.43
0071 KDY374	71	13.38	1.0	231		1.8	5.56	0.93	<0.002	1.39
0072 KDY571	475	4.85	3.5	343		2.0	5.92	4.71	<0.002	2.10
0073 KDY612	3.31%	58.00	49.5	8536		6.7	6.72	209.47	<0.002	11.08
0074 KDY617	3758	3.47	1.9	961		2.1	3.16	6.81	<0.002	1.64
0075 KJE387	7376	10.62	12.0	2259		15.6	4.67	62.74	<0.002	25.22
0076 KJE524	3420	22.62	10.0	953		7.1	2.92	21.94	<0.002	10.47
0077 KJE711	9248	17.54	16.0	2365		18.9	9.03	73.48	<0.002	23.45
0078 KKA384	<20	0.68	0.2	66		2.2	4.48	0.09	<0.002	0.86
0079 KKA519	54	1.84	3.6	86		1.6	2.99	0.45	<0.002	1.85
0080 KKA527	154	1.89	3.4	132		1.5	4.89	1.34	<0.002	1.94

ELEMENTS	Sc	Se	Ta	Te	Th	Ti	Tl	U	W	Y
UNITS	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
DETECTION LIMIT	0.1	0.5	0.01	0.2	0.01	5	0.02	0.01	0.1	0.05
DIGEST	4A/	4A/	4A/	4A/	4A/	4A/	4A/	4A/	4A/	4A/
ANALYTICAL FINISH	MS	MS	MS	MS	MS	MS	MS	MS	MS	MS
SAMPLE NUMBERS										
0041 IQC742	20.2	8.9	0.69	0.6	19.02	2515	1.31	5.36	4.4	13.10
0042 IQC744	14.0	6.6	0.56	0.9	15.76	1865	1.73	3.97	5.4	13.41
0043 IQK216	2.7	3.0	0.35	<0.2	5.38	1194	0.05	1.12	2.8	1.71
0044 IQH843	3.4	<0.5	0.31	<0.2	5.87	634	0.06	2.53	2.4	13.56
0045 IKS295	6.0	0.6	0.15	0.3	4.37	615	0.39	1.73	2.1	8.87
0046 ISB416	7.0	1.1	0.27	0.5	6.77	1003	0.12	1.21	2.0	8.47
0047 ISB458	5.4	<0.5	0.15	<0.2	3.03	863	<0.02	0.66	1.7	3.11
0048 IQL024	28.9	0.8	1.48	0.7	29.09	5422	<0.02	4.13	4.1	23.42
0049 IQL134	3.6	<0.5	0.09	<0.2	2.05	155	0.03	1.50	1.1	7.94
0050 ISR689	29.5	<0.5	0.64	<0.2	8.37	5574	0.41	1.49	1.3	16.85
0051 ISB681	5.4	<0.5	0.25	<0.2	4.71	863	0.15	1.33	3.2	13.46
0052 KAA196	3.1	1.1	0.15	<0.2	3.16	494	<0.02	0.44	2.1	3.29
0053 KAA560	2.6	<0.5	0.10	<0.2	1.55	525	0.07	1.32	2.1	10.54
0054 KAF556	3.2	0.5	0.84	<0.2	4.21	3440	<0.02	1.12	4.5	1.66
0055 IQJ569	3.7	2.7	0.21	<0.2	5.09	743	0.11	1.00	2.0	3.40
0056 KBP675	18.9	<0.5	0.60	<0.2	16.72	2598	0.62	3.96	2.1	24.70
0057 KBP703	31.9	2.2	1.25	0.3	39.65	4876	<0.02	5.07	3.9	16.64
0058 IMU159A	5.2	1.4	0.70	<0.2	6.52	2619	<0.02	1.70	3.7	7.21
0059 IXU682	5.0	11.3	0.38	<0.2	6.03	1326	0.04	1.49	2.2	9.97
0060 IXU692	4.2	4.5	0.28	<0.2	4.56	1050	0.11	1.16	1.7	10.06
0061 IXU931	30.8	2.0	0.85	0.6	19.05	4406	<0.02	4.47	3.0	22.70
0062 IXU939	12.6	0.9	0.44	<0.2	10.10	1651	<0.02	4.08	2.1	11.23
0063 KJK611	3.5	1.0	0.37	<0.2	6.49	1411	<0.02	1.65	2.5	2.06
0064 KJK834	0.9	<0.5	0.02	<0.2	0.31	36	<0.02	0.27	1.4	3.21
0065 IXP068	7.5	<0.5	0.41	0.4	6.68	996	0.09	2.31	1.6	11.95
0066 KBS203	10.1	0.7	0.37	0.3	6.26	1649	0.10	2.52	2.5	15.17
0067 KBS302	6.4	1.1	0.20	<0.2	6.26	1057	0.24	1.18	2.4	11.48
0068 KBS379	12.3	2.1	0.47	0.4	11.18	1365	<0.02	1.68	2.3	6.76
0069 KBS842	3.8	1.2	0.14	<0.2	3.82	418	<0.02	0.50	2.9	2.40
0070 KBS861	16.2	0.6	0.83	0.5	30.46	2344	0.02	5.73	2.9	39.20
0071 KDY374	5.9	<0.5	0.47	<0.2	9.12	1251	0.05	3.20	2.3	12.05
0072 KDY571	7.6	1.7	0.39	<0.2	9.99	1938	0.09	1.24	1.9	4.85
0073 KDY612	20.6	1.7	0.63	0.4	18.11	2384	1.14	3.47	4.0	30.46
0074 KDY617	5.1	0.7	0.25	<0.2	3.49	1239	0.19	0.80	1.5	8.04
0075 KJE387	16.1	1.8	0.38	0.6	14.69	1715	0.33	2.25	2.2	9.29
0076 KJE524	18.7	0.7	0.30	0.6	17.23	1168	0.13	4.61	1.8	24.76
0077 KJE711	25.7	3.9	0.83	0.7	26.36	2659	0.32	5.66	3.7	20.07
0078 KKA384	1.5	1.9	0.35	<0.2	1.06	2118	<0.02	0.40	2.0	1.04
0079 KKA519	7.2	2.3	0.24	<0.2	3.36	1201	<0.02	1.39	1.2	2.78
0080 KKA527	8.2	3.5	0.38	<0.2	6.50	1969	0.03	0.75	1.5	2.84

ELEMENTS	Fe	Mn	P	S	Zn	Pb	Cu	Ba	V	Cr
UNITS	%	ppm	ppm	%	ppm	ppm	ppm	ppm	ppm	ppm
DETECTION LIMIT	0.01	1	50	0.05	1	0.5	0.5	0.1	1	1
DIGEST	4A/	4A/	4A/	4A/	4A/	4A/	4A/	4A/	4A/	4A/
ANALYTICAL FINISH	MS	MS	MS	MS	MS	MS	MS	MS	MS	MS
SAMPLE NUMBERS										
0081 KKA680	49.19	29	131	0.23	2	15.9	6.3	59.8	139	162
0082 KKA684	>50.00	119	546	0.17	8	7.7	12.5	4.7	83	58
0083 KKA686	48.41	56	543	0.25	9	8.4	15.9	5.8	73	51
0084 KKA687	46.42	48	434	0.31	8	10.3	27.6	6.6	122	76
0085 KJW683	29.54	48	323	0.05	3	2.1	3.4	10.2	11	16
0086 KKW195	>50.00	416	512	<0.05	21	2.9	10.5	13.1	22	24
0087 KKW509	47.56	272	171	<0.05	21	19.9	18.1	75.2	208	241
0088 KJV431	42.37	119	538	0.06	21	6.2	10.2	102.5	59	42
0089 KIS196	30.62	519	323	<0.05	175	15.9	108.3	57.6	426	364
0090 KIS257	48.19	104	672	<0.05	38	7.7	55.0	7.3	100	92
0091 KIS260	44.24	77	522	<0.05	42	11.8	64.4	9.4	92	108
0092 KJV904	46.73	31	289	0.13	5	6.3	29.2	27.1	46	57
0093 KNE680	45.47	144	717	0.08	40	8.0	54.4	77.6	144	179
0094 KNF277	32.78	78	540	<0.05	14	3.3	5.5	25.8	7	13
0095 KKK174	46.74	354	485	<0.05	19	10.5	8.5	130.7	53	57
0096 IWV729	>50.00	140	489	0.11	17	20.0	9.8	89.0	101	58
0097 IWV732	48.80	46	487	0.07	49	22.0	15.2	31.0	76	92
0098 IWV832	43.91	34	272	0.06	16	29.4	32.9	13.6	191	147
0099 IKD414	15.83	1445	873	0.06	108	42.6	80.7	570.4	387	270

CHECKS										
0001 IKT635 Rpt	48.05	6900	597	<0.05	239	11.5	43.0	213.7	143	122
0002 ISB681 Rpt	41.49	950	1351	0.10	101	15.9	24.4	423.9	39	68
0003 IXU939 Rpt	46.60	191	1088	<0.05	30	17.9	17.2	4.9	62	52

STANDARDS										
0001 WMS-1a										
0002 GMN-01										
0003 AMIS0275										
0004 OREAS 610	2.36	83	538	3.77	1718	675.0	9561.0	1051.1	32	47
0005 OREAS 25a	6.27	478	465	<0.05	43	22.6	30.2	134.3	151	115
0006 OREAS 256b	4.15	372	552	0.07	75	16.3	94.8	454.2	125	255
0007 AMIS0744	15.85	>5.00%	859	0.07	65	44.3	189.8	31.4	154	1252

BLANKS										
0001 Control Blank	<0.01	<1	<50	<0.05	<1	<0.5	<0.5	<0.1	<1	<1
0002 Control Blank	0.01	<1	<50	<0.05	<1	<0.5	<0.5	0.1	<1	<1
0003 Control Blank	0.01	1	<50	<0.05	<1	<0.5	<0.5	0.4	<1	1
0004 Control Blank	0.01	1	<50	<0.05	<1	<0.5	<0.5	<0.1	<1	1

MISSING SAMPLES: KAE622

ELEMENTS	As	Ni	Co	Sn	Sr	Zr	Na	Ag	Al	Be
UNITS	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
DETECTION LIMIT	0.5	0.5	0.1	0.1	0.05	0.1	20	0.05	50	0.05
DIGEST	4A/	4A/	4A/	4A/	4A/	4A/	4A/	4A/	4A/	4A/
ANALYTICAL FINISH	MS	MS	MS	MS	MS	MS	MS	MS	MS	MS
SAMPLE NUMBERS										
0081 KKA680	13.4	16.1	2.3	2.9	16.03	102.2	294	<0.05	5.29%	0.18
0082 KKA684	12.7	13.5	4.4	1.2	4.21	32.2	164	<0.05	2.86%	0.86
0083 KKA686	16.2	27.1	9.7	1.0	4.12	34.9	154	<0.05	3.73%	2.71
0084 KKA687	17.2	41.6	16.0	1.4	1.15	53.3	264	<0.05	5.05%	2.66
0085 KJW683	2.7	1.8	0.8	0.6	0.73	13.4	27	0.06	6461	0.21
0086 KKW195	6.1	8.9	3.6	0.3	1.58	15.2	57	0.05	9021	0.37
0087 KKW509	15.0	20.3	3.9	3.5	6.90	115.6	381	<0.05	4.63%	0.69
0088 KJV431	11.4	7.7	6.3	1.4	15.36	33.7	113	0.05	1.75%	0.38
0089 KIS196	19.3	64.1	28.6	2.4	39.85	83.3	1951	0.12	6.40%	0.53
0090 KIS257	11.1	23.7	7.7	1.1	7.21	37.1	380	0.09	3.61%	0.45
0091 KIS260	9.2	32.2	8.7	1.2	10.44	40.0	512	0.09	4.67%	0.59
0092 KJV904	15.2	7.1	1.8	0.9	4.94	48.6	276	<0.05	3.47%	0.67
0093 KNE680	21.8	38.8	9.5	1.0	8.45	56.6	119	0.08	3.99%	1.02
0094 KNF277	2.2	8.7	2.6	0.2	0.64	5.5	63	0.06	2388	1.31
0095 KKK174	36.4	11.4	3.7	1.1	16.37	63.2	296	<0.05	2.36%	0.39
0096 IWV729	98.4	11.2	4.0	2.5	13.22	58.7	221	0.14	3.04%	0.62
0097 IWV732	103.8	16.6	3.9	1.8	8.45	100.2	148	0.10	3.88%	0.68
0098 IWV832	97.6	15.0	3.2	5.7	5.06	367.3	178	<0.05	6.52%	0.66
0099 IKD414	19.0	170.5	41.5	2.8	58.28	164.7	1258	<0.05	11.78%	2.52
CHECKS										
0001 IKT635 Rpt	90.9	212.6	65.2	1.9	21.69	57.5	622	0.07	2.72%	2.26
0002 ISB681 Rpt	68.9	31.8	4.2	0.8	9.98	48.1	156	<0.05	3.21%	1.67
0003 IXU939 Rpt	52.5	10.2	2.2	1.2	10.75	100.0	180	<0.05	5.82%	1.95
STANDARDS										
0001 WMS-1a										
0002 GMN-01										
0003 AMIS0275										
0004 OREAS 610	2895.2	24.2	8.0	27.0	316.47	58.7	8234	48.10	5.90%	1.44
0005 OREAS 25a	9.8	41.3	7.3	3.7	44.02	151.4	1214	<0.05	8.58%	0.78
0006 OREAS 256b	297.1	101.2	21.9	5.4	158.77	134.1	5547	1.45	6.37%	1.75
0007 AMIS0744	47.0	93.0	185.7	1.5	18.64	8.8	166	0.17	2153	<0.05
BLANKS										
0001 Control Blank	<0.5	<0.5	<0.1	0.2	<0.05	<0.1	<20	<0.05	<50	<0.05
0002 Control Blank	<0.5	<0.5	<0.1	<0.1	<0.05	<0.1	<20	<0.05	<50	<0.05
0003 Control Blank	<0.5	<0.5	<0.1	0.3	0.07	<0.1	<20	<0.05	<50	<0.05
0004 Control Blank	<0.5	<0.5	<0.1	<0.1	<0.05	<0.1	<20	<0.05	<50	<0.05

MISSING SAMPLES: KAE622

ELEMENTS	Bi	Ca	Cd	Ce	Cs	Fe-Rp1	Ga	Ge	Hf	In
UNITS	ppm	ppm	ppm	ppm	ppm	%	ppm	ppm	ppm	ppm
DETECTION LIMIT	0.01	50	0.02	0.01	0.05	0.01	0.05	0.1	0.05	0.01
DIGEST	4A/	4A/	4A/	4A/	4A/	4AH/	4A/	4A/	4A/	4A/
ANALYTICAL FINISH	MS	MS	MS	MS	MS	OE	MS	MS	MS	MS
SAMPLE NUMBERS										
0081 KKA680	0.26	81	<0.02	2.29	0.08		29.42	6.2	2.86	0.09
0082 KKA684	0.12	54	0.03	3.94	<0.05	54.24	15.59	6.6	0.87	0.05
0083 KKA686	0.13	<50	<0.02	14.43	<0.05		12.76	5.7	0.92	0.06
0084 KKA687	0.18	70	0.03	11.25	<0.05		16.75	6.4	1.34	0.07
0085 KJW683	0.04	<50	<0.02	2.69	<0.05		5.06	3.1	0.37	<0.01
0086 KKW195	0.06	108	0.04	6.03	<0.05	63.29	8.06	4.2	0.37	<0.01
0087 KKW509	0.34	235	0.07	20.80	0.24		39.69	5.0	3.22	0.12
0088 KJV431	0.12	593	0.04	3.14	0.05		13.07	5.0	0.90	0.03
0089 KIS196	0.23	6873	0.23	13.28	0.28		26.38	3.0	2.29	0.21
0090 KIS257	0.16	674	0.06	4.44	<0.05		13.48	4.7	0.99	0.05
0091 KIS260	0.14	857	0.03	24.26	<0.05		14.50	4.9	1.16	0.06
0092 KJV904	0.18	231	<0.02	2.37	0.06		10.79	8.5	1.25	0.06
0093 KNE680	0.18	515	0.08	5.39	0.11		15.16	4.0	1.57	0.07
0094 KNF277	0.02	<50	<0.02	7.57	0.09		4.18	4.2	0.11	<0.01
0095 KKK174	0.20	596	0.04	6.81	0.23		13.83	3.6	1.81	0.03
0096 IWV729	0.46	450	<0.02	6.11	0.10	53.31	22.03	4.3	1.56	0.08
0097 IWV732	0.73	399	0.03	8.07	0.76		18.10	3.4	2.67	0.09
0098 IWV832	2.28	231	<0.02	27.08	0.36		42.11	3.5	6.91	0.33
0099 IKD414	0.90	241	<0.02	118.03	3.74		29.25	3.2	4.51	0.12
CHECKS										
0001 IKT635 Rpt	0.29	432	0.11	41.06	0.19		23.08	1.3	1.56	0.05
0002 ISB681 Rpt	0.22	108	0.07	18.94	0.10		11.04	5.5	1.19	0.03
0003 IXU939 Rpt	0.39	151	0.03	17.29	<0.05		15.37	5.0	2.49	0.05
STANDARDS										
0001 WMS-1a						42.09				
0002 GMN-01						5.21				
0003 AMIS0275						6.58				
0004 OREAS 610	225.69	2280	11.85	49.90	2.10		23.75	5.9	1.99	3.79
0005 OREAS 25a	0.31	2797	0.04	46.13	5.94		24.80	2.0	4.23	0.08
0006 OREAS 256b	5.47	8922	0.08	55.07	3.57		17.35	1.5	3.36	0.06
0007 AMIS0744	0.22	1865	0.03	1.08	0.30		11.22	3.0	0.18	0.05
BLANKS										
0001 Control Blank	<0.01	<50	<0.02	<0.01	<0.05		<0.05	<0.1	<0.05	<0.01
0002 Control Blank	<0.01	<50	<0.02	0.02	<0.05		<0.05	<0.1	<0.05	<0.01
0003 Control Blank	<0.01	<50	<0.02	0.02	<0.05		<0.05	<0.1	<0.05	<0.01
0004 Control Blank	<0.01	<50	<0.02	<0.01	<0.05		<0.05	<0.1	<0.05	<0.01

MISSING SAMPLES: KAE622

ELEMENTS	K	La	Li	Mg	Mn-Rp1	Mo	Nb	Rb	Re	Sb
UNITS	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
DETECTION LIMIT	20	0.01	0.1	20	10	0.1	0.05	0.05	0.002	0.05
DIGEST	4A/	4A/	4A/	4A/	4AH/	4A/	4A/	4A/	4A/	4A/
ANALYTICAL FINISH	MS	MS	MS	MS	OE	MS	MS	MS	MS	MS
SAMPLE NUMBERS										
0081 KKA680	774	0.76	4.7	260		3.3	10.81	0.79	<0.002	1.95
0082 KKA684	111	1.20	1.9	187		1.9	4.76	0.25	<0.002	1.46
0083 KKA686	42	1.34	2.4	167		1.4	3.65	0.24	<0.002	1.26
0084 KKA687	60	1.98	6.9	228		1.5	5.49	0.31	<0.002	1.73
0085 KJW683	47	0.75	1.3	73		0.8	2.66	0.48	<0.002	0.39
0086 KKW195	22	1.12	0.8	239		0.7	1.27	0.13	<0.002	0.43
0087 KKW509	258	6.05	13.3	454		3.6	13.05	2.01	<0.002	2.19
0088 KJV431	66	1.68	1.9	266		1.6	6.43	0.54	<0.002	0.90
0089 KIS196	915	5.49	8.2	5110		1.2	5.75	4.47	<0.002	1.26
0090 KIS257	142	1.37	2.1	1442		1.1	3.55	0.54	<0.002	1.34
0091 KIS260	164	9.43	4.3	1904		1.1	3.55	0.57	<0.002	1.10
0092 KJV904	110	0.79	1.7	81		1.3	3.12	0.44	<0.002	2.10
0093 KNE680	140	5.33	4.4	456		1.3	3.39	1.08	<0.002	1.01
0094 KNF277	78	2.10	1.0	59		0.6	0.42	0.86	<0.002	0.43
0095 KKK174	327	3.49	2.6	393		1.7	3.91	3.04	<0.002	1.93
0096 IWV729	165	2.77	0.6	226		8.6	7.95	1.28	<0.002	4.56
0097 IWV732	1706	6.31	3.9	656		4.2	3.80	14.64	<0.002	4.98
0098 IWV832	97	15.18	12.5	693		13.9	14.69	1.61	<0.002	13.72
0099 IKD414	6000	862.09	7.2	2306		1.1	3.95	35.58	<0.002	33.65
CHECKS										
0001 IKT635 Rpt	317	12.67	16.1	1170		1.1	4.75	1.45	<0.002	8.98
0002 ISB681 Rpt	131	12.28	0.6	214		5.1	3.19	0.60	<0.002	1.87
0003 IXU939 Rpt	31	4.63	0.3	558		2.7	5.09	0.20	<0.002	4.41
STANDARDS										
0001 WMS-1a					619					
0002 GMN-01					13.45%					
0003 AMIS0275					1077					
0004 OREAS 610	1.96%	25.11	28.3	1566		4.8	8.55	64.05	0.002	299.25
0005 OREAS 25a	4608	21.33	33.4	3059		2.3	19.39	57.61	<0.002	0.59
0006 OREAS 256b	1.57%	29.26	24.4	1.63%		6.4	15.82	69.50	<0.002	12.79
0007 AMIS0744	209	0.75	1.2	1921		10.6	4.09	0.83	0.002	13.80
BLANKS										
0001 Control Blank	<20	<0.01	0.1	<20		<0.1	<0.05	<0.05	<0.002	<0.05
0002 Control Blank	<20	<0.01	<0.1	<20		<0.1	<0.05	<0.05	<0.002	<0.05
0003 Control Blank	<20	0.02	<0.1	<20		<0.1	<0.05	<0.05	<0.002	<0.05
0004 Control Blank	<20	<0.01	<0.1	<20		<0.1	<0.05	<0.05	<0.002	<0.05

MISSING SAMPLES: KAE622

ELEMENTS	Sc	Se	Ta	Te	Th	Ti	Tl	U	W	Y
UNITS	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
DETECTION LIMIT	0.1	0.5	0.01	0.2	0.01	5	0.02	0.01	0.1	0.05
DIGEST	4A/	4A/	4A/	4A/	4A/	4A/	4A/	4A/	4A/	4A/
ANALYTICAL FINISH	MS	MS	MS	MS	MS	MS	MS	MS	MS	MS
SAMPLE NUMBERS										
0081 KKA680	10.9	1.7	0.87	<0.2	8.68	5929	<0.02	0.75	2.1	10.62
0082 KKA684	4.7	1.1	0.38	<0.2	2.32	2362	<0.02	0.96	2.1	2.40
0083 KKA686	4.3	1.8	0.29	<0.2	2.67	1743	<0.02	1.20	1.5	2.78
0084 KKA687	6.4	1.8	0.41	<0.2	3.98	2893	<0.02	1.55	1.5	3.75
0085 KJW683	1.5	1.5	0.21	<0.2	0.87	1224	<0.02	0.24	2.0	1.23
0086 KKW195	3.4	0.7	0.10	<0.2	1.17	504	<0.02	0.43	0.8	2.67
0087 KKW509	12.8	1.2	1.04	<0.2	11.75	7190	0.05	1.81	2.3	8.10
0088 KJV431	5.4	1.8	0.48	<0.2	2.41	3251	<0.02	0.56	5.5	2.40
0089 KIS196	29.6	0.9	0.42	0.3	4.36	6066	0.25	0.75	1.0	10.11
0090 KIS257	14.9	2.2	0.28	<0.2	2.46	2010	<0.02	0.91	1.7	3.36
0091 KIS260	20.4	1.3	0.27	<0.2	2.63	2328	<0.02	0.89	1.5	6.02
0092 KJV904	5.4	4.0	0.23	<0.2	3.55	1049	<0.02	0.70	1.0	2.05
0093 KNE680	15.6	1.7	0.24	<0.2	3.18	2439	0.05	0.81	1.2	6.20
0094 KNF277	1.2	<0.5	0.02	<0.2	0.28	103	<0.02	0.26	0.9	5.37
0095 KKK174	5.1	1.3	0.29	<0.2	7.95	1341	0.04	1.14	1.6	4.03
0096 IWV729	6.0	2.2	0.65	0.3	5.56	2748	0.03	1.21	3.7	3.05
0097 IWV732	11.1	6.4	0.29	0.4	11.93	1275	0.06	2.13	2.1	5.00
0098 IWV832	11.1	2.8	1.25	1.1	28.43	4120	<0.02	5.18	6.7	12.31
0099 IKD414	38.2	2.5	0.35	0.4	18.93	1983	0.13	3.42	2.3	70.85
CHECKS										
0001 IKT635 Rpt	8.2	1.4	0.38	<0.2	5.51	2432	0.41	1.80	2.0	12.52
0002 ISB681 Rpt	5.5	<0.5	0.26	<0.2	4.71	858	0.15	1.33	3.3	13.66
0003 IXU939 Rpt	12.1	0.7	0.42	<0.2	9.98	1736	<0.02	4.15	2.4	11.26
STANDARDS										
0001 WMS-1a										
0002 GMN-01										
0003 AMIS0275										
0004 OREAS 610	2.9	28.0	0.69	41.4	8.89	1583	1.85	2.69	7.6	6.50
0005 OREAS 25a	12.2	2.2	1.45	<0.2	14.90	8772	0.33	2.65	1.8	10.00
0006 OREAS 256b	18.2	0.5	1.04	0.3	7.94	3878	0.43	1.62	61.1	13.40
0007 AMIS0744	0.7	<0.5	0.10	<0.2	0.13	122	<0.02	0.48	6.0	0.76
BLANKS										
0001 Control Blank	<0.1	<0.5	<0.01	<0.2	<0.01	<5	<0.02	<0.01	<0.1	<0.05
0002 Control Blank	<0.1	<0.5	<0.01	<0.2	<0.01	<5	<0.02	<0.01	<0.1	<0.05
0003 Control Blank	<0.1	<0.5	<0.01	<0.2	<0.01	6	<0.02	<0.01	<0.1	<0.05
0004 Control Blank	<0.1	<0.5	<0.01	<0.2	<0.01	<5	<0.02	<0.01	<0.1	<0.05

MISSING SAMPLES: KAE622

METHOD CODE DESCRIPTION

Method Code Date Tested	Analysing Laboratory NATA Laboratory Accreditation	NATA Scope of Accreditation
4A/MS **06/04/21 14:00**	Intertek Genalysis Perth **3244 3237**	**MPL_W002, MS_IM_001**
	Multi-acid digest including Hydrofluoric, Nitric, Perchloric and Hydrochloric acids in Teflon Tubes. Analysed by Inductively Coupled Plasma Mass Spectrometry.	

* Denotes not on Scope of Accreditation

MINERALS
TEST REPORT

CLIENT

Nola HACKMAN
PILBARA IRON COMPANY (SERVICES) PTY LIMITED
Level 8
Central Park
152 - 158 St Georges Terrace
PERTH, WA 6000
AUSTRALIA

JOB INFORMATION

JOB CODE	:	1804.0/2102798
NO. SAMPLES	:	99
NO. ELEMENTS	:	72
CLIENT ORDER NO.	:	3104437544 (Job 1 of 1)
SAMPLE SUBMISSION NO.	:	WANG_WCht
PROJECT	:	WANG
SAMPLE TYPE	:	Pulp
DATE RECEIVED	:	19/02/2021
DATE TESTED	:	22/02/2021 - 15/03/2021
DATE REPORTED	:	15/03/2021
DATE PRINTED	:	15/03/2021

REPORT NOTES

1. • PASTE pH and EC were not undertaken due to insufficient sample and have been replaced by Ws5 (1:5 w/v) EC and pH
• Fluoride analysis on NAG liquor is not possible due to aggressive residual acidity effects on the SIE probe and being unsuitable for any other available method.
• Sample IQC744 displayed ultramafic like properties in the negative ANC outcome but with no associated colour change though notable pH drop on peroxide addition.
• Sample IXU692 demonstrated ultramafic properties with associated colour change and respective pH drop.

TESTED BY

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APPROVED SIGNATURE FOR

Craig RITCHIE
Operations Manager - Perth

SIGNIFICANT FIGURES

It is common practice to report data derived from analytical instrumentation to a maximum of two or three significant figures. Some data reported herein may show more figures than this. The reporting of more than two or three figures in no way implies that figures beyond the least significant digit have significance.

For more information on the uncertainty on individual reported values, please contact the laboratory.

MEASUREMENT OF UNCERTAINTY

Measurement of uncertainty estimates are available for most tests upon request.

SAMPLE STORAGE

All solid samples (assay pulps, bulk pulps and residues) will be stored for 60 days without charge. Following this samples will be stored at a daily rate until clients written advice regarding return, collection or disposal is received. If storage information is not supplied on the submission, or arranged with the laboratory in writing the default will be to store the samples with the applicable charges. Storage is charged at $4.00 per m3 per day, expenses related to the return or disposal of samples will be charged at cost. Current disposal cost is charged at $150.00 per m3.

Samples received as liquids, waters or solutions will be held for 60 days free of charge then disposed of, unless written advice fo return or collection is received.

LEGEND	X	= Less than Detection Limit	NA	= Not Analysed
	SNR	= Sample Not Received	UA	= Unable to Assay
	LNR	= Lab Not Received	>	= Value beyond Limit of Method
	DTF	= Result still to come	+	= Extra Sample Received Not Listed
	I/S	= Insufficient Sample for Analysis		

ELEMENTS	Ag	Al	ANC	As	B	Ba
UNITS	mg/Kg	mg/Kg	kgH2SO4/t	mg/Kg	mg/Kg	mg/Kg
DETECTION LIMIT	0.1	1	1	1	1	0.1
DIGEST	NAGx/	NAGx/	ANCx/	NAGx/	NAGx/	NAGx/
ANALYTICAL FINISH	MS	OE	VOL	MS	OE	MS
SAMPLE NUMBERS						
0001 IPX549	<0.1	621	-8	2	24	0.5
0002 KNE128	<0.1	3	4	<1	15	3.9
0003 KNE828	<0.1	9	11	<1	23	1.0
0004 IPR635	<0.1	4	1	<1	12	6.3
0005 IPR791	<0.1	65	24	<1	18	8.1
0006 IPW007	<0.1	55	-1	<1	11	1.1
0007 IPW047	<0.1	6	2	<1	8	22.9
0008 IPW060	<0.1	6	2	<1	10	10.4
0009 IKC060	<0.1	3	3	<1	7	0.7
0010 IKC062	<0.1	3	4	<1	5	0.1
0011 IQI015	<0.1	11	11	<1	7	<0.1
0012 IQI264	<0.1	44	2	<1	6	18.4
0013 IQI357	<0.1	16	2	<1	9	18.1
0014 ISA287	<0.1	6	2	<1	4	8.7
0015 IKT373	<0.1	7	2	<1	3	26.0
0016 IKT635	<0.1	<1	5	<1	9	1.5
0017 IKT735	<0.1	<1	19	<1	7	<0.1
0018 ISR998	<0.1	3	2	<1	5	23.4
0019 ISQ383	<0.1	6	3	<1	3	55.7
0020 ISQ526	<0.1	<1	1	<1	5	11.0
0021 ISQ854	<0.1	8	1	<1	15	0.9
0022 ISQ933	<0.1	3	1	<1	6	118.3
0023 KBU112	<0.1	5	2	<1	3	62.7
0024 KDS668	<0.1	<1	3	<1	7	20.7
0025 KDS722	<0.1	12	2	<1	5	4.5
0026 KDU367	<0.1	10	5	<1	8	82.7
0027 KDK056	<0.1	14	1	<1	11	4.1
0028 KDB643	<0.1	<1	3	<1	8	4.5
0029 KDK147	<0.1	27	1	<1	9	2.3
0030 KDK997	<0.1	5	3	<1	2	0.6
0031 IXO621	<0.1	11	4	<1	3	1.2
0032 KDW888	<0.1	4	2	<1	<1	0.2
0033 KJK122	<0.1	<1	-1	<1	8	51.4
0034 KJK432	<0.1	6	1	<1	1	1.6
0035 KJE033	<0.1	<1	2	<1	3	53.4
0036 IPX089	<0.1	5	4	<1	<1	0.4
0037 IPX094	<0.1	7	3	<1	<1	0.9
0038 IPX289	<0.1	5	4	<1	2	0.8
0039 IQH700	<0.1	<1	0	<1	<1	0.4
0040 IKE803	2.3	10	1	<1	2	0.8

ELEMENTS	Be	Bi	C	C-Acinsol	C-CO3	Ca
UNITS	mg/Kg	mg/Kg	%	%	%	mg/Kg
DETECTION LIMIT	0.1	0.01	0.01	0.01	0.01	1
DIGEST	NAGx/	NAGx/		C71/		NAGx/
ANALYTICAL FINISH	MS	MS	/CSA	CSA	/CALC	OE
SAMPLE NUMBERS						
0001 IPX549	<0.1	0.01	5.34	5.54	<0.01	176
0002 KNE128	<0.1	<0.01	0.05	0.05	<0.01	24
0003 KNE828	<0.1	<0.01	0.84	0.73	0.11	1020
0004 IPR635	<0.1	<0.01	0.13	0.11	0.02	16
0005 IPR791	<0.1	<0.01	0.36	0.07	0.29	4623
0006 IPW007	<0.1	<0.01	0.12	0.03	0.09	6
0007 IPW047	<0.1	<0.01	0.23	0.13	0.10	16
0008 IPW060	<0.1	<0.01	0.20	0.16	0.04	4
0009 IKC060	<0.1	<0.01	0.14	0.13	<0.01	174
0010 IKC062	<0.1	<0.01	0.08	0.06	0.02	102
0011 IQI015	<0.1	<0.01	0.05	0.03	0.02	426
0012 IQI264	<0.1	<0.01	0.12	0.09	0.04	33
0013 IQI357	<0.1	<0.01	0.10	0.06	0.04	16
0014 ISA287	<0.1	<0.01	0.07	0.07	<0.01	7
0015 IKT373	<0.1	<0.01	0.07	0.07	<0.01	9
0016 IKT635	<0.1	<0.01	0.09	0.07	0.02	<1
0017 IKT735	<0.1	<0.01	0.08	0.03	0.05	491
0018 ISR998	<0.1	<0.01	0.05	0.05	<0.01	33
0019 ISQ383	<0.1	<0.01	0.12	0.07	0.05	96
0020 ISQ526	<0.1	<0.01	0.03	0.02	<0.01	29
0021 ISQ854	<0.1	<0.01	0.03	0.02	<0.01	7
0022 ISQ933	<0.1	<0.01	0.03	0.03	<0.01	28
0023 KBU112	<0.1	<0.01	0.04	0.03	<0.01	54
0024 KDS668	<0.1	<0.01	0.26	0.22	0.04	32
0025 KDS722	<0.1	<0.01	0.02	0.01	<0.01	110
0026 KDU367	<0.1	<0.01	0.86	0.54	0.32	172
0027 KDK056	<0.1	<0.01	0.05	0.04	<0.01	53
0028 KDB643	<0.1	<0.01	0.06	0.04	0.02	150
0029 KDK147	<0.1	<0.01	0.04	0.03	<0.01	11
0030 KDK997	<0.1	<0.01	0.07	0.04	0.03	375
0031 IXO621	<0.1	<0.01	0.08	0.07	<0.01	3
0032 KDW888	<0.1	<0.01	0.04	0.03	<0.01	73
0033 KJK122	<0.1	<0.01	0.05	0.03	0.02	<1
0034 KJK432	<0.1	<0.01	0.10	0.06	0.04	9
0035 KJE033	<0.1	<0.01	0.24	0.20	0.04	<1
0036 IPX089	<0.1	<0.01	0.18	0.13	0.05	44
0037 IPX094	<0.1	<0.01	0.12	0.09	0.03	40
0038 IPX289	<0.1	<0.01	0.11	0.12	<0.01	28
0039 IQH700	<0.1	<0.01	0.09	0.06	0.03	10
0040 IKE803	<0.1	<0.01	0.10	0.08	0.02	111

ELEMENTS	Cd	Ce	Cl	Co	ColourChange	Cr
UNITS	mg/Kg	mg/Kg	%	mg/Kg	NONE	mg/Kg
DETECTION LIMIT	0.1	0.01	0.02	0.1	0	1
DIGEST	NAGx/	NAGx/	CL1/	NAGx/	ANCx/	NAGx/
ANALYTICAL FINISH	MS	MS	COL	MS	QUAL	OE
SAMPLE NUMBERS						
0001 IPX549	0.9	1.02	<0.02	28.9	No	<1
0002 KNE128	<0.1	0.01	<0.02	0.0	No	<1
0003 KNE828	<0.1	0.02	<0.02	2.0	No	<1
0004 IPR635	<0.1	0.01	<0.02	0.0	No	<1
0005 IPR791	<0.1	0.01	0.12	0.0	No	2
0006 IPW007	<0.1	0.06	0.04	0.1	No	<1
0007 IPW047	<0.1	0.01	0.05	0.0	No	<1
0008 IPW060	<0.1	<0.01	<0.02	0.0	No	<1
0009 IKC060	<0.1	0.01	0.15	0.1	No	<1
0010 IKC062	<0.1	<0.01	0.16	0.0	No	<1
0011 IQI015	<0.1	<0.01	0.14	0.0	No	<1
0012 IQI264	<0.1	<0.01	0.05	0.1	No	7
0013 IQI357	<0.1	<0.01	0.09	0.0	No	<1
0014 ISA287	<0.1	0.02	<0.02	0.0	No	2
0015 IKT373	<0.1	<0.01	0.04	0.0	No	<1
0016 IKT635	<0.1	0.02	<0.02	0.0	No	<1
0017 IKT735	<0.1	0.05	0.13	0.0	No	<1
0018 ISR998	<0.1	<0.01	0.04	0.1	No	<1
0019 ISQ383	<0.1	<0.01	<0.02	0.0	No	2
0020 ISQ526	<0.1	0.03	<0.02	0.0	No	<1
0021 ISQ854	<0.1	0.01	<0.02	0.0	No	<1
0022 ISQ933	<0.1	0.02	0.02	0.1	No	<1
0023 KBU112	<0.1	0.02	0.05	0.0	No	<1
0024 KDS668	<0.1	0.03	<0.02	0.0	No	<1
0025 KDS722	<0.1	<0.01	0.05	0.0	No	<1
0026 KDU367	<0.1	0.01	0.06	0.0	No	<1
0027 KDK056	<0.1	0.10	0.16	0.2	No	<1
0028 KDB643	<0.1	0.03	0.10	0.2	No	<1
0029 KDK147	<0.1	0.02	0.12	0.0	No	<1
0030 KDK997	<0.1	0.04	0.04	0.0	No	<1
0031 IXO621	<0.1	<0.01	0.04	0.1	No	<1
0032 KDW888	<0.1	0.01	0.19	0.0	No	3
0033 KJK122	<0.1	0.75	0.04	1.6	No	<1
0034 KJK432	<0.1	0.02	0.03	0.0	No	<1
0035 KJE033	<0.1	0.03	0.04	0.0	No	<1
0036 IPX089	<0.1	0.03	0.02	0.0	No	<1
0037 IPX094	<0.1	0.02	0.03	0.0	No	<1
0038 IPX289	<0.1	<0.01	0.02	0.0	No	2
0039 IQH700	<0.1	0.01	<0.02	0.0	No	<1
0040 IKE803	<0.1	0.44	0.03	0.1	No	<1

ELEMENTS	Cs	Cu	EC	Fe	Final-pH	Fizz-Rate
UNITS	mg/Kg	mg/Kg	mS/cm	mg/Kg	NONE	NONE
DETECTION LIMIT	0.005	1	0.01	1	0.1	1
DIGEST	NAGx/	NAGx/	Ws5/	NAGx/	ANCx/	ANCx/
ANALYTICAL FINISH	MS	OE	MTR	OE	MTR	QUAL
SAMPLE NUMBERS						
0001 IPX549	0.042	56	1.71	10348	1.1	<1
0002 KNE128	0.023	6	0.06	<1	1.5	<1
0003 KNE828	0.020	6	0.50	<1	1.2	<1
0004 IPR635	<0.005	5	0.06	<1	1.5	<1
0005 IPR791	<0.005	11	1.51	<1	1.2	2
0006 IPW007	<0.005	<1	0.32	<1	1.5	<1
0007 IPW047	<0.005	1	0.33	<1	1.5	<1
0008 IPW060	<0.005	4	0.06	<1	1.5	<1
0009 IKC060	<0.005	<1	1.41	<1	1.5	<1
0010 IKC062	<0.005	7	1.43	<1	1.6	<1
0011 IQI015	<0.005	2	1.20	<1	1.7	<1
0012 IQI264	0.017	6	0.39	<1	1.7	<1
0013 IQI357	<0.005	4	0.73	<1	1.5	<1
0014 ISA287	<0.005	2	0.07	<1	1.7	<1
0015 IKT373	<0.005	2	0.31	<1	1.5	<1
0016 IKT635	<0.005	10	0.16	<1	1.6	<1
0017 IKT735	0.012	8	1.12	<1	1.7	<1
0018 ISR998	0.007	6	0.24	<1	1.5	<1
0019 ISQ383	<0.005	7	0.10	<1	1.6	<1
0020 ISQ526	0.006	5	0.10	6	1.5	<1
0021 ISQ854	<0.005	6	0.12	<1	1.5	<1
0022 ISQ933	<0.005	2	0.16	<1	1.5	<1
0023 KBU112	<0.005	<1	0.42	<1	1.5	<1
0024 KDS668	<0.005	<1	0.07	<1	1.5	<1
0025 KDS722	<0.005	<1	0.19	<1	1.6	<1
0026 KDU367	<0.005	<1	0.39	<1	1.1	<1
0027 KDK056	<0.005	2	1.10	<1	1.5	<1
0028 KDB643	<0.005	4	0.67	<1	1.6	<1
0029 KDK147	<0.005	2	0.72	<1	1.6	<1
0030 KDK997	<0.005	5	0.17	<1	1.6	<1
0031 IXO621	<0.005	9	0.25	<1	1.6	<1
0032 KDW888	0.005	<1	1.67	2	1.7	<1
0033 KJK122	<0.005	5	0.23	<1	1.6	<1
0034 KJK432	<0.005	<1	0.18	<1	1.6	<1
0035 KJE033	<0.005	<1	0.29	<1	1.6	<1
0036 IPX089	0.022	<1	0.18	<1	1.6	<1
0037 IPX094	0.012	5	0.22	<1	1.7	<1
0038 IPX289	<0.005	6	0.13	12	1.7	<1
0039 IQH700	<0.005	5	0.10	<1	1.6	<1
0040 IKE803	<0.005	6	0.25	<1	1.6	<1

ELEMENTS	Ga	Ge	Hf	Hg	In	K
UNITS	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg
DETECTION LIMIT	0.1	0.1	0.01	0.01	0.01	10
DIGEST	NAGx/	NAGx/	NAGx/	NAGx/	NAGx/	NAGx/
ANALYTICAL FINISH	MS	MS	MS	MS	MS	OE
SAMPLE NUMBERS						
0001 IPX549	<0.1	<0.1	<0.01	0.01	<0.01	62
0002 KNE128	<0.1	<0.1	<0.01	<0.01	<0.01	306
0003 KNE828	<0.1	<0.1	<0.01	<0.01	<0.01	634
0004 IPR635	<0.1	<0.1	<0.01	0.01	<0.01	13
0005 IPR791	<0.1	<0.1	<0.01	<0.01	<0.01	954
0006 IPW007	<0.1	<0.1	<0.01	<0.01	<0.01	247
0007 IPW047	<0.1	<0.1	<0.01	<0.01	<0.01	45
0008 IPW060	<0.1	<0.1	<0.01	<0.01	<0.01	87
0009 IKC060	<0.1	<0.1	<0.01	<0.01	<0.01	246
0010 IKC062	<0.1	<0.1	<0.01	<0.01	<0.01	379
0011 IQI015	<0.1	<0.1	<0.01	<0.01	<0.01	184
0012 IQI264	<0.1	<0.1	<0.01	<0.01	<0.01	186
0013 IQI357	<0.1	<0.1	<0.01	<0.01	<0.01	134
0014 ISA287	<0.1	<0.1	<0.01	0.01	<0.01	<10
0015 IKT373	<0.1	<0.1	<0.01	<0.01	<0.01	24
0016 IKT635	<0.1	<0.1	<0.01	<0.01	<0.01	59
0017 IKT735	<0.1	<0.1	<0.01	<0.01	<0.01	195
0018 ISR998	<0.1	<0.1	<0.01	<0.01	<0.01	61
0019 ISQ383	<0.1	<0.1	<0.01	<0.01	<0.01	87
0020 ISQ526	<0.1	<0.1	<0.01	<0.01	<0.01	<10
0021 ISQ854	<0.1	<0.1	<0.01	<0.01	<0.01	<10
0022 ISQ933	<0.1	<0.1	<0.01	<0.01	<0.01	58
0023 KBU112	<0.1	<0.1	<0.01	<0.01	<0.01	53
0024 KDS668	<0.1	<0.1	<0.01	<0.01	<0.01	52
0025 KDS722	<0.1	<0.1	<0.01	<0.01	<0.01	313
0026 KDU367	<0.1	<0.1	<0.01	<0.01	<0.01	160
0027 KDK056	<0.1	<0.1	<0.01	<0.01	<0.01	64
0028 KDB643	<0.1	<0.1	<0.01	<0.01	<0.01	136
0029 KDK147	<0.1	<0.1	<0.01	<0.01	<0.01	<10
0030 KDK997	<0.1	<0.1	<0.01	<0.01	<0.01	35
0031 IXO621	<0.1	<0.1	<0.01	<0.01	<0.01	254
0032 KDW888	<0.1	<0.1	<0.01	<0.01	<0.01	518
0033 KJK122	<0.1	<0.1	<0.01	<0.01	<0.01	<10
0034 KJK432	<0.1	<0.1	<0.01	<0.01	<0.01	<10
0035 KJE033	<0.1	<0.1	<0.01	<0.01	<0.01	27
0036 IPX089	<0.1	<0.1	<0.01	<0.01	<0.01	120
0037 IPX094	<0.1	<0.1	<0.01	<0.01	<0.01	<10
0038 IPX289	<0.1	<0.1	<0.01	<0.01	<0.01	83
0039 IQH700	<0.1	<0.1	<0.01	<0.01	<0.01	82
0040 IKE803	<0.1	<0.1	<0.01	<0.01	<0.01	53

ELEMENTS	La	Li	Mg	Mn	Mo	MPA
UNITS	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	kgH2SO4/t
DETECTION LIMIT	0.01	0.1	10	1	0.1	1
DIGEST	NAGx/	NAGx/	NAGx/	NAGx/	NAGx/	
ANALYTICAL FINISH	MS	MS	OE	OE	MS	/CALC
SAMPLE NUMBERS						
0001 IPX549	0.22	0.3	128	18	<0.1	190
0002 KNE128	<0.01	<0.1	29	13	0.2	1
0003 KNE828	0.01	0.2	1144	62	0.8	9
0004 IPR635	<0.01	<0.1	34	1	<0.1	3
0005 IPR791	<0.01	<0.1	<10	<1	0.2	30
0006 IPW007	0.09	<0.1	51	2	<0.1	40
0007 IPW047	0.02	<0.1	69	1	<0.1	3
0008 IPW060	0.01	<0.1	30	<1	<0.1	2
0009 IKC060	0.01	<0.1	351	224	<0.1	2
0010 IKC062	0.01	<0.1	314	56	<0.1	2
0011 IQI015	<0.01	<0.1	318	1	<0.1	2
0012 IQI264	0.02	0.2	126	8	<0.1	4
0013 IQI357	<0.01	<0.1	181	71	<0.1	3
0014 ISA287	0.01	<0.1	46	<1	<0.1	<1
0015 IKT373	<0.01	<0.1	68	<1	<0.1	2
0016 IKT635	0.01	0.2	30	5	<0.1	<1
0017 IKT735	0.03	<0.1	353	2	<0.1	2
0018 ISR998	<0.01	0.2	115	61	<0.1	2
0019 ISQ383	<0.01	<0.1	51	3	0.3	3
0020 ISQ526	0.03	<0.1	29	110	<0.1	<1
0021 ISQ854	0.04	<0.1	23	4	<0.1	<1
0022 ISQ933	0.01	<0.1	53	19	<0.1	2
0023 KBU112	0.02	<0.1	105	84	<0.1	2
0024 KDS668	0.01	<0.1	30	<1	<0.1	2
0025 KDS722	<0.01	<0.1	76	2	<0.1	3
0026 KDU367	<0.01	<0.1	228	<1	<0.1	2
0027 KDK056	0.06	0.4	289	2	<0.1	4
0028 KDB643	0.02	0.1	125	453	<0.1	3
0029 KDK147	0.02	0.2	180	<1	<0.1	2
0030 KDK997	0.03	<0.1	45	1	<0.1	<1
0031 IXO621	<0.01	<0.1	49	8	<0.1	1
0032 KDW888	<0.01	<0.1	369	186	<0.1	10
0033 KJK122	0.26	<0.1	32	68	<0.1	4
0034 KJK432	0.01	<0.1	32	2	<0.1	1
0035 KJE033	0.01	0.4	101	<1	<0.1	2
0036 IPX089	0.02	<0.1	44	12	0.1	<1
0037 IPX094	0.02	<0.1	42	<1	0.1	<1
0038 IPX289	0.02	<0.1	51	2	0.1	<1
0039 IQH700	0.01	<0.1	<10	2	<0.1	2
0040 IKE803	0.04	<0.1	58	<1	<0.1	1

ELEMENTS	N-NH3	N-NO2	N-NO3	N-Tot	Na	NAG
UNITS	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	kgH2SO4/t
DETECTION LIMIT	0.5	0.1	0.1	10	10	1
DIGEST	EXT/	EXT/	EXT/	EXT/	NAGx/	NAGx/
ANALYTICAL FINISH	COL	COL	COL	COL	OE	VOL
SAMPLE NUMBERS						
0001 IPX549	3.4	<0.1	<0.1	550	39	126
0002 KNE128	3.7	<0.1	0.1	<10	<10	0
0003 KNE828	6.0	<0.1	0.4	30	57	1
0004 IPR635	4.4	<0.1	0.5	22	71	1
0005 IPR791	3.3	<0.1	1.6	34	802	0
0006 IPW007	3.9	<0.1	0.8	23	148	1
0007 IPW047	4.3	<0.1	0.9	33	264	0
0008 IPW060	4.3	<0.1	0.5	25	35	0
0009 IKC060	5.8	<0.1	0.2	51	1172	0
0010 IKC062	8.7	<0.1	0.2	68	1173	0
0011 IQI015	3.6	<0.1	2.0	<10	805	0
0012 IQI264	4.9	<0.1	0.7	23	311	1
0013 IQI357	3.8	<0.1	0.7	22	589	0
0014 ISA287	4.4	<0.1	0.6	11	39	2
0015 IKT373	4.1	<0.1	0.9	<10	356	0
0016 IKT635	4.1	<0.1	0.9	<10	445	0
0017 IKT735	3.6	0.2	2.3	16	723	0
0018 ISR998	6.7	<0.1	0.2	51	145	1
0019 ISQ383	4.3	<0.1	0.2	12	47	0
0020 ISQ526	4.3	<0.1	0.1	29	65	0
0021 ISQ854	3.6	<0.1	0.2	<10	77	0
0022 ISQ933	4.4	<0.1	0.2	19	168	1
0023 KBU112	3.8	<0.1	0.3	49	486	0
0024 KDS668	4.3	<0.1	0.4	66	128	0
0025 KDS722	3.3	<0.1	0.5	<10	92	1
0026 KDU367	3.6	<0.1	0.8	43	457	1
0027 KDK056	4.0	<0.1	0.4	<10	787	1
0028 KDB643	4.0	<0.1	0.3	29	480	0
0029 KDK147	3.9	<0.1	0.4	26	649	1
0030 KDK997	4.1	<0.1	0.3	65	183	0
0031 IXO621	4.1	<0.1	0.4	<10	424	0
0032 KDW888	5.8	<0.1	0.5	110	1191	1
0033 KJK122	3.6	<0.1	0.3	410	98	0
0034 KJK432	4.5	<0.1	0.5	46	114	0
0035 KJE033	3.3	<0.1	0.4	47	263	0
0036 IPX089	17.0	<0.1	0.4	280	208	0
0037 IPX094	29.0	<0.1	0.3	210	247	0
0038 IPX289	4.2	<0.1	0.4	50	216	0
0039 IQH700	8.8	<0.1	0.3	37	31	0
0040 IKE803	14.0	<0.1	0.3	95	198	0

ELEMENTS	NAGpH	NAG(4.5)	NAPP	Nb	Ni	P
UNITS	NONE	kgH2SO4/t	kgH2SO4/t	mg/Kg	mg/Kg	mg/Kg
DETECTION LIMIT	0.1	1	1	0.05	1	10
DIGEST	NAGx/	NAGx/		NAGx/	NAGx/	NAGx/
ANALYTICAL FINISH	MTR	VOL	/CALC	MS	OE	OE
SAMPLE NUMBERS						
0001 IPX549	1.9	120	198	0.32	63	<10
0002 KNE128	6.9	0	-3	0.21	<1	<10
0003 KNE828	4.2	0	-2	0.49	4	<10
0004 IPR635	5.5	0	2	0.58	2	<10
0005 IPR791	9.8	0	6	0.29	<1	<10
0006 IPW007	3.9	0	41	0.43	<1	<10
0007 IPW047	4.9	0	1	0.32	<1	<10
0008 IPW060	5.4	0	0	0.31	<1	<10
0009 IKC060	6.6	0	-1	0.16	1	<10
0010 IKC062	6.7	0	-2	0.12	<1	<10
0011 IQI015	7.0	0	-9	0.10	<1	<10
0012 IQI264	4.6	0	2	0.56	1	<10
0013 IQI357	5.2	0	1	0.25	<1	<10
0014 ISA287	5.4	0	-1	0.52	<1	<10
0015 IKT373	5.7	0	-0	0.28	<1	<10
0016 IKT635	6.9	0	-4	0.14	3	<10
0017 IKT735	7.0	0	-17	0.09	1	<10
0018 ISR998	4.9	0	0	0.40	<1	<10
0019 ISQ383	6.3	0	-0	0.24	1	<10
0020 ISQ526	6.0	0	-0	0.12	<1	<10
0021 ISQ854	5.2	0	-0	0.11	1	<10
0022 ISQ933	5.0	0	1	0.33	3	<10
0023 KBU112	6.1	0	-0	0.12	<1	<10
0024 KDS668	6.1	0	-1	0.18	<1	<10
0025 KDS722	5.0	0	1	0.33	<1	<10
0026 KDU367	5.4	0	-3	0.34	1	<10
0027 KDK056	4.3	0	3	0.18	1	<10
0028 KDB643	5.6	0	0	0.06	<1	<10
0029 KDK147	5.1	0	1	0.35	<1	<10
0030 KDK997	7.1	0	-2	0.18	<1	<10
0031 IXO621	6.7	0	-3	0.06	<1	<10
0032 KDW888	5.5	0	8	0.30	<1	<10
0033 KJK122	4.4	0	5	0.09	2	<10
0034 KJK432	5.3	0	0	<0.05	1	<10
0035 KJE033	5.4	0	0	0.11	2	<10
0036 IPX089	6.1	0	-4	0.28	<1	<10
0037 IPX094	6.8	0	-3	0.15	<1	<10
0038 IPX289	6.9	0	-3	<0.05	<1	<10
0039 IQH700	5.1	0	2	0.19	<1	<10
0040 IKE803	6.0	0	0	0.08	<1	<10

ELEMENTS	Pb	N-Kjel	pH	pH Drop	Rb	Re
UNITS	mg/Kg	mg/Kg	NONE	NONE	mg/Kg	mg/Kg
DETECTION LIMIT	2	10	0.1	0.1	0.05	0.01
DIGEST	NAGx/	EXT/	Ws5/	ANCx/	NAGx/	NAGx/
ANALYTICAL FINISH	MS	COL	MTR	MTR	MS	MS
SAMPLE NUMBERS						
0001 IPX549	9	550	3.1	3.4	0.45	<0.01
0002 KNE128	<2	<10	6.9	5.0	1.06	<0.01
0003 KNE828	<2	30	7.3	3.1	7.36	<0.01
0004 IPR635	<2	22	5.4	5.0	0.10	<0.01
0005 IPR791	<2	33	7.7	4.8	0.24	<0.01
0006 IPW007	<2	22	3.9	4.8	<0.05	<0.01
0007 IPW047	<2	32	4.7	4.9	0.13	<0.01
0008 IPW060	<2	25	5.1	4.9	<0.05	<0.01
0009 IKC060	<2	51	6.6	4.9	0.25	<0.01
0010 IKC062	<2	68	6.6	4.9	0.54	<0.01
0011 IQI015	<2	<10	7.1	5.0	0.33	<0.01
0012 IQI264	<2	23	4.9	4.9	0.74	<0.01
0013 IQI357	<2	21	5.3	4.9	0.52	<0.01
0014 ISA287	<2	11	5.3	4.9	<0.05	<0.01
0015 IKT373	<2	<10	5.5	4.9	0.09	<0.01
0016 IKT635	<2	<10	4.9	5.0	0.07	<0.01
0017 IKT735	<2	14	7.1	5.3	0.39	<0.01
0018 ISR998	<2	51	4.9	4.9	0.42	<0.01
0019 ISQ383	<2	11	6.3	4.8	0.11	<0.01
0020 ISQ526	<2	29	5.2	4.9	0.07	<0.01
0021 ISQ854	<2	<10	4.6	4.6	<0.05	<0.01
0022 ISQ933	<2	19	4.9	4.9	<0.05	<0.01
0023 KBU112	<2	49	5.5	5.0	0.10	<0.01
0024 KDS668	<2	66	5.7	4.9	0.05	<0.01
0025 KDS722	<2	<10	6.6	4.3	0.20	<0.01
0026 KDU367	<2	42	6.0	4.8	0.26	<0.01
0027 KDK056	<2	<10	4.4	4.8	0.05	<0.01
0028 KDB643	<2	29	4.8	4.9	0.10	<0.01
0029 KDK147	<2	26	5.1	4.9	0.05	<0.01
0030 KDK997	<2	64	6.0	4.9	0.10	<0.01
0031 IXO621	<2	<10	6.4	5.0	0.31	<0.01
0032 KDW888	<2	110	5.5	5.0	0.88	<0.01
0033 KJK122	<2	410	4.1	4.8	<0.05	<0.01
0034 KJK432	<2	45	5.0	4.8	<0.05	<0.01
0035 KJE033	<2	46	5.2	4.9	0.09	<0.01
0036 IPX089	<2	280	6.7	4.9	0.45	<0.01
0037 IPX094	<2	210	6.8	4.8	0.15	<0.01
0038 IPX289	<2	49	6.8	4.9	0.10	<0.01
0039 IQH700	<2	37	5.3	4.8	<0.05	<0.01
0040 IKE803	<2	95	5.4	4.9	0.05	<0.01

ELEMENTS	S	S	S	S-SO4	Sb	Sc
UNITS	%	%	mg/Kg	%	mg/Kg	mg/Kg
DETECTION LIMIT	0.01	0.005	10	0.01	0.05	1
DIGEST		SCR/	NAGx/	S71/	NAGx/	NAGx/
ANALYTICAL FINISH	/CSA	VOL	OE	OE	MS	OE
SAMPLE NUMBERS						
0001 IPX549	6.20	0.460	43114	0.37	0.10	1
0002 KNE128	0.03	<0.005	<10	0.03	<0.05	<1
0003 KNE828	0.29	0.200	2821	0.05	<0.05	<1
0004 IPR635	0.09	<0.005	87	0.09	<0.05	<1
0005 IPR791	0.98	<0.005	2725	0.57	<0.05	<1
0006 IPW007	1.29	<0.005	385	0.94	<0.05	<1
0007 IPW047	0.08	<0.005	177	0.09	<0.05	<1
0008 IPW060	0.08	<0.005	69	0.08	<0.05	<1
0009 IKC060	0.07	<0.005	650	0.07	<0.05	<1
0010 IKC062	0.05	<0.005	565	0.06	0.12	<1
0011 IQI015	0.07	<0.005	575	0.07	<0.05	<1
0012 IQI264	0.13	<0.005	361	0.14	<0.05	<1
0013 IQI357	0.10	<0.005	295	0.10	<0.05	<1
0014 ISA287	0.02	<0.005	37	0.02	<0.05	<1
0015 IKT373	0.05	<0.005	121	0.05	<0.05	<1
0016 IKT635	0.03	<0.005	63	0.02	<0.05	<1
0017 IKT735	0.06	<0.005	601	0.07	<0.05	<1
0018 ISR998	0.07	<0.005	257	0.07	<0.05	<1
0019 ISQ383	0.09	<0.005	138	0.08	<0.05	<1
0020 ISQ526	0.02	<0.005	107	0.01	<0.05	<1
0021 ISQ854	0.03	<0.005	58	0.02	<0.05	<1
0022 ISQ933	0.06	<0.005	145	0.07	<0.05	<1
0023 KBU112	0.07	<0.005	234	0.07	<0.05	<1
0024 KDS668	0.07	<0.005	131	0.07	<0.05	<1
0025 KDS722	0.11	<0.005	380	0.11	<0.05	<1
0026 KDU367	0.05	<0.005	113	0.05	<0.05	<1
0027 KDK056	0.14	<0.005	372	0.14	<0.05	<1
0028 KDB643	0.11	<0.005	502	0.12	<0.05	<1
0029 KDK147	0.05	<0.005	216	0.05	<0.05	<1
0030 KDK997	0.02	<0.005	91	0.02	<0.05	<1
0031 IXO621	0.03	<0.005	74	0.03	<0.05	<1
0032 KDW888	0.32	<0.005	880	0.38	<0.05	<1
0033 KJK122	0.13	<0.005	139	0.13	<0.05	<1
0034 KJK432	0.04	<0.005	56	0.03	<0.05	<1
0035 KJE033	0.07	<0.005	181	0.07	<0.05	<1
0036 IPX089	0.01	<0.005	48	0.01	<0.05	<1
0037 IPX094	0.01	<0.005	77	0.01	<0.05	<1
0038 IPX289	0.02	<0.005	40	0.02	<0.05	<1
0039 IQH700	0.06	<0.005	155	0.04	<0.05	<1
0040 IKE803	0.04	<0.005	779	0.03	<0.05	<1

ELEMENTS	Se	Sn	Sr	Ta	Te	Th
UNITS	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg
DETECTION LIMIT	2	0.1	0.05	0.01	0.1	0.01
DIGEST	NAGx/	NAGx/	NAGx/	NAGx/	NAGx/	NAGx/
ANALYTICAL FINISH	MS	MS	MS	MS	MS	MS
SAMPLE NUMBERS						
0001 IPX549	3	<0.1	0.61	0.01	<0.1	0.61
0002 KNE128	<2	<0.1	1.09	<0.01	<0.1	<0.01
0003 KNE828	<2	<0.1	3.07	0.01	<0.1	<0.01
0004 IPR635	<2	<0.1	0.54	0.02	<0.1	<0.01
0005 IPR791	<2	<0.1	14.50	<0.01	<0.1	<0.01
0006 IPW007	<2	<0.1	1.36	0.02	<0.1	<0.01
0007 IPW047	<2	<0.1	0.76	0.01	<0.1	<0.01
0008 IPW060	<2	<0.1	0.28	0.01	<0.1	<0.01
0009 IKC060	<2	<0.1	1.78	<0.01	<0.1	<0.01
0010 IKC062	<2	<0.1	0.93	<0.01	<0.1	<0.01
0011 IQI015	<2	<0.1	1.69	<0.01	<0.1	<0.01
0012 IQI264	<2	<0.1	1.12	0.02	<0.1	<0.01
0013 IQI357	<2	<0.1	1.22	<0.01	<0.1	<0.01
0014 ISA287	<2	<0.1	0.79	0.02	<0.1	<0.01
0015 IKT373	<2	<0.1	0.91	<0.01	<0.1	<0.01
0016 IKT635	<2	<0.1	0.39	<0.01	<0.1	<0.01
0017 IKT735	<2	<0.1	0.26	<0.01	<0.1	<0.01
0018 ISR998	<2	<0.1	0.84	0.01	<0.1	<0.01
0019 ISQ383	<2	<0.1	3.55	<0.01	<0.1	<0.01
0020 ISQ526	<2	<0.1	0.71	<0.01	<0.1	<0.01
0021 ISQ854	<2	<0.1	0.15	<0.01	<0.1	<0.01
0022 ISQ933	<2	<0.1	0.76	0.01	<0.1	<0.01
0023 KBU112	<2	<0.1	1.23	<0.01	<0.1	<0.01
0024 KDS668	<2	<0.1	0.94	<0.01	<0.1	<0.01
0025 KDS722	<2	<0.1	6.94	0.01	<0.1	<0.01
0026 KDU367	<2	<0.1	3.33	0.02	<0.1	<0.01
0027 KDK056	<2	<0.1	3.97	<0.01	<0.1	<0.01
0028 KDB643	<2	<0.1	1.61	<0.01	<0.1	<0.01
0029 KDK147	<2	<0.1	0.30	0.01	<0.1	<0.01
0030 KDK997	<2	<0.1	0.64	<0.01	<0.1	<0.01
0031 IXO621	<2	<0.1	1.46	<0.01	<0.1	<0.01
0032 KDW888	<2	<0.1	1.84	0.01	<0.1	<0.01
0033 KJK122	<2	<0.1	0.79	<0.01	<0.1	<0.01
0034 KJK432	<2	<0.1	2.35	<0.01	<0.1	<0.01
0035 KJE033	<2	<0.1	0.64	<0.01	<0.1	<0.01
0036 IPX089	<2	<0.1	0.43	0.01	<0.1	<0.01
0037 IPX094	<2	<0.1	0.40	<0.01	<0.1	<0.01
0038 IPX289	<2	<0.1	0.47	<0.01	<0.1	<0.01
0039 IQH700	<2	<0.1	4.17	<0.01	<0.1	<0.01
0040 IKE803	<2	<0.1	0.77	<0.01	<0.1	<0.01

ELEMENTS	Ti	Tl	U	V	W	Y
UNITS	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg
DETECTION LIMIT	1	0.02	0.01	1	0.1	0.05
DIGEST	NAGx/	NAGx/	NAGx/	NAGx/	NAGx/	NAGx/
ANALYTICAL FINISH	OE	MS	MS	OE	MS	MS
SAMPLE NUMBERS						
0001 IPX549	<1	0.02	0.85	<1	0.1	0.94
0002 KNE128	<1	0.06	<0.01	<1	0.2	<0.05
0003 KNE828	<1	0.04	<0.01	2	0.9	<0.05
0004 IPR635	<1	<0.02	<0.01	<1	0.2	<0.05
0005 IPR791	<1	<0.02	<0.01	3	0.4	<0.05
0006 IPW007	<1	<0.02	<0.01	<1	<0.1	0.15
0007 IPW047	<1	<0.02	<0.01	<1	<0.1	<0.05
0008 IPW060	<1	<0.02	<0.01	<1	<0.1	<0.05
0009 IKC060	<1	<0.02	<0.01	<1	<0.1	<0.05
0010 IKC062	<1	<0.02	<0.01	<1	0.2	<0.05
0011 IQI015	<1	<0.02	<0.01	<1	<0.1	<0.05
0012 IQI264	<1	<0.02	<0.01	<1	<0.1	<0.05
0013 IQI357	<1	0.02	<0.01	<1	1.0	<0.05
0014 ISA287	<1	<0.02	<0.01	<1	1.6	<0.05
0015 IKT373	<1	<0.02	<0.01	<1	<0.1	<0.05
0016 IKT635	<1	<0.02	<0.01	3	0.6	<0.05
0017 IKT735	<1	<0.02	<0.01	<1	<0.1	<0.05
0018 ISR998	<1	<0.02	<0.01	<1	0.2	<0.05
0019 ISQ383	<1	<0.02	<0.01	3	0.2	<0.05
0020 ISQ526	<1	0.03	<0.01	<1	0.3	<0.05
0021 ISQ854	<1	<0.02	<0.01	<1	0.2	<0.05
0022 ISQ933	<1	<0.02	<0.01	<1	0.2	<0.05
0023 KBU112	<1	0.04	<0.01	<1	<0.1	<0.05
0024 KDS668	<1	<0.02	<0.01	<1	0.1	<0.05
0025 KDS722	<1	<0.02	<0.01	<1	0.3	<0.05
0026 KDU367	<1	<0.02	<0.01	<1	0.4	<0.05
0027 KDK056	<1	<0.02	<0.01	<1	0.1	0.24
0028 KDB643	<1	0.23	<0.01	<1	<0.1	<0.05
0029 KDK147	<1	<0.02	<0.01	<1	0.2	<0.05
0030 KDK997	<1	<0.02	<0.01	<1	0.6	<0.05
0031 IXO621	<1	<0.02	<0.01	<1	0.1	<0.05
0032 KDW888	<1	<0.02	<0.01	3	0.2	<0.05
0033 KJK122	<1	0.04	<0.01	<1	<0.1	0.60
0034 KJK432	<1	<0.02	<0.01	<1	<0.1	<0.05
0035 KJE033	<1	<0.02	<0.01	<1	<0.1	<0.05
0036 IPX089	<1	<0.02	<0.01	11	0.4	<0.05
0037 IPX094	<1	<0.02	<0.01	23	0.6	<0.05
0038 IPX289	<1	<0.02	<0.01	<1	0.4	<0.05
0039 IQH700	<1	<0.02	<0.01	<1	0.4	<0.05
0040 IKE803	<1	<0.02	<0.01	<1	0.2	<0.05

ELEMENTS	Zn	Zr
UNITS	mg/Kg	mg/Kg
DETECTION LIMIT	1	0.1
DIGEST	NAGx/	NAGx/
ANALYTICAL FINISH	OE	MS
SAMPLE NUMBERS		
0001 IPX549	17	0.3
0002 KNE128	3	<0.1
0003 KNE828	1	<0.1
0004 IPR635	1	<0.1
0005 IPR791	13	<0.1
0006 IPW007	5	<0.1
0007 IPW047	3	<0.1
0008 IPW060	2	<0.1
0009 IKC060	4	<0.1
0010 IKC062	5	<0.1
0011 IQI015	<1	<0.1
0012 IQI264	3	<0.1
0013 IQI357	4	<0.1
0014 ISA287	2	<0.1
0015 IKT373	14	<0.1
0016 IKT635	<1	<0.1
0017 IKT735	<1	<0.1
0018 ISR998	<1	<0.1
0019 ISQ383	<1	<0.1
0020 ISQ526	6	<0.1
0021 ISQ854	10	<0.1
0022 ISQ933	15	<0.1
0023 KBU112	<1	<0.1
0024 KDS668	6	<0.1
0025 KDS722	<1	<0.1
0026 KDU367	<1	<0.1
0027 KDK056	8	<0.1
0028 KDB643	7	<0.1
0029 KDK147	<1	<0.1
0030 KDK997	<1	<0.1
0031 IXO621	<1	<0.1
0032 KDW888	<1	<0.1
0033 KJK122	<1	<0.1
0034 KJK432	<1	<0.1
0035 KJE033	<1	<0.1
0036 IPX089	<1	<0.1
0037 IPX094	<1	<0.1
0038 IPX289	<1	<0.1
0039 IQH700	<1	<0.1
0040 IKE803	4	<0.1

ELEMENTS	Ag	Al	ANC	As	B	Ba
UNITS	mg/Kg	mg/Kg	kgH2SO4/t	mg/Kg	mg/Kg	mg/Kg
DETECTION LIMIT	0.1	1	1	1	1	0.1
DIGEST	NAGx/	NAGx/	ANCx/	NAGx/	NAGx/	NAGx/
ANALYTICAL FINISH	MS	OE	VOL	MS	OE	MS
SAMPLE NUMBERS						
0041 IQC742	<0.1	476	0	<1	2	2.2
0042 IQC744	<0.1	1142	-24	6	8	<0.1
0043 IQK216	<0.1	<1	1	<1	10	13.6
0044 IQH843	<0.1	<1	1	<1	<1	1.5
0045 IKS295	<0.1	3	1	<1	<1	26.4
0046 ISB416	<0.1	6	42	<1	<1	10.5
0047 ISB458	<0.1	7	1	<1	8	2.4
0048 IQL024	<0.1	8	22	1	5	1.3
0049 IQL134	<0.1	317	68	<1	18	1.7
0050 ISR689	<0.1	2	12	<1	4	2.7
0051 ISB681	<0.1	2	1	<1	3	55.3
0052 KAA196	<0.1	5	1	<1	2	58.5
0053 KAA560	<0.1	<1	1	<1	<1	5.7
0054 KAF556	<0.1	7	5	<1	8	4.5
0055 IQJ569	<0.1	<1	0	<1	<1	11.7
0056 KBP675	<0.1	<1	4	<1	2	1.9
0057 KBP703	<0.1	5	2	<1	<1	16.3
0058 IMU159A	<0.1	10	3	<1	3	0.8
0059 IXU682	<0.1	<1	8	<1	7	0.9
0060 IXU692	<0.1	2817	9	<1	15	1.1
0061 IXU931	<0.1	<1	1	<1	6	0.2
0062 IXU939	<0.1	8	3	<1	<1	0.3
0063 KJK611	<0.1	4	2	<1	1	6.9
0064 KJK834	<0.1	8	-1	<1	<1	7.2
0065 IXP068	<0.1	10	1	<1	7	64.3
0066 KBS203	<0.1	16	-1	<1	7	0.4
0067 KBS302	<0.1	5	1	<1	3	10.2
0068 KBS379	<0.1	75	-1	<1	4	10.6
0069 KBS842	<0.1	4	0	<1	3	41.4
0070 KBS861	<0.1	4	0	<1	4	16.7
0071 KDY374	<0.1	5	0	<1	2	3.2
0072 KDY571	<0.1	8	2	<1	<1	2.3
0073 KDY612	<0.1	3	4	<1	6	0.3
0074 KDY617	<0.1	<1	8	<1	5	9.0
0075 KJE387	<0.1	6	4	<1	7	0.7
0076 KJE524	<0.1	10	3	<1	1	0.5
0077 KJE711	<0.1	2	3	<1	<1	0.2
0078 KKA384	<0.1	5	1	<1	7	0.3
0079 KKA519	<0.1	11	1	<1	10	3.9
0080 KKA527	<0.1	8	0	<1	3	18.2

ELEMENTS	Be	Bi	C	C-Acinsol	C-CO3	Ca
UNITS	mg/Kg	mg/Kg	%	%	%	mg/Kg
DETECTION LIMIT	0.1	0.01	0.01	0.01	0.01	1
DIGEST	NAGx/	NAGx/		C71/		NAGx/
ANALYTICAL FINISH	MS	MS	/CSA	CSA	/CALC	OE
SAMPLE NUMBERS						
0041 IQC742	<0.1	<0.01	4.77	4.90	<0.01	1656
0042 IQC744	<0.1	<0.01	4.84	4.89	<0.01	76
0043 IQK216	<0.1	<0.01	0.25	0.16	0.09	337
0044 IQH843	<0.1	<0.01	0.13	0.10	0.03	19
0045 IKS295	<0.1	<0.01	0.15	0.14	<0.01	43
0046 ISB416	<0.1	<0.01	0.51	0.04	0.47	5170
0047 ISB458	<0.1	<0.01	0.10	0.08	0.02	36
0048 IQL024	<0.1	<0.01	0.77	0.42	0.35	5237
0049 IQL134	<0.1	<0.01	0.92	0.12	0.80	2455
0050 ISR689	<0.1	<0.01	0.69	0.59	0.10	291
0051 ISB681	<0.1	<0.01	0.06	0.08	<0.01	41
0052 KAA196	<0.1	<0.01	0.07	0.08	<0.01	23
0053 KAA560	<0.1	<0.01	0.06	0.07	<0.01	23
0054 KAF556	<0.1	<0.01	0.19	0.15	0.04	237
0055 IQJ569	<0.1	<0.01	0.09	0.07	0.08	78
0056 KBP675	<0.1	<0.01	0.24	0.16	0.08	74
0057 KBP703	<0.1	<0.01	0.14	0.12	0.02	98
0058 IMU159A	<0.1	<0.01	0.23	0.19	0.04	52
0059 IXU682	<0.1	<0.01	3.98	1.81	2.17	241
0060 IXU692	0.3	<0.01	23.68	18.06	5.80	1836
0061 IXU931	<0.1	<0.01	0.05	0.05	<0.01	160
0062 IXU939	<0.1	<0.01	0.08	0.06	0.02	68
0063 KJK611	<0.1	<0.01	0.07	0.06	<0.01	66
0064 KJK834	<0.1	<0.01	0.03	0.02	<0.01	28
0065 IXP068	<0.1	<0.01	0.06	0.05	<0.01	69
0066 KBS203	<0.1	<0.01	0.03	0.04	<0.01	69
0067 KBS302	<0.1	<0.01	0.06	0.06	<0.01	25
0068 KBS379	<0.1	<0.01	0.19	0.17	0.02	16
0069 KBS842	<0.1	<0.01	0.13	0.10	0.03	38
0070 KBS861	<0.1	<0.01	0.10	0.08	0.02	62
0071 KDY374	<0.1	<0.01	0.05	0.06	<0.01	43
0072 KDY571	<0.1	<0.01	0.07	0.08	<0.01	56
0073 KDY612	<0.1	<0.01	0.05	0.03	0.02	43
0074 KDY617	<0.1	<0.01	0.16	0.07	0.09	2467
0075 KJE387	<0.1	<0.01	0.04	0.06	<0.01	90
0076 KJE524	<0.1	<0.01	0.06	0.05	<0.01	113
0077 KJE711	<0.1	<0.01	0.05	0.04	<0.01	102
0078 KKA384	<0.1	<0.01	0.32	0.18	0.14	7
0079 KKA519	<0.1	<0.01	0.25	0.17	0.08	49
0080 KKA527	<0.1	<0.01	0.21	0.16	0.05	22

ELEMENTS	Cd	Ce	Cl	Co	ColourChange	Cr
UNITS	mg/Kg	mg/Kg	%	mg/Kg	NONE	mg/Kg
DETECTION LIMIT	0.1	0.01	0.02	0.1	0	1
DIGEST	NAGx/	NAGx/	CL1/	NAGx/	ANCx/	NAGx/
ANALYTICAL FINISH	MS	MS	COL	MS	QUAL	OE
SAMPLE NUMBERS						
0041 IQC742	<0.1	1.48	<0.02	6.6	No	<1
0042 IQC744	<0.1	0.58	<0.02	17.1	No	<1
0043 IQK216	<0.1	0.02	0.03	0.0	No	<1
0044 IQH843	<0.1	0.02	<0.02	0.0	No	<1
0045 IKS295	<0.1	0.02	0.02	0.0	No	1
0046 ISB416	<0.1	0.01	0.04	0.0	No	<1
0047 ISB458	<0.1	0.02	0.03	0.0	No	<1
0048 IQL024	<0.1	0.01	0.06	-0.0	No	2
0049 IQL134	<0.1	<0.01	0.05	0.0	No	<1
0050 ISR689	<0.1	0.01	0.03	0.4	No	<1
0051 ISB681	<0.1	<0.01	0.03	0.0	No	<1
0052 KAA196	<0.1	<0.01	0.02	0.0	No	<1
0053 KAA560	<0.1	<0.01	<0.02	0.4	No	2
0054 KAF556	<0.1	<0.01	0.03	0.0	No	<1
0055 IQJ569	<0.1	0.02	<0.02	0.4	No	<1
0056 KBP675	<0.1	0.04	0.03	0.0	No	3
0057 KBP703	<0.1	0.04	0.03	0.0	No	3
0058 IMU159A	<0.1	0.01	0.02	0.0	No	<1
0059 IXU682	<0.1	0.03	0.05	0.0	Yes	<1
0060 IXU692	<0.1	3.40	0.08	0.4	Yes	12
0061 IXU931	<0.1	0.02	0.02	0.0	No	3
0062 IXU939	<0.1	0.03	0.03	0.0	No	<1
0063 KJK611	<0.1	0.03	0.02	0.0	No	<1
0064 KJK834	<0.1	0.07	0.02	0.0	No	<1
0065 IXP068	<0.1	0.03	0.04	0.0	No	<1
0066 KBS203	<0.1	0.02	0.02	0.0	No	2
0067 KBS302	<0.1	0.05	0.03	0.0	No	<1
0068 KBS379	<0.1	0.04	0.05	0.0	No	3
0069 KBS842	<0.1	<0.01	0.04	0.0	No	<1
0070 KBS861	<0.1	<0.01	0.03	0.0	No	<1
0071 KDY374	<0.1	0.13	0.03	0.1	No	3
0072 KDY571	<0.1	0.02	<0.02	0.0	No	2
0073 KDY612	<0.1	0.04	0.02	0.0	No	<1
0074 KDY617	<0.1	0.03	0.09	0.0	No	<1
0075 KJE387	<0.1	0.01	0.02	0.0	No	1
0076 KJE524	<0.1	0.04	<0.02	0.0	No	<1
0077 KJE711	<0.1	0.03	<0.02	0.0	No	<1
0078 KKA384	<0.1	0.01	<0.02	0.0	No	<1
0079 KKA519	<0.1	0.03	0.02	0.0	No	<1
0080 KKA527	<0.1	0.02	<0.02	0.0	No	<1

ELEMENTS	Cs	Cu	EC	Fe	Final-pH	Fizz-Rate
UNITS	mg/Kg	mg/Kg	mS/cm	mg/Kg	NONE	NONE
DETECTION LIMIT	0.005	1	0.01	1	0.1	1
DIGEST	NAGx/	NAGx/	Ws5/	NAGx/	ANCx/	ANCx/
ANALYTICAL FINISH	MS	OE	MTR	OE	MTR	QUAL
SAMPLE NUMBERS						
0041 IQC742	0.045	30	1.56	4012	1.1	<1
0042 IQC744	0.042	27	4.34	40531	1.1	<1
0043 IQK216	<0.005	9	0.28	10	1.7	<1
0044 IQH843	0.005	6	0.20	<1	1.7	<1
0045 IKS295	<0.005	2	0.16	<1	1.7	<1
0046 ISB416	0.009	3	0.39	<1	1.2	1
0047 ISB458	<0.005	2	0.21	<1	1.6	<1
0048 IQL024	<0.005	6	0.60	<1	1.2	1
0049 IQL134	<0.005	2	0.52	<1	1.3	2
0050 ISR689	<0.005	7	0.25	<1	1.2	<1
0051 ISB681	0.011	5	0.19	<1	1.6	<1
0052 KAA196	<0.005	8	0.09	<1	1.6	<1
0053 KAA560	<0.005	<1	0.09	5	1.6	<1
0054 KAF556	<0.005	4	0.29	<1	1.6	<1
0055 IQJ569	<0.005	4	0.11	<1	1.6	<1
0056 KBP675	0.006	5	0.16	<1	1.8	<1
0057 KBP703	<0.005	6	0.29	<1	1.6	<1
0058 IMU159A	<0.005	7	0.20	<1	1.6	<1
0059 IXU682	0.015	2	0.29	<1	1.6	<1
0060 IXU692	0.020	4	1.34	29030	1.4	<1
0061 IXU931	<0.005	2	0.08	<1	1.6	<1
0062 IXU939	0.005	7	0.17	<1	1.6	<1
0063 KJK611	<0.005	7	0.12	2	1.6	<1
0064 KJK834	<0.005	8	0.18	<1	1.6	<1
0065 IXP068	<0.005	<1	0.27	<1	1.5	<1
0066 KBS203	<0.005	6	0.09	<1	1.5	<1
0067 KBS302	0.005	4	0.18	<1	1.6	<1
0068 KBS379	<0.005	3	0.37	<1	1.5	<1
0069 KBS842	<0.005	3	0.23	<1	1.6	<1
0070 KBS861	<0.005	5	0.19	<1	1.7	<1
0071 KDY374	0.008	3	0.20	<1	1.6	<1
0072 KDY571	<0.005	<1	0.05	<1	1.6	<1
0073 KDY612	0.025	6	I/S	<1	1.6	<1
0074 KDY617	0.009	4	1.56	<1	1.5	<1
0075 KJE387	0.012	<1	0.08	<1	1.6	<1
0076 KJE524	0.007	4	0.07	<1	1.5	<1
0077 KJE711	0.008	5	0.08	<1	1.6	<1
0078 KKA384	<0.005	1	0.08	<1	1.5	<1
0079 KKA519	<0.005	4	0.16	<1	1.6	<1
0080 KKA527	<0.005	<1	0.09	<1	1.6	<1

ELEMENTS	Ga	Ge	Hf	Hg	In	K
UNITS	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg
DETECTION LIMIT	0.1	0.1	0.01	0.01	0.01	10
DIGEST	NAGx/	NAGx/	NAGx/	NAGx/	NAGx/	NAGx/
ANALYTICAL FINISH	MS	MS	MS	MS	MS	OE
SAMPLE NUMBERS						
0041 IQC742	<0.1	<0.1	<0.01	<0.01	<0.01	105
0042 IQC744	<0.1	<0.1	<0.01	<0.01	<0.01	25
0043 IQK216	<0.1	<0.1	<0.01	<0.01	<0.01	<10
0044 IQH843	<0.1	<0.1	<0.01	<0.01	<0.01	<10
0045 IKS295	<0.1	<0.1	<0.01	<0.01	<0.01	73
0046 ISB416	<0.1	<0.1	<0.01	<0.01	<0.01	170
0047 ISB458	<0.1	<0.1	<0.01	<0.01	<0.01	<10
0048 IQL024	<0.1	<0.1	<0.01	<0.01	<0.01	178
0049 IQL134	<0.1	<0.1	<0.01	<0.01	<0.01	550
0050 ISR689	<0.1	<0.1	<0.01	<0.01	<0.01	301
0051 ISB681	<0.1	<0.1	<0.01	<0.01	<0.01	66
0052 KAA196	<0.1	<0.1	<0.01	<0.01	<0.01	53
0053 KAA560	<0.1	<0.1	<0.01	<0.01	<0.01	40
0054 KAF556	<0.1	<0.1	<0.01	<0.01	<0.01	51
0055 IQJ569	<0.1	<0.1	<0.01	<0.01	<0.01	83
0056 KBP675	<0.1	<0.1	<0.01	<0.01	<0.01	499
0057 KBP703	<0.1	<0.1	<0.01	<0.01	<0.01	53
0058 IMU159A	<0.1	<0.1	<0.01	<0.01	<0.01	<10
0059 IXU682	<0.1	<0.1	<0.01	<0.01	<0.01	<10
0060 IXU692	0.1	0.9	0.14	<0.01	<0.01	49
0061 IXU931	<0.1	<0.1	<0.01	<0.01	<0.01	<10
0062 IXU939	<0.1	<0.1	<0.01	<0.01	<0.01	<10
0063 KJK611	<0.1	<0.1	<0.01	<0.01	<0.01	42
0064 KJK834	<0.1	<0.1	<0.01	<0.01	<0.01	25
0065 IXP068	<0.1	<0.1	<0.01	<0.01	<0.01	16
0066 KBS203	<0.1	<0.1	<0.01	<0.01	<0.01	<10
0067 KBS302	<0.1	<0.1	<0.01	<0.01	<0.01	104
0068 KBS379	<0.1	<0.1	<0.01	<0.01	<0.01	50
0069 KBS842	<0.1	<0.1	<0.01	<0.01	<0.01	35
0070 KBS861	<0.1	<0.1	<0.01	<0.01	<0.01	40
0071 KDY374	<0.1	<0.1	<0.01	<0.01	<0.01	<10
0072 KDY571	<0.1	<0.1	<0.01	<0.01	<0.01	59
0073 KDY612	<0.1	<0.1	<0.01	<0.01	<0.01	542
0074 KDY617	<0.1	<0.1	<0.01	<0.01	<0.01	676
0075 KJE387	<0.1	<0.1	<0.01	<0.01	<0.01	253
0076 KJE524	<0.1	<0.1	<0.01	<0.01	<0.01	52
0077 KJE711	<0.1	<0.1	<0.01	<0.01	<0.01	11
0078 KKA384	<0.1	<0.1	<0.01	<0.01	<0.01	<10
0079 KKA519	<0.1	<0.1	<0.01	<0.01	<0.01	<10
0080 KKA527	<0.1	<0.1	<0.01	<0.01	<0.01	51

ELEMENTS	La	Li	Mg	Mn	Mo	MPA
UNITS	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	kgH2SO4/t
DETECTION LIMIT	0.01	0.1	10	1	0.1	1
DIGEST	NAGx/	NAGx/	NAGx/	NAGx/	NAGx/	
ANALYTICAL FINISH	MS	MS	OE	OE	MS	/CALC
SAMPLE NUMBERS						
0041 IQC742	0.25	0.3	412	59	<0.1	101
0042 IQC744	0.19	0.4	97	19	<0.1	359
0043 IQK216	0.01	<0.1	68	2	<0.1	3
0044 IQH843	<0.01	<0.1	31	<1	0.2	2
0045 IKS295	<0.01	<0.1	45	<1	<0.1	2
0046 ISB416	<0.01	<0.1	2303	1	0.2	<1
0047 ISB458	0.01	<0.1	47	<1	<0.1	2
0048 IQL024	0.01	<0.1	395	<1	<0.1	7
0049 IQL134	<0.01	<0.1	<10	<1	<0.1	10
0050 ISR689	<0.01	<0.1	190	18	<0.1	<1
0051 ISB681	<0.01	<0.1	46	11	0.2	3
0052 KAA196	0.02	<0.1	<10	1	<0.1	3
0053 KAA560	<0.01	0.2	15	92	0.1	1
0054 KAF556	<0.01	<0.1	141	<1	0.4	18
0055 IQJ569	0.02	0.5	59	24	<0.1	1
0056 KBP675	0.02	<0.1	69	96	0.1	<1
0057 KBP703	0.02	<0.1	86	5	<0.1	23
0058 IMU159A	<0.01	0.2	60	<1	<0.1	1
0059 IXU682	0.01	<0.1	225	<1	<0.1	6
0060 IXU692	0.54	<0.1	1216	367	<0.1	43
0061 IXU931	<0.01	<0.1	50	<1	0.3	<1
0062 IXU939	0.01	<0.1	85	<1	<0.1	1
0063 KJK611	0.03	<0.1	73	<1	0.2	2
0064 KJK834	0.16	<0.1	23	2	<0.1	2
0065 IXP068	0.03	<0.1	94	10	0.1	3
0066 KBS203	0.02	<0.1	17	6	0.2	2
0067 KBS302	0.02	<0.1	71	<1	0.3	<1
0068 KBS379	0.08	0.6	67	<1	<0.1	7
0069 KBS842	0.02	<0.1	43	1	<0.1	3
0070 KBS861	<0.01	<0.1	110	3	0.3	1
0071 KDY374	0.07	<0.1	68	8	0.2	2
0072 KDY571	0.02	<0.1	42	4	0.1	<1
0073 KDY612	0.02	<0.1	91	13	0.2	2
0074 KDY617	0.02	0.1	163	<1	<0.1	20
0075 KJE387	<0.01	<0.1	75	<1	0.1	1
0076 KJE524	0.02	<0.1	84	<1	0.4	<1
0077 KJE711	0.02	<0.1	76	<1	0.5	1
0078 KKA384	<0.01	<0.1	19	<1	<0.1	4
0079 KKA519	0.02	0.1	82	1	<0.1	4
0080 KKA527	0.01	0.4	19	7	<0.1	3

ELEMENTS	N-NH3	N-NO2	N-NO3	N-Tot	Na	NAG
UNITS	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	kgH2SO4/t
DETECTION LIMIT	0.5	0.1	0.1	10	10	1
DIGEST	EXT/	EXT/	EXT/	EXT/	NAGx/	NAGx/
ANALYTICAL FINISH	COL	COL	COL	COL	OE	VOL
SAMPLE NUMBERS						
0041 IQC742	20.0	<0.1	0.1	920	160	162
0042 IQC744	2.8	0.6	0.4	770	78	107
0043 IQK216	9.1	<0.1	0.7	23	154	0
0044 IQH843	32.0	<0.1	0.4	160	110	0
0045 IKS295	4.7	<0.1	0.4	32	151	0
0046 ISB416	6.1	<0.1	0.8	20	268	0
0047 ISB458	6.9	<0.1	1.0	42	139	0
0048 IQL024	7.6	0.7	0.1	43	500	0
0049 IQL134	7.5	<0.1	2.4	100	747	0
0050 ISR689	16.0	<0.1	0.6	340	516	0
0051 ISB681	10.0	<0.1	0.8	30	124	0
0052 KAA196	6.4	<0.1	0.2	39	110	2
0053 KAA560	4.5	<0.1	0.4	<10	36	0
0054 KAF556	14.0	<0.1	0.5	99	319	2
0055 IQJ569	8.8	<0.1	0.3	46	78	0
0056 KBP675	7.3	<0.1	0.5	58	163	0
0057 KBP703	15.0	<0.1	0.3	140	157	0
0058 IMU159A	3.2	0.1	0.5	19	192	0
0059 IXU682	5.0	<0.1	0.7	300	64	0
0060 IXU692	32.0	<0.1	1.1	3200	296	70
0061 IXU931	4.0	<0.1	0.5	<10	73	0
0062 IXU939	3.2	0.1	1.2	42	100	0
0063 KJK611	3.8	<0.1	0.3	20	123	2
0064 KJK834	3.2	<0.1	7.4	20	45	0
0065 IXP068	4.6	<0.1	0.9	23	169	1
0066 KBS203	4.8	<0.1	1.4	16	39	2
0067 KBS302	5.8	<0.1	0.8	56	197	4
0068 KBS379	4.0	<0.1	1.0	30	169	2
0069 KBS842	4.1	<0.1	1.0	30	155	0
0070 KBS861	5.4	<0.1	3.3	<10	99	3
0071 KDY374	4.6	<0.1	1.9	<10	106	1
0072 KDY571	4.2	<0.1	0.7	29	76	3
0073 KDY612	21.0	<0.1	1.5	1300	67	2
0074 KDY617	4.7	<0.1	2.2	64	412	0
0075 KJE387	4.8	<0.1	1.6	190	239	4
0076 KJE524	4.8	<0.1	0.8	39	46	1
0077 KJE711	5.0	<0.1	1.1	260	44	1
0078 KKA384	4.4	<0.1	0.6	77	23	0
0079 KKA519	4.8	<0.1	1.1	49	90	0
0080 KKA527	3.3	<0.1	0.6	40	85	0

ELEMENTS	NAGpH	NAG(4.5)	NAPP	Nb	Ni	P
UNITS	NONE	kgH2SO4/t	kgH2SO4/t	mg/Kg	mg/Kg	mg/Kg
DETECTION LIMIT	0.1	1	1	0.05	1	10
DIGEST	NAGx/	NAGx/		NAGx/	NAGx/	NAGx/
ANALYTICAL FINISH	MTR	VOL	/CALC	MS	OE	OE
SAMPLE NUMBERS						
0041 IQC742	2.1	150	101	<0.05	24	<10
0042 IQC744	1.6	91	383	<0.05	50	<10
0043 IQK216	5.9	0	2	<0.05	<1	<10
0044 IQH843	5.9	0	1	<0.05	<1	<10
0045 IKS295	5.9	0	1	0.14	<1	<10
0046 ISB416	8.0	0	-41	0.38	<1	<10
0047 ISB458	5.4	0	1	0.15	<1	<10
0048 IQL024	7.4	0	-15	0.75	<1	<10
0049 IQL134	10.0	0	-58	0.14	<1	<10
0050 ISR689	6.7	0	-12	0.09	<1	<10
0051 ISB681	5.0	0	2	0.25	<1	<10
0052 KAA196	5.0	0	2	0.31	<1	<10
0053 KAA560	5.2	0	0	0.18	<1	<10
0054 KAF556	6.3	0	13	0.38	<1	<10
0055 IQJ569	5.9	0	1	0.13	<1	<10
0056 KBP675	6.5	0	-3	0.12	<1	<10
0057 KBP703	5.3	0	21	0.12	<1	<10
0058 IMU159A	6.6	0	-2	<0.05	<1	<10
0059 IXU682	5.6	0	-2	<0.05	<1	<10
0060 IXU692	3.8	4	34	<0.05	5	<10
0061 IXU931	6.2	0	-0	0.28	<1	<10
0062 IXU939	6.4	0	-2	0.05	<1	<10
0063 KJK611	5.9	0	-0	0.27	<1	<10
0064 KJK834	4.7	0	3	0.18	<1	<10
0065 IXP068	4.8	0	2	0.23	<1	<10
0066 KBS203	4.4	0	3	0.25	<1	<10
0067 KBS302	5.9	0	-0	0.34	<1	<10
0068 KBS379	3.9	0	8	0.15	<1	<10
0069 KBS842	4.6	0	3	0.08	<1	<10
0070 KBS861	4.9	0	1	0.17	<1	<10
0071 KDY374	4.8	0	2	0.13	<1	<10
0072 KDY571	6.0	0	-1	0.18	2	<10
0073 KDY612	6.4	0	-2	0.17	<1	<10
0074 KDY617	6.5	0	12	0.05	1	<10
0075 KJE387	6.1	0	-3	0.22	<1	<10
0076 KJE524	6.5	0	-3	0.12	<1	<10
0077 KJE711	6.3	0	-2	0.15	<1	<10
0078 KKA384	5.2	0	3	<0.05	<1	<10
0079 KKA519	5.1	0	3	<0.05	<1	<10
0080 KKA527	5.7	0	3	<0.05	<1	<10

ELEMENTS	Pb	N-Kjel	pH	pH Drop	Rb	Re
UNITS	mg/Kg	mg/Kg	NONE	NONE	mg/Kg	mg/Kg
DETECTION LIMIT	2	10	0.1	0.1	0.05	0.01
DIGEST	NAGx/	EXT/	Ws5/	ANCx/	NAGx/	NAGx/
ANALYTICAL FINISH	MS	COL	MTR	MTR	MS	MS
SAMPLE NUMBERS						
0041 IQC742	<2	920	4.4	3.6	1.20	<0.01
0042 IQC744	<2	770	2.6	3.1	0.93	<0.01
0043 IQK216	<2	23	5.6	4.8	0.09	<0.01
0044 IQH843	<2	160	5.2	4.9	<0.05	<0.01
0045 IKS295	<2	31	5.8	4.8	0.10	<0.01
0046 ISB416	<2	19	8.0	4.8	0.70	<0.01
0047 ISB458	<2	41	4.8	4.9	<0.05	<0.01
0048 IQL024	<2	42	7.6	4.9	0.52	<0.01
0049 IQL134	<2	100	8.0	5.0	0.33	<0.01
0050 ISR689	<2	340	7.1	4.8	0.43	<0.01
0051 ISB681	<2	29	4.9	4.9	0.09	<0.01
0052 KAA196	<2	39	5.1	5.0	0.11	<0.01
0053 KAA560	<2	<10	4.9	4.7	0.07	<0.01
0054 KAF556	<2	98	6.8	4.9	0.27	<0.01
0055 IQJ569	<2	46	5.5	4.7	0.11	<0.01
0056 KBP675	<2	58	6.2	5.0	0.86	<0.01
0057 KBP703	<2	140	5.3	5.0	0.18	<0.01
0058 IMU159A	<2	18	6.7	4.9	<0.05	<0.01
0059 IXU682	<2	300	5.6	2.8	<0.05	<0.01
0060 IXU692	<2	3200	4.7	2.6	0.10	<0.01
0061 IXU931	<2	<10	6.0	5.0	0.08	<0.01
0062 IXU939	<2	41	6.7	5.0	0.07	<0.01
0063 KJK611	<2	20	6.1	4.9	0.21	<0.01
0064 KJK834	<2	13	4.9	5.0	<0.05	<0.01
0065 IXP068	<2	22	4.9	4.9	0.11	<0.01
0066 KBS203	<2	14	4.7	4.9	<0.05	<0.01
0067 KBS302	<2	55	6.1	4.8	0.69	<0.01
0068 KBS379	<2	29	4.0	4.7	0.07	<0.01
0069 KBS842	<2	29	4.4	4.9	0.08	<0.01
0070 KBS861	<2	<10	5.0	4.9	0.14	<0.01
0071 KDY374	<2	<10	4.8	4.9	0.14	<0.01
0072 KDY571	<2	28	6.3	4.9	0.29	<0.01
0073 KDY612	<2	1300	I/S	4.8	1.60	<0.01
0074 KDY617	<2	61	6.9	4.7	0.57	<0.01
0075 KJE387	<2	180	6.8	4.9	1.09	<0.01
0076 KJE524	<2	39	7.0	4.9	0.23	<0.01
0077 KJE711	<2	260	6.8	4.9	0.36	<0.01
0078 KKA384	<2	77	4.8	4.8	<0.05	<0.01
0079 KKA519	<2	48	4.7	4.9	0.06	<0.01
0080 KKA527	<2	39	5.3	4.8	0.08	<0.01

ELEMENTS	S	S	S	S-SO4	Sb	Sc
UNITS	%	%	mg/Kg	%	mg/Kg	mg/Kg
DETECTION LIMIT	0.01	0.005	10	0.01	0.05	1
DIGEST		SCR/	NAGx/	S71/	NAGx/	NAGx/
ANALYTICAL FINISH	/CSA	VOL	OE	OE	MS	OE
SAMPLE NUMBERS						
0041 IQC742	3.30	1.900	24454	0.40	<0.05	<1
0042 IQC744	11.73	8.000	88098	1.16	0.12	<1
0043 IQK216	0.11	<0.005	318	0.11	<0.05	<1
0044 IQH843	0.05	<0.005	230	0.05	0.16	<1
0045 IKS295	0.06	<0.005	130	0.06	<0.05	<1
0046 ISB416	0.02	<0.005	99	0.02	0.08	<1
0047 ISB458	0.06	<0.005	89	0.06	<0.05	<1
0048 IQL024	0.24	<0.005	117	0.25	0.18	<1
0049 IQL134	0.31	<0.005	1290	0.33	<0.05	<1
0050 ISR689	0.01	<0.005	41	0.01	<0.05	<1
0051 ISB681	0.10	<0.005	202	0.10	<0.05	<1
0052 KAA196	0.09	<0.005	138	0.08	<0.05	<1
0053 KAA560	0.04	<0.005	125	0.04	<0.05	<1
0054 KAF556	0.58	<0.005	198	0.48	<0.05	<1
0055 IQJ569	0.04	<0.005	160	0.03	<0.05	<1
0056 KBP675	0.02	<0.005	57	0.02	0.53	<1
0057 KBP703	0.76	<0.005	414	0.34	<0.05	<1
0058 IMU159A	0.04	<0.005	151	0.03	<0.05	<1
0059 IXU682	0.19	0.090	749	0.08	<0.05	<1
0060 IXU692	1.40	0.770	12820	0.21	<0.05	2
0061 IXU931	0.02	<0.005	72	0.03	<0.05	<1
0062 IXU939	0.04	<0.005	112	0.04	<0.05	<1
0063 KJK611	0.06	<0.005	90	0.05	<0.05	<1
0064 KJK834	0.05	<0.005	118	0.04	<0.05	<1
0065 IXP068	0.09	<0.005	216	0.09	<0.05	<1
0066 KBS203	0.07	<0.005	165	0.07	<0.05	<1
0067 KBS302	0.03	<0.005	45	0.02	<0.05	<1
0068 KBS379	0.21	<0.005	355	0.22	<0.05	<1
0069 KBS842	0.10	<0.005	126	0.10	<0.05	<1
0070 KBS861	0.05	<0.005	169	0.05	<0.05	<1
0071 KDY374	0.06	<0.005	140	0.06	<0.05	<1
0072 KDY571	0.03	<0.005	26	0.01	<0.05	<1
0073 KDY612	0.05	<0.005	13	0.05	<0.05	<1
0074 KDY617	0.65	<0.005	2161	0.49	<0.05	<1
0075 KJE387	0.04	<0.005	19	0.04	<0.05	<1
0076 KJE524	0.01	<0.005	26	<0.01	<0.05	<1
0077 KJE711	0.05	<0.005	34	0.04	<0.05	<1
0078 KKA384	0.13	<0.005	61	0.12	<0.05	<1
0079 KKA519	0.11	<0.005	160	0.12	<0.05	<1
0080 KKA527	0.08	<0.005	113	0.08	<0.05	<1

ELEMENTS	Se	Sn	Sr	Ta	Te	Th
UNITS	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg
DETECTION LIMIT	2	0.1	0.05	0.01	0.1	0.01
DIGEST	NAGx/	NAGx/	NAGx/	NAGx/	NAGx/	NAGx/
ANALYTICAL FINISH	MS	MS	MS	MS	MS	MS
SAMPLE NUMBERS						
0041 IQC742	4	<0.1	4.91	<0.01	<0.1	0.11
0042 IQC744	4	<0.1	0.80	<0.01	0.2	0.34
0043 IQK216	<2	<0.1	2.04	<0.01	<0.1	<0.01
0044 IQH843	<2	<0.1	0.32	<0.01	<0.1	<0.01
0045 IKS295	<2	<0.1	0.61	<0.01	<0.1	<0.01
0046 ISB416	<2	<0.1	24.76	0.01	<0.1	<0.01
0047 ISB458	<2	<0.1	0.49	<0.01	<0.1	<0.01
0048 IQL024	<2	<0.1	8.44	0.06	<0.1	<0.01
0049 IQL134	<2	<0.1	16.15	<0.01	<0.1	<0.01
0050 ISR689	<2	<0.1	1.62	<0.01	<0.1	<0.01
0051 ISB681	<2	<0.1	1.24	<0.01	<0.1	<0.01
0052 KAA196	<2	<0.1	1.08	0.01	<0.1	<0.01
0053 KAA560	<2	<0.1	0.43	<0.01	<0.1	<0.01
0054 KAF556	<2	<0.1	3.65	0.02	<0.1	<0.01
0055 IQJ569	<2	<0.1	0.45	<0.01	<0.1	<0.01
0056 KBP675	<2	<0.1	0.82	<0.01	<0.1	<0.01
0057 KBP703	<2	<0.1	1.39	<0.01	<0.1	<0.01
0058 IMU159A	<2	<0.1	0.29	<0.01	<0.1	<0.01
0059 IXU682	2	<0.1	2.54	<0.01	<0.1	<0.01
0060 IXU692	2	<0.1	3.60	<0.01	<0.1	0.25
0061 IXU931	<2	<0.1	0.33	0.02	<0.1	<0.01
0062 IXU939	<2	<0.1	2.15	<0.01	<0.1	<0.01
0063 KJK611	<2	<0.1	3.93	0.02	<0.1	<0.01
0064 KJK834	<2	<0.1	5.85	<0.01	<0.1	<0.01
0065 IXP068	<2	<0.1	2.37	<0.01	<0.1	<0.01
0066 KBS203	<2	<0.1	0.35	0.01	<0.1	<0.01
0067 KBS302	<2	<0.1	1.44	0.02	<0.1	<0.01
0068 KBS379	<2	<0.1	2.17	0.01	<0.1	<0.01
0069 KBS842	<2	<0.1	0.55	<0.01	<0.1	<0.01
0070 KBS861	<2	<0.1	0.47	0.02	<0.1	<0.01
0071 KDY374	<2	<0.1	0.50	0.01	<0.1	0.01
0072 KDY571	<2	<0.1	1.09	0.02	<0.1	<0.01
0073 KDY612	<2	<0.1	0.60	0.02	<0.1	<0.01
0074 KDY617	<2	<0.1	10.41	<0.01	<0.1	<0.01
0075 KJE387	<2	<0.1	0.73	0.02	<0.1	<0.01
0076 KJE524	<2	<0.1	1.08	0.01	<0.1	<0.01
0077 KJE711	<2	<0.1	0.43	0.01	<0.1	<0.01
0078 KKA384	<2	<0.1	0.19	<0.01	<0.1	<0.01
0079 KKA519	<2	<0.1	0.27	<0.01	<0.1	<0.01
0080 KKA527	<2	<0.1	1.45	<0.01	<0.1	<0.01

ELEMENTS	Ti	Tl	U	V	W	Y
UNITS	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg
DETECTION LIMIT	1	0.02	0.01	1	0.1	0.05
DIGEST	NAGx/	NAGx/	NAGx/	NAGx/	NAGx/	NAGx/
ANALYTICAL FINISH	OE	MS	MS	OE	MS	MS
SAMPLE NUMBERS						
0041 IQC742	<1	0.29	1.53	<1	<0.1	0.80
0042 IQC744	<1	0.43	0.90	<1	0.1	0.33
0043 IQK216	<1	<0.02	<0.01	<1	<0.1	<0.05
0044 IQH843	<1	<0.02	<0.01	<1	0.1	<0.05
0045 IKS295	<1	<0.02	<0.01	<1	0.1	<0.05
0046 ISB416	2	<0.02	<0.01	<1	1.5	<0.05
0047 ISB458	<1	<0.02	<0.01	<1	1.0	<0.05
0048 IQL024	2	<0.02	<0.01	11	1.7	<0.05
0049 IQL134	<1	<0.02	0.01	<1	1.3	<0.05
0050 ISR689	<1	<0.02	<0.01	4	0.5	<0.05
0051 ISB681	<1	<0.02	<0.01	<1	0.8	<0.05
0052 KAA196	<1	<0.02	<0.01	<1	1.1	<0.05
0053 KAA560	<1	0.03	<0.01	<1	0.6	<0.05
0054 KAF556	<1	<0.02	<0.01	3	2.5	<0.05
0055 IQJ569	<1	<0.02	<0.01	<1	0.8	<0.05
0056 KBP675	<1	0.03	<0.01	6	1.7	<0.05
0057 KBP703	<1	<0.02	<0.01	<1	1.1	<0.05
0058 IMU159A	<1	<0.02	<0.01	<1	0.6	<0.05
0059 IXU682	<1	<0.02	<0.01	<1	0.5	<0.05
0060 IXU692	<1	0.10	0.68	<1	<0.1	4.18
0061 IXU931	2	<0.02	<0.01	3	1.2	<0.05
0062 IXU939	<1	<0.02	<0.01	<1	0.8	<0.05
0063 KJK611	<1	<0.02	<0.01	<1	2.7	<0.05
0064 KJK834	<1	<0.02	<0.01	<1	1.0	<0.05
0065 IXP068	<1	<0.02	<0.01	<1	1.8	<0.05
0066 KBS203	<1	<0.02	<0.01	<1	1.0	<0.05
0067 KBS302	<1	<0.02	<0.01	1	2.6	<0.05
0068 KBS379	<1	<0.02	<0.01	<1	0.9	0.09
0069 KBS842	<1	<0.02	<0.01	<1	0.7	<0.05
0070 KBS861	<1	<0.02	<0.01	<1	0.9	<0.05
0071 KDY374	<1	<0.02	0.02	<1	0.8	0.06
0072 KDY571	2	<0.02	<0.01	<1	1.7	<0.05
0073 KDY612	<1	0.02	0.01	<1	1.6	<0.05
0074 KDY617	<1	<0.02	<0.01	<1	0.6	<0.05
0075 KJE387	<1	<0.02	<0.01	<1	1.4	<0.05
0076 KJE524	<1	<0.02	<0.01	3	1.0	<0.05
0077 KJE711	<1	<0.02	<0.01	2	1.3	<0.05
0078 KKA384	<1	<0.02	<0.01	<1	0.6	<0.05
0079 KKA519	<1	<0.02	<0.01	<1	0.7	<0.05
0080 KKA527	<1	<0.02	<0.01	<1	0.7	<0.05

ELEMENTS	Zn	Zr
UNITS	mg/Kg	mg/Kg
DETECTION LIMIT	1	0.1
DIGEST	NAGx/	NAGx/
ANALYTICAL FINISH	OE	MS
SAMPLE NUMBERS		
0041 IQC742	6	<0.1
0042 IQC744	7	0.3
0043 IQK216	<1	<0.1
0044 IQH843	<1	<0.1
0045 IKS295	<1	<0.1
0046 ISB416	<1	<0.1
0047 ISB458	6	<0.1
0048 IQL024	<1	<0.1
0049 IQL134	<1	<0.1
0050 ISR689	<1	<0.1
0051 ISB681	<1	<0.1
0052 KAA196	5	<0.1
0053 KAA560	<1	<0.1
0054 KAF556	<1	<0.1
0055 IQJ569	<1	<0.1
0056 KBP675	6	<0.1
0057 KBP703	<1	<0.1
0058 IMU159A	<1	<0.1
0059 IXU682	<1	<0.1
0060 IXU692	3	3.9
0061 IXU931	<1	<0.1
0062 IXU939	<1	<0.1
0063 KJK611	<1	<0.1
0064 KJK834	3	<0.1
0065 IXP068	<1	<0.1
0066 KBS203	<1	<0.1
0067 KBS302	2	<0.1
0068 KBS379	<1	<0.1
0069 KBS842	<1	<0.1
0070 KBS861	<1	<0.1
0071 KDY374	<1	<0.1
0072 KDY571	<1	<0.1
0073 KDY612	<1	<0.1
0074 KDY617	2	<0.1
0075 KJE387	4	<0.1
0076 KJE524	<1	<0.1
0077 KJE711	2	<0.1
0078 KKA384	<1	<0.1
0079 KKA519	<1	<0.1
0080 KKA527	<1	<0.1

ELEMENTS	Ag	Al	ANC	As	B	Ba
UNITS	mg/Kg	mg/Kg	kgH2SO4/t	mg/Kg	mg/Kg	mg/Kg
DETECTION LIMIT	0.1	1	1	1	1	0.1
DIGEST	NAGx/	NAGx/	ANCx/	NAGx/	NAGx/	NAGx/
ANALYTICAL FINISH	MS	OE	VOL	MS	OE	MS
SAMPLE NUMBERS						
0081 KKA680	<0.1	20	-1	<1	14	25.1
0082 KKA684	<0.1	50	0	<1	3	3.0
0083 KKA686	<0.1	28	-1	<1	7	5.2
0084 KKA687	<0.1	41	0	<1	12	5.2
0085 KJW683	<0.1	2	1	<1	3	2.1
0086 KKW195	<0.1	6	-1	<1	1	4.3
0087 KKW509	<0.1	<1	1	<1	4	3.4
0088 KJV431	<0.1	3	2	<1	4	32.4
0089 KIS196	<0.1	10	7	<1	<1	0.7
0090 KIS257	<0.1	9	5	<1	4	0.2
0091 KIS260	<0.1	7	5	<1	<1	0.3
0092 KJV904	<0.1	<1	2	<1	3	5.9
0093 KNE680	<0.1	8	2	<1	<1	7.4
0094 KNF277	<0.1	7	1	<1	5	13.0
0095 KKK174	<0.1	<1	2	<1	4	7.2
0096 IWV729	<0.1	<1	2	<1	5	20.9
0097 IWV732	<0.1	6	3	<1	<1	2.3
0098 IWV832	<0.1	<1	4	<1	3	0.6
0099 IKD414	<0.1	<1	3	<1	7	8.7
CHECKS						
0001 IKC062 Rpt	<0.1	3	4	<1	4	0.2
0002 ISB416 Rpt	<0.1	27	41	<1	<1	10.4
0003 IXU682 Rpt	<0.1	2	7	<1	6	0.8
STANDARDS						
0001 0.5%NaCl-1						
0002 0.5%NaCl-1						
0003 0.5%NaCl-1						
0004 0.5%NaCl-1						
0005 OREAS 277						
0006 TOC-2						
0007 OREAS 278						
0008 OREAS 279						
0009 PD-1						
0010 OREAS 277						
0011 OREAS 278						
0012 OREAS 279						
0013 NAG Std 3	0.7	192		<1	9	1.4
0014 NAG Std 3	0.6	230		<1	19	1.3

ELEMENTS	Be	Bi	C	C-Acinsol	C-CO3	Ca
UNITS	mg/Kg	mg/Kg	%	%	%	mg/Kg
DETECTION LIMIT	0.1	0.01	0.01	0.01	0.01	1
DIGEST	NAGx/	NAGx/		C71/		NAGx/
ANALYTICAL FINISH	MS	MS	/CSA	CSA	/CALC	OE
SAMPLE NUMBERS						
0081 KKA680	<0.1	<0.01	0.06	0.05	<0.01	44
0082 KKA684	<0.1	<0.01	0.29	0.14	0.15	42
0083 KKA686	0.1	<0.01	0.21	0.12	0.09	44
0084 KKA687	0.1	<0.01	0.36	0.13	0.23	52
0085 KJW683	<0.1	<0.01	0.20	0.09	0.11	24
0086 KKW195	<0.1	<0.01	0.10	0.08	0.02	40
0087 KKW509	<0.1	<0.01	0.05	0.04	<0.01	7
0088 KJV431	<0.1	<0.01	0.21	0.14	0.07	167
0089 KIS196	<0.1	<0.01	0.24	0.18	0.06	118
0090 KIS257	<0.1	<0.01	0.25	0.24	<0.01	54
0091 KIS260	<0.1	<0.01	0.23	0.20	0.03	57
0092 KJV904	<0.1	<0.01	0.22	0.18	0.04	41
0093 KNE680	<0.1	<0.01	0.12	0.11	<0.01	84
0094 KNF277	<0.1	<0.01	0.05	0.04	<0.01	30
0095 KKK174	<0.1	<0.01	0.07	0.06	<0.01	71
0096 IWV729	<0.1	<0.01	0.30	0.21	0.09	103
0097 IWV732	<0.1	<0.01	0.26	0.22	0.04	48
0098 IWV832	<0.1	<0.01	0.26	0.18	0.08	77
0099 IKD414	<0.1	<0.01	0.09	0.09	<0.01	53

CHECKS						
0001 IKC062 Rpt	<0.1	<0.01	0.08	0.07	<0.01	116
0002 ISB416 Rpt	<0.1	<0.01	0.50	0.04	0.46	5601
0003 IXU682 Rpt	<0.1	<0.01	4.00	1.90	2.10	234

STANDARDS						
0001 0.5%NaCl-1						
0002 0.5%NaCl-1						
0003 0.5%NaCl-1						
0004 0.5%NaCl-1						
0005 OREAS 277				0.12		
0006 TOC-2				0.42		
0007 OREAS 278				0.17		
0008 OREAS 279				0.22		
0009 PD-1						
0010 OREAS 277						
0011 OREAS 278						
0012 OREAS 279						
0013 NAG Std 3	0.3	<0.01				5140
0014 NAG Std 3	0.3	<0.01				5377

ELEMENTS	Cd	Ce	Cl	Co	ColourChange	Cr
UNITS	mg/Kg	mg/Kg	%	mg/Kg	NONE	mg/Kg
DETECTION LIMIT	0.1	0.01	0.02	0.1	0	1
DIGEST	NAGx/	NAGx/	CL1/	NAGx/	ANCx/	NAGx/
ANALYTICAL FINISH	MS	MS	COL	MS	QUAL	OE
SAMPLE NUMBERS						
0081 KKA680	<0.1	0.02	0.03	0.1	No	2
0082 KKA684	<0.1	0.03	0.04	0.2	No	3
0083 KKA686	<0.1	0.15	0.05	0.5	No	1
0084 KKA687	<0.1	0.14	0.05	0.8	No	<1
0085 KJW683	<0.1	0.02	<0.02	0.0	No	<1
0086 KKW195	<0.1	0.03	<0.02	0.0	No	<1
0087 KKW509	<0.1	0.02	0.04	0.0	No	<1
0088 KJV431	<0.1	0.02	<0.02	0.0	No	<1
0089 KIS196	<0.1	0.02	<0.02	0.1	No	3
0090 KIS257	<0.1	0.02	<0.02	0.0	No	3
0091 KIS260	<0.1	0.02	0.03	0.0	No	5
0092 KJV904	<0.1	<0.01	<0.02	-0.0	No	2
0093 KNE680	<0.1	0.02	<0.02	0.0	No	3
0094 KNF277	<0.1	0.02	<0.02	0.0	No	<1
0095 KKK174	<0.1	0.02	<0.02	0.0	No	1
0096 IWV729	<0.1	0.02	0.02	0.0	No	<1
0097 IWV732	<0.1	<0.01	<0.02	0.0	No	<1
0098 IWV832	<0.1	0.01	0.02	0.0	No	1
0099 IKD414	<0.1	0.02	0.16	0.0	No	6
CHECKS						
0001 IKC062 Rpt	<0.1	0.03	0.16	0.0	No	<1
0002 ISB416 Rpt	<0.1	<0.01	0.04	-0.0	No	2
0003 IXU682 Rpt	<0.1	0.04	0.05	0.0	Yes	<1
STANDARDS						
0001 0.5%NaCl-1			0.32			
0002 0.5%NaCl-1			0.32			
0003 0.5%NaCl-1			0.32			
0004 0.5%NaCl-1			0.31			
0005 OREAS 277						
0006 TOC-2						
0007 OREAS 278						
0008 OREAS 279						
0009 PD-1						
0010 OREAS 277						
0011 OREAS 278						
0012 OREAS 279						
0013 NAG Std 3	1.5	0.50		4.2		<1
0014 NAG Std 3	1.3	0.53		4.0		<1

ELEMENTS	Cs	Cu	EC	Fe	Final-pH	Fizz-Rate
UNITS	mg/Kg	mg/Kg	mS/cm	mg/Kg	NONE	NONE
DETECTION LIMIT	0.005	1	0.01	1	0.1	1
DIGEST	NAGx/	NAGx/	Ws5/	NAGx/	ANCx/	ANCx/
ANALYTICAL FINISH	MS	OE	MTR	OE	MTR	QUAL
SAMPLE NUMBERS						
0081 KKA680	<0.005	5	0.33	<1	1.6	<1
0082 KKA684	<0.005	<1	0.34	2	1.6	<1
0083 KKA686	<0.005	9	0.28	<1	1.6	<1
0084 KKA687	<0.005	7	0.45	<1	1.2	<1
0085 KJW683	<0.005	5	0.06	<1	1.6	<1
0086 KKW195	<0.005	2	0.05	<1	1.5	<1
0087 KKW509	<0.005	2	0.23	<1	1.6	<1
0088 KJV431	<0.005	2	0.13	<1	1.6	<1
0089 KIS196	<0.005	3	0.09	<1	1.7	<1
0090 KIS257	<0.005	3	0.12	<1	1.7	<1
0091 KIS260	<0.005	<1	0.18	<1	1.7	<1
0092 KJV904	<0.005	<1	0.10	<1	1.6	<1
0093 KNE680	<0.005	<1	0.08	<1	1.6	<1
0094 KNF277	<0.005	3	0.08	<1	1.6	<1
0095 KKK174	<0.005	4	0.08	<1	1.6	<1
0096 IWV729	<0.005	7	0.15	<1	1.6	<1
0097 IWV732	<0.005	2	0.09	<1	1.6	<1
0098 IWV832	0.016	3	0.15	<1	1.7	<1
0099 IKD414	0.011	6	1.26	<1	1.6	<1
CHECKS						
0001 IKC062 Rpt	<0.005	4	1.43	<1	1.6	<1
0002 ISB416 Rpt	0.011	<1	0.38	<1	1.2	1
0003 IXU682 Rpt	0.014	5	0.29	<1	1.6	<1
STANDARDS						
0001 0.5%NaCl-1						
0002 0.5%NaCl-1						
0003 0.5%NaCl-1						
0004 0.5%NaCl-1						
0005 OREAS 277						
0006 TOC-2						
0007 OREAS 278						
0008 OREAS 279						
0009 PD-1						
0010 OREAS 277						
0011 OREAS 278						
0012 OREAS 279						
0013 NAG Std 3	0.698	12		2197		
0014 NAG Std 3	0.657	8		2153		

ELEMENTS	Ga	Ge	Hf	Hg	In	K
UNITS	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg
DETECTION LIMIT	0.1	0.1	0.01	0.01	0.01	10
DIGEST	NAGx/	NAGx/	NAGx/	NAGx/	NAGx/	NAGx/
ANALYTICAL FINISH	MS	MS	MS	MS	MS	OE
SAMPLE NUMBERS						
0081 KKA680	<0.1	<0.1	<0.01	<0.01	<0.01	75
0082 KKA684	<0.1	<0.1	<0.01	<0.01	<0.01	108
0083 KKA686	<0.1	<0.1	<0.01	<0.01	<0.01	<10
0084 KKA687	<0.1	<0.1	<0.01	<0.01	<0.01	41
0085 KJW683	<0.1	<0.1	<0.01	<0.01	<0.01	11
0086 KKW195	<0.1	<0.1	<0.01	<0.01	<0.01	<10
0087 KKW509	<0.1	<0.1	<0.01	<0.01	<0.01	136
0088 KJV431	<0.1	<0.1	<0.01	<0.01	<0.01	<10
0089 KIS196	<0.1	<0.1	<0.01	<0.01	<0.01	54
0090 KIS257	<0.1	<0.1	<0.01	<0.01	<0.01	24
0091 KIS260	<0.1	<0.1	<0.01	<0.01	<0.01	55
0092 KJV904	<0.1	<0.1	<0.01	<0.01	<0.01	<10
0093 KNE680	<0.1	<0.1	<0.01	<0.01	<0.01	<10
0094 KNF277	<0.1	<0.1	<0.01	<0.01	<0.01	<10
0095 KKK174	<0.1	<0.1	<0.01	<0.01	<0.01	42
0096 IWV729	<0.1	<0.1	<0.01	<0.01	<0.01	<10
0097 IWV732	<0.1	<0.1	<0.01	<0.01	<0.01	27
0098 IWV832	<0.1	<0.1	<0.01	<0.01	<0.01	30
0099 IKD414	<0.1	<0.1	<0.01	<0.01	<0.01	214
CHECKS						
0001 IKC062 Rpt	<0.1	<0.1	<0.01	<0.01	<0.01	341
0002 ISB416 Rpt	<0.1	<0.1	<0.01	<0.01	<0.01	148
0003 IXU682 Rpt	<0.1	<0.1	<0.01	<0.01	<0.01	11
STANDARDS						
0001 0.5%NaCl-1						
0002 0.5%NaCl-1						
0003 0.5%NaCl-1						
0004 0.5%NaCl-1						
0005 OREAS 277						
0006 TOC-2						
0007 OREAS 278						
0008 OREAS 279						
0009 PD-1						
0010 OREAS 277						
0011 OREAS 278						
0012 OREAS 279						
0013 NAG Std 3	<0.1	<0.1	<0.01	<0.01	<0.01	1652
0014 NAG Std 3	<0.1	<0.1	<0.01	<0.01	<0.01	1608

ELEMENTS	La	Li	Mg	Mn	Mo	MPA
UNITS	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	kgH2SO4/t
DETECTION LIMIT	0.01	0.1	10	1	0.1	1
DIGEST	NAGx/	NAGx/	NAGx/	NAGx/	NAGx/	
ANALYTICAL FINISH	MS	MS	OE	OE	MS	/CALC
SAMPLE NUMBERS						
0081 KKA680	<0.01	0.3	167	<1	0.1	8
0082 KKA684	0.04	0.3	109	2	<0.1	5
0083 KKA686	0.04	0.2	90	4	<0.1	8
0084 KKA687	0.08	0.7	133	3	<0.1	9
0085 KJW683	0.02	<0.1	17	<1	<0.1	2
0086 KKW195	0.01	<0.1	14	<1	<0.1	<1
0087 KKW509	0.01	<0.1	52	4	<0.1	1
0088 KJV431	0.01	0.2	29	<1	0.1	2
0089 KIS196	<0.01	<0.1	100	6	<0.1	<1
0090 KIS257	0.02	<0.1	79	<1	0.1	<1
0091 KIS260	<0.01	<0.1	79	<1	0.2	<1
0092 KJV904	<0.01	<0.1	18	<1	<0.1	4
0093 KNE680	0.01	<0.1	53	<1	0.1	2
0094 KNF277	0.01	<0.1	11	<1	<0.1	<1
0095 KKK174	<0.01	<0.1	44	5	<0.1	<1
0096 IWV729	<0.01	<0.1	67	5	0.2	3
0097 IWV732	<0.01	<0.1	25	<1	0.1	3
0098 IWV832	<0.01	0.5	108	<1	0.2	2
0099 IKD414	0.01	<0.1	239	1	<0.1	2
CHECKS						
0001 IKC062 Rpt	0.02	<0.1	327	51	<0.1	2
0002 ISB416 Rpt	<0.01	<0.1	2658	<1	0.2	<1
0003 IXU682 Rpt	0.02	<0.1	229	<1	<0.1	7
STANDARDS						
0001 0.5%NaCl-1						
0002 0.5%NaCl-1						
0003 0.5%NaCl-1						
0004 0.5%NaCl-1						
0005 OREAS 277						
0006 TOC-2						
0007 OREAS 278						
0008 OREAS 279						
0009 PD-1						
0010 OREAS 277						
0011 OREAS 278						
0012 OREAS 279						
0013 NAG Std 3	0.28	0.6	2925	738	<0.1	
0014 NAG Std 3	0.31	0.6	2863	732	<0.1	

ELEMENTS	N-NH3	N-NO2	N-NO3	N-Tot	Na	NAG
UNITS	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	kgH2SO4/t
DETECTION LIMIT	0.5	0.1	0.1	10	10	1
DIGEST	EXT/	EXT/	EXT/	EXT/	NAGx/	NAGx/
ANALYTICAL FINISH	COL	COL	COL	COL	OE	VOL
SAMPLE NUMBERS						
0081 KKA680	5.6	<0.1	0.7	18	187	2
0082 KKA684	4.0	<0.1	1.1	35	134	1
0083 KKA686	5.1	<0.1	2.0	40	134	1
0084 KKA687	4.6	<0.1	2.6	47	233	1
0085 KJW683	3.4	<0.1	0.3	35	20	0
0086 KKW195	3.3	<0.1	0.1	39	36	0
0087 KKW509	3.6	<0.1	0.5	20	320	1
0088 KJV431	3.3	<0.1	0.5	32	67	0
0089 KIS196	3.4	<0.1	0.3	41	125	0
0090 KIS257	3.4	<0.1	0.3	41	289	1
0091 KIS260	3.7	<0.1	1.6	43	386	1
0092 KJV904	3.2	<0.1	0.6	26	147	0
0093 KNE680	4.2	<0.1	0.8	39	50	1
0094 KNF277	3.2	<0.1	0.1	26	31	0
0095 KKK174	3.3	<0.1	0.2	28	156	1
0096 IWV729	4.6	<0.1	0.5	50	155	0
0097 IWV732	3.4	<0.1	0.6	39	71	0
0098 IWV832	3.7	<0.1	2.9	33	57	0
0099 IKD414	5.3	<0.1	1.3	65	1199	3

CHECKS						
0001 IKC062 Rpt					1174	0
0002 ISB416 Rpt					284	0
0003 IXU682 Rpt					78	0

STANDARDS						
0001 0.5%NaCl-1						
0002 0.5%NaCl-1						
0003 0.5%NaCl-1						
0004 0.5%NaCl-1						
0005 OREAS 277						
0006 TOC-2						
0007 OREAS 278						
0008 OREAS 279						
0009 PD-1						
0010 OREAS 277						
0011 OREAS 278						
0012 OREAS 279						
0013 NAG Std 3					56	24
0014 NAG Std 3					63	23

ELEMENTS	NAGpH	NAG(4.5)	NAPP	Nb	Ni	P
UNITS	NONE	kgH2SO4/t	kgH2SO4/t	mg/Kg	mg/Kg	mg/Kg
DETECTION LIMIT	0.1	1	1	0.05	1	10
DIGEST	NAGx/	NAGx/		NAGx/	NAGx/	NAGx/
ANALYTICAL FINISH	MTR	VOL	/CALC	MS	OE	OE
SAMPLE NUMBERS						
0081 KKA680	4.4	0	9	0.11	2	<10
0082 KKA684	4.3	0	5	0.09	<1	<10
0083 KKA686	4.4	0	9	<0.05	<1	<10
0084 KKA687	4.5	0	9	<0.05	<1	<10
0085 KJW683	5.7	0	1	<0.05	<1	<10
0086 KKW195	6.3	0	2	<0.05	<1	<10
0087 KKW509	6.0	0	0	0.09	3	<10
0088 KJV431	6.5	0	0	<0.05	1	<10
0089 KIS196	6.6	0	-7	0.10	<1	<10
0090 KIS257	6.6	0	-4	0.07	<1	<10
0091 KIS260	6.4	0	-5	0.14	<1	<10
0092 KJV904	5.9	0	2	<0.05	<1	<10
0093 KNE680	6.0	0	-0	0.07	<1	<10
0094 KNF277	6.0	0	-0	<0.05	<1	<10
0095 KKK174	6.3	0	-1	0.08	2	<10
0096 IWV729	6.0	0	1	<0.05	1	<10
0097 IWV732	6.4	0	-0	<0.05	<1	<10
0098 IWV832	6.1	0	-2	<0.05	<1	<10
0099 IKD414	5.2	0	-1	0.08	<1	<10

CHECKS						
0001 IKC062 Rpt	6.7	0	-2	0.11	<1	<10
0002 ISB416 Rpt	8.0	0	-40	0.34	1	<10
0003 IXU682 Rpt	5.7	0	-0	<0.05	<1	<10

STANDARDS						
0001 0.5%NaCl-1						
0002 0.5%NaCl-1						
0003 0.5%NaCl-1						
0004 0.5%NaCl-1						
0005 OREAS 277						
0006 TOC-2						
0007 OREAS 278						
0008 OREAS 279						
0009 PD-1						
0010 OREAS 277						
0011 OREAS 278						
0012 OREAS 279						
0013 NAG Std 3	2.6	20		0.17	9	<10
0014 NAG Std 3	2.6	20		<0.05	10	<10

ELEMENTS	Pb	N-Kjel	pH	pH Drop	Rb	Re
UNITS	mg/Kg	mg/Kg	NONE	NONE	mg/Kg	mg/Kg
DETECTION LIMIT	2	10	0.1	0.1	0.05	0.01
DIGEST	NAGx/	EXT/	Ws5/	ANCx/	NAGx/	NAGx/
ANALYTICAL FINISH	MS	COL	MTR	MTR	MS	MS
SAMPLE NUMBERS						
0081 KKA680	<2	17	4.7	5.0	0.34	<0.01
0082 KKA684	<2	34	4.3	4.9	0.16	<0.01
0083 KKA686	<2	38	4.3	4.9	0.11	<0.01
0084 KKA687	<2	44	4.2	4.9	0.16	<0.01
0085 KJW683	<2	35	4.8	4.5	<0.05	<0.01
0086 KKW195	<2	39	6.2	4.8	0.06	<0.01
0087 KKW509	<2	19	5.8	5.0	0.19	<0.01
0088 KJV431	<2	32	6.3	4.8	0.14	<0.01
0089 KIS196	<2	41	6.8	4.9	0.16	<0.01
0090 KIS257	<2	40	6.9	5.0	0.07	<0.01
0091 KIS260	<2	41	6.6	4.9	0.08	<0.01
0092 KJV904	<2	25	5.7	5.0	<0.05	<0.01
0093 KNE680	<2	38	5.8	4.9	0.09	<0.01
0094 KNF277	<2	26	5.3	3.9	<0.05	<0.01
0095 KKK174	<2	28	6.7	4.8	0.34	<0.01
0096 IWV729	<2	49	5.9	4.8	0.21	<0.01
0097 IWV732	<2	38	6.0	4.9	0.16	<0.01
0098 IWV832	<2	30	5.9	4.9	0.38	<0.01
0099 IKD414	<2	64	5.3	5.0	1.07	<0.01
CHECKS						
0001 IKC062 Rpt	<2		6.6	4.9	0.58	<0.01
0002 ISB416 Rpt	<2		7.8	4.8	0.72	<0.01
0003 IXU682 Rpt	<2		5.6	2.7	0.06	<0.01
STANDARDS						
0001 0.5%NaCl-1						
0002 0.5%NaCl-1						
0003 0.5%NaCl-1						
0004 0.5%NaCl-1						
0005 OREAS 277						
0006 TOC-2						
0007 OREAS 278						
0008 OREAS 279						
0009 PD-1						
0010 OREAS 277						
0011 OREAS 278						
0012 OREAS 279						
0013 NAG Std 3	377				11.62	<0.01
0014 NAG Std 3	358				10.86	<0.01

ELEMENTS	S	S	S	S-SO4	Sb	Sc
UNITS	%	%	mg/Kg	%	mg/Kg	mg/Kg
DETECTION LIMIT	0.01	0.005	10	0.01	0.05	1
DIGEST		SCR/	NAGx/	S71/	NAGx/	NAGx/
ANALYTICAL FINISH	/CSA	VOL	OE	OE	MS	OE
SAMPLE NUMBERS						
0081 KKA680	0.25	<0.005	393	0.22	<0.05	<1
0082 KKA684	0.18	<0.005	249	0.17	<0.05	<1
0083 KKA686	0.28	<0.005	232	0.28	<0.05	<1
0084 KKA687	0.30	<0.005	305	0.32	<0.05	<1
0085 KJW683	0.06	<0.005	63	0.06	<0.05	<1
0086 KKW195	0.03	<0.005	27	0.01	<0.05	<1
0087 KKW509	0.03	0.006	62	0.01	<0.05	<1
0088 KJV431	0.07	<0.005	156	0.07	<0.05	<1
0089 KIS196	0.02	<0.005	13	<0.01	<0.05	<1
0090 KIS257	0.03	0.009	45	0.02	<0.05	<1
0091 KIS260	0.02	<0.005	56	0.01	<0.05	<1
0092 KJV904	0.12	<0.005	151	0.13	<0.05	<1
0093 KNE680	0.06	<0.005	85	0.07	<0.05	<1
0094 KNF277	0.02	<0.005	33	0.02	<0.05	<1
0095 KKK174	0.03	<0.005	37	0.01	<0.05	<1
0096 IWV729	0.11	<0.005	171	0.11	<0.05	<1
0097 IWV732	0.08	<0.005	102	0.08	<0.05	<1
0098 IWV832	0.05	<0.005	161	0.05	<0.05	<1
0099 IKD414	0.08	<0.005	541	0.09	<0.05	<1
CHECKS						
0001 IKC062 Rpt	0.05		569	0.06	<0.05	<1
0002 ISB416 Rpt	0.02		119	0.02	0.06	<1
0003 IXU682 Rpt	0.21		746	0.09	<0.05	<1
STANDARDS						
0001 0.5%NaCl-1						
0002 0.5%NaCl-1						
0003 0.5%NaCl-1						
0004 0.5%NaCl-1						
0005 OREAS 277						
0006 TOC-2						
0007 OREAS 278						
0008 OREAS 279						
0009 PD-1				4.30		
0010 OREAS 277				0.16		
0011 OREAS 278				0.23		
0012 OREAS 279				0.32		
0013 NAG Std 3			16856		0.07	<1
0014 NAG Std 3			16480		0.06	<1

ELEMENTS	Se	Sn	Sr	Ta	Te	Th
UNITS	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg
DETECTION LIMIT	2	0.1	0.05	0.01	0.1	0.01
DIGEST	NAGx/	NAGx/	NAGx/	NAGx/	NAGx/	NAGx/
ANALYTICAL FINISH	MS	MS	MS	MS	MS	MS
SAMPLE NUMBERS						
0081 KKA680	<2	<0.1	1.52	0.01	<0.1	<0.01
0082 KKA684	<2	<0.1	0.72	<0.01	<0.1	<0.01
0083 KKA686	<2	<0.1	3.45	<0.01	<0.1	<0.01
0084 KKA687	<2	<0.1	0.64	<0.01	<0.1	<0.01
0085 KJW683	<2	<0.1	0.30	<0.01	<0.1	<0.01
0086 KKW195	<2	<0.1	0.52	<0.01	<0.1	<0.01
0087 KKW509	<2	<0.1	0.47	0.01	<0.1	<0.01
0088 KJV431	<2	<0.1	6.03	<0.01	<0.1	<0.01
0089 KIS196	<2	<0.1	1.18	<0.01	<0.1	<0.01
0090 KIS257	<2	<0.1	0.52	<0.01	<0.1	<0.01
0091 KIS260	<2	<0.1	0.63	0.02	<0.1	<0.01
0092 KJV904	<2	<0.1	1.15	<0.01	<0.1	<0.01
0093 KNE680	<2	<0.1	1.28	<0.01	<0.1	<0.01
0094 KNF277	<2	<0.1	0.25	<0.01	<0.1	<0.01
0095 KKK174	<2	<0.1	1.43	0.01	<0.1	<0.01
0096 IWV729	<2	<0.1	4.39	<0.01	<0.1	<0.01
0097 IWV732	<2	<0.1	0.91	<0.01	<0.1	<0.01
0098 IWV832	<2	<0.1	0.71	<0.01	<0.1	<0.01
0099 IKD414	<2	<0.1	1.54	0.01	<0.1	<0.01
CHECKS						
0001 IKC062 Rpt	<2	<0.1	0.99	<0.01	<0.1	<0.01
0002 ISB416 Rpt	<2	<0.1	24.79	0.02	<0.1	<0.01
0003 IXU682 Rpt	2	<0.1	2.41	<0.01	<0.1	<0.01
STANDARDS						
0001 0.5%NaCl-1						
0002 0.5%NaCl-1						
0003 0.5%NaCl-1						
0004 0.5%NaCl-1						
0005 OREAS 277						
0006 TOC-2						
0007 OREAS 278						
0008 OREAS 279						
0009 PD-1						
0010 OREAS 277						
0011 OREAS 278						
0012 OREAS 279						
0013 NAG Std 3	<2	<0.1	10.97	<0.01	<0.1	0.06
0014 NAG Std 3	<2	<0.1	10.19	<0.01	<0.1	0.06

ELEMENTS	Ti	Tl	U	V	W	Y
UNITS	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg
DETECTION LIMIT	1	0.02	0.01	1	0.1	0.05
DIGEST	NAGx/	NAGx/	NAGx/	NAGx/	NAGx/	NAGx/
ANALYTICAL FINISH	OE	MS	MS	OE	MS	MS
SAMPLE NUMBERS						
0081 KKA680	<1	<0.02	<0.01	<1	0.8	<0.05
0082 KKA684	<1	<0.02	<0.01	<1	1.3	<0.05
0083 KKA686	<1	<0.02	<0.01	<1	0.8	0.08
0084 KKA687	<1	<0.02	<0.01	<1	0.8	0.14
0085 KJW683	<1	<0.02	<0.01	<1	0.6	<0.05
0086 KKW195	<1	<0.02	<0.01	<1	0.9	<0.05
0087 KKW509	2	<0.02	<0.01	4	1.0	<0.05
0088 KJV431	<1	<0.02	<0.01	<1	1.3	<0.05
0089 KIS196	3	<0.02	<0.01	21	1.1	<0.05
0090 KIS257	<1	<0.02	<0.01	13	1.5	<0.05
0091 KIS260	<1	<0.02	<0.01	7	0.6	<0.05
0092 KJV904	<1	<0.02	<0.01	<1	0.1	<0.05
0093 KNE680	1	<0.02	<0.01	1	0.5	<0.05
0094 KNF277	<1	<0.02	<0.01	<1	0.1	<0.05
0095 KKK174	<1	<0.02	<0.01	<1	1.0	<0.05
0096 IWV729	<1	<0.02	<0.01	<1	0.1	<0.05
0097 IWV732	<1	<0.02	<0.01	<1	0.2	<0.05
0098 IWV832	<1	<0.02	<0.01	<1	0.1	<0.05
0099 IKD414	<1	<0.02	<0.01	17	0.2	<0.05
CHECKS						
0001 IKC062 Rpt	<1	<0.02	<0.01	<1	<0.1	<0.05
0002 ISB416 Rpt	<1	<0.02	<0.01	1	2.0	<0.05
0003 IXU682 Rpt	<1	<0.02	<0.01	<1	0.5	<0.05
STANDARDS						
0001 0.5%NaCl-1						
0002 0.5%NaCl-1						
0003 0.5%NaCl-1						
0004 0.5%NaCl-1						
0005 OREAS 277						
0006 TOC-2						
0007 OREAS 278						
0008 OREAS 279						
0009 PD-1						
0010 OREAS 277						
0011 OREAS 278						
0012 OREAS 279						
0013 NAG Std 3	<1	2.16	0.62	<1	<0.1	1.68
0014 NAG Std 3	<1	2.01	0.60	<1	<0.1	1.72

ELEMENTS	Zn	Zr
UNITS	mg/Kg	mg/Kg
DETECTION LIMIT	1	0.1
DIGEST	NAGx/	NAGx/
ANALYTICAL FINISH	OE	MS
SAMPLE NUMBERS		
0081 KKA680	<1	<0.1
0082 KKA684	<1	<0.1
0083 KKA686	2	<0.1
0084 KKA687	<1	<0.1
0085 KJW683	<1	<0.1
0086 KKW195	<1	<0.1
0087 KKW509	<1	<0.1
0088 KJV431	<1	<0.1
0089 KIS196	<1	<0.1
0090 KIS257	<1	<0.1
0091 KIS260	<1	<0.1
0092 KJV904	<1	<0.1
0093 KNE680	<1	<0.1
0094 KNF277	<1	<0.1
0095 KKK174	<1	<0.1
0096 IWV729	<1	<0.1
0097 IWV732	<1	<0.1
0098 IWV832	<1	<0.1
0099 IKD414	<1	<0.1

CHECKS		
0001 IKC062 Rpt	<1	<0.1
0002 ISB416 Rpt	5	<0.1
0003 IXU682 Rpt	<1	<0.1

STANDARDS		
0001 0.5%NaCl-1		
0002 0.5%NaCl-1		
0003 0.5%NaCl-1		
0004 0.5%NaCl-1		
0005 OREAS 277		
0006 TOC-2		
0007 OREAS 278		
0008 OREAS 279		
0009 PD-1		
0010 OREAS 277		
0011 OREAS 278		
0012 OREAS 279		
0013 NAG Std 3	503	<0.1
0014 NAG Std 3	480	<0.1

ELEMENTS	Ag	Al	ANC	As	B	Ba
UNITS	mg/Kg	mg/Kg	kgH2SO4/t	mg/Kg	mg/Kg	mg/Kg
DETECTION LIMIT	0.1	1	1	1	1	0.1
DIGEST	NAGx/	NAGx/	ANCx/	NAGx/	NAGx/	NAGx/
ANALYTICAL FINISH	MS	OE	VOL	MS	OE	MS
STANDARDS						
0015 NAG Std 3	0.6	212		<1	<1	1.4
0016 NAG Std 3	0.7	324		<1	4	1.4
0017 ANC-4			97			
0018 ANC-4			97			
0019 ANC-4			97			
0020 ANC-4			97			
0021 AMIS0558						
0022 OREAS 277						
0023 OREAS 600b						
0024 OREAS 278						
0025 GWS-4						
0026 GWS-4						
0027 GWS-4						
0028 GWS-4						

BLANKS						
0001 Control Blank	<0.1	<1	0	<1	13	<0.1
0002 Control Blank	<0.1	5	0	<1	7	<0.1
0003 Control Blank	<0.1	<1	0	<1	<1	0.4

MISSING SAMPLES: KAE622

ELEMENTS	Be	Bi	C	C-Acinsol	C-CO3	Ca
UNITS	mg/Kg	mg/Kg	%	%	%	mg/Kg
DETECTION LIMIT	0.1	0.01	0.01	0.01	0.01	1
DIGEST	NAGx/	NAGx/		C71/		NAGx/
ANALYTICAL FINISH	MS	MS	/CSA	CSA	/CALC	OE
STANDARDS						
0015 NAG Std 3	0.3	<0.01				5291
0016 NAG Std 3	0.3	<0.01				5183
0017 ANC-4						
0018 ANC-4						
0019 ANC-4						
0020 ANC-4						
0021 AMIS0558			1.81			
0022 OREAS 277			1.85			
0023 OREAS 600b			0.22			
0024 OREAS 278			1.43			
0025 GWS-4						
0026 GWS-4						
0027 GWS-4						
0028 GWS-4						

BLANKS						
0001 Control Blank	<0.1	<0.01	<0.01	<0.01		<1
0002 Control Blank	<0.1	<0.01	<0.01	<0.01	<0.01	<1
0003 Control Blank	<0.1	<0.01	<0.01	<0.01		<1

MISSING SAMPLES: KAE622

ELEMENTS	Cd	Ce	Cl	Co	ColourChange	Cr
UNITS	mg/Kg	mg/Kg	%	mg/Kg	NONE	mg/Kg
DETECTION LIMIT	0.1	0.01	0.02	0.1	0	1
DIGEST	NAGx/	NAGx/	CL1/	NAGx/	ANCx/	NAGx/
ANALYTICAL FINISH	MS	MS	COL	MS	QUAL	OE
STANDARDS						
0015 NAG Std 3	1.4	0.52		4.2		1
0016 NAG Std 3	1.4	0.74		4.1		<1
0017 ANC-4						
0018 ANC-4						
0019 ANC-4						
0020 ANC-4						
0021 AMIS0558						
0022 OREAS 277						
0023 OREAS 600b						
0024 OREAS 278						
0025 GWS-4						
0026 GWS-4						
0027 GWS-4						
0028 GWS-4						
BLANKS						
0001 Control Blank	<0.1	<0.01	<0.02	0.0		<1
0002 Control Blank	<0.1	<0.01	<0.02	0.0		<1
0003 Control Blank	<0.1	0.02	<0.02	0.0		<1

MISSING SAMPLES: KAE622

ELEMENTS	Cs	Cu	EC	Fe	Final-pH	Fizz-Rate
UNITS	mg/Kg	mg/Kg	mS/cm	mg/Kg	NONE	NONE
DETECTION LIMIT	0.005	1	0.01	1	0.1	1
DIGEST	NAGx/	NAGx/	Ws5/	NAGx/	ANCx/	ANCx/
ANALYTICAL FINISH	MS	OE	MTR	OE	MTR	QUAL
STANDARDS						
0015 NAG Std 3	0.680	11		2143		
0016 NAG Std 3	0.674	8		2420		
0017 ANC-4					1.7	
0018 ANC-4					1.7	
0019 ANC-4					1.8	
0020 ANC-4					1.8	
0021 AMIS0558						
0022 OREAS 277						
0023 OREAS 600b						
0024 OREAS 278						
0025 GWS-4			0.33			
0026 GWS-4			0.33			
0027 GWS-4			0.33			
0028 GWS-4			0.33			
BLANKS						
0001 Control Blank	<0.005	<1	<0.01	<1	1.5	
0002 Control Blank	<0.005	1	<0.01	<1	1.6	
0003 Control Blank	<0.005	3	<0.01	<1	1.5	<1

MISSING SAMPLES: KAE622

ELEMENTS	Ga	Ge	Hf	Hg	In	K
UNITS	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg
DETECTION LIMIT	0.1	0.1	0.01	0.01	0.01	10
DIGEST	NAGx/	NAGx/	NAGx/	NAGx/	NAGx/	NAGx/
ANALYTICAL FINISH	MS	MS	MS	MS	MS	OE
STANDARDS						
0015 NAG Std 3	<0.1	<0.1	<0.01	<0.01	<0.01	1573
0016 NAG Std 3	<0.1	<0.1	<0.01	<0.01	<0.01	1580
0017 ANC-4						
0018 ANC-4						
0019 ANC-4						
0020 ANC-4						
0021 AMIS0558						
0022 OREAS 277						
0023 OREAS 600b						
0024 OREAS 278						
0025 GWS-4						
0026 GWS-4						
0027 GWS-4						
0028 GWS-4						

BLANKS						
0001 Control Blank	<0.1	<0.1	<0.01	<0.01	<0.01	<10
0002 Control Blank	<0.1	<0.1	<0.01	<0.01	<0.01	14
0003 Control Blank	<0.1	<0.1	<0.01	<0.01	<0.01	<10

MISSING SAMPLES: KAE622

ELEMENTS	La	Li	Mg	Mn	Mo	MPA
UNITS	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	kgH2SO4/t
DETECTION LIMIT	0.01	0.1	10	1	0.1	1
DIGEST	NAGx/	NAGx/	NAGx/	NAGx/	NAGx/	
ANALYTICAL FINISH	MS	MS	OE	OE	MS	/CALC
STANDARDS						
0015 NAG Std 3	0.28	0.6	2975	776	<0.1	
0016 NAG Std 3	0.40	0.8	3110	779	<0.1	
0017 ANC-4						
0018 ANC-4						
0019 ANC-4						
0020 ANC-4						
0021 AMIS0558						41
0022 OREAS 277						19
0023 OREAS 600b						9
0024 OREAS 278						30
0025 GWS-4						
0026 GWS-4						
0027 GWS-4						
0028 GWS-4						

BLANKS						
0001 Control Blank	<0.01	<0.1	<10	<1	<0.1	<1
0002 Control Blank	<0.01	<0.1	<10	<1	<0.1	<1
0003 Control Blank	<0.01	<0.1	11	<1	<0.1	<1

MISSING SAMPLES: KAE622

ELEMENTS	N-NH3	N-NO2	N-NO3	N-Tot	Na	NAG
UNITS	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	kgH2SO4/t
DETECTION LIMIT	0.5	0.1	0.1	10	10	1
DIGEST	EXT/	EXT/	EXT/	EXT/	NAGx/	NAGx/
ANALYTICAL FINISH	COL	COL	COL	COL	OE	VOL
STANDARDS						
0015 NAG Std 3					50	24
0016 NAG Std 3					47	23
0017 ANC-4						
0018 ANC-4						
0019 ANC-4						
0020 ANC-4						
0021 AMIS0558						
0022 OREAS 277						
0023 OREAS 600b						
0024 OREAS 278						
0025 GWS-4						
0026 GWS-4						
0027 GWS-4						
0028 GWS-4						

BLANKS						
0001 Control Blank					<10	5
0002 Control Blank					<10	7
0003 Control Blank					<10	7

MISSING SAMPLES: KAE622

ELEMENTS	NAGpH	NAG(4.5)	NAPP	Nb	Ni	P
UNITS	NONE	kgH2SO4/t	kgH2SO4/t	mg/Kg	mg/Kg	mg/Kg
DETECTION LIMIT	0.1	1	1	0.05	1	10
DIGEST	NAGx/	NAGx/		NAGx/	NAGx/	NAGx/
ANALYTICAL FINISH	MTR	VOL	/CALC	MS	OE	OE
STANDARDS						
0015 NAG Std 3	2.5	20		<0.05	9	<10
0016 NAG Std 3	2.6	20		<0.05	10	<10
0017 ANC-4						
0018 ANC-4						
0019 ANC-4						
0020 ANC-4						
0021 AMIS0558						
0022 OREAS 277						
0023 OREAS 600b						
0024 OREAS 278						
0025 GWS-4						
0026 GWS-4						
0027 GWS-4						
0028 GWS-4						

BLANKS						
0001 Control Blank	4.9	0	0	0.80	<1	<10
0002 Control Blank	4.8	0	0	0.42	2	<10
0003 Control Blank	4.9	0	0	0.17	<1	<10

MISSING SAMPLES: KAE622

ELEMENTS	Pb	N-Kjel	pH	pH Drop	Rb	Re
UNITS	mg/Kg	mg/Kg	NONE	NONE	mg/Kg	mg/Kg
DETECTION LIMIT	2	10	0.1	0.1	0.05	0.01
DIGEST	NAGx/	EXT/	Ws5/	ANCx/	NAGx/	NAGx/
ANALYTICAL FINISH	MS	COL	MTR	MTR	MS	MS
STANDARDS						
0015 NAG Std 3	364				11.12	<0.01
0016 NAG Std 3	347				10.78	<0.01
0017 ANC-4						
0018 ANC-4						
0019 ANC-4						
0020 ANC-4						
0021 AMIS0558						
0022 OREAS 277						
0023 OREAS 600b						
0024 OREAS 278						
0025 GWS-4			8.9			
0026 GWS-4			9.0			
0027 GWS-4			8.9			
0028 GWS-4			8.7			

BLANKS						
0001 Control Blank	<2		5.5		<0.05	<0.01
0002 Control Blank	<2		5.6		<0.05	<0.01
0003 Control Blank	<2		5.6		<0.05	<0.01

MISSING SAMPLES: KAE622

ELEMENTS	S	S	S	S-SO4	Sb	Sc
UNITS	%	%	mg/Kg	%	mg/Kg	mg/Kg
DETECTION LIMIT	0.01	0.005	10	0.01	0.05	1
DIGEST		SCR/	NAGx/	S71/	NAGx/	NAGx/
ANALYTICAL FINISH	/CSA	VOL	OE	OE	MS	OE
STANDARDS						
0015 NAG Std 3			17179		0.06	<1
0016 NAG Std 3			16696		0.05	<1
0017 ANC-4						
0018 ANC-4						
0019 ANC-4						
0020 ANC-4						
0021 AMIS0558	1.35					
0022 OREAS 277	0.63					
0023 OREAS 600b	0.29					
0024 OREAS 278	0.99					
0025 GWS-4						
0026 GWS-4						
0027 GWS-4						
0028 GWS-4						

BLANKS						
0001 Control Blank	<0.01		<10	<0.01	<0.05	<1
0002 Control Blank	<0.01		<10	<0.01	<0.05	<1
0003 Control Blank	<0.01		<10	<0.01	<0.05	<1

MISSING SAMPLES: KAE622

ELEMENTS	Se	Sn	Sr	Ta	Te	Th
UNITS	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg
DETECTION LIMIT	2	0.1	0.05	0.01	0.1	0.01
DIGEST	NAGx/	NAGx/	NAGx/	NAGx/	NAGx/	NAGx/
ANALYTICAL FINISH	MS	MS	MS	MS	MS	MS
STANDARDS						
0015 NAG Std 3	<2	<0.1	10.95	<0.01	<0.1	0.06
0016 NAG Std 3	<2	<0.1	10.57	<0.01	<0.1	0.07
0017 ANC-4						
0018 ANC-4						
0019 ANC-4						
0020 ANC-4						
0021 AMIS0558						
0022 OREAS 277						
0023 OREAS 600b						
0024 OREAS 278						
0025 GWS-4						
0026 GWS-4						
0027 GWS-4						
0028 GWS-4						

BLANKS						
0001 Control Blank	<2	<0.1	<0.05	0.03	<0.1	<0.01
0002 Control Blank	<2	<0.1	<0.05	0.03	<0.1	<0.01
0003 Control Blank	<2	<0.1	<0.05	0.02	<0.1	<0.01

MISSING SAMPLES: KAE622

ELEMENTS	Ti	Tl	U	V	W	Y
UNITS	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg
DETECTION LIMIT	1	0.02	0.01	1	0.1	0.05
DIGEST	NAGx/	NAGx/	NAGx/	NAGx/	NAGx/	NAGx/
ANALYTICAL FINISH	OE	MS	MS	OE	MS	MS
STANDARDS						
0015 NAG Std 3	<1	2.11	0.65	<1	0.3	1.69
0016 NAG Std 3	<1	2.09	0.79	<1	0.7	2.18
0017 ANC-4						
0018 ANC-4						
0019 ANC-4						
0020 ANC-4						
0021 AMIS0558						
0022 OREAS 277						
0023 OREAS 600b						
0024 OREAS 278						
0025 GWS-4						
0026 GWS-4						
0027 GWS-4						
0028 GWS-4						

BLANKS						
0001 Control Blank	<1	<0.02	<0.01	<1	0.9	<0.05
0002 Control Blank	<1	<0.02	<0.01	<1	1.1	<0.05
0003 Control Blank	<1	<0.02	<0.01	<1	0.3	<0.05

MISSING SAMPLES: KAE622

ELEMENTS	Zn	Zr
UNITS	mg/Kg	mg/Kg
DETECTION LIMIT	1	0.1
DIGEST	NAGx/	NAGx/
ANALYTICAL FINISH	OE	MS
STANDARDS		
0015 NAG Std 3	507	<0.1
0016 NAG Std 3	518	<0.1
0017 ANC-4		
0018 ANC-4		
0019 ANC-4		
0020 ANC-4		
0021 AMIS0558		
0022 OREAS 277		
0023 OREAS 600b		
0024 OREAS 278		
0025 GWS-4		
0026 GWS-4		
0027 GWS-4		
0028 GWS-4		

BLANKS		
0001 Control Blank	1	<0.1
0002 Control Blank	4	<0.1
0003 Control Blank	16	<0.1

MISSING SAMPLES: KAE622

METHOD CODE DESCRIPTION

Method Code Date Tested	Analysing Laboratory NATA Laboratory Accreditation	NATA Scope of Accreditation
/CALC 09/03/21 15:29	Intertek Genalysis Perth 3244 3237 No digestion or other pre-treatment undertaken. Results Determined by calculation from other reported data.	*
/CSA 15/03/21 10:03	Intertek Genalysis Perth 3244 3237 Induction Furnace Analysed by Infrared Spectrometry	ENV_W061
ANCx/MTR 22/02/21 09:09	Intertek Genalysis Perth 3244 3237 Acid Neutralizing Capacity Digestion Procedure. Analysed with Electronic Meter Measurement	ENV_W035
ANCx/QUAL 22/02/21 09:09	Intertek Genalysis Perth 3244 3237 Acid Neutralizing Capacity Digestion Procedure. Analysed by Qualitative Inspection	ENV_W035
ANCx/VOL 22/02/21 09:09	Intertek Genalysis Perth 3244 3237 Acid Neutralizing Capacity Digestion Procedure. Analysed by Volumetric Technique.	ENV_W035
C71/CSA 22/02/21 15:29	Intertek Genalysis Perth 3244 3237 Digestion by hot acid(s) and Induction Furnace Analysed by Infrared Spectrometry	ENV_W063
CL1/COL 22/02/21 09:09	Intertek Genalysis Perth 3244 3237 Carbonate leach specific for Chlorine. Analysed by UV-Visible Spectrometry.	ENV_W014
EXT/COL 15/03/21 10:03	Intertek Genalysis Perth 3244 3237 Extraction by an external provider. Analysed by UV-Visible Spectrometry.	

METHOD CODE DESCRIPTION

Method Code Date Tested	Analysing Laboratory NATA Laboratory Accreditation	NATA Scope of Accreditation
NAGx/MS **23/02/21 13:24**	Intertek Genalysis Perth **3244 3237** Net Acid Generation Extraction of samples with H2O2 Analysed by Inductively Coupled Plasma Mass Spectrometry.	**ENV_W036**
NAGx/MTR **23/02/21 13:24**	Intertek Genalysis Perth **3244 3237** Net Acid Generation Extraction of samples with H2O2 Analysed with Electronic Meter Measurement	**ENV_W036**
NAGx/OE **23/02/21 13:24**	Intertek Genalysis Perth **3244 3237** Net Acid Generation Extraction of samples with H2O2 Analysed by Inductively Coupled Plasma Optical (Atomic) Emission Spectrometry.	**ENV_W036**
NAGx/VOL **23/02/21 13:24**	Intertek Genalysis Perth **3244 3237** Net Acid Generation Extraction of samples with H2O2 Analysed by Volumetric Technique.	**ENV_W036**
S71/OE **23/02/21 07:17**	Intertek Genalysis Perth **3244 3237** Digestion to eliminate sulphides. Analysed by Inductively Coupled Plasma Optical (Atomic) Emission Spectrometry.	**ENV_W062, ICP_IM_001**
SCR/VOL **03/03/21 10:39**	Intertek Genalysis Perth **3244 3237** Chromium Reducible Suplhur Analysed by Volumetric Technique.	*
Ws5/MTR **15/03/21 10:03**	Intertek Genalysis Perth **3244 3237** Water Extraction using a sample:water ratio of 1:5. Analysed with Electronic Meter Measurement	*

* Denotes not on Scope of Accreditation

C.8: Acid Mine Drainage Source Hazard Risk Assessment West Angelas

AMD Source Hazard Risk Assessment

West Angelas Mine

27 August 2021

J-AU0122-002-R-Rev2

MINE WASTE MANAGEMENT
GREENROAD GROUP

Rio Tinto

AMD Source Hazard Risk Assessment

West Angelas Mine

Document Number: J-AU0122-002-R-Rev2

Document Date: 27 August 2021

Prepared for:

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REVISION	DATE	AUTHOR	RECORD OF REVIEW
RevA	14 February 2021	MF	JP
Rev0	14 June 2021	MF	JP
Rev1	25 June 2021	MF	JP
Rev2	27 August 2021	MF	JP

EXECUTIVE SUMMARY

Mine Waste Management Pty Ltd (MWM) completed an update of Rio Tinto Iron Ore's (RTIOs) existing acid and metalliferous drainage (AMD) risk assessment for the West Angelas deposits with consideration to their internal risk assessment approach.

This AMD risk assessment utilised the West Angelas sulfur assay database to assess the bulk acid generation potential of the deposits. The assay database was used to assess the chemical enrichment of the deposit with respect to average crustal abundances. To complement the assay datasets, RTIO's environmental geochemical database was used to further assess the acid base accounting (ABA) characteristics and element mobility potential of the West Angelas geological materials. The inferred AMD characteristics were then assessed in context of the proposed mine plans. Tonnages of higher AMD risk material were estimated along with potential surface are exposures within the pits. This information was then combined with site specific pathway and receptor information to populate RTIO's internally developed ARD Hazard Score Sheets to provide a risk rating for each of the deposits.

It should be noted that the pit shells will change over time and updates to the geological and mining models will be made; the tonnages reported in this document are subject to change.

Key findings of the assessment are as follows:

- Assay results for in-pit material suggest a low risk of acid generating potential.
- Of the 209 West Angelas ABA samples within the environmental geochemical database:
  - 19 samples were classified as potentially acid forming (PAF). Ten of these PAF samples are low-moderate sulfur samples (0.09-0.17 wt%S); 13 WF samples, 5 MM samples, and 1 DOR sample.
  - ANC is generally low with median values ≤3 kg H_2SO_4/t for most stratigraphies and low-moderate (7 kg H_2SO_4/t) for the ALL and BIF samples. ABCC results suggest that ANC is readily availability in the ALL, DET, and WF samples. Variable ANC availability was observed in the 15 MM samples tested ($ENC_{4.5}$ 18-153% of titrated ANC) suggesting an inconsistency in the presence of fast reacting carbonate ANC.
  - Median NAPP values are negative for all stratigraphy groups. Reflective of Pilbara iron ore deposits with low sulfur and low ANC, median NAPP values are only slightly negative (-6 to -0.5 kg H_2SO_4/t).
- Extensive assay sampling has identified several elements (As, Cr, Fe, Pb, and Sn) enriched relative to average crustal abundances. Acid digestion testing on a subset of samples identified additional elements (B, S, Sb, and Se) to be enriched. However, enrichment does not imply mobility at concentrations harmful to a given receptor.
- Generally, mobility of trace elements is low with leachates slightly acidic to alkaline (5.8-8.9) and containing low to moderate salinity (21-889 µS/cm). Fe, Mn, Si, and Zn were the only elements measured above 1 mg/L.

- No waste rock within the mining models was assigned by RTIO a sulfide risk rating or 3 (e.g., high AMD risk classification; *BS-HOT*). No unoxidised black shale is predicted for any of the deposits (to be mined or to remain in final pit surfaces).

- 3.4 Mt of *BS-COLD* waste rock is predicted (0.1% of the total waste rock). Deposit D (44.5%), Deposit J (45.3%), and Deposit A (9%) contain the greatest quantities of predicted BS-COLD tonnages. FWZ (142 Kt) and MCS (1,306 Kt) waste rock classified as BS-COLD, typically higher AMD risk lithologies, is predicted from Deposit J. However, TS is low for these waste blocks (median and average TS <0.1 wt%S) and is predicted within pits 1, 2, and 3, at elevations of 776-936 mRL. Exposures of FWZ and MCS BS-COLD material are predicted for Deposit J (136,270 m^2); approximately 8% of the total final pit surface area for Deposit J.

- 145 Mt of *BS-OXIDE* waste rock is predicted, representing 5.2% of the total West Angelas waste rock. *BS-OXIDE* waste rock is expected from all deposits except the B, C, and D deposits. Deposit J (28%) and Western Hill (54%) contain the greatest quantities of predicted BS-OXIDE tonnages. All MCS and FWZ waste blocks classified as BS-OXIDE are from Deposit J and Western Hill and are generally low TS waste blocks. BS-OXIDE (MCS and FWZ only) exposures are predicted for Deposit J and Western Hill (35,820 m^2 and 52,370 m^2 respectively); approximately 2% of the total final pit surface area for both deposits.

- As presented in the below table, combined hazard scores for Deposit A, Deposit A West, Deposit B, Deposit C, Deposit D, Deposit E, Deposit F, Deposit G, Deposit H, and Mount Ella East Extension are low. Combined hazard scores for Deposit J and Western Hill are moderate. Although these deposits have a moderate risk score, minimal below water table mining is expected and any measured sulfur is likely sulfate.

DEPOSIT	PRELIM. SCORE	DETAILED SCORE	COMBINED SCORE	RISK RANKING
Deposit A	52	15	28	LOW
Deposit A West	44	15	26	LOW
Deposit B	48	16	28	LOW
Deposit C	49	17	29	LOW
Deposit D	45	17	28	LOW
Deposit E	45	17	28	LOW
Deposit F	43	15	26	LOW
Deposit G	39	15	25	LOW
Deposit H	39	17	27	LOW
Deposit J	44	20	31	MODERATE
Mount Ella East Extension	29	18	25	LOW
Western Hill	51	19	32	MODERATE

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1 INTRODUCTION

Mine Waste Management Pty Ltd (MWM) has prepared this acid and metalliferous drainage (AMD) source hazard risk assessment for Rio Tinto Iron Ore's (RTIO's) West Angelas Mine (West Angelas). This report has been prepared with consideration to RTIO's internal AMD source hazard risk assessment method, including *RTIO's AMD Risk Assessment Summary Sheet* (Appendix A) and *ARD Hazard Score Sheet* (Appendix B). This report was completed in accordance with the proposal J-AU0122-002-P-Rev0 (31 August 2020) provided to RTIO.

1.1 Objectives

The primary objectives of the work completed were:

- To complete an AMD source hazard risk assessment for West Angelas to support a mine closure plan (MCP) for the operations.
- Highlight any AMD at-risk geological materials requiring management during operations and into closure.

1.2 Scope of Work

The scope of work completed to achieve the objectives were:

- Provide a draft table of contents for approval by RTIO personnel.
- Liaised with key RTIO personnel to collect the necessary datasets.
- Reviewed provided data.
- Assessed AMD source hazard risk as per RTIO's standard approach (*RTIO AMD Risk Assessment Summary Sheet*; Appendix A). This included interrogation of West Angelas:
  - o assay database:
  - o environmental geochemical dataset; and
  - o mining models.
- Estimated the potential surface area exposures of black shale to remain on final pit surfaces.
- Updated RTIO's ARD Hazard Score Sheets for West Angelas by incorporating up-to-data assay data, environmental geochemical data, and mine plans.

Prepared a report that includes site background information, identified potential pathways and receptors, assessment results from the assay database, environmental geochemical dataset, and mining model interrogation.

2 BACKGROUND INFORMATION AND SURROUNDING ENVIRONMENT

The following section provides relevant background information for West Angelas.

2.1 Site Location and Description

The West Angelas Operations are located approximately 130 km west of Newman in the Pilbara region of Western Australia. For this assessment, a total of 12 deposits encompassing 37 pits, for which mining models and pit shells were provided, were included in the assessment (Figure 1).

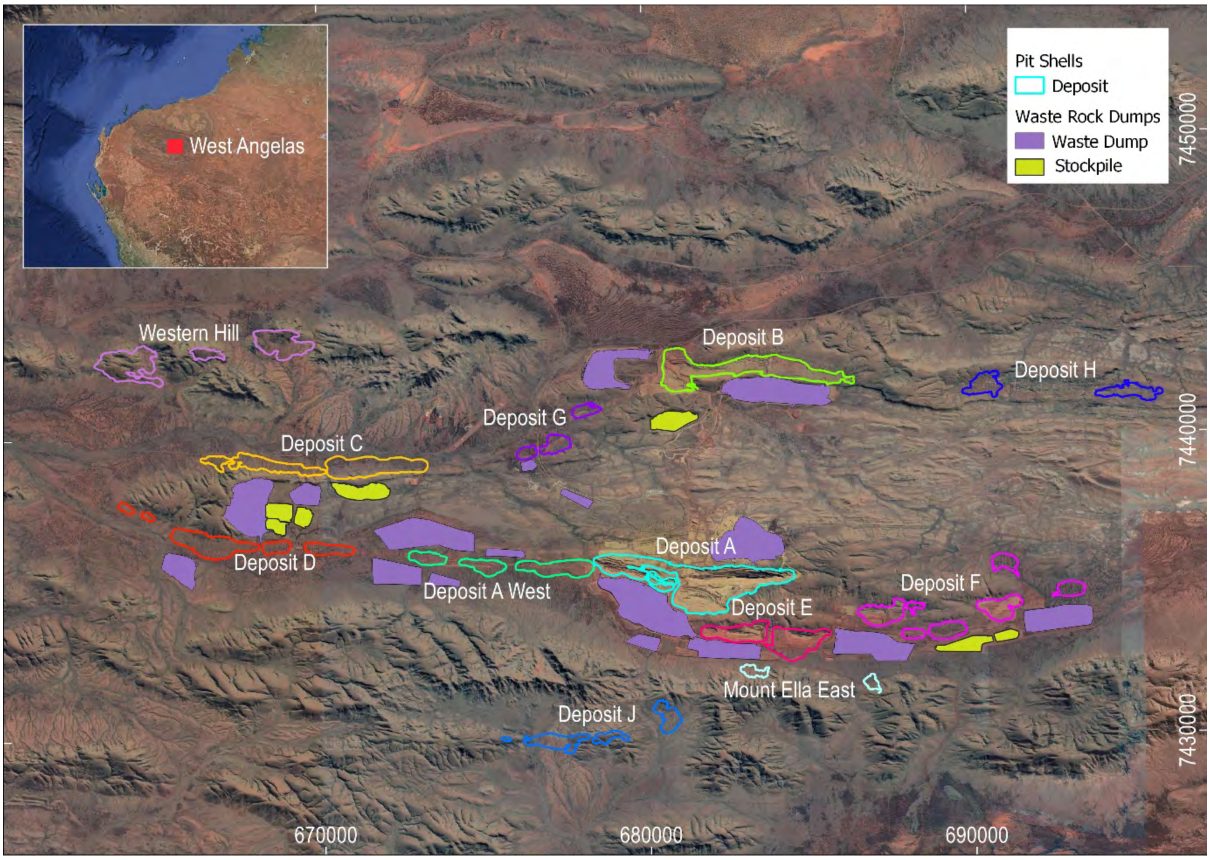

Figure 1: Location of deposits, pit shells, waste rock dumps, and ore stockpiles within the West Angelas mining area.

West Angelas has been mined for iron ore since 2002 by conventional open-cut drilling, blasting, loading and hauling methods. Waste rock is transported to designated waste rock dumps (WRDs) and iron ore is crushed and processed on site before being transported by rail link to the Cape Lambert port for export.

Indicative life of mine material quantities for West Angelas are presented in Table 1. Waste rock quantities are split as above water table (AWT) and below water table (BWT) quantities.

Table 1. Indicative mining material quantities for West Angelas (RTIO, 2018a and mining models).

DEPOSIT	NUMBER OF PITS	PIT MATERIAL (Mt)		
		ORE	$WASTE_{AWT}$	$WASTE_{BWT}$
Deposit A (DepA)	2	758	1,061	114
Deposit A West (DepA West)	3	42	178	3
Deposit B (DepB)	1	178	345	4
Deposit C (DepC)	3	85	122	21
Deposit D (DepD)	5	71	162	45
Deposit E (DepE)	2	69	249	31
Deposit F (DepF)	7	88	213	<1
Deposit G (DepG)	3	32	53	2
Deposit H (DepH)	2	43	25	<1
Deposit J (DepJ)	4	51	65	<1
Mount Ella East (MTEE)	2	16	15	<1
Western Hill (WSTH)	3	182	149	<1

2.2 Regional Geology

Regional geology is characterised by late Archean to Paleoproterozoic sedimentary and volcanic rocks of the Hamersley Basin. The Hamersley Basin consist of three groups including the Fortescue, the Hamersley and the Turee Groups.

The Fortescue Group presents the oldest sequence and is comprised of sedimentary and volcanic rocks. The Hamersley Group overlie the Fortescue Group and contains units of banded iron formations (BIF) that characterise the Hamersley Basin. In addition to containing BIF, the Hammersley Group includes chert, dolomite, siltstone and mudstones. The Turee Group presents the youngest geological sequences of the aforementioned groups and is comprised of sandstone, siltstone, diamictite and dolostone (Geoscience Australia, 2020). Following a series of late Archaean to Proterozoic tectonic events the geological deposits became folded and faulted with dolerite dyke swarms intruding the formations in the region.

A stratigraphic column of the Hammersley Group, which hosts the ore bodies mined at West Angelas, is presented in Figure 2.

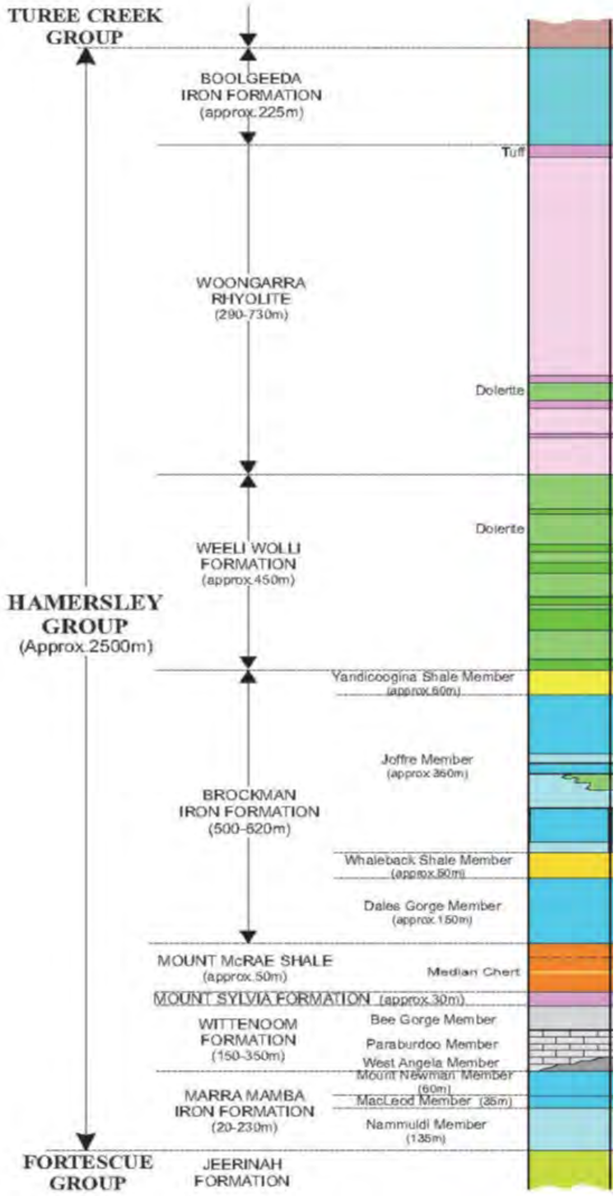

Figure 2: Stratigraphic column for the Hamersley (Green & Borden, 2011).

2.3 Local Geology

The West Angelas project area includes sixteen discrete areas of mineralisation. These deposits lie on the limbs of the east-west trending, west plunging Wonmunna Anticline located in the eastern part of the Ophthalmia Fold Belt. The West Angelas deposits, are comprised mainly of the Marra Mamba Iron Formation with mineralisation occurring in both NE1 and NE2 of the Mt Newman Member. Mineralisation is found in limited quantities in the Macleod Member and the lower portion of the West Angelas Member below AS3. Tertiary Detrital material derived from both the Marra Mamba and Brockman Iron Formations also accumulates throughout the project area.

Material from the MacLeod and Mt Newman Members of the Marra Mamba Iron Formation has been observed to contain pyrite and based on drill hole assay data material from the MacLeod and Nammuldi Members are expected to pose a low to moderate risk of AMD (RTIO 2016).

Deposits A, D, E F, and J are located on the southern limb of the Wonmunna anticline and Deposits B, C, G and H are located along the northern limb (RTIO, 2010). A geological cross section of Deposit A is presented in Figure 3.

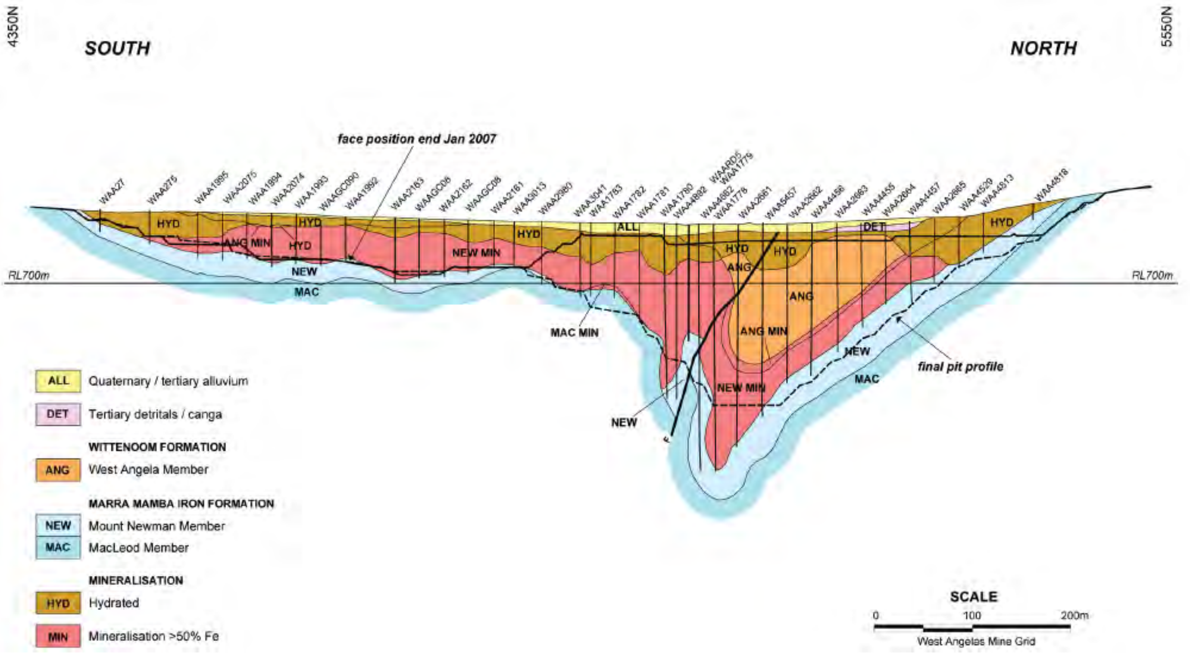

Figure 3: Cross-section of Deposit A – looking west (RTIO, 2010).

2.3.1.1 Deposit A (2 Pits)

Deposit A is situated on the Southern Limb of the Wonmunna anticline. Mineralisation occurs within second order synclines. It has a strike length of 6.5 km and varies in width from 400 m to 1,500 m. Most of the iron enrichment occurs in the upper two thirds of the Mt Newman Member of the Marra Mamba Iron Formation, with minor mineralisation in the lower 6 m of the overlying West Angela Member of the Wittenoom Formation.

2.3.1.2 Deposit A West (3 Pits)

Deposit A West, sits on the southerly limb of the west plunging, east west trending Wonmunna Anticline. It strikes west for approximately 6.4 km from the western extent of A Deposit. Bedding at Deposit A West is typically dipping south at approximately 35 degrees and characterised by minor folding along the strike. Mineralisation in Deposit A West is predominately contained in the Mt Newman Member, mostly in the N2U and N2L layers. Mt Newman Member mineralisation is typically goethite-hematite rich material. Detrital units are typically low grade with thick clay and waste, with minor amounts of mineralised limonitic and mature detrital.

2.3.1.3 Deposit B (1 Pits)

Deposit B is located on the northern limb of the Wonmunna anticline. The strike length is approximately 7.6 kilometres long and is structurally complex, existing as a doubly plunging syncline that is truncated by two shallow dipping thrust faults to the West. High-grade hematite-goethite mineralisation occurs generally in the Mt Newman Member of the Marra Mamba Iron Formation. Lower grade mineralisation occurs occasionally within the lower West Angela Member of the Wittenoom Formation and in the MacLeod Member of the Marra Mamba Formation. Detrital mineralisation is discrete occurring as pods in paleo-channels.

2.3.1.4 Deposit C (3 Pits)

Deposit C is in the eastern part of the Ophthalmia Fold Belt, sitting on the western closure of the northerly limb of the west plunging, east west trending Wonmunna Anticline. The strike length is approximately 8 km. The deposit has two distinct regions, the east is relatively simple, with bedding typically dipping north at approximately 30 degrees and is characterised by minor folding along strike. In the west, bedding becomes strongly folded. Bedding mineralisation in the deposit is typical Marra Mamba sequence, with thick Wittenoom Formation shale, into Mt Newman, McLeod and Nammuldi Members. Mineralisation is typically goethite-hematite rich material that is predominately contained in the Mt Newman member, primarily in the N2U and N2L layers. Hydrated, bedded mineralisation and detritals cover much of the deposit. The detrital units intersected are generally of a lower grade and are pisolitic or limonitic in lithology.

2.3.1.5 Deposit D (5 Pits)

West Angelas Deposit D is in the eastern part of the Ophthalmia Fold Belt and sits on the western closure on the southerly limb of the Wonmunna Anticline. It strikes for approximately 15 km from the nose of the fold to the western most extent of Deposit A. Structurally, Deposit D has two distinct regions. The eastern region is relatively simple, with bedding typically dipping south at approximately 35 degrees and characterised by minor folding along strike. In the west, bedding becomes somewhat more complicated with a synclinal structure interpreted. Bedding in the deposit is typical Marra Mamba sequence, with thick Wittenoom Formation shales, into Mt Newman, McLeod and Nammuldi Member. The Mt Newman Member makes up most of the resource material with the N2U and N2L preferentially mineralised when compared to the NE1. Newman mineralisation is hematite and goethite rich, with variable amounts of hydrated material recorded close to surface.

2.3.1.6 Deposit E (2 Pits)

The West Angelas Deposit E is situated on the southern limb of the west plunging, east-west striking Wonmunna Anticline. The deposit extends approximately 3.5 km in strike, 300 m in width, with varying thickness of 45 m to 60 m. Deposit E is defined by strong folding and faulting of the West Angela Member and the underlying Marra Mamba Iron Formation. Most of the bedded mineralisation occurs within the Mt Newman Member of the Marra Mamba Iron Formation. This mineralisation occurs predominantly within the NE2 unit with occasional low-grade enrichment within the NE1 unit. Minor low grade (>50% to <58% Fe) to high grade (>58% Fe) mineralisation occurs within the West Angela Member.

2.3.1.7 Deposit F (7 Pits)

Deposit F is located on the southern limb of the anticline, approximately 5 km ESE of Deposit A and abuts Deposit E to the east. The orebody has an interrupted geometry of approximately 7.5 km in strike length and up to 1 km in width. Mineralisation is found in the tertiary mature detritals that blanket the paleo-topography, as well as the E-W striking folded Marra Mamba Iron Formation, with economic interest focussed on the mineralised Mt Newman Member. The iron ore resource at Deposit F North is found within tertiary mature detritals that blanket the paleo-topography and in the E-W striking folded Marra Mamba Iron Formation. Mature detritals intermittently overlie a hydrated bedded material that transitions into mineralised Mt Newman and sometimes the Macleod Member. Immature detrital, clay and quaternary alluvial material overlies the mineralised zone with thicknesses from 2 to 80 metres.

2.3.1.8 Deposit G (3 Pits)

The West Angelas deposits lie within the east-west fold belt associated with the Wonmunna Anticline, part of the Archean-Proterozoic Ophthalmia Fold Belt. The bedded mineralisation in the deposit is divided into a northern orebody and a southern orebody that is separated by the northern fault. The Northern orebody is present mostly under cover and is constrained by synclinal structure which gently plunges to the west. The Southern orebody is northerly dipping, getting steeper as you go west. It is localised within a series of antiform and synform structures within an interpreted graben structure which is controlled by two WNW-ESE trending normal faults in the area. Most of the bedded mineralisation occurs within the Mt Newman Member of the Marra Mamba Iron Formation. The Mt Newman Member makes up the majority of the resource material with the NE2 (N2U and N2L) preferentially mineralised when compared to NE1. Enrichment within the Mt Newman Member nearly always extends at least to the base of NE2.

2.3.1.9 Deposit H (2 Pits)

Deposit H is the eastern most West Angelas deposit on the northern half of the Wonmunna Anticline. The 5.5 km long deposit is approximately 3.5 km east of adjacent Deposit B, and 9 km north-east of infrastructure at West Angelas Mine. Geologically Deposit H is similar to the eastern part of Deposit B, with the majority of mineralisation occurring in the limbs of the anticline, with limited mineralisation in the surrounding hills. Structurally Deposit H is an asymmetric doubly plunging syncline of mineralised and unmineralised Marra Mamba Members. Bedded mineralisation is primarily observed in the upper Newman Members, with low grade material also found in the West Angela Shale and MacLeod Members. Detritals are primarily unmineralised.

2.3.1.10 Deposit J (4 Pits)

Deposit J lies on the southern limb of the Wonmunna Anticline. Locally the area contains a series of tight E-W striking parasitic folds. The deposit is divided into an Eastern and Western side by an open colluvium valley. The stratigraphic sequence of the Eastern Hill includes a strongly folded sequence of Mt Sylvia to Joffre. On the Western side of the colluvium valley, the Dales Gorge and McRae Shale outcrop as a series of tight upright to overturned folds. Mineralisation is discontinuous and generally confined to the Dales Gorge Member with isolated patchy mineralisation in the Joffre Member and Whaleback members.

2.3.1.11 Mount Ella East (2 Pits)

Mount Ella East (MTEE) is predominantly a detrital deposit. It is a mostly concealed deposit with some altered Brockman mapped in the hills to the south. Mineralisation occurs in layers of variably pisolitic/magnetic detritals, hematite-rich with siliceous clay matrix, overlying a distinctly limonitic/goethitic detrital sequence. There are some pods of general mature detritals, pisolitic waste, and internal or basal clay.

2.3.1.12 Western Hill (3 Pits)

Western Hill (WSTH) lies along the Northern limb of the Wonmunna Anticline, and consists predominantly of lower Brockman Iron Formation rocks, flanked by secondary detrital deposits.

2.4 Climate

The region is predominantly arid to semi-arid with hot summers and mild winters. The area receives summer rainfall, typically associated with episodic events such as tropical depressions or cyclones.

Average annual rainfall has been reported as 341 mm for rainfall records between 2005 and 2018 (RTIO, 2019). Due to the episodic nature of these rainfall events annual rainfall would be expected to have significant variation from year to year. The annual mean Class A pan evaporation rate is expected to range between 3,200 and 3,600 mm per year based on an average evaporation map produced by the Bureau of Meteorology (BOM, 2006).

2.5 Hydrogeology

The mineralised Mt Newman Member of the Mara Mamba Iron Formation and the Wittenoom Formation (where mineralised or weathering has occurred) has been identified as the main aquifers at West Angelas. The low permeability basal units of the Mara Mamba Iron Formation (consisting of the un-mineralised MacLeod and Nammuldi Members) are in turn considered to form a hydraulic barrier to groundwater flow (RTIO, 2018a). Similarly, the mudstone, basalt and shale of the Jeerinah Formation (Fortescue Group) would be expected to have low permeability generally presenting an aquitard (RPS, 2015).

In general groundwater flow is expected to be from east to west at the majority of mining areas. A dolerite dyke located between Deposit C2 and C3 is considered to present a potential groundwater divide, with groundwater flow at Deposit C3, G and B being from the west to the east (RTIO, 2018a). For deposits where dewatering is required for open pit mining, localised groundwater flow will be expected to be towards the pits and dewatering bores/dewatering sumps.

Based on groundwater quality data from Deposit A, groundwater is circumneutral to slightly alkaline (with reported pH values between 7.4 and 8.2). Salinity levels are low to moderate, with reported total dissolved solids concentrations between 490 and 820 mg/L (RTIO, 2018a).

2.6 Surface Water

The majority of the West Angelas deposits (including Deposits A, A West, B, C, D, E, the four western pits of Deposit F, Deposit G, MTEE and WSTH) are located within the upper reaches of the Turee Creek catchment that forms part of the Ashburton River catchment. Deposit F straddles the Turee Creek and Weeli Wolli catchments, with the three eastern pits of Deposit F located in the upper reaches of the Weeli Wolli Creek catchment that forms part of the Upper Fortescue River catchment (RTIO, 2018a). Deposit H is also located within the catchment of Weeli Wolli Creek, on an adjacent tributary to that draining Deposit F (Pebble Mouse Creek). Deposit J is located within the Angelo River Catchment, a tributary of the Ashburton River (Figure 4; Table 2).

All WRDs and ore stockpiles are within the Turee Creek East catchment, except for the eastern most WRD and eastern most ore stockpile for Deposit F, which are within the Weeli Wooli Creek catchment (Table 2).

Turee Creek East (the eastern branch of the Turee Creek) is the most significant named watercourse in the area and flows generally west across the West Angelas operation. Turee Creek East continues west south-westerly, through the Karijini National Park before merging with Turee Creek that ultimately drains into the Ashburton River (RTIO, 2018a). The confluence of Turee Creek and the Ashburton River is located more than 100 km from the West Angelas deposits.

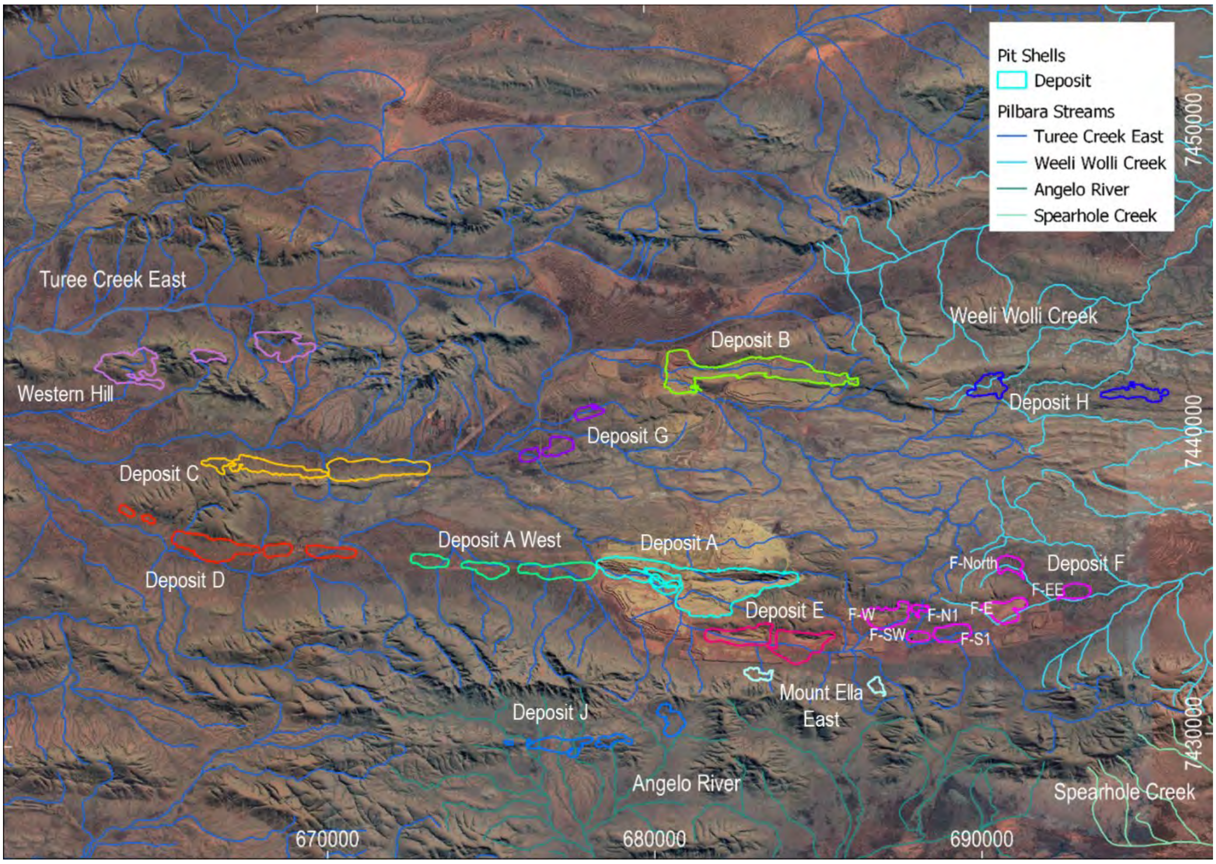

Figure 4. Surface water features which drain the West Angelas deposits.

Table 2. Mine domains per catchment.

DEPOSIT	PITS	WRDS OR STOCKPILES	CATCHMENT
DepA	DEPA	wadf_hydrated_dump_fs_astipped	
DepA West	AW1; AW2; AW3	awest_hyd2_new_cut; awest_hyd1_new_cut; awest_dump_adjusted_cut; awest_lg_new_cut	
DepB	DEPB	depb_wwd_uwf02; depb_lg_uwf01; depb_ewd_uwf09	
DepC	C1; C2; C3	c_fs_wd1_cf; c_fs_lga-lgs_cf; c_fs_hga_cf,	
DepD	D1; D2; D3; D4; D5	d_fs_wd3_cf; d_fs_wd2_cf_v3; d_fs_lgs_cf_v3; d_fs_lga_cf_v3	Turee Creek East
DepE	E-East; E-West	dewd_uwf01; desd_uwf02.1	
DepF	F-W; F-N1; F-SW; F-S1	wadf_west_dump_fs_astipped_opt3_cut; wadf_lg_dump_fs_astipped_cut	
DepG	G1; G2	depg_wd_2_v2; deg_wd_3	
MTEE	MTEE-East; MTEE-West		
WSTH	Pit1; Pit2; Pit3		
DepF	F-North; F-E; F-EE	wadf_east_dump_fs_astipped_cut, swd_uwf15	Weeli Wolli Creek

DEPOSIT	PITS	WRDS OR STOCKPILES	CATCHMENT
DepH	H-East; H-West		Weeli Wolli Creek (via Pebble Mouse Creek)
DepJ	Pit1; Pit2; Pit3; Pit4		Angelo River

Due to evaporation generally far exceeding rainfall, rainfall events below approximately 20 mm tend to be insufficient to generate runoff (RPS, 2015). Consequently, creek flow is ephemeral, diffuse recharge to regional groundwater systems occur at low rates and groundwater recharge occurs predominantly during rainfall runoff events along the main creeks and areas of surface water concentration (such as surface water pools). In order to manage flood flows, stream diversion infrastructure has been constructed at Deposit B and Deposit F. Diversion channels at Deposit C and Deposit D are proposed (RTIO, 2018a).

Surface water flows along Turee Creek East naturally pond behind Mt McRae Shale outcrops that cross the creek, which result in the formation of surface water pools that persist for an extended period of time following flow events in the ephemeral creek (RTIO, 2018a). The closest semi-permanent or permanent surface water feature is Paperbark Spring on Turee Creek East, located more than 60 km from West Angelas (RTIO, 2018b).

Surplus dewatering water, exceeding operational water demand, is discharged to Turee Creek East under Licence L7774/2000. While the licence allows for discharge of up to 6 GL/a, discharge reportedly rarely exceeds 30% of the licenced limit (RTIO, 2018b).

2.7 Water Supply and Groundwater Use

The mine borefield provides water for operations with groundwater licenced to be abstracted under Groundwater Licence GWL 98740. The abstraction licence was issued under the *Rights in Water and Irrigation Act 1914* (the RIWI Act) and includes abstraction for dewatering and water supply purposes. Water uses include dust suppression, water for earthwork and construction purposes, exploration drilling operations, industrial processing and power plant supply. The licence allows for abstraction of up to 5.38 GL/a. The production bores associated with the mine borefield are located within close-proximity and within deposit A, B, E and F (RTIO, 2019).

Potable water for the West Angelas operations is supplied through the Turee B Borefield, located approximately 35 km west of the mine operations. Water is abstracted under groundwater Licence GWL 103136 issued under the RIWI Act, with the licence allowing for the abstraction of approximately 3.1 GL/a of water for potable use (RTIO, 2018b).

2.8 Groundwater Dependant Ecosystems

RTIO has identified potential groundwater dependant ecosystem (GDE) within the alluvial channel of Turee Creek East, located within the Karijini National Park. As presented in Figure 5, the potential GDE is located approximately 7 km to the west and downgradient of Deposit C (RTIO, 2018a).

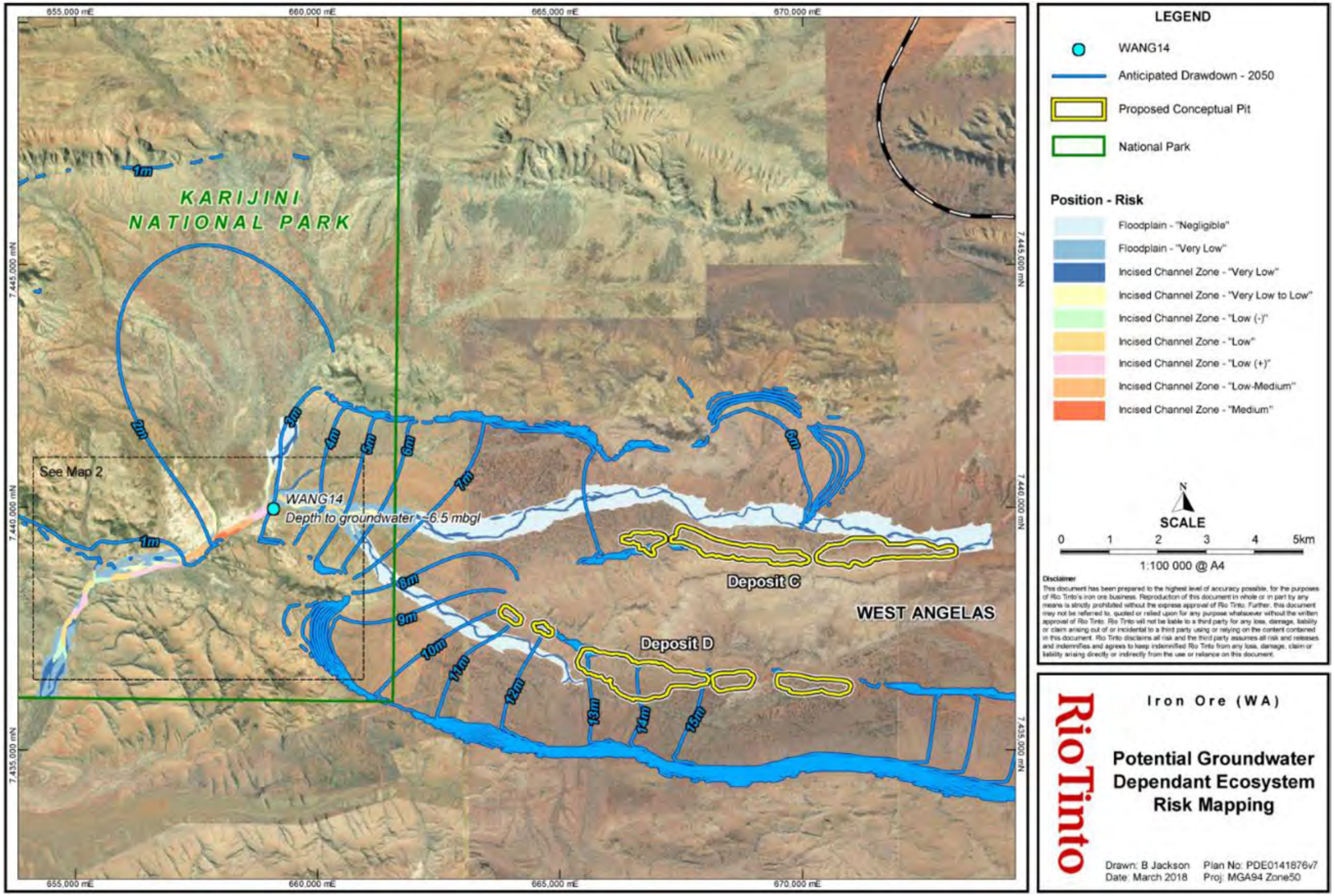

Figure 5. Potential Groundwater Dependent Ecosystem risk mapping (*taken from* RTIO, 2018).

3 AMD SOURCE HAZARD ASSESSMENT METHODS

The following section details the methods employed to assess the AMD source hazard risk for the West Angelas Operations. An introduction to AMD basics and standard methods is provided in Appendix C.

For the purpose of this assessment, AMD is defined in accordance with *Preventing Acid and Metalliferous Drainage – Leading Practice Sustainable Development Program for the Mining Industry* (DITR, 2016), that is, acid and metalliferous drainage (AMD), which includes acidic drainage (acid rock drainage; ARD), pH neutral metalliferous drainage (NMD), and saline drainage (SD), is generally caused by the oxidation of sulfide minerals, or the leaching of secondary sulfide oxidation products. Potential sources of AMD are sulfide minerals within fresh rock (e.g., pyrite, FeS_2) and/or soluble or sparingly soluble secondary acid generating sulfate minerals within partially weathered rock (e.g., melanterite, alunite, jarosite).

The types of AMD, can be defined as:

- Acidic Drainage: A form of AMD, characterised by low pH, elevated trace metal/metalloid concentrations, high sulfate concentrations and high salinity.
- Neutral-Metalliferous Drainage (NMD): A form of AMD characterised by near-neutral pH, elevated metal/metalloid concentrations, and high sulfate salinity.
- Saline Drainage (SD): A form of AMD, characterised by high sulfate salinity but near-neutral pH and low concentrations of metals/metalloids.

3.1 Supplied Data

MWM reviewed the provided data in the context of identifying potential AMD source hazards as well as already identified, by RTIO, pathways and receptors. Table 3 presents the data sources provided.

Table 3. Data sources provided.

DATA SOURCE TYPE	FILE NAME	
Env. Geochem. Database (Nov 2019)	• RTIO- POWER-BI-DATASHEET.xlsx	
Previous Geochemical Characterisation Programs	• Acid Gen. Potential, Selected Core Samples Mt Newman Member BIF (Golder Associates, 1998); • ARD Characterisation of West Angeles Sample (ANSTO, 2007); • Geochem. charact. of Paraburdoo Lens 2, Dales Gorge and West Angelas Samples (SRK, 2008); • Geochem. Charact. of Banded Iron Formation Samples from the West Angelas Mine (SRK, 2010); • Geochemical Assessment of Samples from West Angelas (EGi, 2013); • Geochemical Characterisation of Waste Rock from West Angelas Deposit F (EGi, 2014); and • Greater West Angelas AMD Risk Assessment (RTIO, 2016).	
Groundwater Reports and Supporting Data	• Triennial Aquifer Review 2016 – 2018 (RTIO, 2019); • AHGF_Mapped_Stream_Major.shp; and • AHGF_Mapped_Stream_Minor.shp.	
Closure Plan	• West Angelas Closure Plan (RTIO, 2018)	
Assay Database Exports (Sept 2020)	• DEPA_2020geolSampleDetails.csv; • DEPAW_2020geolSampleDetails.csv; • DEPB_2020geolSampleDetails.csv; • DEPC_2020geolSampleDetails.csv; • DEPD_2020geolSampleDetails.csv; • DEPE_2020geolSampleDetails.csv;	• DEPF_FN_2020geolSampleDetails.csv; • DEPG_2020geolSampleDetails.csv; • DEPH_2020geolSampleDetails.csv; • DEPJ_2020geolSampleDetails.csv; • MTEE_2020geolSampleDetails.csv; and • WSTH_2020geolSampleDetails.csv.
Mining Models	• waapr2_DepA_20161026_004.bmf; • waapr2_DepA_20191025_014.bmf; • waepr_DepB_20200324_007.bmf; • waepr_DepC_20200218_007.bmf; • waepr_DepE_20181016_025.bmf; • waipr_DepAwest_20190715_015.bmf; • waipr_DepD_20200702_003.bmf;	• waipr_DepF_20200123_019.bmf; • waipr_DepG_20191126_032.bmf; • waipr_DepH_20200129_005.bmf; • waipr_DepJ_20180618_011.bmf; • waipr_mtee_20180605_002.bmf; and • waipr_whill_20200113_006.bmf.
Mining Model Exports (clipped to pit shells)	• waapr2_DepA_20161026_004.csv; • waapr2_DepA_20191025_014.csv; • waepr_DepB_20200324_007.csv; • waepr_DepC_20200218_007.csv; • waepr_DepE_20181016_025.csv; • waipr_DepAwest_20190715_015.csv; • waipr_DepD_20200702_003.csv;	• waipr_DepF_20200123_019.csv; • waipr_DepG_20191126_032.csv; • waipr_DepH_20200129_005.csv; • waipr_DepJ_20180618_011.csv; • waipr_mtee_20180605_002.csv; and • waipr_whill_20200113_006.csv.

DATA SOURCE TYPE	FILE NAME	
Pit Shells and Spatial Files	• AW1_CF11_surface.shp; • AW2_CF10_surface.shp; • AW3_CF07_surface.shp; • C1S1_PIT_UF_06_surface.shp; • DEPA_UF21.0.2_osurface.shp; • DEPC_C2_UF03_surface.shp; • DEPC_C3_UF09.1_surface.shp; • DEPD_D2_UF01_surface.shp; • DEPD_D3_UF01_surface.shp; • DEPD_D4_UF01_surface.shp; • DEPD_D5_UF01_D5_surface.shp; • DEPE_UF16.5.3_surface.shp; • DEPE_UF16.5.3_WEST_surface.shp; • DEPG1_REV3_surface.shp; • DEPG2_REV6_surface.shp; • DEPH_EAST_US100_CUT_surface.shp;	• DEPH_WEST_US100_CUT_surface.shp; • DEPJ_SH32_V3_surface.shp; • DFE_UF202C_surface.shp; • DFEE_UF100_surface.shp; • DFN1_CF02.7_surface.shp; • DFS1_UF2.7_surface.shp; • DFSW_UF100_surface.shp; • DFW_CF2.6.5_surface.shp; • FNORTH_UF101_CUT_surface.shp; • MTEE_SH21_V2_surface.shp; • WA_DEPG3_UF05_surface.shp; • WAB_UF17.10_surface.shp; • WAD_D1_UF1._surface.shp; • whill_sh23_awt_surface.shp; and • WPS_CUTBACK_OP7_surface.shp.

3.2 AMD Source Hazard Risk Assessment Method

RTIO has developed an internal process for assessing AMD source hazard risk, which is detailed in *Geochemical Risk Assessment Process for Rio Tinto's Pilbara Iron Ore Mines* (Green and Borden, 2011) and in *Mineral Waste Management in the Pilbara: A Position Statement* (Brown, 2012). A risk-based process is used to identify those rock types which require specific management to mitigate the impacts associated with AMD (RTIO, 2016).

Mineral waste is defined as waste rock and tailings that are exposed or produced during operations. The innate AMD hazard associated with a project area and its type of mineral waste is assessed by the *AMD Hazard Score* (Appendix B). This score takes into account geology/geochemistry, incipient risk, the scale of disturbance, transport pathways, and receiving environments. It should be noted that the AMD Hazard Score used here has been modified specifically for RTIO Pilbara operations to be more reflective of conditions at those sites; for instance, an iron ore operation may score as posing a high AMD hazard relative to other RTIO operations, however it may only pose a moderate AMD hazard relative to a copper operation (RTIO, 2016).

It is recognised that sulfur-related AMD includes acid drainage (elevated sulfate and metals/metalloids at low pH), neutral drainage (elevated sulfate and metals/metalloids at near-neutral pH), and saline drainage (elevated sulfate at near-neutral pH) (INAP, 2010; DITR, 2016). For those rock types associated with sulfides or some sulfate minerals, it is understood that metalliferous drainage requires, at a minimum, low-pH conditions on a microscopic scale as a mechanism to initially solubilise contaminants. If the potentially acid forming (PAF) rock also has sufficient acid neutralising capacity (ANC), the acid generated is subsequently neutralised; however, as a result of this reaction, concentrations of some contaminants (e.g., Zn, As, Ni, and Cd) do not precipitate at near-neutral pH, and remain in solution resulting in poor-quality drainage (DITR, 2016). An analysis of total sulfur in mineral waste will identify the likelihood for that rock type to generate acidity which may lead to poor quality drainage characterised by both low-pH and near-neutral pH (RTIO, 2016).

With regards to sulfur-related AMD as defined above, RTIO characterises mineral waste by undertaking a geochemical assessment based on an analysis of total sulfur assay values. Sulfur trigger values have been pre-determined by RTIO based on the results of static ABA, mineralogy, and kinetic column leach tests which RTIO has completed over multiple decades to identify the potential for certain rock types to generate acidity. These tests have been completed by RTIO using nationally and internationally recognised methods (e.g., Sobek, 1978; Miller, 1997, as referenced in Maest et al. (2005); AMIRA, 2002) (RTIO, 2016).

RTIO has previously concluded that existing ABA data for Pilbara-wide black MCS confirms that a sulfur cut-off of 0.1 wt%S could be adopted as the boundary value to delineate acid forming waste rock and tailings from inert/non-acid forming (NAF) waste rock and tailings. RTIO refers to black MCS with sulfur values generally less than 0.1 wt%S as cold black MCS, where black MCS with sulfur values generally greater than 0.1 wt%S is referred to by RTIO as hot black MCS. The latter may pose a moderate to high acid drainage risk, depending on the actual sulfur (sulfide) content. For other lithologies such as BIF and detrital rock types, a 0.3 wt%S value was determined by RTIO as the most appropriate trigger value (Brown, 2008). The applicability of this higher trigger value is based on low net acid generation derived from sulfate minerals and relatively high ANC (RTIO, 2016). Therefore, sulfur cut-off levels of both 0.1 wt%S and 0.3 wt%S are considered for the purpose of this assessment.

In oxidised waste rock and tailings, sulfur is likely present as either non-acid generating sulfate (gypsum-type sulfur) or acid generating sulfate (alunite-type sulfur). Although alunite-type sulfur through dissolution can generate acidity, it generates less acidity than sulfide-type sulfur per molar equivalent and can be kinetically constrained. However, to account for this potential low-capacity acidity source, a sulfur cut-off value of 0.1 wt%S in oxidised samples is used by RTIO to designate waste rock and tailings as having elevated sulfur.

3.2.1 Acidic Drainage Potential

The key data sources interrogated were the geological assay database, the mining model, the proposed pit shell, and the environmental geochemical dataset. The assay and mining model assessment was restricted to material within the bounds of the proposed pit shell as well as material to remain in the pit wall following mining.

The environmental geochemical dataset was used to assess the geochemical properties of key materials via standard industry AMD characterisation procedures (Appendix C). Acid base accounting (ABA) was conducted to predict the acid generation characteristics of a waste rock material through determination of the acid neutralising capacity (ANC) and the maximum potential acidity (MPA). The environmental geochemical dataset was assessed to facilitate the refinement, where needed, of the current understanding of potential AMD hazard risk of key materials. The environmental geochemical dataset provides detailed results regarding the potential acidity, neutralising potential, metals and metalloids, and salts.

The mining model provides the primary data source for the assessment of potential AMD hazards. Additional mining model parameters assessed include spatial coordinates, waste block tonnages, black shale classifications, proximity to the pre-mining groundwater table, and predicted assay elemental concentrations (e.g., sulfur). Tonnages of waste rock per black shale classification are tabulated and assessed as well as waste tonnages per lithology. Data processing and visualisation software Microsoft PowerBI was used to analyse the datasets and estimate the potential AMD hazard.

The RTIO Mineral Waste Management Plan provides guidelines for assigning a sulfide risk variable in the geological model. In general, sulfide risk is allocated by assigning all mining blocks into one of four categories:

- 0 = no risk;
- 1 = low risk for AMD (oxidised MCS and WS waste should be assigned a 1 at a minimum; referred to as *BS-OXIDE* in mining model);
- 2 = moderate risk for AMD (includes un-oxidised MCS located below water table where sulfur is generally <0.1%;
- 3 = high risk for AMD and spontaneous combustion (un-oxidised MCS located below water table where sulfur is generally >0.1%; *BS-HOT* generally within this category); and
- 4 = potentially high neutralising material (e.g., calcrete).

MWM notes that these classifications were pre-assigned within the supplied mining model due to earlier work completed by RTIO. Validation of the mining model codes has not been completed and MWM assumes all mining model designations are correct and as intended by RTIO.

The management of the MCS during mining, using this profile and the associated sulfide risk variable in the model as a guideline, is outlined in the RTIO Spontaneous Combustion and ARD (SCARD) Management Plan. The SCARD Management Plan provides guidelines for how to mitigate acid drainage and spontaneous combustion in the waste dumps, how to manage gas and dust exposure, and also addresses the spontaneous combustion risk relating to premature blast detonation associated with hot black MCS.

Although the mining model represents the primary source of data, the drillhole assay database, clipped to the proposed pit shell, was interrogated to assess raw assay data. This is completed as a quality control step to assess whether geochemical information pertinent to AMD risk has been captured through extrapolation and interpolation modelling processes.

Estimation of final pit shell surface areas per sulfide risk categories 1, 2, and 3 (oxidised, cold, and hot black shale) was undertaken to assess the potential for exposed hot and cold black MCS surfaces to generate AMD. The method used was as follows:

- Mining models and pit shells were loaded into Maptek's Vulcan software.
- The pit shells strings were triangulated to create a 3D surface.
- A 3D surface showing the intersections of triangulated pit shells and the mining model was created to identify exposures of sulfide risk categories 1, 2, and 3.

3.2.2 Neutral Metalliferous and Saline Drainage Potential

This assessment is designed to identify neutral metalliferous drainage (NMD) and/or saline drainage (SD) characteristics (e.g., high sulfur, high ANC) for key material domains within the proposed pit that are associated with sulfide oxidation. It was completed to highlight lithologies and/or mine domains that may pose a higher NMD/SD risk.

The key data sources interrogated to assess the NMD/SD source hazard potential of waste rock and wall rock at West Angelas were, the geological assay database, the mining model, the proposed pit shell, and the environmental geochemical dataset. The assessment was restricted to material within the bounds of the proposed pit shell as well as material to remain in the pit wall following mining.

High sulfate is a characteristic of both NMD and SD, therefore, in the absence of elevated sulfur, NMD and SD would be unlikely. Sulfur and ANC were interrogated within the environmental geochemical dataset to identify high sulfur material (0.5-1 wt%S and >1 wt%S) with accompanying negative net acid production potential (NAPP) values. The potential for NMD/SD is not limited to high sulfur materials that also contain high ANC materials. For instance, co-disposal of high ANC waste rock with high sulfur waste rock as a management approach can lead to elevated sulfate and/or metal/metalloid concentrations. Therefore, the assessment of NMD and SD was not limited to materials containing both high sulfur and high ANC and was also considered when recommending waste rock disposal options.

The NMD and/or SD hazard potential was also assessed using other environmental geochemical data, specifically sulfur speciation, NAG, and mineralogy.

3.2.3 Elemental Composition

Solid phase total or near-total analysis is achieved in two major steps. In the first step, the sample is digested in a strong acid combination or hot chemical flux. This is followed by analysis of the digestion solution by a technique such as inductively coupled plasma (ICP) or x-ray fluorescence (XRF). Total elemental analysis can be used to identify elements enriched relative to average crustal abundances. However, an enrichment in a specific element does not imply mobility or bioavailability.

Relevant to acidic, neutral metalliferous, and saline drainage potential, an elemental enrichment assessment was completed using the Geochemical Abundance Index (GAI; Förstner et al. 1993). The GAI quantifies an assay result for a particular element in terms of the average crustal abundance of that element. The GAI (based on a log-2 scale) is expressed in 7 integer increments (viz. 0 to 6). A GAI of 0 indicates that the content of the element is less than, or similar to, the average crustal-abundance; a GAI of 3 corresponds to a 12-fold enrichment above the average crustal-abundance; and so forth, up to a GAI of 6 which corresponds to a 96-fold, or greater, enrichment above average crustal abundances. Generally, a GAI of 3 or greater signifies enrichment that warrants further examination. The average-crustal-abundances of the elements for the GAI calculations are based on the values listed in Field Geologists' Manual (AusIMM, 2011) supplemented with data from Bowen (1979) for mean crustal abundance for the elements Al, Ca, Fe, K, Mg, Na, P, S, and Ti.

4 RESULTS

The following section details the results of the AMD Source Hazard Risk Assessment. Existing environmental geochemistry assessment reports, environmental geochemistry data, tabulated assay database results, and key mining model outputs are provided in:

- Appendix A – RTIO AMD Risk Assessment Sheets;
- Appendix B – ARD Hazard Score Sheets;
- Appendix D – Existing Environmental Geochemistry Reports;
- Appendix E – Environmental Geochemistry Data;
- Appendix F – Drillhole Assay Data; and
- Appendix G – Mining Model Data.

4.1 Environmental Geochemical Dataset

A summary of previously completed geochemistry assessments for West Angelas is presented in Table 4. Data from these geochemical testing programs is incorporated into RTIO's environmental geochemistry dataset that has been used for this analysis. Reports are provided in Appendix E.

Table 4: Summary of completed West Angelas geochemical assessments.

PROGRAM	YEAR	PROGRAM SUMMARY
Golder Associates	1998	Acid Generating Potential, Selected Core Samples Mt Newman Member BIF, West Angeles Deposit A Open Pit. 5 samples analysed for paste pH/EC, total sulfur (TS), acid neutralising capacity (ANC), and net acid generating (NAG) testing. A subset of samples analysed for sulfate sulfur (SO_4-S) (*n* = 3).
ANSTO	2007	ARD Characterisation of West Angeles Sample. 1 sample analysed for TS, total carbon (TC), paste pH/EC, ANC, NAG, and intrinsic oxidation rate (IOR).
SRK	2008	Geochem. Charact. of Paraburdoo Lens 2, Dales Gorge, and West Angelas samples. 8 samples analysed for TS, ANC, paste pH/EC, and major element assay. A subset of samples analysed for NAG (*n* = 3), multi-element analysis (*n* = 3), deionised (DI) water leach extraction (1:5 and 1:2) (*n* = 3), acid buffering characteristics curve (ABCC) (*n* = 2).
SRK	2010	Geochem. Charact. of BIF Samples from the West Angelas Mine. 10 samples analysed for paste pH/EC, TS, TC, ANC, NAG, and multi element assay. Subset of samples analysed for SO4-S (*n* = 5), carbon spec. (*n* = 5), DI water leach extraction (*n* = 5), ABCC (*n* = 3), mineralogy (XRD) (*n* = 3), kinetic NAG testing (*n* = 2), and IOR (*n* = 1).
EGi	2013	Geochemical Assessment of Samples from West Angelas. 135 samples analysed for paste pH/EC, TS, and ANC. A subset of samples analysed for NAG testing (*n* = 32), ABCC (*n* = 16), total organic carbon (TOC) (*n* = 16), chromium reducible sulfur (CRS) (*n* = 7), SO4-S (*n* = 7), kinetic NAG (*n* = 5), sequential NAG (*n* = 4), multi-element scans on solids (*n* = 20), and multi-element scans on water extracts (*n* = 20).
EGi	2014	Geochemical Characterisation of Waste Rock from West Angelas Deposit F. 50 samples analysed for paste pH/EC, TS, ANC. A subset of samples analysed for NAG testing (*n* = 6), ABCC (*n* = 4), multi element scans on solids (*n* = 10), and multi-element scans on water extracts (*n* = 10).

4.1.1 Acid Base Accounting Summary

A sample was considered having ABA data if at a minimum, total sulfur (TS) and acid neutralising capacity (ANC) data was available. Therefore, the environmental geochemical dataset for West Angelas includes ABA data for 209 samples (Figure 6) from five deposits (Deposit A, *n = 21*; Deposit A West, *n = 44*; Deposit B, *n = 64*; Deposit D, *n = 27*; Deposit F, *n = 50*; and Not Specified, *n = 3*).

ABA data is available for a total of six stratigraphy groups; Alluvials (ALL), Detritals (DET)[2], Dolerite (DOR), Banded Iron Formation (BIF), Wittenoom Formation (WF) and Marra Mamba Iron Formation (MM). A summary of median ABA results is presented in Table 5 (*n = 209*). Also presented are acid generating classifications. These have been assigned with consideration to:

- TS content. Samples with total sulfur ≤0.05 wt%S are considered NAF;
- the AMIRA Classification System (AMIRA, 2002) for samples with TS, ANC, and NAG pH data available at a minimum; and
- the Price Classification System (Price 2009) for samples with TS and ANC data at a minimum.

The ranges of total sulfur, ANC, NAPP, and neutralisation potential ratio (NPR) per lithology are presented in Figure 7. Median total sulfur values are low[3] (<0.1 wt%S) for all stratigraphy groups. It should be noted that the sample population with ABA data is naturally skewed towards higher sulfur samples as higher sulfur samples are more likely to be acid generating, and therefore have been given higher priority in the ABA sample selection process. This can be observed by comparing the median values within Table 5 to sulfur data presented in following sections.

Most median paste pH values are circum-neutral ($pH_{1:2}$ 7-8) and fresh ($EC_{1:2}$ <400 µS/cm). The exception is a slightly alkaline paste pH for the BIF sample and a slightly saline median EC value for the ALL stratigraphy. Median maximum potential acidity (MPA) values are low (≤1.8 kg H_2SO_4/t) for all stratigraphies.

ANC is generally low with median values ≤3 kg H_2SO_4/t for most stratigraphies and low-moderate (7 kg H_2SO_4/t) for the ALL and BIF samples. Acid buffering characteristic curves (ABCC) are available for 25 samples (Table E4 and Figure E2, Appendix E). The quantity of acid a sample can buffer to pH 4.5 during the ABCC test, referred to as effective neutralising capacity ($ENC_{4.5}$), can be used in comparison with the standard titrated ANC value to give a fairer indication of the proportion of readily available ANC. Of the 25 samples with ABCC curves, 23 have estimated ENC values (Table 6).[4] ABCC results suggest that ANC is readily availability in the ALL, DET, and WF samples ($ENC_{4.5}$ >75% of titrated ANC) tested. Less than half of the measured ANC within the single DOR sample submitted for ABCC testing is readily available (Figure 8). Variable ANC availability was observed in the 15 MM samples tested ($ENC_{4.5}$ 18-153% of titrated ANC) suggesting an inconsistency in the presence of fast reacting carbonate ANC.

Median NAPP values are negative for all stratigraphy groups. Reflective of Pilbara iron ore deposits with low sulfur and low ANC, median NAPP values are only slightly negative (-6 to -0.5 kg H_2SO_4/t).

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[2] No calcrete (DET-CAL) or lignite (DET-LIG) samples were identified in the West Angelas env. geochemical dataset.

3 To relatively assess results within the environ. geochemical dataset, for the purpose of this assessment, TS is considered low if less than 0.1wt%S, low-moderate if between 0.1-0.3 wt%S, moderate if between 0.3-0.5 wt%S, and high if ≥0.5 wt%S.

4 ENC4.5 values are not available for all 25 samples with ABCC data. Only samples with either ABCC raw data or high resolution ABCC curves facilitated $ENC_{4.5}$ estimation.

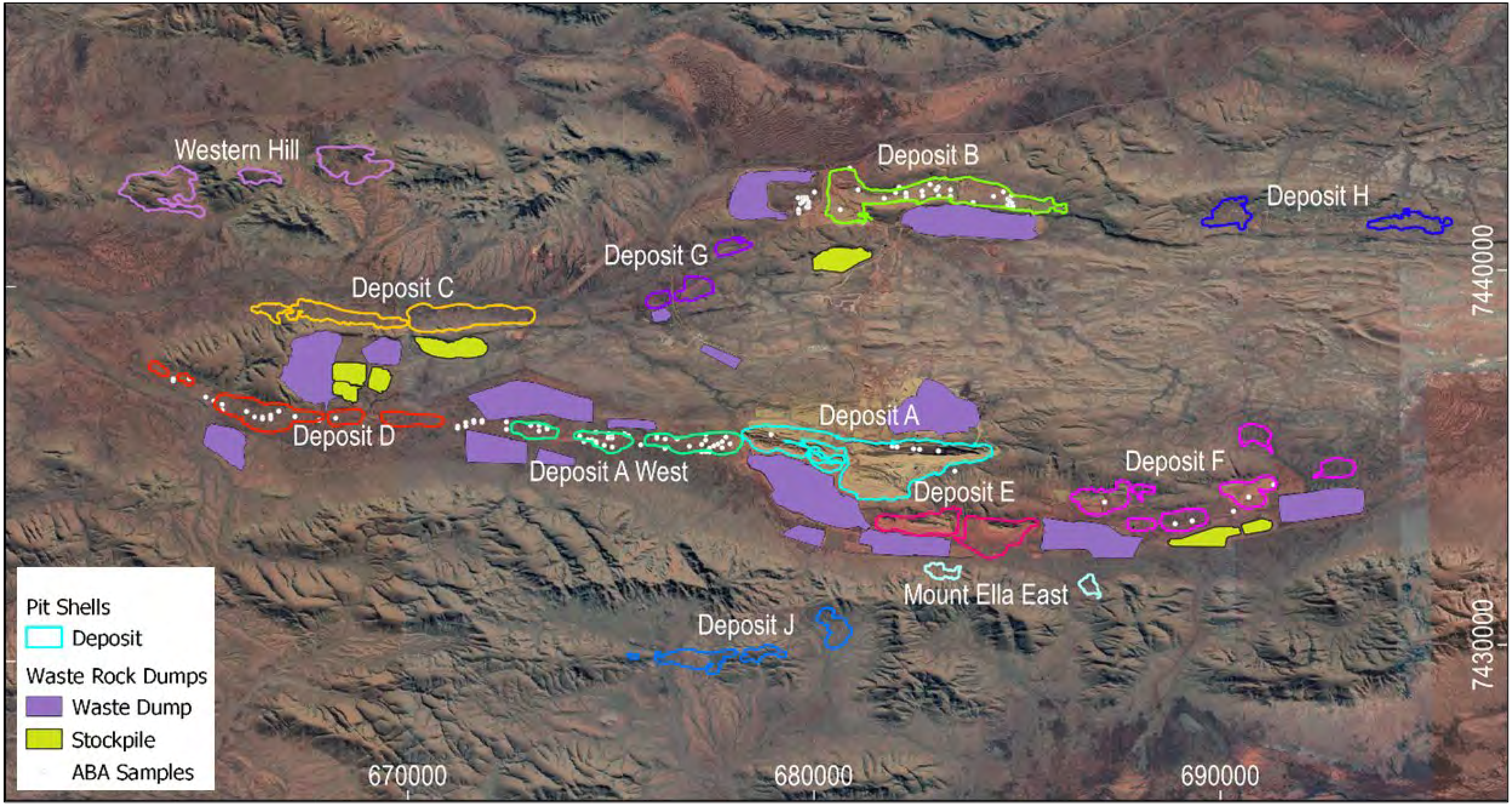

Figure 6. Location of ABA samples used in assessment for West Angelas.

Table 5: Median ABA results for stratigraphic units sampled from West Angelas.

		PARAMETER	$pH_{1:2}$	$EC_{1:2}$	TS	ANC	MPA	NAPP	NPR	ACID GENERATING CLASSIFICATIONS			
		UNITS	-	µS/cm	wt%S	kg H_2SO_4/t	kg H_2SO_4/t	kg H_2SO_4/t	-	NAF	UC-NAF	UC-PAF	PAF
STRAT	*n* = 209	LOR	0.1	10	0.01	0.5	0.5	0.5	0.1	*n* = 175	*n* = 15	*n* = 0	*n* = 19
ALL	3		7.3	559	0.05	6.9	1.5	-6.0	7.5	3	-	-	-
DET[1]	52		7.4	182	0.03	3.0	0.9	-1.5	2.6	46	6	-	-
DOR	5		7.8	154	0.04	1.8	1.2	-1.1	2.8	4	-	-	1
WF	53		7.3	174	0.03	1.7	0.9	-0.4	1.3	35	5	-	13
BIF[2]	1		8.4	56	0.06	6.5	1.8	-4.7	3.5	1	-	-	-
MM	95		7.6	155	0.03	1.7	0.9	-0.8	2.0	86	4	-	5

[1]No calcrete (DET-CAL) or lignite (DET-LIG) samples were identified in the env. geochemical dataset. [2]Only one BIF sample, therefore data presented represents actual data for this sample.

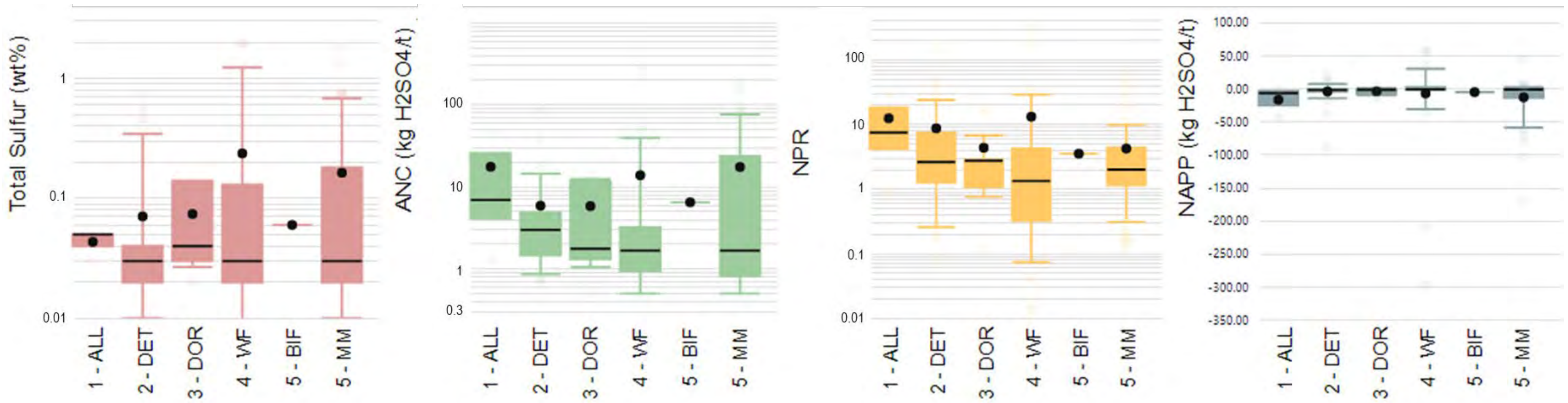

Figure 7: Total sulfur, ANC, NPR, and NAPP box plots. Total sample numbers per stratigraphy group are presented in Table 5. Boxes represent values between the 25th and 75th percentiles. Whiskers represent 5th and 95th percentiles. Outliers represent values <5th percentile or >95th percentile.

Table 6. Comparison between ANC and $ENC_{4.5}$ for West Angelas samples with ABCC data.

SAMPLE ID	DEPOSIT	STRAT	ANC (kg H_2SO_4/t)	ENC4.5 (kg H_2SO_4/t)	% READILY AVAILABLE ANC
FNC563	Deposit B	ALL	44.7	36	81%
FQR817	Deposit A West	DET	38.0	40	105%
FRD062	Deposit A West	DET	89.4	96	107%
EYT782	Deposit B	DET	9.9	8	81%
FRM221	Deposit D	DET	11.9	11	92%
FRM113	Deposit D	DOR	11.8	5	42%
ECP052	Deposit A	MM-MAC	82.1	94	114%
ECP165	Deposit A	MM-MAC	101.0	83	82%
FNC467	Deposit B	MM-MAC	39.8	34	85%
FOG111	Deposit B	MM-NAM	144.0	65	45%
FOH416	Deposit B	MM-MAC	19.5	13	67%
FOH824	Deposit B	MM-MAC	25.6	6	21%
FOH843	Deposit B	MM-MAC	80.0	37	46%
FOH852	Deposit B	MM-NAM	11.1	17	153%
FOH853	Deposit B	MM-NAM	44.1	53	120%
FOH858	Deposit B	MM-NAM	34.9	33	95%
FWP080	Deposit F	MM-MAC	30.0	14	47%
FWP092	Deposit F	MM-MAC	21.9	4	18%
FWP156	Deposit F	MM-NEW	49.8	62	125%
FYN843	Deposit F	MM-NEW	50.4	53	105%
ECP355	West Angelas	MM-MAC	55.3	16	29%
FOM940	Deposit D	WF	297.5	261	88%
FRI220	Deposit D	WF	27.3	21	77%

[1]*Calculated using $ENC_{4.5}$ of 0.5 kg H_2SO_4/t.*

MM-NEW = Mt Newman Member; MM-MAC = Macleod Member; MM-NAM = Nammuldi Member.

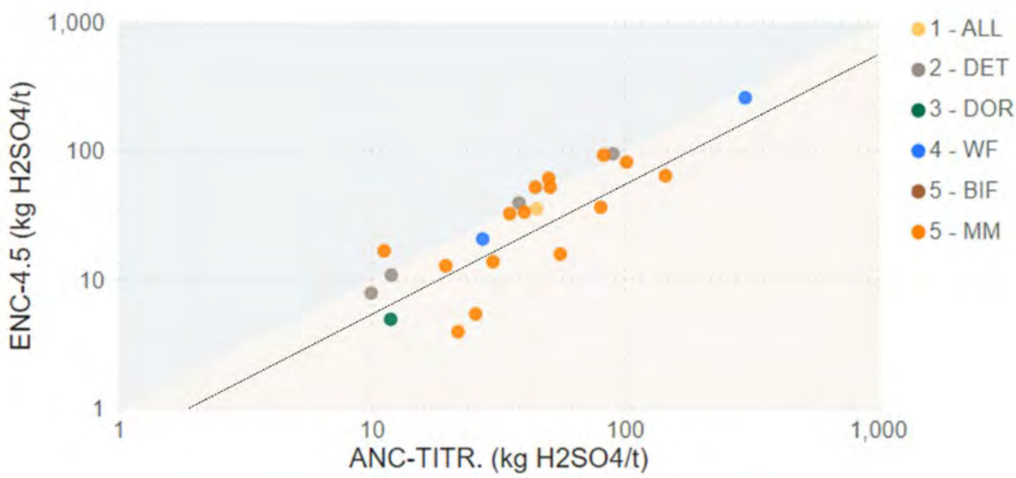

Figure 8. Titrated ANC vs $ENC_{4.5}$. Samples below the black dashed line all have <50% readily available ANC.

Within the West Angelas environmental geochemical dataset, the WF stratigraphy group represents the greatest source of potentially acid forming (PAF) samples (n_{PAF} = 13). These samples were collected from Deposit A (*n* = 5), Deposit A West (*n* = 1), and Deposit B (*n* = 7). The MM stratigraphy group represents the next greatest source (n_{PAF} = 5) with one sample collected from Deposit A, three samples collected from Deposit B, and one from Deposit F. The only other sample classified as PAF was a Deposit A West DOR sample.

Key findings for each lithology are as follows:

- ALL: The three Deposit B samples are classified non-acid forming (NAF) due to low TS (≤0.05 wt%S) and low to moderate ANC (1.3-45 kg H_2SO_4/t). Although one sample produced a slightly positive NAPP (0.3 kg H_2SO_4/t) and a neutralisation potential ratio (NPR) of <1, this is due to low TS (0.5 wt%S) and low ANC (1.3 kg H_2SO_4/t) and is unlikely to generate acidic drainage. Paste extracts are circum-neutral ($pH_{1:2}$ 6.7-7.4) with low to moderate salinity ($EC_{1:2}$ 346-976 µS/cm).
- DET: Paste extracts are slightly acidic to slightly alkaline ($pH_{1:2}$ 6.3-8.3) with low to moderate salinity ($EC_{1:2}$ 24-1,150 µS/cm). The majority (*n* =46) of DET samples are classified non-acid forming (NAF) due to low TS (≤0.07 wt%S) and low to high ANC (0.7-89 kg H_2SO_4/t). Although five samples produced slightly positive NAPP values (0.3-1.1 kg H_2SO_4/t) and NPR's of <1, these low TS and low ANC samples unlikely to generate acidic drainage. Six samples from Deposit A West, Deposit D, and Deposit F are classified as UC-NAF due to conflicting positive NAPP values (0.2-22 kg H_2SO_4/t) and NAG pH values >4.5. These clay, pisolite, mature, and immature detrital samples have low to high TS (0.11-0.77 wt%S), low ANC (≤3.4 kg H_2SO_4/t), slightly acidic NAG pH values (NAG pH 5.4-6), and low NAG_7 capacity (4.2-6.3 kg H_2SO_4/t).
- DOR: One Deposit A West sample is classified PAF due to a positive NAPP of 3.8 kg H_2SO_4/t and acidic NAG pH of 3.2. This PAF sample has low-moderate TS (0.14 wt%S) and negligent ANC (<1 kg H_2SO_4/t) and could be considered low capacity PAF. The remaining four samples from Deposit A West and Deposit D are classified NAF due to negative NAPP values with low to low-moderate TS (0.02-0.14 wt%S). Paste extracts are circum-neutral ($pH_{1:2}$ 7.1-7.9) with low salinity ($EC_{1:2}$ 139-176 µS/cm).

- WF: Paste extracts are acidic to slightly alkaline ($pH_{1:2}$ 5.1-8.2) with low to moderate salinity ($EC_{1:2}$ 16-981 µS/cm). The majority (*n* =35) of WF samples are classified NAF due to low TS (≤0.05 wt%S) and low to high ANC (<1-297 kg H_2SO_4/t). Although three samples produced slightly positive NAPP values (0.1-0.6 kg H_2SO_4/t) and NPR's of <1, these low TS and low ANC samples are unlikely to generate acidic drainage. Two Deposit A samples are classified as UC-NAF due to high TS (0.92-1.25 wt%S), moderate ANC (26-32 kg H_2SO_4/t), and NPR's close to 1 (0.7-1.1). Three samples from Deposit B and Deposit D are classified as UC-NAF due to conflicting positive NAPP values (0.9-59 kg H_2SO_4/t) and NAG pH values >4.5. These Deposit B and Deposit D UC-NAF samples have low to high TS (0.09-2 wt%S), low ANC (≤1.9 kg H_2SO_4/t), slightly acidic to circum-neutral NAG pH values (NAG pH 5.3-7.2), and low NAG_7 capacity (<0.5-1.1 kg H_2SO_4/t). Five Deposit A samples, collected during blasthole drilling over a 5 m interval due to observed pyrite, are classified as PAF due to moderate to high TS (0.42-1.9 wt%S), positive NAPP values (8.7-57 kg H_2SO_4/t), and acidic NAG pH values (NAG pH 2-2.2) for two samples submitted for NAG testing. Three of these Deposit A samples submitted for sulfate analysis suggests sulfur is sulfidic (97-99% of TS). Eight samples from Deposit A West (*n* = 1) and Deposit B (*n* = 7) are classified PAF due to positive NAPP values (2.6-37 kg H_2SO_4/t) and acidic NAG pH values (NAG pH 2.5-3.9). The Deposit A West PAF sample has high TS (1.2 wt%S) and generated high NAG acidity (NAG_7 34 kg H_2SO_4/t). The seven Deposit B samples have low-moderate TS (0.0.1-0.17 wt%S), negligent ANC (<1 kg H_2SO_4/t), and generated low to low-moderate NAG acidity (NAG_7 3.1-7.4 kg H_2SO_4/t).
- BIF: The single BIF sample was classified as NAF due to low TS (0.6 wt%S), a negative NAPP value. And NPR >2. ANC for this sample was 6.4 kg H_2SO_4/t and it generated a slightly alkaline paste pH ($pH_{1:2}$ 8.4) with low salinity (56 µS/cm).
- MM: Paste extracts are slightly acidic to alkaline ($pH_{1:2}$ 6.1-9) with low to slightly moderate salinity ($EC_{1:2}$ 35-568 µS/cm). Measured ANC for the MM stratigraphy group is variable (<1-180 kg H_2SO_4/t). The majority (*n* =86) of MM samples are classified NAF, largely due to negative NAPP values, although 14 NAF samples have slightly positive NAPP values due to low TS (≤0.05 wt%S) and low ANC (≤1.1 kg H_2SO_4/t). TS for NAF samples is low to high (0.01-1.35 wt%S). All samples with TS >0.1 wt%S have been submitted for NAG testing and generated NAG pH values >4.5. Four samples from Deposit A West, Deposit B, and Deposit D are classified as UC-NAF due to conflicting positive NAPP values (1.1-8.7 kg H_2SO_4/t) and NAG pH values >4.5. These UC-NAF samples have low to moderate TS (0.07-0.4 wt%S), negligible to moderate ANC (<1-11 kg H_2SO_4/t), slightly acidic to circumneutral NAG pH values (NAG pH 5.3-7.3), and low NAG_7 capacity (4-5.7 kg H_2SO_4/t). Five samples from Deposit A (*n* = 1), Deposit B (*n* = 3), and Deposit F (*n* = 1) are classified PAF due to positive NAPP values (2.3-45 kg H_2SO_4/t) and acidic NAG pH values (NAG pH 2.6-4.3). It should be noted the Deposit F PAF sample was from 188-190 m below ground level and is from below the expected base of the proposed pits for Deposit F (130-150 m below ground level).

4.1.2 Kinetic Testing Summary

RTIO completed kinetic testing of one West Angelas shale sample (WF stratigraphy group) (ANSTO, 2007) and one Deposit A MM sample (SRK, 2010). Measured IOR values were 18.4^{E-11} and $1.6E^{-10}$ kg O_2/kg/sec for the WF and MM samples, respectively. ANSTO noted that although the low TS

(0.06 wt%S) WF sample was classified as NAF, the material may have been suitable for use as an oxygen consuming layer to surround PAF material within a waste rock dump. Although the high sulfur (0.76 wt%S) MM sample could also be considered for similar use due to its NAF classification and faster IOR, oxidation of this higher sulfide material may release sulfate and metals/metalloids as neutral metalliferous (NMD) or saline drainage (SD).

Kinetic NAG tests were completed in 2008 on two WF Deposit A samples (1 PAF and 1 NAF) (SRK, 2008), in 2010 on two MM Deposit A NAF samples (SRK, 2010), and in 2013 on four Deposit B PAF samples, two WF and two MM samples, and one WF Deposit A West PAF sample (EGi, 2013). Kinetic NAG data and figures are provided in Table E3 (Appendix E).

The kinetic NAG results for the two WF Deposit A samples suggest that the onset of acidification would be delayed (SRK, 2008). The kinetic NAG results for the two MM Deposit A NAF samples suggest that the sulfide minerals are relative slow reacting, and the rate of neutralisation may be sufficient to neutralise any acidity concurrently produced (SRK, 2010).

The kinetic NAG test results on the five PAF samples from Deposit A West and Deposit B can be summarised from the EGi report (2013) as follows:

- The results for WF Deposit B sample FRK244 suggest that materials represented by this sample may have a short lag period of months to a year before onset of acid conditions. Sulfides within this low-moderate TS (0.17 wt%S) sample are likely slow reacting.
- As pH remained between 4-4.5 for the duration of the test for WF Deposit B sample FTI114, materials represented by this sample may have a long lag period.
- The results for MM Deposit B sample FRK393 suggest that materials represented by this sample may have a short lag period of months to a year before onset of acid conditions.
- The quick pH drop to <4 at the beginning of the test for WF Deposit A West sample FQR860 suggests that materials represented by this sample may have a short lag period of weeks to months before onset of acid conditions. Sulfides within this high TS (1.22 wt%S) sample are likely moderately reactive.
- As pH remained between 4-4.5 for the duration of the test for MM Deposit B sample FQR860, materials represented by this sample would likely have a long lag period of two or more years. Sulfides within this high TS (0.73 wt%S) sample are likely slow reacting.

No long-term column leach testing has been completed on waste rock from West Angelas.

4.2 Acidic Drainage Potential

This section presents results of sulfur analysis within the assay database and mining models.

4.2.1 Sulfur Assay Analysis

An analysis of sulfur values in drillhole data extracted from the RTIO database in September 2020 was undertaken to identify rock types that require further investigation related to acid-forming potential (and the related impact of metalliferous drainage). An outcome of this analysis included determining the likelihood that a particular rock type would pose an acid drainage risk (via total sulfur analysis) and whether it was enriched in any elements relative to average crustal abundance. For the purpose of this assessment, samples were grouped into rock types based on their “geozone”. It should be noted that the following factors may also influence the interpretations within this report:

- Total sulfur was measured using XRF rather than LECO. The XRF method may underestimate the total sulfur concentration when sulfur values are high.
- Exported sulfur values recorded as “-99’ or “0” indicate that sulfur was not assayed and samples with these values were excluded from this analysis.
- Negative assay results represent concentrations below the detection limit (excluding -99 values, which were considered as representing no data) and were considered half the limit of detection. This approach is conservative, as the true values for these assays may be below the halved detection limit value.
- CLA, CAL, DI, and DM were grouped into a DET undifferentiated group. DG1-DG3 were grouped into a DG undifferentiated group. J1-J5 were grouped into a JOF undifferentiated group. WS1 and WS2 were grouped into a WS undifferentiated group.
- Some rock types have been grouped into the OTHER rock type category due to being represented in the assay database by very few samples (n < 500; or <0.05% of total assay samples, excluding samples from the Joffre Member). Rock types grouped into the OTHER category were CA, CAV, FILL, FOR, LIG, ROD, SID and WW.
- A substantial quantity of early assay results from Deposit A do not have assigned geozone codes (or strand codes) in the assay database exports provided. However, the 2016 AMD risk assessment has assigned these samples to key lithologies and therefore, this assessment references the previous AMD risk assessment’s results for Deposit A (RTIO, 2016).
- Samples were separated into waste and ore material type based on assigned geozone codes. Geozone codes less than 10 or ending in 0 and 1 were classified as waste. Geozone codes ending in 2 or 6 and geozone 18 were classified as ore. Geozones ending with 5 were classified as hydrated ore.
- The drillhole database for the deposits is extensive but there are less assay results on waste material. Information on all waste material that has or will be mined in the future may be missing due to the focus on characterisation of the orebody rather than the waste material.
- Limited information exists related to the neutralising potential of the drillhole samples; the presumed risk of acid drainage may be over-stated if the available neutralising capacity of that rock type is unaccounted for.

Table 7 provides a summary of the sulfur assay data available for the entire West Angelas project area. Figure 9 presents borehole locations and Figure 10 highlights those boreholes with sulfur greater than 0.3 wt%S or between 0.1-0.3 wt%S. Table 8 provides a summary of the assay dataset clipped to within the pit shells, as provided by RTIO, with Figure 11 presenting the locations of these in-pit samples. As presented in Table 8, the TS content for the West Angelas in-pit material is low. Only 2.8% of all in-pit samples have TS greater than 0.1 wt%S and a minor proportion (0.2% of all in-pit samples) have TS greater than 0.3 wt%S. Table F1 (Appendix F) presents in-pit TS assay summary data per deposit. Figure F1 (Appendix F) presents the relative proportions of assay samples per stratigraphy with TS greater than 0.1 wt%S, for each of the deposits.

Table 7: West Angelas project area sulfur assay summary.

ROCK TYPE	TOTAL S ASSAY SAMPLES	S >0.1 wt%S		S >0.3 wt%S		AVERAGE S wt%S	
	n	*n*	% of total *n*	*n*	% of total *n*	of n_{TOT}	of $n_{S>0.1wt\%S}$
ALL	6,847	209	3.1%	19	0.3%	0.034	0.191
DET-CLA	71,153	355	0.5%	80	0.1%	0.019	0.287
DET-CAL	2,916	10	0.3%			0.019	0.156
DET	63,237	952	1.5%	174	0.3%	0.026	0.245
DOR	2,942	84	2.9%	20	0.7%	0.027	0.288
WS	628	167	26.6%	36	5.7%	0.108	0.289
DG	17,460	675	3.9%	75	0.4%	0.033	0.221
FWZ	4,170	193	4.6%	11	0.3%	0.034	0.176
MCS	6,217	373	6.0%	176	2.8%	0.114	1.529
MTS	1,023	39	3.8%	18	1.8%	0.068	1.181
WF	12,003	535	4.5%	169	1.4%	0.035	0.388
ANG	60,159	2,767	4.6%	202	0.3%	0.028	0.180
NEW	69,348	449	0.6%	31	<0.1%	0.011	0.161
MAC	27,240	1,806	6.6%	243	0.9%	0.036	0.200
NAM	6,925	401	5.8%	90	1.3%	0.035	0.251
DET-ORE	30,258	1,294	4.3%	155	0.5%	0.034	0.192
WS-HYD	461	149	32.3%	12	2.6%	0.092	0.180
DG-ORE	20,286	913	4.5%	87	0.4%	0.036	0.207
DG-HYD	6,216	763	12.3%	40	0.6%	0.058	0.170
FWZ-ORE	4,999	349	7.0%	8	0.2%	0.042	0.142
WF-ORE	1,215					0.009	
ANG-ORE	16,377	240	1.5%			0.018	0.129
ANG-HYD	12,546	428	3.4%	38	0.3%	0.031	0.193
NEW-ORE	74,268	730	1.0%	40	0.1%	0.016	0.157
MAC-ORE	7,938	1,154	14.5%	15	0.2%	0.048	0.146
NAM-ORE	765	63	8.2%	3	0.4%	0.044	0.155
MM-HYD	36,400	1,856	5.1%	118	0.3%	0.041	0.169
OTHER	911	154	16.9%	41	4.5%	0.098	0.432
UNKNOWN	302,098	7,940	2.6%	682	0.2%	0.024	0.195
TOTALS	867,006	25,048	2.9%	2,583	0.3%	0.026	0.218

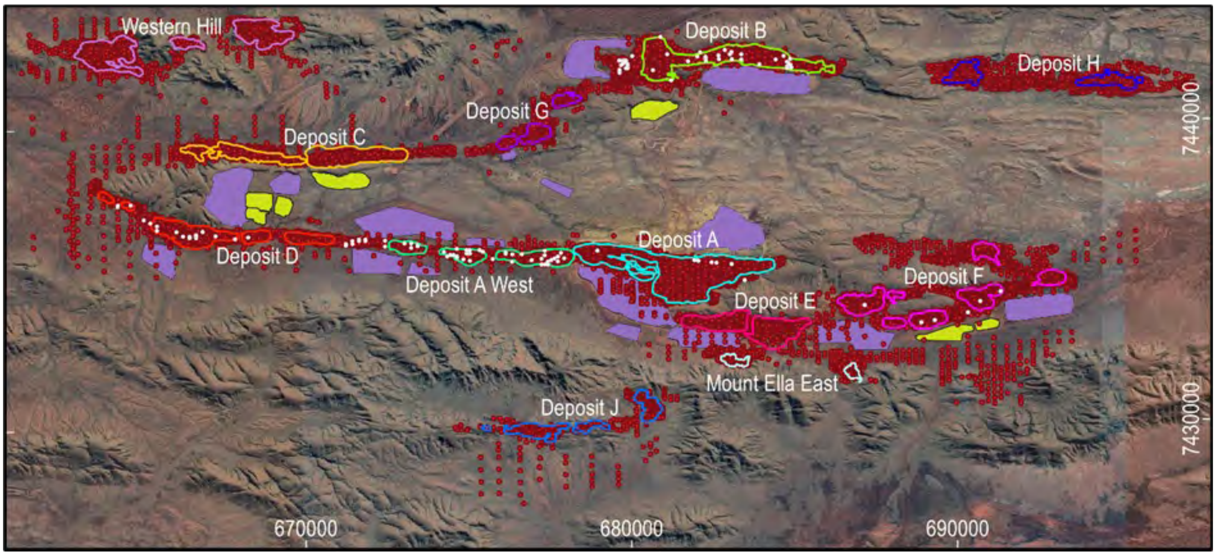

Figure 9. West Angelas assay samples (red solid circles) and ABA samples (white solid circles).

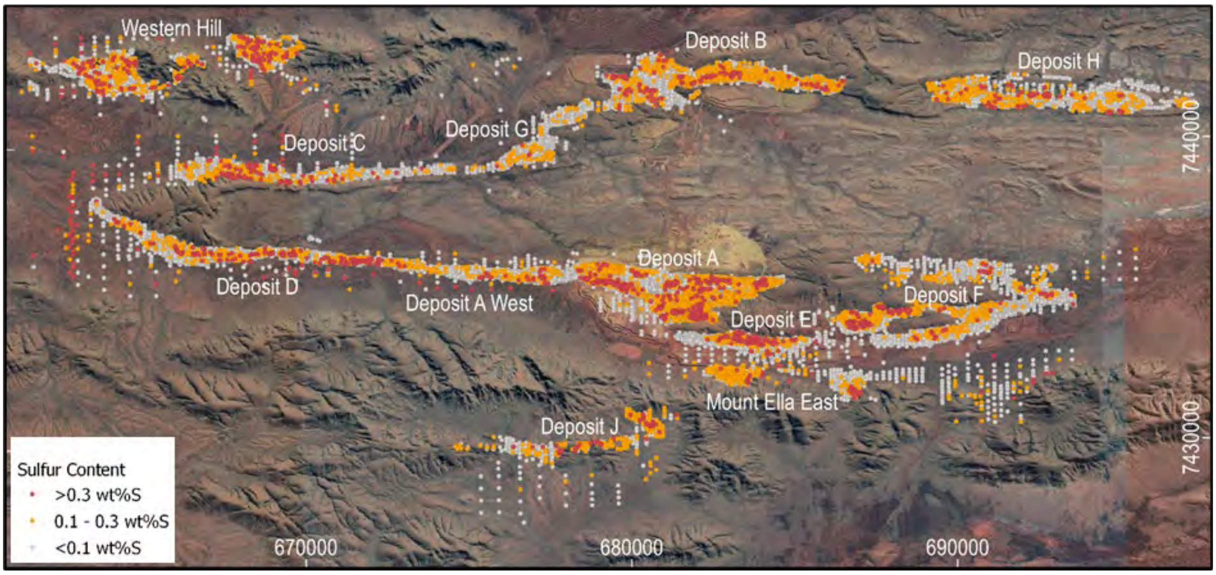

Figure 10. Location of assay samples with <0.1 wt%S, 0.1-0.3 wt%S, and >0.3 wt%S.

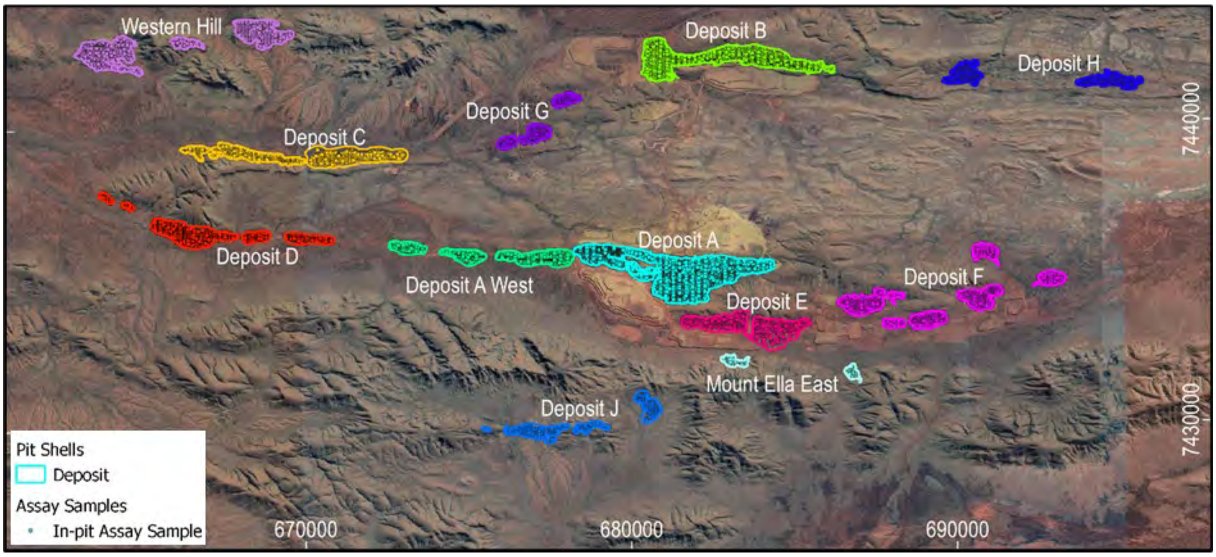

Figure 11: West Angelas assay samples (solid circles) within final pit shells.

Table 8: In-pit West Angelas sulfur assay summary.

ROCK TYPES	TOTAL S ASSAY SAMPLES	S >0.1 wt%S		S >0.3 wt%S		AVERAGE S wt%S	
	n	*n*	% of total *n*	*n*	% of total *n*	of n_{TOT}	of $n_{S>0.1wt\%S}$
ALL	5,208	193	3.7%	17	0.3%	0.036	0.191
CAV	4					0.048	
DET-CAL	533	1	0.2%			0.019	0.171
DET-CLA	37,548	106	0.3%	7	<0.1%	0.018	0.233
DET	31,662	414	1.3%	51	0.2%	0.025	0.199
DOR	820	6	0.7%	2	0.2%	0.020	0.368
WS	385	104	27.0%	27	7.0%	0.116	0.322
DG	3,398	194	5.7%	22	0.6%	0.041	0.188
FWZ	250	25	10.0%			0.043	0.142
MCS	150	12	8.0%	1	0.7%	0.042	0.178
MTS	3					0.045	
WF	1,139	7	0.6%	2	0.2%	0.021	0.607
ANG	25,852	2,277	8.8%	95	0.4%	0.041	0.161
NEW	11,542	107	0.9%	1	<0.1%	0.014	0.134
MAC	2,650	149	5.6%	21	0.8%	0.038	0.228
NAM	149					0.012	
FOR	1					0.026	
FILL	15					0.028	
DET-ORE	16,844	797	4.7%	110	0.7%	0.036	0.198
WS-ORE	47	17	36.2%			0.076	0.148
WS-HYD	245	68	27.8%	8	3.3%	0.093	0.198
DG-ORE	8,126	419	5.2%	35	0.4%	0.039	0.204
DG-HYD	3,005	354	11.8%	21	0.7%	0.058	0.173
FWZ-ORE	513	53	10.3%	2	0.4%	0.047	0.160
WF-ORE	245					0.007	
ANG-ORE	8,785	206	2.3%			0.022	0.128
ANG-HYD	7,817	349	4.5%	15	0.2%	0.035	0.168
NEW-ORE	47,999	575	1.2%	38	0.1%	0.018	0.162
MAC-ORE	2,651	492	18.6%	6	0.2%	0.053	0.146
NAM-ORE	38					0.007	
MM-HYD	20,144	842	4.2%	61	0.3%	0.040	0.173
UNKNOWN	236,330	5,651	2.4%	384	0.2%	0.024	0.176
TOTAL	474,098	13,418	2.8%	926	0.2%		

Key findings per Deposit are as follows:

- DEPOSIT A: A large proportion of samples from Deposit A do not have a geozone or strand code assigned and therefore have been grouped within the UNKNOWN category (*n* = 227,903). As presented in Table F1 (Appendix F), the UNKNOWN category represents most of the Deposit A samples with TS greater than 0.1 wt%S. The maximum TS value for Deposit A is also an UNKNOWN sample (3.37 wt%S). A minor proportion (0.16%) of the total Deposit A samples have TS greater than 0.3 wt%S.

  Overall, due to the low proportion of the total Deposit A samples with TS greater than 0.1 wt%S, equivalent to approximately 3 kg H_2SO_4/t acidity should all measured sulfur be pyritic, **the sulfur risk for Deposit A is low**. Only three samples with TS greater than 0.1 wt%S were collected from below the pre-mining water table (640 mAHD; RTIO, 2018a), suggesting measured sulfur in the majority of elevated sulfur samples is likely oxidised (RTIO, 2016). However, the environmental geochemical dataset, through targeted sampling, suggests pyritic sulfur is present. However, the bulk of the waste rock likely reflects a low sulfur risk.

- DEPOSIT A WEST: Samples with TS greater than 0.1 wt%S are predominantly associated with the Detritals stratigraphy (maximum TS of 0.559 wt%S). Less than 1% of the total Deposit A West samples have TS greater than 0.1 wt%S and an order of magnitude less samples have TS greater than 0.3 wt%S (Table F1; Appendix F). Therefore, **the sulfur risk for Deposit A West is low**.

- DEPOSIT B: The proportion of total Deposit B assay samples with TS in excess of 0.1 wt%S is 7.1% and 0.2% of total assay samples have TS in excess of 0.3 wt%S. The ANG, DET-ORE, and MAC-ORE all have approximately 10% of their total samples within the 0.1 wt%S subset. Only one Deposit B sample has been collected from below the pre-mining groundwater level (approximately 630 mAHD; RTIO, 2018a). This would suggest elevated sulfur is likely present as either non-acid generating gypsum-type sulfur or potentially acid generating alunite-type sulfur. With less than 2% of the waste rock to be mined at Deposit B to be mined from BWT (approximately 4 Mt), the initial sulfur risk could be considered low.

  However, although RTIO's internal sulfur assessment criteria for non-black shale lithologies (e.g., BIF and detrital rock types) is 0.3 wt%S (RTIO, 2016), the environmental geochemical dataset presents several Deposit B samples classified as PAF with TS between 0.1-0.2 wt%S. These WF and MM samples were sampled from various depths between 10 and 72 m below ground level. These results suggest the presence of pyritic sulfur in these samples and therefore **the sulfur risk for Deposit B is moderate**.

- DEPOSIT C: A minor proportion of total Deposit C samples (1.3%) have TS greater than 0.1 wt%S and less than 0.5% have TS greater than 0.3 wt%S (Table F1; Appendix F). A small amount of ANG and MAC waste rock samples have TS in excess of 1 wt%S. These shallow samples were collected from between 0-30 below ground level and are likely contain sulfur as either non-acid generating gypsum-type sulfur or potentially acid generating alunite-type sulfur. **The sulfur risk for Deposit C is low**.

- DEPOSIT D: A minor proportion of total Deposit D samples (1.1%) have TS greater than 0.1 wt%S and less than 0.5% have TS greater than 0.3 wt%S (Table F1; Appendix F). Only four samples (DET, MAC, and WF waste rock samples) have TS in excess of 1 wt%S. These shallow samples were collected from between 0-30 below ground level and are likely contain sulfur as either non-acid generating gypsum-type sulfur or potentially acid generating alunite-type sulfur. **The sulfur risk for Deposit D is low**.

- DEPOSIT E: A minor proportion of total Deposit E samples (1.4%) have TS greater than 0.1 wt%S and less than 0.2% have TS greater than 0.3 wt%S (Table F1; Appendix F). No Deposit E samples have TS in excess of 1 wt%S. **The sulfur risk for Deposit E is low**.

- DEPOSIT F: Almost 2% of the total Deposit F samples have TS greater than 0.1 wt%S and less than 0.5% have TS greater than 0.3 wt%S (Table F1; Appendix F). However, only 1.2% of total waste samples have TS greater than 0.1 wt%S, mainly from the ANG stratigraphy. Higher sulfur ore samples are from the DET, ANG, and MAC stratigraphies. **The sulfur risk for Deposit F is low**. With BWT mining not expected for Deposit F, the minimal sulfur measured is likely oxidised and would therefore further support a low-risk classification.

- DEPOSIT G: A minor proportion of total Deposit G samples (0.8%) have TS greater than 0.1 wt%S and less than 0.1% have TS greater than 0.3 wt%S (Table F1; Appendix F). No Deposit G samples have TS in excess of 0.5 wt%S. **The sulfur risk for Deposit G is low**.

- DEPOSIT H: The proportion of total Deposit H assay samples with TS in excess of 0.1 wt%S is 4.2% with less than 0.2% of total assay samples having TS in excess of 0.3 wt%S. All samples with TS greater than 0.1 wt%S were collected between 0-24 m below surface. This would suggest sulfur is likely present as either non-acid generating gypsum-type sulfur or potentially acid generating alunite-type sulfur. Only one waste assay sample from the ANG stratigraphy has TS greater than 0.5 wt%S. With BWT mining not expected for Deposit H, the sulfur measured is likely oxidised and would therefore support a low-risk classification. **The sulfur risk for Deposit H is low**.

- DEPOSIT J: The proportion of total Deposit J assay samples with TS in excess of 0.1 wt%S is 8.6% with 0.8% of total assay samples having TS in excess of 0.3 wt%S. All samples with TS greater than 0.1 wt%S were collected above 800 mAHD, up to 70 m above groundwater as indicated by the mining model. This would suggest sulfur is likely present as lower risk sulfates. Only one waste assay sample from the DOR stratigraphy has TS greater than 1 wt%S, and only 17 DOR waste samples have TS greater than 0.5 wt%S. With significant BWT mining not expected for Deposit J (i.e., groundwater intercepts base of pit), the sulfur measured is likely oxidised and would therefore support a low-risk classification. **The sulfur risk for Deposit J is low**.

- MOUNT ELLA EAST EXTENSION (MTEE): The proportion of total MTEE assay samples with TS in excess of 0.1 wt%S is 8.5% with 0.6% of total assay samples having TS in excess of 0.3 wt%S. However, only 2 WS waste samples have TS greater than 0.2 wt%S and no waste samples have TS in excess of 0.3 wt%S. With BWT mining not expected for MTEE, the minimal sulfur measured is likely oxidised and would therefore further support a low-risk classification. **The sulfur risk for MTEE is low**.

- WESTERN HILL: The proportion of total Western Hill assay samples with TS in excess of 0.1 wt%S is 6.2% with 0.6% of total assay samples having TS in excess of 0.3 wt%S. The majority of mining at Western Hill will be above water table mining (<1 Mt BWT waste rock). Waste samples with TS greater than 0.1 wt%S are predominantly from the DET, DG, and WS stratigraphies, with minor quantities also from the MCS stratigraphy. As BWT mining is only anticipated at the base of the pit, this would suggest sulfur is likely present as lower risk sulfates. **The sulfur risk for Western Hill is low-moderate**.

Table 9: In-pit total sulfur assay summaries per Deposit.

DEPOSIT	TOTAL S ASSAY SAMPLES	S >0.1 wt%		S >0.3 wt %		AVERAGE S wt %	
	n	*n*	% of total *n*	*n*	% of total *n*	of n_{TOT}	of $n_{S>0.1wt\%S}$
Deposit A	235,881	5,547	2.4%	372	0.2%	0.024	0.176
Deposit A W	20,445	170	0.8%	15	0.1%	0.021	0.172
Deposit B	54,352	3,856	7.1%	87	0.2%	0.036	0.151
Deposit C	18,041	242	1.3%	39	0.2%	0.027	0.235
Deposit D	26,402	291	1.1%	63	0.2%	0.021	0.241
Deposit E	42,650	599	1.4%	75	0.2%	0.021	0.193
Deposit F	40,115	767	1.9%	115	0.3%	0.024	0.212
Deposit G	6,165	48	0.8%	3	<0.1%	0.024	0.154
Deposit H	5,730	243	4.2%	8	0.1%	0.030	0.146
Deposit J	4,355	376	8.6%	37	0.8%	0.045	0.202
MTEE	2,230	190	8.5%	14	0.6%	0.048	0.175
Western Hill	17,477	1,089	6.2%	99	0.6%	0.042	0.192

4.2.2 Sulfur and Sulfide Risk in the Mining Model

This section provides an assessment of sulfide risk designation tonnages within the supplied mining models and estimates of waste blocks pit exposures with sulfide risk designations 1, 2, 3, or 4.

The supplied mining models provide life of mine total tonnages for West Angelas. Predicted waste rock tonnages for each deposit per lithology and per sulfide risk category are provided in Table G1, Appendix G. Table 10 presents mining model summary tonnages per deposit per sulfide risk category and

Table 11 presents mining model summary tonnages per TS bin per sulfide risk category.

Key findings are as follows:

- SULFIDE RISK = 0 and 1: These no AMD risk and low AMD risk classifications have been assigned to 94.6% and 5.1% of the total West Angelas waste rock. Waste rock assigned a no AMD risk classification is represented at all deposits. Waste rock classified as Sulfide Risk 1 is represented at all deposits except Deposits B, C, and D. The predicted median and average TS values within the mining model for the total Sulfide Risk 0 and 1 waste rock are <0.05 wt%S.

- <u>SULFIDE RISK = 2:</u> Approximately 3 Mt of waste rock is assigned a Sulfide Risk 2 classification (moderate AMD risk). This represents a minor component of West Angelas waste rock (0.1% of total) and is expected to be mined from the A, C, D, E, and J deposits. Above water table low TS MCS (maximum TS of 0.06 wt%S) from Deposit J represents 46% of the total Sulfide Risk 2 waste rock. MAC waste rock represents 47% of the total Sulfide Risk 2 waste rock. The majority of this is expected from Deposit D, below the water table low TS (maximum TS of 0.05 wt%S). The remaining 6% of the total Sulfide Risk 2 waste rock is elevated TS WF waste rock from Deposit A and C (maximum and median TS of 0.79 wt%S and 0.34 wt%S, respectively).

- <u>SULFIDE RISK = 3:</u> No waste rock has been assigned this high AMD risk classification within the West Angelas mining models. That is, no unoxidised black shale is predicted for any of the deposits. Relatively minor waste rock tonnages of WS, MCS, and MTS with TS less than or equal to 0.2 wt%S are expected from above the water table from Deposit J and Western Hill. A minor quantity (28.5 Kt) of below water table FOR waste rock is predicted from Deposit B, although TS is predicted to be less than 0.05 wt%.

- <u>SULFIDE RISK = 4:</u> Approximately 6.5 Mt of potential calcrete waste rock is assigned a Sulfide Risk 4 classification (potential acid neutralisation material). This represents a minor component of West Angelas waste rock (0.2% of total) and is expected to be mined from above the water table at the C, D, and G deposits.

Table 10: Mining model tonnages of waste blocks per sulfide risk category for West Angelas.

DEPOSIT	SULFIDE RISK = 0 (t)	SULFIDE RISK = 1 (t)	SULFIDE RISK = 2 (t)	SULFIDE RISK = 4 (t)	TOTALS (t)
Deposit A	1,168,528,000	157,500	158,800	-	1,168,844,300
Deposit A West	176,549,700	20,900	-	-	176,570,600
Deposit B	336,407,300	-	-	-	336,407,300
Deposit C	136,639,200	-	32,200	1,239,400	137,910,800
Deposit D	199,153,100	-	1,463,900	4,681,700	205,298,700
Deposit E	273,267,500	130,900	14,900	-	273,413,300
Deposit F	195,184,400	11,287,400	-	-	206,471,800
Deposit G	47,065,100	5,494,000	-	611,400	53,170,500
Deposit H	22,858,600	31,700	-	-	22,890,300
Deposit J	19,704,900	40,215,100	1,437,100	-	61,357,100
MTEE	5,287,000	8,914,800	-	-	14,201,800
WSTH	66,450,800	75,294,300	-	-	141,745,100
TOTAL	2,647,095,600	141,546,600	3,106,900	6,532,500	2,798,281,600
% TOTAL WASTE	94.6%	5.1%	0.1%	0.2%	100%

Table 11: Mining model tonnages of waste blocks per sulfide risk category per TS bins.

TS BINS	SULFIDE RISK = 0 (t)	SULFIDE RISK = 1 (t)	SULFIDE RISK = 2 (t)	SULFIDE RISK = 4 (t)	TOTALS (t)	% OF TOTAL
0.05	2,351,729,600	115,701,800	2,875,300	6,525,500	2,476,832,200	88.5%
0.10	239,686,200	19,195,200	40,700	7,000	258,929,100	9.3%
0.15	41,420,400	3,569,100	-	-	44,989,500	1.6%
0.20	9,452,400	822,600	-	-	10,275,000	0.4%
0.25	2,560,800	532,600	17,400	-	3,110,800	0.1%
0.30	1,063,300	420,800	22,100	-	1,506,200	0.1%
0.35	523,100	419,600	79,400	-	1,022,100	<0.1%
0.40	221,700	404,600	27,100	-	653,400	<0.1%
0.45	130,700	432,700	28,600	-	592,000	<0.1%
0.50	110,500	20,500	7,400	-	138,400	<0.1%
100	196,900	27,100	8,900	-	232,900	<0.1%
TOTAL	2,647,095,600	141,546,600	3,106,900	6,532,500	2,798,281,600	100%

Table 11 show that 97.8% of total waste rock tonnes fall within the lowest two TS bins (i.e., TS <0.1 wt%S) and 99.4% fall within the lowest three (i.e., TS <0.15 wt%S). With respect to ore tonnes within the mining model, 98.6% of total ore tonnes fall within the lowest two TS bins (i.e., TS <0.1 wt%S) and 99.7% fall within the lowest three (i.e., TS <0.15 wt%S).

RTIO also have black shale flags within the mining model that particularly target both unoxidised and oxidised MCS, FWZ, MTS, and WS. Although, the flags are not restricted to black shale stratigraphies. As presented in Table 12, no waste blocks are classified as *BS-HOT* (which correlates with the Sulfide Risk 3 classification.

As presented in Table 12, total *BS-COLD* waste tonnages (3.4 Mt) are similar to Sulfide Risk 2 classification deposit distribution and tonnage totals. The *BS-COLD* waste tonnages represent a minor component of West Angelas waste rock (0.1% of total) and is expected to be mined from the A, A West, C, D, E, F, and J deposits. Waste blocks classified as *BS-COLD* are expected from both above and below water table in relatively even quantities and include the DET, DOR, FWZ, MCS, WF, ANG, MAC, and NEW stratigraphies.

The deposits containing the largest *BS-COLD* waste tonnages are Deposit D (44.5% of total *BS-COLD* waste tonnes) and Deposit J (45.3% of total *BS-COLD* waste tonnes). Deposit A contains approximately 9% of the total predicted *BS-COLD* tonnages which is mainly elevated sulfur ANG waste blocks (median and average TS 0.28 wt%S). FWZ (142 Kt) and MCS (1,306 Kt) waste rock classified as *BS-COLD*, typically higher AMD risk lithologies, is predicted from Deposit J. Generally, TS is low for these waste blocks (median and average TS <0.1 wt%S). Figure 12 presents cross-sections for Deposit J showing the *BS-COLD* distribution. FWZ and MCS is predicted within pits 1, 2, and 3, at elevations of 776-936 mRL (Table 13).

As presented in Table 12, approximately 145 Mt of *BS-OXIDE* waste rock is predicted, which is similar to the tonnages predicted for the sulfide risk 1 classification (low AMD risk). The *BS-OXIDE* waste tonnages represent 5.2% of the total West Angelas waste rock. BS-OXIDE waste rock is expected from all deposits except the B, C, and D deposits.

Table 12: Mining model tonnages of waste blocks classified as *BS-HOT*, *BS-COLD*, and *BS-OXIDE*.

DEPOSIT	BS-HOT (t)	BS-COLD (t)	BS-OXIDE (t)	SUB-TOTAL (t)	% OF TOTAL WASTE
Deposit A	-	292,200	152,700	444,900	<0.1%
Deposit A West	-	800	324,500	325,300	<0.1%
Deposit B	-	-	-	-	<0.1%
Deposit C	-	34,300	-	34,300	<0.1%
Deposit D	-	1,497,300	-	1,497,300	0.1%
Deposit E	-	15,300	145,700	161,000	<0.1%
Deposit F	-	400	11,551,000	11,551,400	0.4%
Deposit G	-	-	5,456,300	5,456,300	0.2%
Deposit H	-	-	39,000	39,000	<0.1%
Deposit J	-	1,526,300	40,551,300	42,077,600	1.5%
MTEE	-	-	8,997,600	8,997,600	0.3%
WSTH	-	-	77,635,200	77,635,200	2.8%
TOTALS	-	3,366,600	144,853,300	148,219,900	
% TOTAL WASTE	-	0.1%	5.2%	5.3%	5.3%

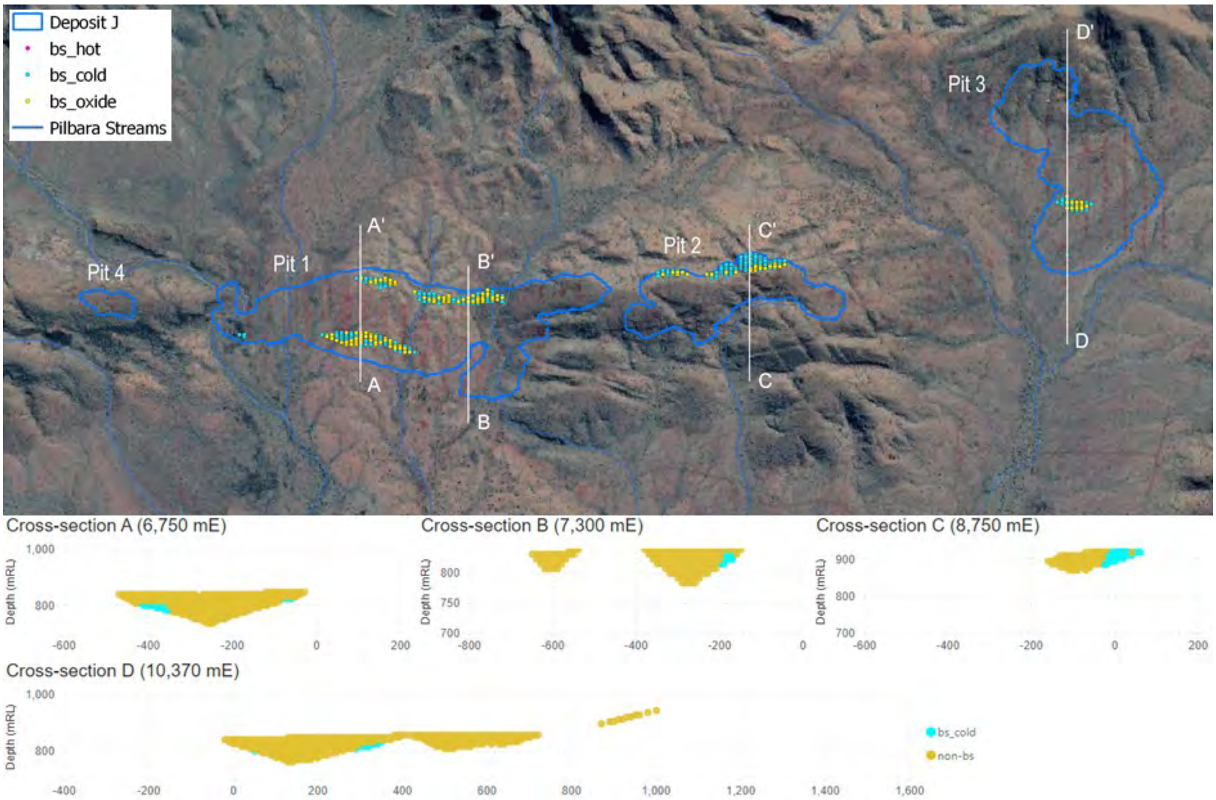

Figure 12. Cross-sections showing *BS-COLD* distribution within Deposit J. Depth and width not to scale. Approximate pre-mining groundwater level is 736 mRL.

Table 13: Estimated elevations of predicted *BS-COLD* waste rock for each deposit.

DEPOSIT	BS-COLD (t)	MIN-RL	MAX-RL	% OF TOTAL	AWT/BWT
Deposit A	292,200	698	784	8.7%	AWT
Deposit A West	800	636	636	<0.1%	AWT
Deposit C	34,300	652	708	1.0%	AWT
Deposit D	1,497,300	548	620	44.5%	AWT
Deposit E	15,300	648	672	0.5%	AWT/BWT
Deposit F	400	670	670	<0.1%	BWT
Deposit J	1,526,300	776	936	45.3%	AWT
TOTAL	3,366,600				

The deposits containing the largest *BS-OXIDE* waste tonnages are Deposit J (28% of total *BS-OXIDE* waste tonnes) and Western Hill (53.6% of total *BS-OXIDE* waste tonnes). All MCS and FWZ waste blocks classified as *BS-OXIDE* are from these two deposits (approximately 4.5 Mt from each deposit) and are generally low TS waste blocks (median and average TS <0.05 wt%S).

Table 14: Estimated elevations of predicted *BS-OXIDE* waste rock for each deposit.

DEPOSIT	*BS-OXIDE* (t)	MIN-RL	MAX-RL	% OF TOTAL	AWT/BWT
Deposit A	152,700	752	784	0.1%	AWT
Deposit A West	324,500	660	716	0.2%	AWT

DEPOSIT	*BS-OXIDE* (t)	MIN-RL	MAX-RL	% OF TOTAL	AWT/BWT
Deposit E	145,700	720	744	0.1%	BWT
Deposit F	11,551,000	670	790	8.0%	BWT
Deposit G	5,456,300	588	756	3.8%	AWT/BWT
Deposit H	39,000	794	834	<0.1%	AWT
Deposit J	40,551,300	752	952	28.0%	AWT
MTEE	8,997,600	720	824	6.2%	AWT
WSTH	77,635,200	608	848	53.6%	AWT/BWT
TOTAL	144,853,300				

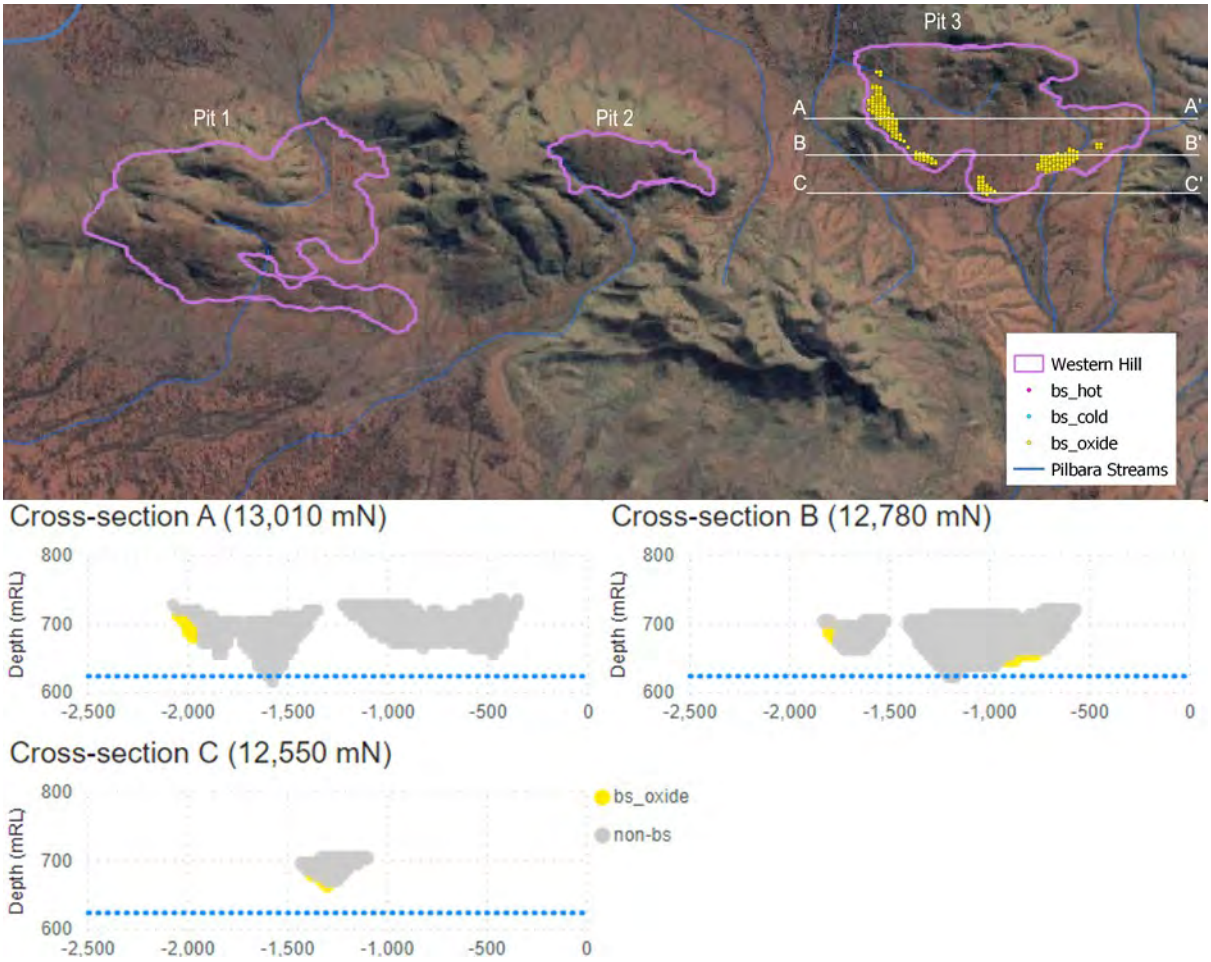

Figure 13. Cross-sections showing *BS-OXIDE* (MCS and FWZ only) distribution at Western Hill. Depth and width not to scale. Blue dotted line represents approximate pre-mining groundwater level (736mRL).

Figure 14 (Deposit J) and Figure 15 (Western Hill) present the visual outputs from the surface area modelling. Table 15 (Deposit J) and Table 16 (Western Hill) present the estimated surface areas. As shown, exposures of *BS-COLD* material are predicted for Deposit J (136,270 m^2). This represents approximately 8% of the total surface area of Deposit J. *BS-OXIDE* (MCS and FWZ only) exposures are predicted for Deposit J and Western Hill (35,820 m^2 and 52,370 m^2 respectively). This represents 2% of the total surface area for both the Deposit J and Western Hill deposits.

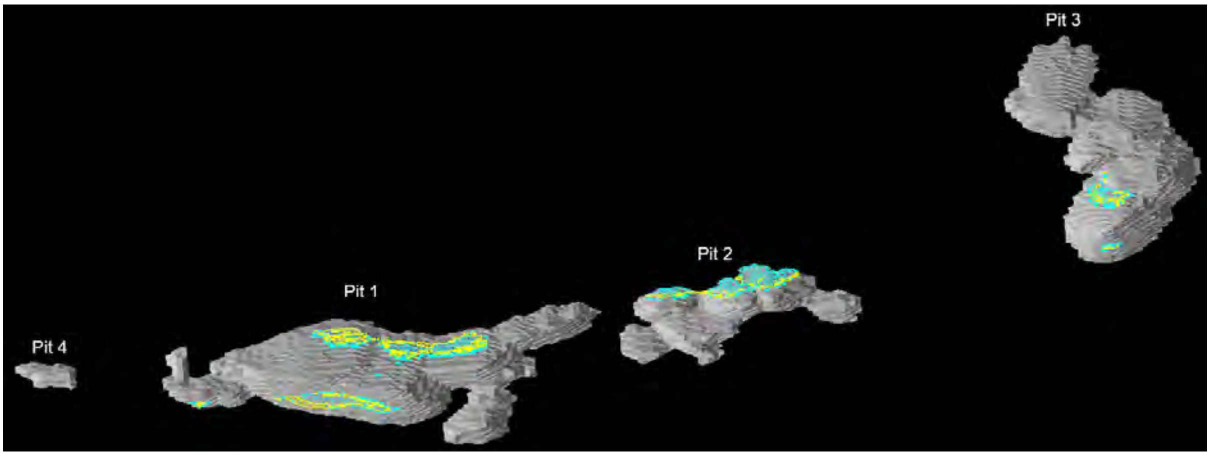

Figure 14. *BS-COLD* (blue) and *BS-OXIDE* (MCS and FWZ only) exposures on Deposit J final pit shells.

Table 15: Estimated surface areas of *BS-COLD* and *BS-OXIDE* in Deposit J final pit shells.

MM CODE	PIT 4 (m^2)	PIT 1 (m^2)	PIT 2 (m^2)	PIT 3 (m^2)	TOTAL (m^2)
BS-COLD	0	81,580	39,760	14,930	136,270
BS-OXIDE	0	26,340	5,080	4,400	35,820

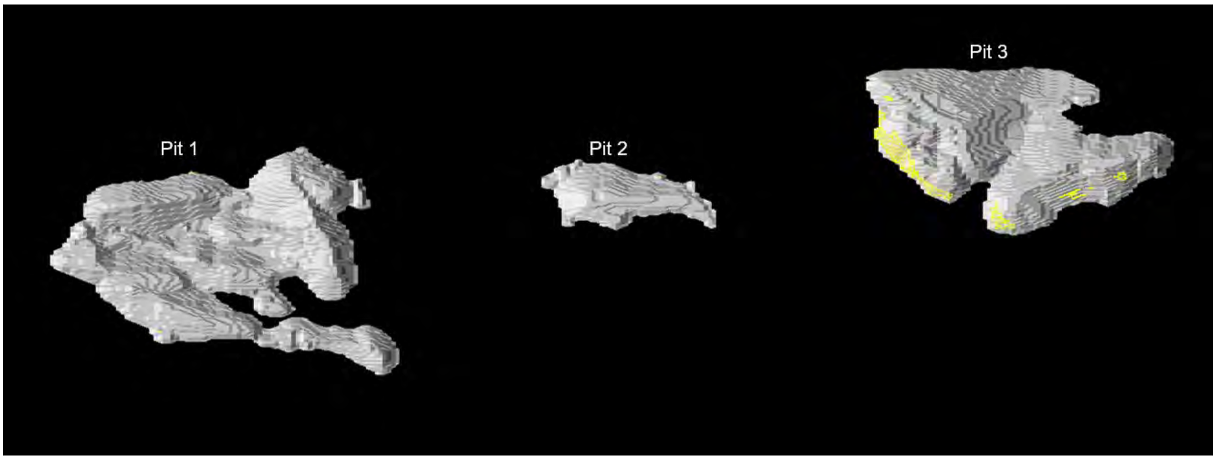

Figure 15. *BS-OXIDE* (MCS and FWZ only) exposures on Western Hill final pit shells.

Table 16: Estimated surface areas of *BS-OXIDE* in Western Hill final pit shells.

MM CODE	PIT 1 (m^2)	PIT 2 (m^2)	PIT 3 (m^2)	TOTAL (m^2)
Oxidised MCS	220	130	52,020	52,370

4.3 Neutral Metalliferous and Saline Drainage Potential

The risk of generating neutral metalliferous drainage (NMD) or saline drainage (SD) associated with neutralisation of oxidation products is unlikely. Generally, the deposit contains very little sulfur with moderate (≥0.5 wt%S) and high (≥1 wt%S) TS assay samples restricted to less than 0.1% and 0.05% of the total assay database respectively. When considering the high TS samples within the environmental geochemistry database, only one MM sample has a negative NAPP. When considering the moderate TS samples within the environmental geochemistry database, 40% of the samples have negative NAPP values. Therefore, the proportion of samples within the assay database that have moderate or high sulfur and may have sufficient ANC to be classified as NAF, is likely very low.

When interrogating the mining model:

- An insignificant quantity of waste blocks has predicted TS ≥1 wt%S (3,900 t). This ANG material is expected from below the water table at Deposit F.
- Only minor quantities of waste rock with predicted moderate TS of 0.5-1 wt%S, is expected from West Angelas. These 229 Kt is expected from the A, C, F, J, Mount Ella East Extension, and Western Hill deposits.

4.4 Chemical Enrichment and Mobility

Approximately 950,000 samples from across the West Angelas project have been analysed for routine chemical element suite of Al, Ca, Fe, K, Mg, Mn, Na, P, S and/or Ti, as well as, Ba, Cl, Co, Cr, Cu, Ni, Pb, Si, Sn, Sr, V, Zn and Zr. As part of the ABA suite of tests, and to support the liquid extract analyses 48 samples have been analysed for an extended elemental suite Table 17. To investigate the potential for identified enriched elements to mobilise, static leach testing (liquid extract analysis) has been completed on 38 samples.

Table 17. XRF (assay samples), total elemental (e.g., acid digest), and liquid extract data available per parameter.

PARAMETER	ASSAY SAMPLES		TOTAL ELEMENTAL SAMPLES	LIQUID EXTRACT SAMPLES
	TOTAL	IN-PIT		
Al	902,921	485,882	48	38
As	735,564	363,296	43	38
Ba	734,908	362,692	43	38
Ca	869,204	467,495	48	38
Cl	733,886	362,501	0	35
Co	735,563	363,295	43	38
Cr	735,563	363,295	43	33
Cu	871,688	472,367	43	38
Fe	863,439	462,426	48	38
K	882,631	477,295	48	38
Mg	884,653	478,523	48	38
Mn	871,718	469,414	43	38
Mo	0	0	43	38
Na	723,011	358,909	48	38
Ni	735,564	363,296	40	38

PARAMETER	ASSAY SAMPLES		TOTAL ELEMENTAL SAMPLES	LIQUID EXTRACT SAMPLES
	TOTAL	IN-PIT		
P	903,044	485,997	43	38
Pb	884,337	478,385	40	38
S	867,006	463,992	48	8 (SO_4; 38)
Si	902,914	485,877	18	38
Sn	735,564	363,296	40	38
Sr	734,932	362,692	43	38
Ti	874,476	470,381	48	5
V	735,564	363,296	40	8
Zn	874,228	470,091	40	38
Zr	734,931	362,691	30	0
Extended Suite Parameters			Ag (43), Au (13), B (13), Be (30),Bi (43), Cd (43), Ce (30), Cs (30), F (10), Ga (30), Ge (30), Hf (30), Hg (43), In (20), La (30), Li (30), Nb (30), Rb (30), Sb (43), Sc (30), Se (40), Th (43), Tl (30), U (43), W (30) Y (33)	Ag (38), B (38), Be (30), Bi (8), Cd (38), F (38), Hg (38), N (5), Sb (38), Se (38), Th (35), U (35)

As presented in Table 18, several rock types have median enrichments of 3 or greater in As and/or Fe, when assessing the assay dataset. Other elements with median GAI values greater than 0 include Cr, Pb, and Sn. When assessing the total elemental dataset (or acid digest dataset) Table E6 (Appendix E), B, S, Sb, and Se also present enrichment. It should be noted that although a material may be enriched relative to average crustal abundances, it does not imply this element will be mobilised at levels harmful to a specific receptor.

A total of 38 West Angelas samples have been submitted for short-term leach testing; DET (n = 6), DOR (n = 2), WF (n = 12), and MM (n = 18). The following key findings are noted from the static leach testing:

- Generally, mobility of trace elements is low with leachates slightly acidic to alkaline (5.8-8.9) and containing low to moderate salinity (21-889 µS/cm). Fe, Mn, Si, and Zn were the only elements measured above 1 mg/L.
- Sulfate concentrations are generally low (<500 mg/L). The exception is three Deposit A MM samples with sulfate between 555-1,650 mg/L.
- Of the elements identified through GAI analysis as being enriched:
  - As was not mobilised above 0.02 mg/L.
  - Fe was only mobilised from one Deposit A West DOR sample in excess of 1 mg/L (1.5 mg/L).

- Cr was mobilised above the limit of reporting in two samples at low concentrations (0.003 and 0.009 mg/L).
- Sb and Se were only measured in one WF sample above the limit of limit or reporting. Measured Sb and Se concentrations were low (0.006 and 0.02 mg/L respectively)
- Pb and Sn were not mobilised above the limit of limit or reporting.

Table 18. Median (and maximum) GAI values as derived from the assay database for As and Fe, as well as other elements with GAI values of 1 or 2.

STRAT	MEDIAN As GAI (MAX As GAI)	MEDIAN Fe GAI (MAX Fe GAI)	MEDIAN GAI >0 (MAX GAI)
ALL	3 (6)	2 (3)	Sn (5)
DET-CLA	2 (6)	1 (3)	
DET-CAL	0 (5)	1 (2)	
DET	2 (7)	2 (3)	
DOR	2 (5)	1 (3)	
WS	3 (8)	2 (3)	
DG	2 (7)	2 (3)	
FWZ	4 (7)	2 (3)	
MCS	5 (8)	1 (2)	Pb (3)
MTS	5 (5)	1 (1)	Pb (1)
ANG	3 (7)	2 (3)	
MAC	1 (5)	2 (3)	
NAM	0 (4)	2 (2)	
NEW	1 (6)	2 (3)	Sn (5)
UNKNOWN	3 (7)	2 (3)	Cr (2), Sn (5)
DET-ORE	2 (5)	2 (3)	
WS-ORE	3 (5)	2 (3)	
DG-ORE	2 (7)	3 (3)	
FWZ-ORE	3 (7)	2 (3)	
ANG-ORE	3 (7)	2 (3)	Sn (4)
NEW-ORE	1 (6)	3 (3)	Sn (7)
MAC-ORE	1 (5)	2 (3)	
NAM-ORE	1 (2)	2 (3)	

5 RTIO ARD SCORE SHEET

Individual ARD Score Sheets were completed for each of the West Angelas deposits. Table 19 provides the summary results with each completed ARD hazard score cards provided in Appendix B.

Table 19. RTIO ARD hazard score cards.

DEPOSIT	PRELIM. ASSESS. SCORE	DETAILED ASSESS. SCORE	COMBINED HAZARD SCORE	RISK RANKING
Deposit A	52	15	28	LOW
Deposit A West	44	15	26	LOW
Deposit B	48	16	28	LOW
Deposit C	49	17	29	LOW
Deposit D	45	17	28	LOW
Deposit E	45	17	28	LOW
Deposit F	43	15	26	LOW
Deposit G	39	15	25	LOW
Deposit H	39	20	30	LOW
Deposit J	44	23	34	MODERATE
Mount Ella East Extension	29	21	28	LOW
Western Hill	51	22	35	MODERATE

6 CONCLUSIONS

The AMD risk for the West Angelas deposits has been investigated in line with RTIO's standard approach (Appendix A).

- Assay results for in-pit material suggest a low risk of acid generating potential:
  - Approximately 2.8% of all in-pit samples had greater than 0.1 wt%S.
  - Approximately 0.2% of all in-pit samples contained sulfur above 0.3 wt%S.
  - Although the sulfur risk for Deposit B is low, a number of PAF samples within the environmental geochemical dataset suggest the potential for pyrite and could therefore be considered a moderate sulfur risk.
- Of the 209 samples within the West Angelas environmental geochemical database with ABA data:
  - The WF stratigraphy group represents the greatest source of PAF samples (n_{PAF} = 13). These samples were collected from Deposit A (n = 5), Deposit A West (n = 1), and Deposit B (n = 7). The MM stratigraphy group represents the next greatest source (n_{PAF} = 5) with one sample collected from Deposit A, three samples collected from Deposit B, and one from Deposit F. The only other sample classified as PAF was a Deposit A West DOR sample.
  - Most median paste pH values are circum-neutral ($pH_{1:2}$ 7-8) and fresh ($EC_{1:2}$ <400 µS/cm).
  - ANC is generally low with median values ≤3 kg H_2SO_4/t for most stratigraphies and low-moderate (7 kg H_2SO_4/t) for the ALL and BIF samples. ABCC results suggest that ANC is readily availability in the ALL, DET, and WF samples. Variable ANC availability was observed in the 15 MM samples tested ($ENC_{4.5}$ 18-153% of titrated ANC) suggesting an inconsistency in the presence of fast reacting carbonate ANC.
  - Median NAPP values are negative for all stratigraphy groups. Reflective of Pilbara iron ore deposits with low sulfur and low ANC, median NAPP values are only slightly negative (-6 to -0.5 kg H_2SO_4/t).
- Extensive assay sampling has identified several elements (As, Cr, Fe, Pb, and Sn) enriched relative to average crustal abundances. Acid digestion testing on a subset of samples within the environmental geochemistry database identified additional elements (B, S, Sb, and Se) to be enriched. However, enrichment does not imply mobility at concentrations harmful to a given receptor.
- Generally, mobility of trace elements is low with leachates slightly acidic to alkaline (5.8-8.9) and containing low to moderate salinity (21-889 µS/cm). Fe, Mn, Si, and Zn were the only elements measured above 1 mg/L.
- No long-term column leach testing has been completed on waste rock from West Angelas.
- IORs values were 18.4^{E-11} and $1.6E^{-10}$ kg O_2/kg/sec for the WF and MM samples tested.

- No waste rock within the mining models was assigned by RTIO a sulfide risk rating or 3 (e.g., high AMD risk classification; *BS-HOT*). No unoxidised black shale is predicted for any of the deposits.
- A total of 3.4 Mt of *BS-COLD* waste rock is predicted (0.1% of the total waste rock). The *BS-COLD* tonnages correlate closely with the sulfur risk 2 waste block tonnages and deposit distribution.
- The deposits containing the largest *BS-COLD* waste tonnages are Deposit D (44.5% of total *BS-COLD* waste tonnes) and Deposit J (45.3% of total *BS-COLD* waste tonnes). Deposit A contains approximately 9% of the total predicted *BS-COLD* tonnages which is mainly elevated sulfur ANG waste blocks (median and average TS 0.28 wt%S).
- FWZ (142 Kt) and MCS (1,306 Kt) waste rock classified as *BS-COLD* is predicted from Deposit J. Generally, TS is low for these waste blocks (median and average TS <0.1 wt%S) and is predicted within pits 1, 2, and 3, at elevations of 776-936 mRL.
- A total of 3.4 Mt of *BS-COLD* waste rock is predicted (0.1% of the total waste rock). The *BS-COLD* tonnages correlate closely with the sulfur risk 2 waste block tonnages and deposit distribution.
- Approximately 145 Mt of *BS-OXIDE* waste rock is predicted, which correlates to the tonnages predicted for the sulfide risk 1 classification (low AMD risk). The *BS-OXIDE* waste tonnages represent 5.2% of the total West Angelas waste rock. *BS-OXIDE* waste rock is expected from all deposits except the B, C, and D deposits.
- The deposits containing the largest *BS-OXIDE* waste tonnages are Deposit J (28% of total *BS-OXIDE* waste tonnes) and Western Hill (53.6% of total BS-OXIDE waste tonnes). All MCS and FWZ waste blocks classified as *BS-OXIDE* are from these two deposits (approximately 4.5 Mt from each deposit). and are generally low TS (median and average TS <0.05 wt%S).
- No exposures of *BS-HOT* waste rock are expected in the final pit walls.
- Exposures of *BS-COLD* material are predicted for Deposit J (136,270 m^2); approximately 8% of the total final pit surface area for Deposit J.
- *BS-OXIDE* (MCS and FWZ only) exposures are predicted for Deposit J and Western Hill (35,820 m^2 and 52,370 m^2 respectively); approximately 2% of the total final pit surface area for both deposits.
- Combined hazard scores for Deposit A, Deposit A West, Deposit B, Deposit C, Deposit D, Deposit E, Deposit F, Deposit G, Deposit H, and Mount Ella East Extension are low.
- Combined hazard scores for Deposit J and Western Hill are moderate. Although these deposits have a moderate risk score, minimal below water table mining is expected and any measured sulfur is likely sulfate.

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8 LIMITATIONS

Attention is drawn to the document "Limitations", which is included in Appendix D of this report. The statements presented in this document are intended to provide advice on what the realistic expectations of this report should be, and to present recommendations on how to minimise the risks associated with this project. The document is not intended to reduce the level of responsibility accepted by Mine Waste Management, but rather to ensure that all parties who may rely on this report are aware of the responsibilities each assumes in doing so.

APPENDIX A RTIO AMD RISK ASSESSMENT SHEETS

(12 MS Excel Sheets; DepA, DepA W, DepB, DepC, DepD, DepE, DepF, DepG, DepH, DepJ, MTEE, and WSTH)

APPENDIX B ARD HAZARD SCORE SHEETS

(12 Sheets; DepA, DepA W, DepB, DepC, DepD, DepE, DepF, DepG, DepH, DepJ, MTEE, and WSTH)

Project Name	West Angelas Deposit A
Assessment Date	14/02/2020
Compiled by	Mine Waste Management
Final ARD Hazard Assessment	LOW

Version Date: 13/02/12
Version Number: 2

RTIO ARD Hazard Score

1. Preliminary Assessment (Order of Magnitude/Exploration)

A. Preliminary Geology Hazard

	Select Relevant Option Below	Score	Option Details
Ore Deposit Type	C) Enriched Marra Mamba Formation and Joffre Member, and/or channel and detrital ore bodies mined below the water table (un-oxidised lignite and black shales other than Mt McRae may be present). Enriched Dales Gorge Member mined above the water table only	14	Moderate / moderate
Host & Country Rock Neutralising Potential	None (<5%)	10	
Brownfield's / Greenfields	Brownfield		
Known ARD Issues on Site	No	0	
		Geology Hazard Score	**24**

Complete following sections

B. Incipient ARD Risk

	Select Relevant Option Below	Score
Operation Age	10 -20 years	2

**By default, all new projects should receive a <5 years value*

C. Scale of Disturbance

	Select Relevant Option Below	Score	
Total Waste Stored	>1 billion tonnes	15	1,168 Mt from Mining Model
Footprint	250 - 1000 hectares	6	547 Ha, pit footprint

D. Transport Pathways

	Select Relevant Option Below	Score	
Project / Exploration?	No		
Precipitation / Areal Potential Evapo-transpiration Ratio	1/10 to 1/3 ratio_mining below the water table in an aquitard or an isolated local aquifer	2	RTIO, 2016

**All new projects should respond Yes to Project / Exploration*

E. Sensitivity of Receiving Environment

	Select Relevant Option Below	Score	
Distance to Perennial/Ephemeral Water Bodies	>2000 metres	0	RTIO, 2016
Alkalinity	10 - 35 mg/L	3	RTIO, 2016
Distance to closest protected / permanently inhabited area	>10000 metres	0	RTIO, 2016

Preliminary Hazard Assessment

Preliminary Hazard Score	52
Preliminary Risk Assessment	MODERATE

2. Detailed Assessment (Pre Feasibility/ Feasibility/Mining)

This assessment should be completed by an ARD expert

Pit	**West Angelas Deposit A**

F. Geochemical Hazard (Interrogate the drill hole database)

	Select Relevant Option Below	Score	Option Details
Waste sulfur risk	Total number of waste samples with S>0.1% is less than 3%	0	2.4% of in-pit waste samples contain >0.1 wt%S
Ore grade sulfur risk	Total number of ore grade samples with S>0.1% is less than 3%	0	0.8% of in-pit ore samples contain >0.1 wt%S
Spatial distribution of sulfur	Sulfur scattered throughout the pit and through numerous lithologies	3	Elevated sulfur in other rock types likely to be in the form of sulfate
Chemical enrichment	Enrichments of contaminants that are unlikely to mobilise into groundwater	1	Unlikely that sulfidic material will be exposed

G. Mine Planning Hazard

	Select Relevant Option Below	Score	Option Details
PAF material management	No special waste management needed	0	No significant PAF tonnages to be mined
Bulk NPR (Mass of neutralising material x mean ANC) / (Percent of lithology greater than 0.1% x tonnes of lithology x mean sulfur concentration for all data greater than 0.1 x 30.6 + repeat for each PAF lithologies)	>3	0	No significant PAF tonnages to be mined
PAF rock mass disturbed or exposed (waste tonnes with S>0.1%)/(total tonnes of waste)*100	< 3% of the total disturbed mass	0	No significant PAF tonnages to be mined
Pit backfilling	Pit will not be backfilled	5	No commitment to backfill pits (RTIO, 2016)

H. Water Management Hazard

	Select Relevant Option Below	Score	Option Details
Dewatering volume	0 to 80 ML/day	1	RTIO, 2016
Surface water	Catchment area above the pit	5	Lower Risk due to sump before Dep E, limiting flow through to Dep A (RTIO, 2016)
Water treatment during Operation	No water treatment or special management for ARD needed	0	No unoxidised black shale expected to be encountered
Final void management	No PAF rock exposures likely on final pit shell	0	No unoxidised black shale expected to be encountered

Combined Hazard Assessment

Preliminary Assessment Score	52
Detailed Assessment Score	15
Combined Hazard Score	28
Risk Ranking	LOW

This risk ranking score card is relevant for Pilbara based iron ore operations and the ranking system can be used to assess the relative risk of each operation. The ranking system is likely to overestimate the risk if compared to porphry copper or some coal deposits.

For RTIO internal distribution only. The manager of Technical Projects and Development will need to review and approve this prior to external release.
This risk assessment should be read in conjunction with the detailed ARD Risk Assessment

Project Name	West Angelas Deposit A West	
Assessment Date	14/02/2020	
Compiled by	Mine Waste Management	
Final ARD Hazard Assessment	**LOW**	

Version Date: 13/02/12
Version Number: 2

RTIO ARD Hazard Score

1. Preliminary Assessment (Order of Magnitude/Exploration)

A. Preliminary Geology Hazard

	Select Relevant Option Below	Score	Option Details
Ore Deposit Type	C) Enriched Marra Mamba Formation and Joffre Member, and/or channel and detrital ore bodies mined below the water table (un-oxidised lignite and black shales other than Mt McRae may be present). Enriched Dales Gorge Member mined above the water table only	14	Moderate / moderate
Host & Country Rock Neutralising Potential	None (<5%)	10	
Brownfield's / Greenfields	Greenfield		
Known ARD Issues on Site	No	0	
		Geology Hazard Score	**26**

Complete following sections

B. Incipient ARD Risk

	Select Relevant Option Below	Score
Operation Age	< 5 years	5

**By default, all new projects should receive a <5 years value*

C. Scale of Disturbance

	Select Relevant Option Below	Score	
Total Waste Stored	50 - 250 million tonnes	5	176 Mt from Mining Model
Footprint	100 - 250 hectares	3	191 ha pit footprint

D. Transport Pathways

	Select Relevant Option Below	Score	
Project / Exploration?	No		RTIO, 2016
Precipitation / Areal Potential Evapo-transpiration Ratio	1/10 to 1/3 ratio_mining below the water table in an aquitard or an isolated local aquifer	2	RTIO, 2016

**All new projects should respond Yes to Project / Exploration*

E. Sensitivity of Receiving Environment

	Select Relevant Option Below	Score	
Distance to Perennial/Ephemeral Water Bodies	>2000 metres	0	RTIO, 2016
Alkalinity	10 - 35 mg/L	3	RTIO, 2016
Distance to closest protected / permanently inhabited area	>10000 metres	0	RTIO, 2016

Preliminary Hazard Assessment

Preliminary Hazard Score	44
Preliminary Risk Assessment	**MODERATE**

2. Detailed Assessment (Pre Feasibility/ Feasibility/Mining)

This assessment should be completed by an ARD expert

Pit	**West Angelas Deposit A West**

F. Geochemical Hazard (Interrogate the drill hole database)

	Select Relevant Option Below	Score	Option Details
Waste sulfur risk	Total number of waste samples with S>0.1% is less than 3%	0	0.7% of in-pit waste samples contain >0.1 wt%S
Ore grade sulfur risk	Total number of ore grade samples with S>0.1% is less than 3%	0	1.4% of in-pit ore samples contain >0.1 wt%S
Spatial distribution of sulfur	Sulfur scattered throughout the pit and through numerous lithologies	3	Elevated sulfur in other rock types likely to be in the form of sulfate
Chemical enrichment	Enrichments of contaminants that are unlikely to mobilise into groundwater	1	Unlikely that sulfidic material will be exposed

G. Mine Planning Hazard

	Select Relevant Option Below	Score	Option Details
PAF material management	No special waste management needed	0	No significant PAF tonnages to be mined
Bulk NPR (Mass of neutralising material x mean ANC) / (Percent of lithology greater than 0.1% x tonnes of lithology x mean sulfur concentration for all data greater than 0.1 x 30.6 + repeat for each PAF lithologies)	>3	0	No significant PAF tonnages to be mined
PAF rock mass disturbed or exposed (waste tonnes with S>0.1%)/(total tonnes of waste)*100	< 3% of the total disturbed mass	0	No significant PAF tonnages to be mined
Pit backfilling	Pit will not be backfilled	5	Unlikely to be backfilled (RTIO, 2016)

H. Water Management Hazard

	Select Relevant Option Below	Score	Option Details
Dewatering volume	0 to 80 ML/day	1	RTIO, 2016
Surface water	Catchment area above the pit	5	RTIO, 2016
Water treatment during Operation	No water treatment or special management for ARD needed	0	No unoxidised black shale expected to be encountered
Final void management	No PAF rock exposures likely on final pit shell	0	No unoxidised black shale expected to be encountered

Combined Hazard Assessment

Preliminary Assessment Score	44
Detailed Assessment Score	15
Combined Hazard Score	26
Risk Ranking	**LOW**

This risk ranking score card is relevant for Pilbara based iron ore operations and the ranking system can be used to assess the relative risk of each operation. The ranking system is likely to overestimate the risk if compared to porphry copper or some coal deposits.

For RTIO internal distribution only. The manager of Technical Projects and Development will need to review and approve this prior to external release.
This risk assessment should be read in conjunction with the detailed ARD Risk Assessment

Project Name	West Angelas Deposit B
Assessment Date	14/02/2020
Compiled by	Mine Waste Management
Final ARD Hazard Assessment	LOW

Version Date: 13/02/12
Version Number: 2

RTIO ARD Hazard Score

1. Preliminary Assessment (Order of Magnitude/Exploration)

A. Preliminary Geology Hazard

	Select Relevant Option Below	Score	Option Details
Ore Deposit Type	C) Enriched Marra Mamba Formation and Joffre Member, and/or channel and detrital ore bodies mined below the water table (un-oxidised lignite and black shales other than Mt McRae may be present). Enriched Dales Gorge Member mined above the water table only	14	Moderate / moderate
Host & Country Rock Neutralising Potential	None (<5%)	10	
Brownfield's / Greenfields	Brownfield		
Known ARD Issues on Site	No	0	
		Geology Hazard Score	24

Complete following sections

B. Incipient ARD Risk

	Select Relevant Option Below	Score	
Operation Age	5 - 10 years	3	MCP (RTIO,2018)

**By default, all new projects should receive a <5 years value*

C. Scale of Disturbance

	Select Relevant Option Below	Score	
Total Waste Stored	250 - 1 billions tonnes	10	336 Mt from mining model
Footprint	250 - 1000 hectares	6	341 ha pit footprint

D. Transport Pathways

	Select Relevant Option Below	Score	
Project / Exploration?	No		
Precipitation / Areal Potential Evapo-transpiration Ratio	1/10 to 1/3 ratio_mining below the water table in an aquitard or an isolated local aquifer	2	RTIO, 2016

**All new projects should respond Yes to Project / Exploration*

E. Sensitivity of Receiving Environment

	Select Relevant Option Below	Score	
Distance to Perennial/Ephemeral Water Bodies	>2000 metres	0	RTIO, 2016
Alkalinity	10 - 35 mg/L	3	RTIO, 2016
Distance to closest protected / permanently inhabited area	>10000 metres	0	RTIO, 2016

Preliminary Hazard Assessment

Preliminary Hazard Score	48
Preliminary Risk Assessment	MODERATE

2. Detailed Assessment (Pre Feasibility/ Feasibility/Mining)

This assessment should be completed by an ARD expert

Pit | **West Angelas Deposit B**

F. Geochemical Hazard (Interrogate the drill hole database)

	Select Relevant Option Below	Score	Option Details
Waste sulfur risk	Total number of waste samples with S>0.1% is between 3% and 10%, less than 0.5% of samples have S>0.3%	2	7.9% of in-pit waste samples contain >0.1 wt%S. 0.2% of in-pit samples contain >0.3 wt%S
Ore grade sulfur risk	Total number of ore grade samples with S>0.1% is between 3% and 10% but less than 0.5% of the samples have S>0.3%	2	5.9% of in-pit ore samples contain >0.1 wt%S. 0.1% of in-pit ore samples contain >0.3 wt%S
Spatial distribution of sulfur	Sulfur scattered throughout the pit and through numerous lithologies	3	Elevated sulfur in other rock types likely to be in the form of sulfate
Chemical enrichment	Enrichments of contaminants that are unlikely to mobilise into groundwater	1	Unlikely that sulfidic material will be exposed

G. Mine Planning Hazard

	Select Relevant Option Below	Score	Option Details
PAF material management	No special waste management needed	0	No significant PAF tonnages to be mined
Bulk NPR (Mass of neutralising material x mean ANC) / (Percent of lithology greater than 0.1% x tonnes of lithology x mean sulfur concentration for all data greater than 0.1 x 30.6 + repeat for each PAF lithologies)	>3	0	No significant PAF tonnages to be mined
PAF rock mass disturbed or exposed (waste tonnes with S>0.1%)/(total tonnes of waste)*100	< 3% of the total disturbed mass	0	No significant PAF tonnages to be mined
Pit backfilling	Pit will be backfilled to above the post mining water table but below ground surface	2	Planned (RTIO, 2016)

H. Water Management Hazard

	Select Relevant Option Below	Score	Option Details
Dewatering volume	0 to 80 ML/day	1	RTIO, 2016
Surface water	Catchment area above the pit	5	Reduced due to diversion berm and channel designed to contain 2000 year ARI event
Water treatment during Operation	No water treatment or special management for ARD needed	0	No unoxidised black shale expected to be encountered
Final void management	No PAF rock exposures likely on final pit shell	0	No unoxidised black shale expected to be encountered

Combined Hazard Assessment

Preliminary Assessment Score	48
Detailed Assessment Score	16
Combined Hazard Score	28
Risk Ranking	LOW

This risk ranking score card is relevant for Pilbara based iron ore operations and the ranking system can be used to assess the relative risk of each operation. The ranking system is likely to overestimate the risk if compared to porphry copper or some coal deposits.

For RTIO internal distribution only. The manager of Technical Projects and Development will need to review and approve this prior to external release.
This risk assessment should be read in conjunction with the detailed ARD Risk Assessment

Project Name	West Angelas Deposit C
Assessment Date	14/02/2020
Compiled by	Mine Waste Management
Final ARD Hazard Assessment	LOW

Version Date: 13/02/12
Version Number: 2

RTIO ARD Hazard Score

1. Preliminary Assessment (Order of Magnitude/Exploration)

A. Preliminary Geology Hazard

	Select Relevant Option Below	Score	Option Details
Ore Deposit Type	C) Enriched Marra Mamba Formation and Joffre Member, and/or channel and detrital ore bodies mined below the water table (un-oxidised lignite and black shales other than Mt McRae may be present). Enriched Dales Gorge Member mined above the water table only	14	Moderate / moderate
Host & Country Rock Neutralising Potential	None (<5%)	10	
Brownfield's / Greenfields	Greenfield		
Known ARD Issues on Site	No	0	
		Geology Hazard Score	26

Complete following sections

B. Incipient ARD Risk

	Select Relevant Option Below	Score
Operation Age	< 5 years	5

**By default, all new projects should receive a <5 years value*

C. Scale of Disturbance

	Select Relevant Option Below	Score	
Total Waste Stored	50 - 250 million tonnes	5	138 Mt from mining model
Footprint	250 - 1000 hectares	6	289 Ha pit footprint

D. Transport Pathways

	Select Relevant Option Below	Score	
Project / Exploration?	No		
Precipitation / Areal Potential Evapo-transpiration Ratio	1/10 to 1/3 ratio_mining below the water table in a rock mass that is connected to a regionally significant aquifer	3	RTIO, 2016

**All new projects should respond Yes to Project / Exploration*

E. Sensitivity of Receiving Environment

	Select Relevant Option Below	Score	
Distance to Perennial/Ephemeral Water Bodies	100 - 500 metres	3	RTIO, 2018
Alkalinity	>35 mg/L	1	RTIO, 2016
Distance to closest protected / permanently inhabited area	>10000 metres	0	RTIO, 2016

Preliminary Hazard Assessment

Preliminary Hazard Score	49
Preliminary Risk Assessment	MODERATE

2. Detailed Assessment (Pre Feasibility/ Feasibility/Mining)

This assessment should be completed by an ARD expert

Pit | **West Angelas Deposit C**

F. Geochemical Hazard (Interrogate the drill hole database)

	Select Relevant Option Below	Score	Option Details
Waste sulfur risk	Total number of waste samples with S>0.1% is less than 3%	0	1.2% of in-pit waste samples contain >0.1 wt%S
Ore grade sulfur risk	Total number of ore grade samples with S>0.1% is less than 3%	0	1.4% of in-pit ore samples contain >0.1 wt%S
Spatial distribution of sulfur	Sulfur scattered throughout the pit and through numerous lithologies	3	Elevated sulfur in other rock types likely to be in the form of sulfate
Chemical enrichment	Enrichments of contaminants that are unlikely to mobilise into groundwater	1	Release of metals controlled by weathering and dissolution

G. Mine Planning Hazard

	Select Relevant Option Below	Score	Option Details
PAF material management	No special waste management needed	0	No significant PAF tonnages to be mined
Bulk NPR (Mass of neutralising material x mean ANC) / (Percent of lithology greater than 0.1% x tonnes of lithology x mean sulfur concentration for all data greater than 0.1 x 30.6 + repeat for each PAF lithologies)	>3	0	No significant PAF tonnages to be mined
PAF rock mass disturbed or exposed (waste tonnes with S>0.1%)/(total tonnes of waste)*100	< 3% of the total disturbed mass	0	No significant PAF tonnages to be mined
Pit backfilling	Pit will not be backfilled	5	Unlikely (RTIO, 2016)

H. Water Management Hazard

	Select Relevant Option Below	Score	Option Details
Dewatering volume	0 to 80 ML/day	1	RTIO, 2016
Surface water	Creek flow	7	Diversion of Turee Creek East required (RTIO, 2016)
Water treatment during Operation	No water treatment or special management for ARD needed	0	No unoxidised black shale expected to be encountered
Final void management	No PAF rock exposures likely on final pit shell	0	No unoxidised black shale expected to be encountered

Combined Hazard Assessment

Preliminary Assessment Score	49
Detailed Assessment Score	17
Combined Hazard Score	29
Risk Ranking	LOW

This risk ranking score card is relevant for Pilbara based iron ore operations and the ranking system can be used to assess the relative risk of each operation. The ranking system is likely to overestimate the risk if compared to porphry copper or some coal deposits.

For RTIO internal distribution only. The manager of Technical Projects and Development will need to review and approve this prior to external release.
This risk assessment should be read in conjunction with the detailed ARD Risk Assessment

Project Name	West Angelas Deposit D
Assessment Date	14/02/2020
Compiled by	Mine Waste Management
Final ARD Hazard Assessment	LOW

Version Date: 13/02/12
Version Number: 2

RTIO ARD Hazard Score

1. Preliminary Assessment (Order of Magnitude/Exploration)

A. Preliminary Geology Hazard

	Select Relevant Option Below	Score	Option Details
Ore Deposit Type	C) Enriched Marra Mamba Formation and Joffre Member, and/or channel and detrital ore bodies mined below the water table (un-oxidised lignite and black shales other than Mt McRae may be present). Enriched Dales Gorge Member mined above the water table only	14	Moderate / moderate
Host & Country Rock Neutralising Potential	None (<5%)	10	
Brownfield's / Greenfields	Greenfield		
Known ARD Issues on Site	No	0	
		Geology Hazard Score	**26**

Complete following sections

B. Incipient ARD Risk

	Select Relevant Option Below	Score
Operation Age	< 5 years	5

**By default, all new projects should receive a <5 years value*

C. Scale of Disturbance

	Select Relevant Option Below	Score	
Total Waste Stored	50 - 250 million tonnes	5	205 Mt from mining model
Footprint	100 - 250 hectares	3	240 Ha pit footprint

D. Transport Pathways

	Select Relevant Option Below	Score	
Project / Exploration?	No		
Precipitation / Areal Potential Evapo-transpiration Ratio	1/10 to 1/3 ratio_mining below the water table in a rock mass that is connected to a regionally significant aquifer	3	RTIO, 2016

**All new projects should respond Yes to Project / Exploration*

E. Sensitivity of Receiving Environment

	Select Relevant Option Below	Score	
Distance to Perennial/Ephemeral Water Bodies	>2000 metres	0	RTIO, 2016
Alkalinity	10 - 35 mg/L	3	RTIO, 2016
Distance to closest protected / permanently inhabited area	>10000 metres	0	RTIO, 2016

Preliminary Hazard Assessment

Preliminary Hazard Score	45
Preliminary Risk Assessment	MODERATE

2. Detailed Assessment (Pre Feasibility/ Feasibility/Mining)

This assessment should be completed by an ARD expert

Pit	**West Angelas Deposit D**

F. Geochemical Hazard (Interrogate the drill hole database)

	Select Relevant Option Below	Score	Option Details
Waste sulfur risk	Total number of waste samples with S>0.1% is less than 3%	0	0.8% of in-pit waste samples contain >0.1 wt%S
Ore grade sulfur risk	Total number of ore grade samples with S>0.1% is less than 3%	0	1.6% of in-pit ore samples contain >0.1 wt%S
Spatial distribution of sulfur	Sulfur scattered throughout the pit and through numerous lithologies	3	Elevated sulfur in other rock types likely to be in the form of sulfate
Chemical enrichment	Enrichments of contaminants that are unlikely to mobilise into groundwater	1	No PAF material to be encountered

G. Mine Planning Hazard

	Select Relevant Option Below	Score	Option Details
PAF material management	No special waste management needed	0	No significant PAF tonnages to be mined
Bulk NPR (Mass of neutralising material x mean ANC) / (Percent of lithology greater than 0.1% x tonnes of lithology x mean sulfur concentration for all data greater than 0.1 x 30.6 + repeat for each PAF lithologies)	>3	0	No significant PAF tonnages to be mined
PAF rock mass disturbed or exposed (waste tonnes with S>0.1%)/(total tonnes of waste)*100	< 3% of the total disturbed mass	0	No significant PAF tonnages to be mined
Pit backfilling	Pit will not be backfilled	5	No commitment to backfill pits (RTIO, 2016)

H. Water Management Hazard

	Select Relevant Option Below	Score	Option Details
Dewatering volume	0 to 80 ML/day	1	RTIO, 2016
Surface water	Creek flow	7	RTIO, 2016
Water treatment during Operation	No water treatment or special management for ARD needed	0	No unoxidised black shale expected to be encountered
Final void management	No PAF rock exposures likely on final pit shell	0	No unoxidised black shale expected to be encountered

Combined Hazard Assessment

Preliminary Assessment Score	45
Detailed Assessment Score	17
Combined Hazard Score	28
Risk Ranking	LOW

This risk ranking score card is relevant for Pilbara based iron ore operations and the ranking system can be used to assess the relative risk of each operation. The ranking system is likely to overestimate the risk if compared to porphry copper or some coal deposits.

For RTIO internal distribution only. The manager of Technical Projects and Development will need to review and approve this prior to external release.
This risk assessment should be read in conjunction with the detailed ARD Risk Assessment

Project Name	West Angelas Deposit E
Assessment Date	14/02/2020
Compiled by	Mine Waste Management
Final ARD Hazard Assessment	**LOW**

Version Date: 13/02/12
Version Number: 2

RTIO ARD Hazard Score

1. Preliminary Assessment (Order of Magnitude/Exploration)

A. Preliminary Geology Hazard

	Select Relevant Option Below	Score	Option Details
Ore Deposit Type	C) Enriched Marra Mamba Formation and Joffre Member, and/or channel and detrital ore bodies mined below the water table (un-oxidised lignite and black shales other than Mt McRae may be present). Enriched Dales Gorge Member mined above the water table only	14	Moderate / moderate
Host & Country Rock Neutralising Potential	None (<5%)	10	
Brownfield's / Greenfields	Brownfield		
Known ARD Issues on Site	No	0	
		Geology Hazard Score	24

Complete following sections

B. Incipient ARD Risk

	Select Relevant Option Below	Score	
Operation Age	5 - 10 years	3	MCP (RTIO, 2018)

**By default, all new projects should receive a <5 years value*

C. Scale of Disturbance

	Select Relevant Option Below	Score	
Total Waste Stored	250 - 1 billions tonnes	10	273 Mt from mining model
Footprint	100 - 250 hectares	3	233 Ha Pit footprint

D. Transport Pathways

	Select Relevant Option Below	Score	
Project / Exploration?	No		
Precipitation / Areal Potential Evapo-transpiration Ratio	1/10 to 1/3 ratio_mining below the water table in an aquitard or an isolated local aquifer	2	RTIO, 2016

**All new projects should respond Yes to Project / Exploration*

E. Sensitivity of Receiving Environment

	Select Relevant Option Below	Score	
Distance to Perennial/Ephemeral Water Bodies	>2000 metres	0	RTIO, 2016
Alkalinity	10 - 35 mg/L	3	RTIO, 2016
Distance to closest protected / permanently inhabited area	>10000 metres	0	RTIO, 2016

Preliminary Hazard Assessment

Preliminary Hazard Score	45
Preliminary Risk Assessment	**MODERATE**

2. Detailed Assessment (Pre Feasibility/ Feasibility/Mining)

This assessment should be completed by an ARD expert

Pit	**West Angelas Deposit E**

F. Geochemical Hazard (Interrogate the drill hole database)

	Select Relevant Option Below	Score	Option Details
Waste sulfur risk	Total number of waste samples with S>0.1% is less than 3%	0	1.2% of in-pit waste samples contain >0.1 wt%S
Ore grade sulfur risk	Total number of ore grade samples with S>0.1% is less than 3%	0	1.8% of in-pit ore samples contain >0.1 wt%S
Spatial distribution of sulfur	Sulfur scattered throughout the pit and through numerous lithologies	3	Elevated sulfur in other rock types likely to be in the form of sulfate
Chemical enrichment	Enrichments of contaminants that are unlikely to mobilise into groundwater	1	Unlikely that sulfidic material will be exposed

G. Mine Planning Hazard

	Select Relevant Option Below	Score	Option Details
PAF material management	No special waste management needed	0	No significant PAF tonnages to be mined
Bulk NPR (Mass of neutralising material x mean ANC) / (Percent of lithology greater than 0.1% x tonnes of lithology x mean sulfur concentration for all data greater than 0.1 x 30.6 + repeat for each PAF lithologies)	>3	0	No significant PAF tonnages to be mined
PAF rock mass disturbed or exposed (waste tonnes with S>0.1%)/(total tonnes of waste)*100	< 3% of the total disturbed mass	0	No significant PAF tonnages to be mined
Pit backfilling	Pit will not be backfilled	5	No commitment to backfill pits (RTIO, 2016)

H. Water Management Hazard

	Select Relevant Option Below	Score	Option Details
Dewatering volume	0 to 80 ML/day	1	RTIO, 2016
Surface water	Creek flow	7	Waste dump and sump will limit runoff from events up to 20% AEP
Water treatment during Operation	No water treatment or special management for ARD needed	0	No unoxidised black shale expected to be encountered
Final void management	No PAF rock exposures likely on final pit shell	0	No unoxidised black shale expected to be encountered

Combined Hazard Assessment

Preliminary Assessment Score	45
Detailed Assessment Score	17
Combined Hazard Score	28
Risk Ranking	**LOW**

This risk ranking score card is relevant for Pilbara based iron ore operations and the ranking system can be used to assess the relative risk of each operation. The ranking system is likely to overestimate the risk if compared to porphry copper or some coal deposits.

For RTIO internal distribution only. The manager of Technical Projects and Development will need to review and approve this prior to external release.
This risk assessment should be read in conjunction with the detailed ARD Risk Assessment

Project Name	West Angelas Deposit F	
Assessment Date	14/02/2020	
Compiled by	Mine Waste Management	
Final ARD Hazard Assessment	**LOW**	

Version Date: 13/02/12
Version Number: 2

RTIO ARD Hazard Score

1. Preliminary Assessment (Order of Magnitude/Exploration)

A. Preliminary Geology Hazard

	Select Relevant Option Below	Score	Option Details
Ore Deposit Type	C) Enriched Marra Mamba Formation and Joffre Member, and/or channel and detrital ore bodies mined below the water table (un-oxidised lignite and black shales other than Mt McRae may be present). Enriched Dales Gorge Member mined above the water table only	14	Moderate / moderate
Host & Country Rock Neutralising Potential	None (<5%)	10	
Brownfield's / Greenfields	Brownfield		
Known ARD Issues on Site	No	0	
		Geology Hazard Score	24

Complete following sections

B. Incipient ARD Risk

	Select Relevant Option Below	Score	
Operation Age	5 - 10 years	3	MCP (RTIO, 2018)

By default, all new projects should receive a <5 years value

C. Scale of Disturbance

	Select Relevant Option Below	Score	
Total Waste Stored	50 - 250 million tonnes	5	214 Mt, from mining model
Footprint	250 - 1000 hectares	6	308 ha, pit footprint

D. Transport Pathways

	Select Relevant Option Below	Score	
Project / Exploration?	No		
Precipitation / Areal Potential Evapo-transpiration Ratio	1/10 to 1/3 ratio_mining below the water table in an aquitard or an isolated local aquifer	2	RTIO, 2016

All new projects should respond Yes to Project / Exploration

E. Sensitivity of Receiving Environment

	Select Relevant Option Below	Score	
Distance to Perennial/Ephemeral Water Bodies	>2000 metres	0	RTIO, 2016
Alkalinity	10 - 35 mg/L	3	RTIO, 2016
Distance to closest protected / permanently inhabited area	>10000 metres	0	RTIO, 2016

Preliminary Hazard Assessment

Preliminary Hazard Score	43
Preliminary Risk Assessment	MODERATE

2. Detailed Assessment (Pre Feasibility/ Feasibility/Mining)

This assessment should be completed by an ARD expert

Pit	**West Angelas Deposit F**

F. Geochemical Hazard (Interrogate the drill hole database)

	Select Relevant Option Below	Score	Option Details
Waste sulfur risk	Total number of waste samples with S>0.1% is less than 3%	0	1.9% of in-pit waste samples contain >0.1 wt%S
Ore grade sulfur risk	Total number of ore grade samples with S>0.1% is less than 3%	0	1.8% of in-pit ore samples contain >0.1 wt%S
Spatial distribution of sulfur	Sulfur scattered throughout the pit and through numerous lithologies	3	Elevated sulfur in other rock types likely to be in the form of sulfate
Chemical enrichment	Enrichments of contaminants that are unlikely to mobilise into groundwater	1	Unlikely that sulfidic material will be exposed

G. Mine Planning Hazard

	Select Relevant Option Below	Score	Option Details
PAF material management	No special waste management needed	0	No significant PAF tonnages to be mined
Bulk NPR (Mass of neutralising material x mean ANC) / (Percent of lithology greater than 0.1% x tonnes of lithology x mean sulfur concentration for all data greater than 0.1 x 30.6 + repeat for each PAF lithologies)	>3	0	No significant PAF tonnages to be mined
PAF rock mass disturbed or exposed (waste tonnes with S>0.1%)/(total tonnes of waste)*100	< 3% of the total disturbed mass	0	No significant PAF tonnages to be mined
Pit backfilling	Pit will not be backfilled	5	No commitment to backfill pits (RTIO, 2016)

H. Water Management Hazard

	Select Relevant Option Below	Score	Option Details
Dewatering volume	0 to 80 ML/day	1	RTIO, 2016
Surface water	Catchment area above the pit	5	RTIO, 2016
Water treatment during Operation	No water treatment or special management for ARD needed	0	No unoxidised black shale expected to be encountered
Final void management	No PAF rock exposures likely on final pit shell	0	No unoxidised black shale expected to be encountered

Combined Hazard Assessment

Preliminary Assessment Score	43
Detailed Assessment Score	15
Combined Hazard Score	26
Risk Ranking	LOW

This risk ranking score card is relevant for Pilbara based iron ore operations and the ranking system can be used to assess the relative risk of each operation. The ranking system is likely to overestimate the risk if compared to porphry copper or some coal deposits.

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This risk assessment should be read in conjunction with the detailed ARD Risk Assessment

Project Name	West Angelas Deposit G
Assessment Date	14/02/2020
Compiled by	Mine Waste Management
Final ARD Hazard Assessment	**LOW**

Version Date: 13/02/12
Version Number: 2

RTIO ARD Hazard Score

1. Preliminary Assessment (Order of Magnitude/Exploration)

A. Preliminary Geology Hazard

	Select Relevant Option Below	Score	Option Details
Ore Deposit Type	C) Enriched Marra Mamba Formation and Joffre Member, and/or channel and detrital ore bodies mined below the water table (un-oxidised lignite and black shales other than Mt McRae may be present). Enriched Dales Gorge Member mined above the water table only	14	Moderate / moderate
Host & Country Rock Neutralising Potential	None (<5%)	10	
Brownfield's / Greenfields	Greenfield		
Known ARD Issues on Site	No	0	
		Geology Hazard Score	26

Complete following sections

B. Incipient ARD Risk

	Select Relevant Option Below	Score
Operation Age	< 5 years	5

**By default, all new projects should receive a <5 years value*

C. Scale of Disturbance

	Select Relevant Option Below	Score	
Total Waste Stored	50 - 250 million tonnes	5	53 Mt from mining model
Footprint	<100 hectares	0	89 ha pit footprint

D. Transport Pathways

	Select Relevant Option Below	Score	
Project / Exploration?	No		
Precipitation / Areal Potential Evapo-transpiration Ratio	1/10 to 1/3 ratio_mining below the water table in an aquitard or an isolated local aquifer	2	BWT mining expected

**All new projects should respond Yes to Project / Exploration*

E. Sensitivity of Receiving Environment

	Select Relevant Option Below	Score	
Distance to Perennial/Ephemeral Water Bodies	>2000 metres	0	RTIO, 2016
Alkalinity	>35 mg/L	1	RTIO, 2016
Distance to closest protected / permanently inhabited area	>10000 metres	0	RTIO, 2016

Preliminary Hazard Assessment

Preliminary Hazard Score	39
Preliminary Risk Assessment	**LOW**

2. Detailed Assessment (Pre Feasibility/ Feasibility/Mining)

This assessment should be completed by an ARD expert

Pit	**West Angelas Deposit G**

F. Geochemical Hazard (Interrogate the drill hole database)

	Select Relevant Option Below	Score	Option Details
Waste sulfur risk	Total number of waste samples with S>0.1% is less than 3%	0	0.9% of in-pit waste samples contain >0.1 wt%S
Ore grade sulfur risk	Total number of ore grade samples with S>0.1% is less than 3%	0	0.7% of in-pit ore samples contain >0.1 wt%S
Spatial distribution of sulfur	Sulfur scattered throughout the pit and through numerous lithologies	3	Elevated sulfur in other rock types likely to be in the form of sulfate
Chemical enrichment	Enrichments of contaminants that are unlikely to mobilise into groundwater	1	Release of metals controlled by weathering and dissolution

G. Mine Planning Hazard

	Select Relevant Option Below	Score	Option Details
PAF material management	No special waste management needed	0	No significant PAF tonnages to be mined
Bulk NPR (Mass of neutralising material x mean ANC) / (Percent of lithology greater than 0.1% x tonnes of lithology x mean sulfur concentration for all data greater than 0.1 x 30.6 + repeat for each PAF lithologies)	>3	0	No significant PAF tonnages to be mined
PAF rock mass disturbed or exposed (waste tonnes with S>0.1%)/(total tonnes of waste)*100	< 3% of the total disturbed mass	0	No significant PAF tonnages to be mined
Pit backfilling	Pit will not be backfilled	5	No commitment to backfill pits (RTIO, 2016)

H. Water Management Hazard

	Select Relevant Option Below	Score	Option Details
Dewatering volume	0 to 80 ML/day	1	Unknown - RTIO to confirm
Surface water	Catchment area above the pit	5	RTIO, 2016
Water treatment during Operation	No water treatment or special management for ARD needed	0	No unoxidised black shale expected to be encountered
Final void management	No PAF rock exposures likely on final pit shell	0	No unoxidised black shale expected to be encountered

Combined Hazard Assessment

Preliminary Assessment Score	39
Detailed Assessment Score	15
Combined Hazard Score	25
Risk Ranking	**LOW**

This risk ranking score card is relevant for Pilbara based iron ore operations and the ranking system can be used to assess the relative risk of each operation. The ranking system is likely to overestimate the risk if compared to porphyry copper or some coal deposits.

For RTIO internal distribution only. The manager of Technical Projects and Development will need to review and approve this prior to external release.
This risk assessment should be read in conjunction with the detailed ARD Risk Assessment

Project Name	West Angelas Deposit H
Assessment Date	14/02/2020
Compiled by	Mine Waste Management
Final ARD Hazard Assessment	LOW

Version Date: 13/02/12
Version Number: 2

RTIO ARD Hazard Score

1. Preliminary Assessment (Order of Magnitude/Exploration)

A. Preliminary Geology Hazard

	Select Relevant Option Below	Score	Option Details
Ore Deposit Type	C) Enriched Marra Mamba Formation and Joffre Member, and/or channel and detrital ore bodies mined below the water table (un-oxidised lignite and black shales other than Mt McRae may be present). Enriched Dales Gorge Member mined above the water table only	14	Moderate / moderate
Host & Country Rock Neutralising Potential	None (<5%)	10	
Brownfield's / Greenfields	Greenfield		
Known ARD Issues on Site	No	0	
		Geology Hazard Score	26

Complete following sections

B. Incipient ARD Risk

	Select Relevant Option Below	Score
Operation Age	< 5 years	5

**By default, all new projects should receive a <5 years value*

C. Scale of Disturbance

	Select Relevant Option Below	Score	
Total Waste Stored	<50 million tonnes	0	23 Mt from mining model
Footprint	100 - 250 hectares	3	125 ha pit footprint

D. Transport Pathways

	Select Relevant Option Below	Score	
Project / Exploration?	Yes		
Precipitation / Areal Potential Evapo-transpiration Ratio	1/10 to 1/3 ratio_mining above the water table exclusively	2	Groundwater intersects base of pit. RTIO to confirm.

**All new projects should respond Yes to Project / Exploration*

E. Sensitivity of Receiving Environment

	Select Relevant Option Below	Score	
Distance to Perennial/Ephemeral Water Bodies	>2000 metres	0	From Section 2.5. RTIO to confirm.
Alkalinity	10 - 35 mg/L	3	Similar to nearby deposits. RTIO to confirm.
Distance to closest protected / permanently inhabited area	>10000 metres	0	Similar to nearby deposits. RTIO to confirm.

Preliminary Hazard Assessment

Preliminary Hazard Score	39
Preliminary Risk Assessment	LOW

2. Detailed Assessment (Pre Feasibility/ Feasibility/Mining)

This assessment should be completed by an ARD expert

Pit | **West Angelas Deposit H**

F. Geochemical Hazard (Interrogate the drill hole database)

	Select Relevant Option Below	Score	Option Details
Waste sulfur risk	Total number of waste samples with S>0.1% is between 3% and 10%, less than 0.5% of samples have S>0.3%	2	7.4% of in-pit waste samples contain >0.1 wt%S. 0.2% of in-pit waste samples contain >0.3 wt%S
Ore grade sulfur risk	Total number of ore grade samples with S>0.1% is less than 3%	0	1.1% of in-pit ore samples contain >0.1 wt%S
Spatial distribution of sulfur	Sulfur scattered throughout the pit and through numerous lithologies	3	Elevated sulfur in other rock types likely to be in the form of sulfate
Chemical enrichment	Enrichments of contaminants that are unlikely to mobilise into groundwater	1	Unlikely that sulfidic material will be exposed

G. Mine Planning Hazard

	Select Relevant Option Below	Score	Option Details
PAF material management	No special waste management needed	0	No significant PAF tonnages to be mined
Bulk NPR (Mass of neutralising material x mean ANC) / (Percent of lithology greater than 0.1% x tonnes of lithology x mean sulfur concentration for all data greater than 0.1 x 30.6 + repeat for each PAF lithologies)	1 to 3	3	Bulk ANC cannot be calculated due to no ANC data for Deposit J. Conservative estimate.
PAF rock mass disturbed or exposed (waste tonnes with S>0.1%)/(total tonnes of waste)*100	< 3% of the total disturbed mass	0	No significant PAF tonnages to be mined
Pit backfilling	Pit will not be backfilled	5	No commitment to backfill pits (RTIO, 2016)

H. Water Management Hazard

	Select Relevant Option Below	Score	Option Details
Dewatering volume	0 to 80 ML/day	1	Similar to nearby deposits. RTIO to confirm.
Surface water	Catchment area above the pit	5	Similar to nearby deposits. RTIO to confirm.
Water treatment during Operation	No water treatment or special management for ARD needed	0	No unoxidised black shale expected to be encountered
Final void management	No PAF rock exposures likely on final pit shell	0	No unoxidised black shale expected to be encountered

Combined Hazard Assessment

Preliminary Assessment Score	39
Detailed Assessment Score	20
Combined Hazard Score	30
Risk Ranking	LOW

This risk ranking score card is relevant for Pilbara based iron ore operations and the ranking system can be used to assess the relative risk of each operation. The ranking system is likely to overestimate the risk if compared to porphry copper or some coal deposits.

For RTIO internal distribution only. The manager of Technical Projects and Development will need to review and approve this prior to external release.
This risk assessment should be read in conjunction with the detailed ARD Risk Assessment

Project Name	West Angelas Deposit J
Assessment Date	14/02/2020
Compiled by	Mine Waste Management
Final ARD Hazard Assessment	MODERATE

Version Date: 13/02/12
Version Number: 2

RTIO ARD Hazard Score

1. Preliminary Assessment (Order of Magnitude/Exploration)

A. Preliminary Geology Hazard

	Select Relevant Option Below	Score	Option Details
Ore Deposit Type	C) Enriched Marra Mamba Formation and Joffre Member, and/or channel and detrital ore bodies mined below the water table (un-oxidised lignite and black shales other than Mt McRae may be present). Enriched Dales Gorge Member mined above the water table only	14	Moderate / moderate
Host & Country Rock Neutralising Potential	None (<5%)	10	
Brownfield's / Greenfields	Greenfield		
Known ARD Issues on Site	No	0	
	Geology Hazard Score		26

Complete following sections

B. Incipient ARD Risk

	Select Relevant Option Below	Score
Operation Age	< 5 years	5

By default, all new projects should receive a <5 years value

C. Scale of Disturbance

	Select Relevant Option Below	Score	
Total Waste Stored	50 - 250 million tonnes	5	61 Mt from mining model
Footprint	100 - 250 hectares	3	151 ha pit footprint

D. Transport Pathways

	Select Relevant Option Below	Score	
Project / Exploration?	No		
Precipitation / Areal Potential Evapo-transpiration Ratio	1/10 to 1/3 ratio_mining below the water table in an aquitard or an isolated local aquifer	2	Groundwater intersects base of pit. RTIO to confirm.

All new projects should respond Yes to Project / Exploration

E. Sensitivity of Receiving Environment

	Select Relevant Option Below	Score	
Distance to Perennial/Ephemeral Water Bodies	>2000 metres	0	From Section 2.5. RTIO to confirm.
Alkalinity	10 - 35 mg/L	3	Similar to nearby deposits. RTIO to confirm.
Distance to closest protected / permanently inhabited area	>10000 metres	0	Similar to nearby deposits. RTIO to confirm.

Preliminary Hazard Assessment

Preliminary Hazard Score	44
Preliminary Risk Assessment	MODERATE

2. Detailed Assessment (Pre Feasibility/ Feasibility/Mining)

This assessment should be completed by an ARD expert

Pit	**West Angelas Deposit J**

F. Geochemical Hazard (Interrogate the drill hole database)

	Select Relevant Option Below	Score	Option Details
Waste sulfur risk	Total number of waste samples with S>0.1% is between 3% and 10%, less than 0.5% of samples have S>0.3%	2	8.6% of samples contain TS >0.1 wt%S. Although 0.7% of samples contain TS >0.3 wt%S, this rating is more appropriate than the next highest rating.
Ore grade sulfur risk	Total number of ore grade samples with S>0.1% is between 3% and 10% but less than 0.5% of the samples have S>0.3%	2	4% of samples contain TS >0.1 wt%S. 0.5% of samples contain TS >0.3 wt%S
Spatial distribution of sulfur	Sulfur scattered throughout the pit and through numerous lithologies	3	Elevated sulfur likely to be in the form of sulfate
Chemical enrichment	Enrichments of contaminants that are unlikely to mobilise into groundwater	1	Unlikely that sulfidic material will be exposed

G. Mine Planning Hazard

	Select Relevant Option Below	Score	Option Details
PAF material management	PAF waste dumps will be in-pit	2	Small quantitiy of BS-OXID requiring management. Assume in-pit disposal. RTIO to confirm.
Bulk NPR (Mass of neutralising material x mean ANC) / (Percent of lithology greater than 0.1% x tonnes of lithology x mean sulfur concentration for all data greater than 0.1 x 30.6 + repeat for each PAF lithologies)	1 to 3	3	Bulk ANC cannot be calculated due to no ANC data for Deposit J. Conservative estimate.
PAF rock mass disturbed or exposed (waste tonnes with S>0.1%)/(total tonnes of waste)*100	< 3% of the total disturbed mass	0	Some BS-COLD expected.
Pit backfilling	Waste will be tipped over black shale exposures	2	Conservative assumption.

H. Water Management Hazard

	Select Relevant Option Below	Score	Option Details
Dewatering volume	0 to 80 ML/day	1	Similar to nearby deposits. RTIO to confirm.
Surface water	Catchment area above the pit	5	Similar to nearby deposits. RTIO to confirm.
Water treatment during Operation	No water treatment or special management for ARD needed	0	Unoxidised black shale not expected to be encountered
Final void management	Less than 3% PAF exposed	2	Unoxidised black shale not expected to be encountered. Some BS-OXID expected.

Combined Hazard Assessment

Preliminary Assessment Score	44
Detailed Assessment Score	23
Combined Hazard Score	34
Risk Ranking	MODERATE

This risk ranking score card is relevant for Pilbara based iron ore operations and the ranking system can be used to assess the relative risk of each operation. The ranking system is likely to overestimate the risk if compared to porphry copper or some coal deposits.

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This risk assessment should be read in conjunction with the detailed ARD Risk Assessment

Project Name	West Angelas Mt Ella East	
Assessment Date	14/02/2020	
Compiled by	Mine Waste Management	
Final ARD Hazard Assessment	**LOW**	

Version Date: 13/02/12
Version Number: 2

RTIO ARD Hazard Score

1. Preliminary Assessment (Order of Magnitude/Exploration)

A. Preliminary Geology Hazard

	Select Relevant Option Below	Score	Option Details
Ore Deposit Type	B) Enriched Marra Mamba Formation and Joffre Member, and/or channel and detrital ore bodies mined above water table only (no Mt McRae Shale present and all rock types likely oxidised).	7	Low / moderate
Host & Country Rock Neutralising Potential	None (<5%)	10	
Brownfield's / Greenfields	Greenfield		
Known ARD Issues on Site	No	0	
		Geology Hazard Score	19

Complete following sections

B. Incipient ARD Risk

	Select Relevant Option Below	Score
Operation Age	< 5 years	5

**By default, all new projects should receive a <5 years value*

C. Scale of Disturbance

	Select Relevant Option Below	Score	
Total Waste Stored	<50 million tonnes	0	14 Mt from mining model
Footprint	<100 hectares	0	40 ha pit footprint

D. Transport Pathways

	Select Relevant Option Below	Score	
Project / Exploration?	Yes		
Precipitation / Areal Potential Evapo-transpiration Ratio	1/10 to 1/3 ratio_mining above the water table exclusively	2	AWT only

**All new projects should respond Yes to Project / Exploration*

E. Sensitivity of Receiving Environment

	Select Relevant Option Below	Score	
Distance to Perennial/Ephemeral Water Bodies	>2000 metres	0	Similar to nearby deposits. RTIO to confirm.
Alkalinity	10 - 35 mg/L	3	Similar to nearby deposits. RTIO to confirm.
Distance to closest protected / permanently inhabited area	>10000 metres	0	Similar to nearby deposits. RTIO to confirm.

Preliminary Hazard Assessment

Preliminary Hazard Score	29
Preliminary Risk Assessment	**LOW**

2. Detailed Assessment (Pre Feasibility/ Feasibility/Mining)

This assessment should be completed by an ARD expert

Pit	**West Angelas Mt Ella East**

F. Geochemical Hazard (Interrogate the drill hole database)

	Select Relevant Option Below	Score	Option Details
Waste sulfur risk	Total number of waste samples with S>0.1% is between 3% and 10%, less than 0.5% of samples have S>0.3%	2	8.5% of in-pit waste samples contain >0.1 wt%S. Although 0.6% of samples contain TS >0.3 wt%S, this rating is more appropriate than the next highest rating.
Ore grade sulfur risk	Total number of ore grade samples with S>0.1% is between 3% and 10% but less than 0.5% of the samples have S>0.3%	2	4.2% of samples contain TS >0.1 wt%S. 0.4% of samples contain TS >0.3 wt%S
Spatial distribution of sulfur	Sulfur scattered throughout the pit and through numerous lithologies	3	Elevated sulfur likely to be in the form of sulfate. Associated with detritals and DG
Chemical enrichment	Enrichments of contaminants that are unlikely to mobilise into groundwater	1	Unlikely that sulfidic material will be exposed

G. Mine Planning Hazard

	Select Relevant Option Below	Score	Option Details
PAF material management	No special waste management needed	0	No significant PAF tonnages to be mined
Bulk NPR (Mass of neutralising material x mean ANC) / (Percent of lithology greater than 0.1% x tonnes of lithology x mean sulfur concentration for all data greater than 0.1 x 30.6 + repeat for each PAF lithologies)	1 to 3	3	Bulk ANC cannot be calculated due to no ANC data for Deposit J. Conservative estimate.
PAF rock mass disturbed or exposed (waste tonnes with S>0.1%)/(total tonnes of waste)*100	< 3% of the total disturbed mass	0	No significant PAF tonnages to be mined
Pit backfilling	Pit will not be backfilled	5	No commitment to backfill pits (RTIO, 2016)

H. Water Management Hazard

	Select Relevant Option Below	Score	Option Details
Dewatering volume	No releases of water	0	AWT only
Surface water	Catchment area above the pit	5	Similar to nearby deposits. RTIO to confirm.
Water treatment during Operation	No water treatment or special management for ARD needed	0	Unoxidised black shale not expected to be encountered
Final void management	No PAF rock exposures likely on final pit shell	0	Unoxidised black shale not expected to be encountered

Combined Hazard Assessment

Preliminary Assessment Score	29
Detailed Assessment Score	21
Combined Hazard Score	28
Risk Ranking	**LOW**

This risk ranking score card is relevant for Pilbara based iron ore operations and the ranking system can be used to assess the relative risk of each operation. The ranking system is likely to overestimate the risk if compared to porphry copper or some coal deposits.

For RTIO internal distribution only. The manager of Technical Projects and Development will need to review and approve this prior to external release.
This risk assessment should be read in conjunction with the detailed ARD Risk Assessment

Project Name	West Angelas Western Hill Deposit
Assessment Date	14/02/2020
Compiled by	Mine Waste Management
Final ARD Hazard Assessment	**MODERATE**

Version Date: 13/02/12
Version Number: 2

RTIO ARD Hazard Score

1. Preliminary Assessment (Order of Magnitude/Exploration)

A. Preliminary Geology Hazard

	Select Relevant Option Below	Score	Option Details
Ore Deposit Type	C) Enriched Marra Mamba Formation and Joffre Member, and/or channel and detrital ore bodies mined below the water table (un-oxidised lignite and black shales other than Mt McRae may be present). Enriched Dales Gorge Member mined above the water table only	14	Moderate / moderate
Host & Country Rock Neutralising Potential	None (<5%)	10	
Brownfield's / Greenfields	Greenfield		
Known ARD Issues on Site	No	0	
		Geology Hazard Score	26

Complete following sections

B. Incipient ARD Risk

	Select Relevant Option Below	Score
Operation Age	< 5 years	5

By default, all new projects should receive a <5 years value

C. Scale of Disturbance

	Select Relevant Option Below	Score	
Total Waste Stored	50 - 250 million tonnes	5	142 Mt from mining model
Footprint	250 - 1000 hectares	6	303 ha pit footprint

D. Transport Pathways

	Select Relevant Option Below	Score	
Project / Exploration?	Yes		
Precipitation / Areal Potential Evapo-transpiration Ratio	1/10 to 1/3 ratio_mining below the water table in a rock mass that is connected to a regionally significant aquifer	5	Similar to nearby deposits. RTIO to confirm.

All new projects should respond Yes to Project / Exploration

E. Sensitivity of Receiving Environment

	Select Relevant Option Below	Score	
Distance to Perennial/Ephemeral Water Bodies	500 - 2000 metres	1	Approx 1.5km to Turee Creek East. Section 2.5.
Alkalinity	10 - 35 mg/L	3	Similar to nearby deposits. RTIO to confirm.
Distance to closest protected / permanently inhabited area	>10000 metres	0	Similar to nearby deposits. RTIO to confirm.

Preliminary Hazard Assessment

Preliminary Hazard Score	51
Preliminary Risk Assessment	**MODERATE**

2. Detailed Assessment (Pre Feasibility/ Feasibility/Mining)

This assessment should be completed by an ARD expert

Pit	**West Angelas Western Hill Deposit**

F. Geochemical Hazard (Interrogate the drill hole database)

	Select Relevant Option Below	Score	Option Details
Waste sulfur risk	Total number of waste samples with S>0.1% is between 3% and 10%, less than 0.5% of samples have S>0.3%	2	6.2% of samples contain TS >0.1 wt%S. Although 0.6% of samples contain TS >0.3 wt%S, this rating is more appropriate than the next highest rating.
Ore grade sulfur risk	Total number of ore grade samples with S>0.1% is between 3% and 10% but less than 0.5% of the samples have S>0.3%	2	2.1% of samples contain TS >0.1 wt%S. 0.5% of samples contain TS >0.1 wt%S
Spatial distribution of sulfur	Sulfur scattered throughout the pit and through numerous lithologies	3	Elevated-sulfur mainly concentrated within WS and FWZ
Chemical enrichment	Enrichments of contaminants that are unlikely to mobilise into groundwater	1	Unlikely that sulfidic material will be exposed

G. Mine Planning Hazard

	Select Relevant Option Below	Score	Option Details
PAF material management	No special waste management needed	0	No BS-COLD or BS-HOT expected to be mined.
Bulk NPR (Mass of neutralising material x mean ANC) / (Percent of lithology greater than 0.1% x tonnes of lithology x mean sulfur concentration for all data greater than 0.1 x 30.6 + repeat for each PAF lithologies)	1 to 3	3	Bulk ANC cannot be calculated due to no ANC data for Deposit J. Conservative estimate.
PAF rock mass disturbed or exposed (waste tonnes with S>0.1%)/(total tonnes of waste)*100	< 3% of the total disturbed mass	0	No significant PAF tonnages to be mined
Pit backfilling	Pit will not be backfilled	5	No commitment to backfill pits. RTIO to confirm.

H. Water Management Hazard

	Select Relevant Option Below	Score	Option Details
Dewatering volume	0 to 80 ML/day	1	Similar to nearby deposits. RTIO to confirm.
Surface water	Catchment area above the pit	5	Similar to nearby deposits. RTIO to confirm.
Water treatment during Operation	No water treatment or special management for ARD needed	0	Unoxidised black shale not expected to be encountered
Final void management	No PAF rock exposures likely on final pit shell	0	Unoxidised black shale not expected to be encountered

Combined Hazard Assessment

Preliminary Assessment Score	51
Detailed Assessment Score	22
Combined Hazard Score	35
Risk Ranking	**MODERATE**

This risk ranking score card is relevant for Pilbara based iron ore operations and the ranking system can be used to assess the relative risk of each operation. The ranking system is likely to overestimate the risk if compared to porphry copper or some coal deposits.

For RTIO internal distribution only. The manager of Technical Projects and Development will need to review and approve this prior to external release.
This risk assessment should be read in conjunction with the detailed ARD Risk Assessment

APPENDIX C AMD BASICS AND LABORATORY METHODS

Rocks containing sulfide minerals such as pyrite exposed to oxygen and water as a result of mining undergo weathering processes (reaction with oxygen and water) and oxidise releasing acid and metals. Pyrite is the main form of sulfide mineral present at the Project. The oxidation of pyrite is explained by Equation 1 to Equation 3 where ferric (Fe^{3+}) iron precipitates in a goethite or ferrihydrite type form (iron-oxyhydroxide).

Equation 1: $FeS_{2(s)} + \frac{7}{2}O_{2(g)} + H_2O_{(l)} \rightarrow Fe^{2+}{}_{(aq)} + 2SO_4{}^{2-}{}_{(aq)} + 2H^+{}_{(aq)} + energy$

Equation 2: $Fe^{2+}{}_{(aq)} + \frac{1}{4}O_{2(g)} + H^+{}_{(aq)} \rightarrow Fe^{3+}{}_{(aq)} + \frac{1}{2}H_2O_{(l)} + energy$

Equation 3: $Fe^{3+}{}_{(aq)} + 3H_2O_{(l)} \rightarrow Fe(OH)_{3(s)} + 3H^+{}_{(aq)}$

Often there is incomplete oxidation of ferrous (Fe^{2+}) to ferric iron and ferrous salts such as melanterite, $FeSO_4$ (Equation 4) can form. These salts, when hydrolysed, release stored ferrous acidity (Equation 5). These acid sulfate salts are highly soluble.

Equation 4: $FeS_{2(s)} + \frac{7}{2}O_{2(g)} + H_2O_{(l)} \rightarrow FeSO_{4(s)} + 2SO_4{}^{2-}{}_{(aq)} + 2H^+{}_{(aq)} + energy$

Equation 5: $FeSO_{4(s)} + \frac{1}{4}O_{2(g)} + \frac{5}{2}H_2O_{(l)} \rightarrow Fe(OH)_{3(s)} + SO_4{}^{2-}{}_{(aq)} + 2H^+{}_{(aq)}$

However, if oxidation to ferric iron is complete yet the hydrolysis is incomplete, jarosite type secondary minerals can form. Jarosite type minerals form at pH values below 3.5 and release only 2 moles of acidity per mole of ferric iron incorporated into the jarosite mineral lattice, not the associated 3 moles of acidity associated with complete iron hydrolysis. Thus, jarosite type minerals store acidity that can be released once pH increases or if the environmental conditions change such that the mineral is no longer stable (Equation 6). Jarosite is stable at pH values < 4 in oxic conditions. Above pH 4.7 jarosite is soluble, dissolving slowly (Li et al., 2007), which has long term implications for the rebound of pH to circum-neutral conditions after sulfide exhaustion and/or for the treatment of AMD impacted waters.

Equation 6: $KFe^3(SO_4)_2(OH)_{6(s)} + 3H_2O_{(l)} \rightarrow 3Fe(OH)_{3(s)} + 2SO_4{}^{2-}{}_{(aq)} + 3H^+{}_{(aq)} + K^+{}_{(aq)}$

The acidity load associated with the dissolution of ferrous salts such as melanterite will occur immediately upon wetting. This acidity can be measured by simple leach tests followed by back titration to determine the acidity load in kg of H_2SO_4 per tonne of waste rock. The jarosite type minerals have much slower dissolution kinetics and are not determined by simple wetting tests, rather 4M HCl digestion.

The acidity released by pyrite oxidation and secondary acidic salts can be neutralised by carbonate minerals and silicate minerals present within the waste rock. Neutralisation by calcium carbonate (limestone) typically results in 2 moles of hydrogen ions being neutralised per mole of limestone (Equation 7) provided CO_2 can form and be released.

Equation 7: $CaCO_{3(g)} + 2H^+{}_{(aq)} \rightarrow Ca^{2+}{}_{(aq)} + CO_{2(g)} + H_2O_{(l)}$

Silicate mineralogy will often be the key to understanding the long-term weathering potential of waste rock. Silicate weathering consumes hydrogen ions as the mineral either completely dissolves (congruent weathering) or is transformed into another phase (incongruent weathering) (Lottermoser, 2010). For example, the congruent weathering of potassium feldspar can be represented by Equation

8. However, the rate at which this reaction occurs is far slower than the dissolution of carbonates (Lottermoser, 2010).

Equation 8: $KAlSi_3O_{8(s)} + H^+{}_{(aq)} + 7H_2O_{(l)} \rightarrow K^+{}_{(aq)} + Al^{3+}{}_{(aq)} + 3H_4SiO_{4(aq)} + 3OH^-{}_{(aq)}$

ACID BASE ACCOUNTING

Acid base accounting (ABA) is conducted to predict the acid generation characteristics of a waste rock material through determination of the acid neutralising capacity (ANC) and the maximum potential acidity (MPA). Although analysis of pH using distilled water is not a standard ABA test, it is often completed to aid in the interpretation of the ABA data as ancillary information.

The net acid production potential (NAPP) is a measure of the samples overall acid generating capacity and is calculated by subtracting the ANC of the sample from the MPA. A negative NAPP indicates that the sample has a net neutralising capacity and a positive NAPP indicates that the sample has a net acid generating capacity. NAPP, MPA, and ANC are expressed in kg H_2SO_4/tonne equivalent.

ANC is determined by acid digestion (using HCl) of the sample followed by back-titration (using NaOH) to determine the quantity of acid consumed by neutralising minerals within the rock sample. MPA is based on total sulfur in wt%S (or sulfide sulfur if available) multiplied by the stoichiometric conversion factor 30.6. This conversion factor is determined from the stoichiometry of pyrite oxidation. NAPP is calculated via Equation 9 (all units are in kg H_2SO_4/t):

Equation 9: $NAPP = MPA - ANC$

Thus, potentially acid forming (PAF) material have a positive NAPP and non-acid forming (NAF) material have a negative NAPP.

ABA analysis for this project included the following:

- Paste pH/EC: Pulverised sample (25 g) is equilibrated with deionised water at a 1:2 ratio and left for 12 hours (or overnight) before pH and EC measurements of the slurry are recorded (AMIRA, 2002).

- Total Sulfur (TS): Measured by heating a pulverised sample (< 2 g) in a LECO furnace to ~1,650°C and measuring the sulfur dioxide production. Assay sulfur values measured by XRF analysis on pelletised samples can be used as a substitute for total sulfur measured by LECO.

- Total Carbon (TC): Measured by heating a pulverised sample (< 2 g) in a LECO furnace to ~1,650°C and measuring the carbon dioxide production.

- Acid Soluble Sulfur (S-SO_4 or S_{HCl}): Method uses 3M hydrochloric acid (HCl) to extract soluble and slightly soluble sulfate from a pulverised sample (< 2 g) over a 1-hour period. Sulfides should not react and would normally be expelled; extracted sulfur is determined by ICP analysis of the digestion liquor.

- Chromium Reducible Sulfur (S-CRS): Method is based on the conversion of reduced inorganic sulfur to H_2S by a hot acidic $CrCl_2$ solution. The evolved H_2S is trapped in a zinc acetate solution as ZnS which is then quantified by iodometric titration (Ahern et al., 2004).

- Sulfide Sulfur: Can be calculated indirectly, if sulfide sulfur has not been measured directly, via Equation 10.

Equation 10: $\text{Sulfide Sulfur} = TS - S\text{-}SO4$

- Maximum Potential Acidity (MPA): A measure of the maximum potential of a sample to generate acidity. MPA can be calculated using TS or sulfide sulfur (all units are in kg H_2SO_4/t):

Equation 11: $MPA = TS \times 30.6$

- Acid Neutralising Capacity (ANC): Measures the amount of HCl a pulped sample (2 g) can neutralise with gentle heating and the addition of hydrogen peroxide (2 drops of 30%) to dissolve any ferrous iron present (AMIRA, 2002).

- Net Acid Production Potential (NAPP): The NAPP value is calculated as the difference between MPA and ANC as per Equation 9. A negative NAPP value indicates that a sample may have sufficient ANC to prevent acid generation and conversely, if MPA exceeds ANC, the material may be acid generating.

- Single Addition Net Acid Generation (NAG) Test: A pulverised sample (2.5 g) is digested with 250 mL of 15% hydrogen peroxide and allowed to react to completion before measuring the pH of the NAG liquor. The NAG liquor is then titrated with NaOH to pH 4.5 and pH 7. Acidity measured by the titration to pH 4.5 is due to free hydrogen ion as well as acidity from aluminium and iron (AMIRA, 2002). Additional acidity measured by the titration to pH 7 can be attributed to metal hydrolysis reactions such as copper and zinc (AMIRA, 2002).

- Sequential NAG Test: Involves conducting a series of single addition NAG tests to obtain the maximum NAG acidity value. This may be required for high sulfide bearing samples where complete oxidation may not occur. Incomplete oxidation can also be due to the catalytic decomposition of the hydrogen peroxide from high organic carbon contents (AMIRA, 2002).

TOTAL ELEMENTAL ANALYSIS

The results from solid phase total or near-total analysis such as total elemental (TE) analysis or x-ray fluorescence (XRF) analysis can be used to make an inference regarding elements of potential environmental concern. Results can be assessed using tools such as the geochemical abundance index (GAI) to identify elements that may be enriched in respect to average values. However, an enrichment in a specific element does not imply mobility or bioavailability.

It is important to understand the strengths and weaknesses of each method, particularly the various digestions so that drainage predictions are not adversely affected (Price 2009).

Solid samples are digested to enable analysis with inductively coupled plasma mass spectrometry (ICP-MS) or ICP atomic emission spectrometry (ICP-AES). Various digestions can be utilised depending on the mineralogy of the sample or if specific elements are targeted, such as:

- Lithium Borate Fusion: Lithium borate flux is mixed with a pulped sample to lower the melting point and is then fused to produce a glass disc. The glass disc is either analysed directly by XRF or if a lower detection limit is required, the disc can be dissolved and analysed by ICP (Price, 2009).

- Sodium Peroxide Fusion: Sodium peroxide and sodium hydroxide is added to a pulped sample before being heated to 550°C. Diluted nitric acid is then used to dissolve the digested residue before analysis with ICP. This flux is typically used to digest samples with sulfide contents greater than 5% or other refractory or resistant minerals (Price, 2009).

- Four Acid Digest: Hydrofluoric acid, perchloric acid and nitric acid are added to a pulped sample and taken to near dryness before leaching the nearly dry cake with hydrochloric acid (Price, 2009). The majority of the samples within the environmental geochemical dataset would have been digested using this method.

Aqua Regia Digest: Samples digested in a heated water bath with a 3:1 mixture of hydrochloric acid and nitric acids (less complete digestion than the four-acid digest).

APPENDIX D EXISTING ENVIRONMENTAL GEOCHEMISTRY REPORTS

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Golder Associates

6 July 1998

98640185

Robe River Iron Associates
12 St Georges Terrace
PERTH WA 6000

8 JUL 1998

Facsimile: **9421 4777**

Attention: Mr Chris Robinson

Dear Sirs

ACID GENERATING POTENTIAL, SELECTED CORE SAMPLES
MT NEWMAN MEMBER BIF,
WEST ANGELES DEPOSIT A OPEN PIT

INTRODUCTION

In accordance with your instructions, Golder Associates Pty Ltd have arranged for laboratory testing of selected core samples recovered from the proposed Deposit A open pit. The purpose of the testing was to provide a preliminary assessment of the potential for generation of acid drainage from mine workings or waste dumps associated with the West Angeles Deposit A open pit. This letter presents the results of preliminary testing and makes recommendations for future geochemical characterisation of rock at the Deposit A open pit.

Testing was carried out on samples selected by Robe River Iron Associates. Table 1 presents a summary of the samples submitted for testing. Table 2 summarises the results of laboratory testing carried out by Australian Environmental Laboratories (AEL) and by Graeme Campbell & Associates Pty Ltd. A copy of the test report prepared by Graeme Campbell & Associates is presented in Attachment A.

RESULTS OF LABORATORY TESTING

Three of the samples tested (WAA 992 125.37 - 125.50, WAA 994 108.5 - 108.65, and WAA 994 109.00 - 109.19) were recovered from within the rock mass above the level of the proposed pit floor. The remaining two samples were from rock below the level of the pit floor. All samples tested were classified as having low salinity and all had alkaline reactions (when ground to less than 2 mm and tested as a one part water to two parts deionised water slurry).

Only one of the five samples tested (WAA 994 108.5 - 108.65) was determined to have acid generating potential. This sample was also the only sample to contain visible sulphides in the core sample provided. The estimated concentration of sulphide-sulphur in this sample was about 2%, compared with concentrations of about 0.5% or less in the other four samples.

Three of the samples tested (WAA 944 109.00 - 109.19, WAA 994 117.04 - 117.18, and WAA 994 152.32 - 152.52) contained reactive carbonates which showed slight to moderate effervescence when tested with cold hydrochloric acid. These three samples, as expected, had the highest measured acid neutralising capacity of the five samples tested.

CONCLUSIONS AND RECOMMENDATIONS

The results of preliminary geochemical testing carried out on five samples of banded iron formation from the West Angeles Deposit A open pit indicated that at least some of the rock within the proposed pit volume has acid generating potential. A more detailed evaluation of the variation in sulphide content in a complete range of rock types at West Angeles is recommended.

As acid generating wastes may require special placement and management techniques, we recommend that any future logging of core should carefully note the presence of visible sulphides. As well, representative samples should be tested for reactive carbonate by testing their reaction to cold hydrochloric acid additions. This information will assist in estimating the approximate quantity of acid generating rock within the volume to be mined.

In addition to carrying out the qualitative testing described above, selected additional representative core samples should be submitted for more detailed laboratory testing in order to confirm the likely rate and quantity of acid generation. Data on rock sulphide content should be integrated with other geological data such that, if required, it can be modelled to assist in future mine planning and scheduling of acid generating materials.

We trust this information is sufficient for your present purposes. Please ring Lisa Chandler on 08 9381 3444 if you wish to discuss any aspect of this letter or of the attached laboratory reports.

Yours faithfully
GOLDER ASSOCIATES PTY LTD
per:

Lisa Chandler
Manager Environmental Services

Attachment A Report by Graeme Campbell and Associates Pty Ltd ("*West Angeles Gold Project, Acid-Formation Potential of Waste-Rock Samples, Preliminary Testwork Programme*", May 1998)

TABLE 1

DESCRIPTION OF SAMPLES SUBMITTED FOR TESTING

Borehole No	Depth (downhole), m	Approximate RL of sample	Rock type and degree of weathering	Description
WAA 992	125.37-125.50	633	Mt Newman Member	
WAA 994	108.50-108.65	670	Mt Newman Member BIF, predominantly fresh	Thinly banded, very high strength magnetite; high strength to very high strength white chert and bands of moderate strength green-grey stilpnomelane
WAA 994	109.00-109.19	669	Mt Newman Member BIF, predominantly fresh	Thinly banded, very high strength magnetite; high strength to very high strength white chert and bands of moderate strength green-grey stilpnomelane
WAA 994	117.04-117.18	661	Mt Newman Member BIF, predominantly fresh	Thinly banded, very high strength magnetite; high strength to very high strength white chert and bands of moderate strength green-grey stilpnomelane
WAA 994	152.32-152.52	630	Shale and quartz vein (in McLeod Member BIF)	Possible shear zone, green-grey shale and chert pods, very low to moderate strength; milky white, very high strength quartz.

TABLE 2

SUMMARY OF LABORATORY TEST RESULTS

Sample ID	pH (1:2 slurry)	Electrical conductivity (1:2 slurry), mS/cm	Total sulphur, %	Acid neutralising capacity, kg H2SO4 / tonne rock	Net acid producing potential, kg H2SO4 / tonne rock	Net Acid Generation pH (after peroxide addition)
WAA 992, 125.37-125.50	8.3 (no effervescence when tested with hydrochloric acid)	0.12 (Low salinity)	0.14	12	-7.7	8.3 (Non acid forming)
WAA 994, 108.50-108.65	8.5 (no effervescence when tested with hydrochloric acid)	0.087 (Low salinity)	1.8 (Visible sulphides)	10	45	2.6 (Moderate capacity for acid formation)
WAA 994, 109.00-109.19	8.9 (Moderate effervescence)	0.11 (Low salinity)	0.14	28	-23	9.4 (Non acid forming)
WAA 994, 117.04-117.18	9.1 (Slight effervescence)	0.15 (Low salinity)	0.54	27	-11	8.8 (Non acid forming)
WAA 994, 152.32-152.52	9.0 (Moderate effervescence)	0.27 (Low salinity)	0.33	180	-170	8.6 (Non acid forming)

Note: This table is based upon results presented in a report prepared by Graeme Campbell and Associates Pty Ltd, and upon laboratory testing carried out by Australian Environmental Laboratories. For additional test results, details of test methods, and quality assurance test results, refer to the complete laboratory reports presented in Attachment A.

ATTACHMENT A

REPORT BY GRAEME CAMPBELL AND ASSOCIATES PTY LTD

GOLDERS ASSOCIATES PTY LTD

WEST ANGELES GOLD PROJECT

ACID-FORMATION POTENTIAL

OF WASTE-ROCK SAMPLES

Preliminary Testwork Programme

GRAEME CAMPBELL AND ASSOCIATES PTY LTD
(ACN 061 827674)
MAY 1998
Job No. 9824

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TABLE, FIGURE & APPENDIX
(At Back of Report Text)

1.0 INTRODUCTION

Golder Associates Pty Ltd is undertaking a range of geotechnical and engineering investigations for the West Angeles Gold Project in Malaysia.

Graeme Campbell & Associates Pty Ltd (GCA) was commissioned to determine the Acid-Formation Potential of a range of waste-rock samples submitted for testing.

The testwork results obtained are presented and discussed in this report.

2.0 TESTWORK PROGRAMME

2.1 Samples

Five (5) samples of waste-rock materials were provided to GCA for testing.

The samples were 60 mm, HQ, drillcore samples, and were derived from down-hole intervals of approximately 0.1-0.2 m.

No details were provided on the waste-rock types represented by the samples.

2.2 Testwork

Prior to preparation and testing, all samples were assigned GCA Sample Numbers, and relevant details recorded in the GCA Sample Register.

The samples were prepared by crushing (nominal 2 mm) and pulverising (nominal 75 μm) for specific tests.

The testwork methods employed in this study are based on recognised procedures for the geochemical characterisation of mine-waste materials (e.g. Smith 1992; Coastech Research 1991; BC AMD Task Force 1989).

Part of the testwork was carried out by Australian Environmental Laboratories [AEL] (Welshpool), and the analyses performed by AEL have NATA endorsement, except for Total-S.[1]

Other testing was undertaken by Dr. Graeme Campbell in the GCA Testing Laboratory (Bridgetown).

Copies of the laboratory reports are presented in the Appendix.

The waste-rock samples were tested for:

- pH and Electrical Conductivity (EC) on sample slurries.
- Total Sulphur (Total-S) and Sulphate Sulphur (SO_4-S).

[1] NATA = National Association of Testing Authorities.

- Acid-Neutralisation Capacity (ANC).
- Net-Acid-Producing Potential (NAPP).
- Net-Acid Generation (NAG).

The pH and EC of the samples were determined on slurries prepared using deionised-water, and a solid:water ratio of approximately 1:2 (w/w). The resulting pH (1:2) and EC (1:2) values provide a measure of the inherent acidity/alkalinity and salinity of the samples.

The Total-S was determined by Leco combustion, and SO_4-S was determined by the Na_2CO_3-Extraction Method.[2] The difference between the Total-S and SO_4-S values indicates the Sulphide-S concentrations in the samples.[3]

The ANC was measured by the addition of HCl to the samples, allowing the samples time to react (with heating), and back-titration with NaOH to determine the amount of acid consumed. This is the standard method for the determination of the 'Total-ANC' of mine-waste samples (BC AMD Task Force, 1989), and exposes the samples to strongly-acidic (viz. pH less than 2) conditions.

Acid consumption by selected samples was also determined by a method based on the BC Research Initial Test (Coastech Research, 1991). In this test, the sample is reacted with H_2SO_4 under ambient conditions, and the pH is maintained above pH 3 over the course of a few days. This Modified-ANC Test is much-less aggressive than the standard ANC Test, and so provides a better measure of acid-consumption within the disposal environment (e.g. waste dump).[4]

The NAPP values of the samples were calculated from the corresponding Total-S, SO_4-S and ANC values, assuming that all of the Non-Sulphate-S occurs in the form of pyrite. The NAPP calculations serve as a starting

[2] Only selected samples were tested for SO_4-S.

[3] It was assumed that pyrite was the dominant sulphide mineral in the waste-rock samples.

[4] The Modified-ANC Tests (and NAG Tests) were undertaken by Dr. Graeme Campbell in the GCA Testing Laboratory.

point in the assessment of the Acid-Formation Potential of sulphide-bearing materials.

The NAG Test is a direct measure of a mine-waste sample's potential to produce acid through sulphide oxidation, and also provides an indication of the reactivity of the sulphides, and the availability of the Total-ANC (Miller et al. 1994). In this test, the sample is reacted with H_2O_2 to rapidly oxidise contained sulphides, and allow the produced acid to react with the acid-neutralising materials. The NAG Test supplements the NAPP-based assessment of the Acid-Formation Potential of mine-waste materials.

3.0 TESTWORK OUTCOMES

The testwork results on the acid-base chemistry and salinity of the waste-rock samples are presented in Table 3.1, and shown on Figure 1. These results are discussed in the following sections.

3.1 pH and Salinity

The waste-rock samples had pH (1:2) values within the range 8.3-9.1, and EC (1:2) values within the range 0.087-0.28 mS/cm (Table 3.1).

The testwork results indicate that the waste-rock samples were all mildly-alkaline, with low contents of soluble salts.

3.2 Sulphur Forms

The waste-rock samples had Total-S values within the range 0.14-1.8 % (Table 3.1).

The samples tested for SO_4-S had SO_4-S values of 0.02-0.03 % (Table 3.1).

The testwork results indicate that samples GCA2324 and GCA2326 contained trace amounts of pyrite, corresponding to Sulphide-S concentrations of 0.1-0.2 %.

Samples GCA2327 and GCA2328 contained trace-to-minor amounts of pyrite, corresponding to Sulphide-S concentrations of approximately 0.5 %.

Sample GCA2325 contained minor amounts of pyrite, corresponding to a Sulphide-S concentration of approximately 2 %.[5]

3.3 Acid-Neutralisation Capacity

The waste-rock samples had ANC values within the range 10-180 kg H_2SO_4/tonne (Table 3.1).[6]

[5] Medium-to-coarse-grained sulphides were visually apparent in the drillcore of this sample.

[6] ANC values of 10-180 kg H_2SO_4/tonne are equivalent to 1.0-18 % (as $CaCO_3$).

Sample GCA2325 with a Total-S value of 1.8 % had a NAPP value of 45 kg H_2SO_4/tonne (Table 3.1). The positive NAPP value of this sample means that there is a shortfall between the content of alkalinity forms, and the amount of acid that could theoretically be produced through sulphide oxidation.

The NAPP calculations indicate that, with the exception of sample GCA2325, all waste-rock samples are classified as Non-Acid Forming (NAF).

Sample GCA2325 is classified as Potentially-Acid Forming (PAF), and in terms of the amount of acid that may potentially be produced through sulphide oxidation, this sample may be further classified as PAF[Moderate-Capacity].

3.5 Net-Acid Generation

The waste-rock samples were characterised by NAG-pH values of 2.6-9.4, and NAG values that ranged from less than 0.5 kg H_2SO_4/tonne, to 35-36 kg H_2SO_4/tonne (Table 3.1).

All samples, except sample GCA2325, produced NAG values less than 0.5 kg H_2SO_4/tonne, and these samples did not acidify under the strongly-oxidising conditions of the NAG Test.

Sample GCA2325 produced a NAG-pH value of 2.6, and a NAG value of 35-36 kg H_2SO_4/tonne (Table 3.1). The measured NAG value was consistent with the calculated NAPP value of 45 kg H_2SO_4/tonne (Table 3.1).

The NAG testwork supports the above NAPP-based classifications of the waste-rock samples.

4.0 CONCLUSIONS

Based on the testwork results obtained in this **preliminary** study, it is concluded that certain waste-rock types will be a source of Acid-Rock Drainage (ARD) if left exposed to O_2 and water.

Certain rock types comprise Low-S materials with a high capacity to consume acid, although such materials may be characterised by a limited availability of alkalinity forms for reaction with acid.

It is recommended that additional testwork is undertaken on samples which are representative of the major types of waste-rock and mineralised-waste to be produced from the Weathered-Zone, Transition-Zone and Primary-Zone of the open-pit(s). This will allow a full assessment to be made of the ARD-Formation Potential of the various materials, and so identify materials requiring selective handling and deep burial in the waste dumps.

5.0 REFERENCES

British Columbia Acid Mine Drainage Task Force Report, 1989, "Draft Acid Rock Drainage Technical Guide: Volume 1".

Coastech Research Inc., 1991, "Acid Rock Drainage Prediction Manual".

Miller SD, Jeffery JJ and Donohue TA, 1994, *"Developments in Predicting and Management of Acid Forming Mine Wastes in Australia and Southeast Asia"*, in "Proceedings of the International Land Reclamation and Mine Drainage Conference and Third International Conference on the Abatement of Acidic Drainage", Volume 1, Pittsburgh, 24-29 April 1994.

Smith A, 1992, *"Prediction of Acid Generation Potential"*, in Hutchison IPG and Ellison RD (eds), "Mine Waste Management", Lewis Publishers, Michigan.

TABLE

Table 3.1: Acid-Base-Analysis and Net-Acid-Generation Results for Waste-Rock Samples

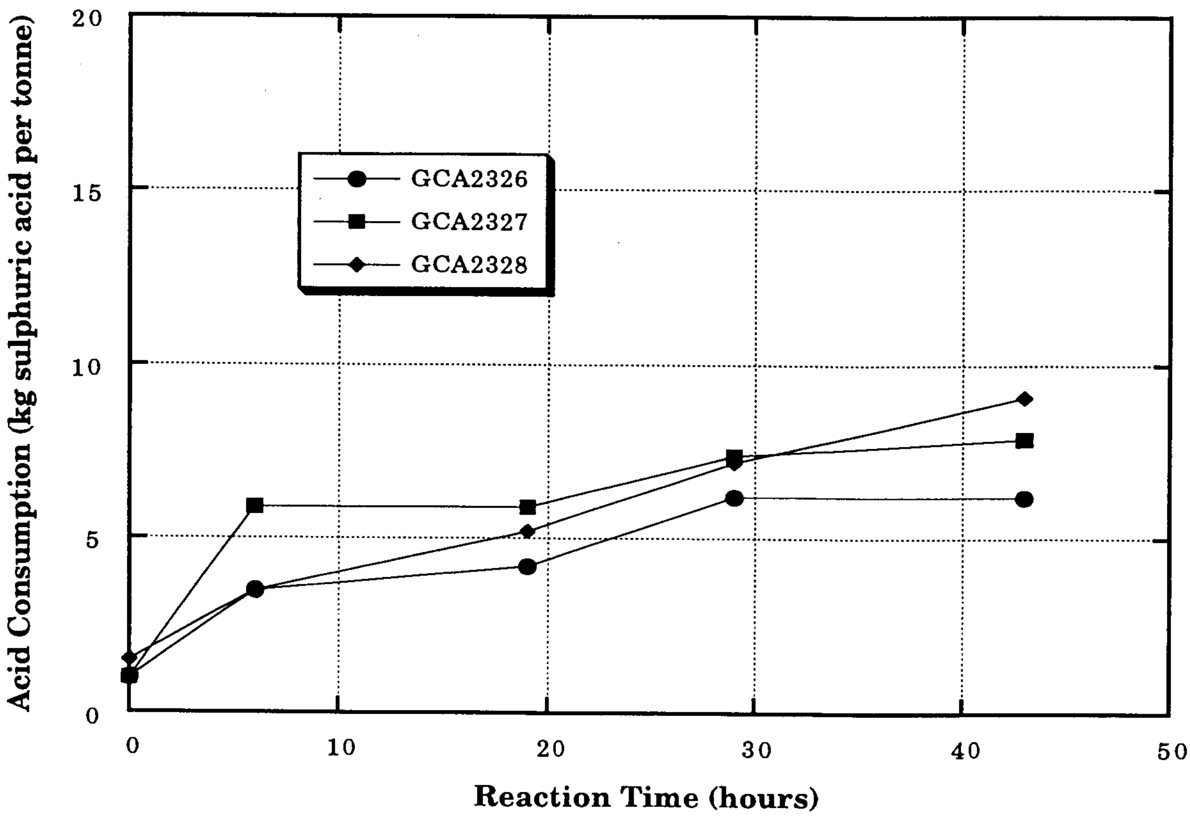
GCA SAMPLE NO.	DRILLHOLE NO.	DOWN-HOLE INTERVAL (m)	WASTE-ROCK TYPE	pH (1:2)	EC (1:2) [mS/cm]	TOTAL-S (%)	SO_4-S (%)	ANC	NAPP	NAG	NAG-pH
								kg H_2SO_4/tonne			
GCA2324	WAA 992	125.37-125.50	Details not provided.	8.3	0.12	0.14	nm	12	-7.7	<0.5	8.3
GCA2325	WAA 994	108.50-108.65	Details not provided.	8.5	0.087	1.8	0.03	10	45	36 (35)	2.6 (2.6)
GCA2326	WAA 994	109.00-109.19	Details not provided.	8.9	0.11	0.14	nm	28*	-23	<0.5	9.4
GCA2327	WAA 994	117.04-117.18	Details not provided.	9.1	0.15	0.54	0.02	27	-11	<0.5	8.8
GCA2328	WAA 994	152.32-152.52	Details not provided.	9.0 (9.0)	0.27 (0.28)	0.33	0.03 (0.03)	180* (180*)	-170	<0.5	8.6

Notes:
EC = Electrical Conductivity; ANC = Acid-Neutralisation Capacity; NAPP = Net-Acid-Producing Potential; NAG = Net-Acid Generation; nm = not measured.
pH (1:2) and EC (1:2) correspond to measurements of pH and EC on sample slurries prepared using deionised-water, and a rock:water ratio of approximately 1:2 (w/w).
ANC values labelled with an asterisk indicate that green suspensions were produced as the pH=7 end-point was approached in the ANC Tests.
All values expressed on a dry-weight basis, except for pH(1:2), EC (1:2) and NAG-pH.
Values in parentheses represent duplicates.

FIGURE

Figure 1

Titration Curves for Modified-ANC Tests on Waste-Rock Samples



APPENDIX

LABORATORY REPORTS

Australian Environmental Laboratories

PB/smp

26 May, 1998

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Attn: Dr G Campbell
PO Box 247
BRIDGETOWN WA 6255

OUR REFERENCE: GRA203.0560.39743
YOUR REFERENCE: GCA 9824
NATA ACCREDITATION: 1712

Dear Sir

On the 13th of May 1998 you forwarded testwork instructions for five (5) waste rock samples which were received at the laboratory the following day. This report replaces our preliminary data sent by facsimile dated 22nd of May 1998.

All samples were crushed to a nominal 2mm particle size and a split pulped to a nominal 75µ particle size for total sulphur determination. Splits of each size were retained with the remainder forward to the GCA Testing Laboratory as requested. Results of the testwork performed follow:

Sample Number	pH (pH Units)	Conductivity @ 25°C (µS/cm)	Total Sulphur S (% w/w)	Sulphate Sulphur SO_4-S (% w/w)
GCA2324	8.3	120	0.14	-
GCA2325	8.5	87	1.8	0.03
GCA2326	8.9	110	0.14	-
GCA2327	9.1	150	0.54	0.02
GCA2328	9.0	270	0.33	0.03
GCA2328 Rpt	9.0	280	-	0.03

NOTES:

1. *pH and conductivity were determined on a 1:2 w/w as received crushed sample to deionised water extract after 24 hours ambient aging.*

2. *Total sulphur was determined on dried pulped sample by LECO induction furnace, IR detection, and is reported on that basis. This testwork was performed by Analabs, Welshpool, report number WM035246.*

3. *Sulphate sulphur was determined on as received crushed sample by Na_2CO_3 extraction, $BaSO_4$ precipitation with results reported on the as received sample basis.*

(Analabs Pty. Ltd.) ACN 004 591 664
52 Murray Road Welshpool Western Australia 6106 Australia
Telephone: (08) 9458 7278 Facsimile: (08) 9451 3505

Acid Neutralisation Capacity (ANC):

Sample Number	Fizz Rating	Initial Effervescence	Effervescence on Warming	ANC Solution pH	ANC (kg H_2SO_4/tonne)
GCA2324	0	nil	nil	1.7	12
GCA2325	0	nil	nil	1.7	10
GCA2326*	2	moderate	nil	0.4	28
GCA2327	1	slight	nil	0.4	27
GCA2328*	2	moderate	nil	0.3	180
GCA2328 Rpt	2	moderate	nil	0.4	180

Acid neutralisation capacity was performed on the crushed as received sample and is reported on that basis. Samples marked with an asterisk (*) displayed a green colouration as the pH=7 endpoint was approached.

It is noted that the pH and conductivity extraction procedure and total sulphur are not covered by our terms of NATA accreditation.

Yours faithfully,
Australian Environmental Laboratories

PETER BAMFORD
Manager Laboratory Service

National Association of Testing Authorities, Australia
NATA ENDORSED DOCUMENT
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pp Steven Ednett

JANICE VENNING
Manager Operations

NET-ACID-GENERATION (NAG) TESTWORK

Sample Number	Sample Weight (g)	Comments	pH of Test Mixture Before Boiling Step	Test Mixture After Boiling Step		Titre [0.1 M-NaOH] (mL)	NAG (kg H_2SO_4/ tonne)
				pH	EC (µS/cm)		
GCA2324	2.1	Boiled overnight.	7.3	8.3	130	-	<0.5
GCA2325	2.1	Boiled within 4 hrs.	2.6	2.6	1,600	15.30	36
GCA2325 (Repeat)	2.1	Boiled within 4 hrs.	2.6	2.6	1,800	14.90	35
GCA2326	2.0	Boiled overnight.	7.6	9.4	170	-	<0.5
GCA2327	2.1	Boiled overnight.	7.6	8.8	200	-	<0.5
GCA2328	2.2	Boiled overnight.	8.0	8.6	160	-	<0.5
Feldspar Blank	2.6		5.6	7.1	57	-	<0.5

Note: The pH of the 15 % (v/v) H_2O_2 solution was adjusted to 4.5 using 0.1 M-NaOH prior to commencing the NAG Tests.

Dr GD Campbell
25 May 1998

Graeme Campbell & Associates Pty Ltd

Laboratory Report

MODIFIED-ANC TESTWORK

(ANC = Acid-Neutralisation Capacity)

GCA2326 (10.0 g)					
REACTION TIME (hours)	**pH**	**TITRE OF 0.5 M-H_2SO_4**		**ACID CONSUMPTION**	
		Incremental Titre (mL)	**Cumulative Titre (mL)**	**Incremental**	**Cumulative**
				kg H_2SO_4/tonne	
0.00	8.4	0.20	0.20	0.98	1.0
6.0	5.4	0.50	0.70	2.45	3.5
19	3.4	0.15	0.85	0.74	4.2
29	3.5	0.40	1.25	1.96	6.2
43	3.0	0.00	1.25	0.00	6.2

Notes:

The Modified-ANC Test was carried out on a crushed (nominal 2 mm) sample, and using 100 mL of deionised-water to prepare the test-mixture slurry prior to addition of 0.5 M-H_2SO_4.

The addition of 0.5 M-H_2SO_4 was undertaken at different times on the test-mixture slurry, agitated using a magnetic stirrer.

The 0.5 M-H_2SO_4 was added until pH 3.0-3.5 was reached.

After this time, the test mixture was left to stand in contact with the air until the next titre addition.

G D Campbell

Dr GD Campbell
26 May 1998

Graeme Campbell & Associates Pty Ltd

Laboratory Report

MODIFIED-ANC TESTWORK

(ANC = Acid-Neutralisation Capacity)

GCA2327 (10.0 g)					
REACTION TIME (hours)	**pH**	**TITRE OF 0.5 M-H_2SO_4**		**ACID CONSUMPTION**	
		Incremental Titre (mL)	**Cumulative Titre (mL)**	**Incremental**	**Cumulative**
				kg H_2SO_4/tonne	
0.00	8.6	0.20	0.20	0.98	1.0
6.0	6.0	1.00	1.20	4.9	5.9
19	3.0	0.00	1.20	0.00	5.9
29	3.2	0.30	1.50	1.47	7.4
43	3.1	0.10	1.60	0.49	7.9

Notes:

The Modified-ANC Test was carried out on a crushed (nominal 2 mm) sample, and using 100 mL of deionised-water to prepare the test-mixture slurry prior to addition of 0.5 M-H_2SO_4.

The addition of 0.5 M-H_2SO_4 was undertaken at different times on the test-mixture slurry, agitated using a magnetic stirrer.

The 0.5 M-H_2SO_4 was added until pH 3.0-3.5 was reached.

After this time, the test mixture was left to stand in contact with the air until the next titre addition.

Dr GD Campbell
26 May 1998

Graeme Campbell & Associates Pty Ltd

Laboratory Report

MODIFIED-ANC TESTWORK

(ANC = Acid-Neutralisation Capacity)

GCA2328 (10.0 g)					
REACTION TIME (hours)	**pH**	**TITRE OF 0.5 M-H_2SO_4**		**ACID CONSUMPTION**	
		Incremental Titre (mL)	**Cumulative Titre (mL)**	**Incremental**	**Cumulative**
				kg H_2SO_4/tonne	
0.00	8.7	0.30	0.30	1.47	1.5
6.0	6.2	0.40	0.70	1.96	3.5
19	5.8	0.35	1.05	1.72	5.2
29	5.6	0.40	0.40	1.96	7.2
43	5.4	0.40	0.40	1.96	9.1

Notes:
The Modified-ANC Test was carried out on a crushed (nominal 2 mm) sample, and using 100 mL of deionised-water to prepare the test-mixture slurry prior to addition of 0.5 M-H_2SO_4.
The addition of 0.5 M-H_2SO_4 was undertaken at different times on the test-mixture slurry, agitated using a magnetic stirrer.
The 0.5 M-H_2SO_4 was added until pH 3.0-3.5 was reached.
After this time, the test mixture was left to stand in contact with the air until the next titre addition.

Dr GD Campbell
26 May 1998

Rio Tinto Iron Ore

Geochemical Characterisation of Paraburdoo Lens 2, Dales Gorge and West Angelas Samples

Report Prepared for

Ros Green
Rio Tinto Iron Ore

Prepared by
Claire Linklater
SRK Consulting
Engineers and Scientists

PIL003

January 2008

Geochemical Characterisation of Paraburdoo Lens 2, Dales Gorge and West Angelas Samples

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January 2008

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Executive Summary

This report presents the results from ongoing geochemical characterisation of samples from Rio Tinto Iron Ore mining operations and resource evaluation studies.

Summary of Objectives

The primary objectives of the program were to undertake a geochemical assessment of samples from Paraburdoo, Dales Gorge and West Angelas, in order to establish:

- The acid generating potential of the samples;
- The rate at which the samples could oxidise;
- Whether the samples contain significant quantities of leachable contaminants.

Outline of Work Program

The samples studied were supplied by Rio Tinto Iron Ore staff and represent known sulphur-bearing lithologies in the area. In the current work, the following measurements were undertaken:

- Total sulphur and carbon contents;
- Acid-base accounting testwork;
- Net acid generation testwork (sequential and kinetic);
- Intrinsic oxidation rates (IORs);
- Acid-base characteristic curves.

Results

Following collation and interpretation of the data obtained, the following conclusions were reached:

- Acidic paste pH values and high electroconductivities correlated positively with the total S content of the samples. This was interpreted as evidence of the presence of sulphide oxidation reaction products in these samples;
- Measurements on selected samples showed that 90% or more of the sulphur present was in the unoxidised sulphide sulphur form.
- The samples from the different sites showed distinct acid-base accounting characteristics:
    - The Dales Gorge samples were associated with significant ANC and classified as non acid forming. CarbNP estimates and ABCC measurements suggested that the available ANC is in the form of carbonate minerals and readily available for reaction;
    - The majority of the Paraburdoo Lens 2 samples were classified as potentially acid forming. The limited ANC available is likely to be a combination of carbonates and aluminsilicates, and may not all be available for reaction (adding weight to categorisation of the samples as potentially acid forming). Exceptions were samples located in the topmost depth intervals, in a transitional zone between deeper black shales to green and yellow/brown shales, were classified as non-acid forming;
    - Seven of eight West Angelas samples studied were classified as potentially acid forming. CarbNP estimates and ABCC measurements were variable; in some samples ANC appeared to be in the form of readily available carbonates, whereas in other samples the ANC was not readily available.
- IOR values were measured in the case of composite samples of sulphur-rich material from Paraburdoo Lens 2. The values obtained, 3-4 × 10^{-10} kg(O_2)kg(dry material)$^{-1}$s^{-1}, lie within the range of values obtained in previous studies of samples from Rio Tinto Iron Ore sites;
- Sequential NAG tests suggested that for most samples early reaction (and most substantial acid generation) was dominated by oxidation of iron-bearing sulphides. The exception was

one of the West Angelas samples (#428, a banded iron formation sample) where all measurable acidity was associated with the titration between pH 4.5 and pH 7, indicative of metals other than ferric iron;

- In all but one of the Paraburdoo Lens 2 samples studied, kinetic NAG tests suggested that sulphide present was readily oxidised with no significant lag time to reaction and acidification. For the remaining Paraburdoo Lens 2 sample, and both West Angelas samples studied, kinetic NAG tests suggested that the onset of acidification would be delayed. Additional kinetic testwork could allow estimation of timescales (see below);
- In at least some of the samples, the following elements were present in quantities that were enriched relative to average crustal abundances: C, S, As, Au, Bi, Mo, Sb, Se, Sn;
- Of these enriched elements, only Mo and Se were readily leachable in the samples. Other (not enriched) minor elements present in readily leachable form were B (one sample only), Co, Cr, Mn, Ni and Zn. Three of the Paraburdoo Lens 2 samples (all black pyritic shales) were associated with the highest percentages of leached minor elements. It should be noted that weathering and acidification reactions could be expected the change the solubility and leachability of several of the trace metals present.

Recommendations

A number of recommendations were made following characterisation of the previous batch of samples (Linklater et al, 2007). These recommendations remain valid and are summarised below:

- Undertaking leach tests under a wider range of conditions. For example, using acid solution as the leachant. Given the potentially acid forming nature of many of the Rio Tinto Iron Ore waste materials, it would be insightful to measure the leachability of contaminants under acidic conditions.
- Conducting weathering or kinetic tests in columns to determine reaction kinetics and overall rates and potential for trace element release from the waste rock. These results can be used to complete water and load balance calculations (i) to determine the overall potential for contaminant release from the waste rock dumps and (ii) to determine minimum requirements for closure and ensure that contaminant loads are sustained within acceptable levels.

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Disclaimer

The opinions expressed in this report have been based on the information supplied to Steffen Robertson & Kirsten (Australasia) Pty Ltd ("SRK") by Rio Tinto Iron Ore ("RTIO"). The opinions in this report are provided in response to a specific request from RTIO to do so. SRK has exercised all due care in reviewing the supplied information. Whilst SRK has compared key supplied data with expected values, the accuracy of the results and conclusions from the review are entirely reliant on the accuracy and completeness of the supplied data. SRK does not accept responsibility for any errors or omissions in the supplied information and does not accept any consequential liability arising from commercial decisions or actions resulting from them.

1 Introduction

This report describes work undertaken as part of ongoing geochemical characterisation of samples from Rio Tinto Iron Ore mining operations and resource evaluation studies. The samples tested herein were collected from the Paraburdoo, Dales Gorge and West Angelas sites. Consideration of overall site geology and the selection of individual samples for inclusion in the geochemical characterisation programme are activities undertaken by Rio Tinto Iron Ore staff, as is collection of the samples from available drill core or blast materials. In the current work, for each site, most samples provided were selected to represent known sulphur-bearing lithologies in the area.

In the longer term, the database generated will be used to underpin planning for the rehabilitation and closure of the mining operations.

2 Work Program

2.1 Program Objectives

The primary objectives of the testing program were to undertake a geochemical assessment of samples, in order to establish:

- The acid generating potential of the samples;
- The rate at which the samples could oxidise;
- Whether the samples contain significant quantities of leachable contaminants.

2.2 Work Program

A total of 44 samples were studied, comprising:

- Five samples from a groundwater monitoring borehole located on the western side of North Deposit, Dales Gorge. The samples were obtained at depths coincident with the Dales Gorge 2 stratigraphic unit and are likely to comprise banded iron formation and/or shale lithologies;
- Thirty one samples from Paraburdoo Lens 2, from core produced from two diamond drill boreholes denoted GT064EMP0001 and GT064EMP0003. The samples included a range of lithologies: black shale, black pyritic shale, banded iron formation, chert;
- Eight samples from West Angelas (Deposit A), taken following a blast denoted WEP2/652/902. The samples included banded iron formation and shales.

All the samples received were subject to an initial phase of analyses, as follows:

- Total S and C content by Leco, wt%;
- Acid neutralising capacity, ANC.

This first phase of analyses was undertaken by Australian Laboratory Services, Brisbane.

Based on results from the first phase, certain samples were selected for a second phase of more detailed characterisation work. The second phase involved the following analyses:

- Intrinsic oxidation rate (2 samples)
- Net acid generating potential (up to 3 sequential stages) (13 samples);
- Sulphate sulphur (17 samples);
- Organic carbon (12 samples);

- Acid-base characteristics curves (9 samples);
- Kinetic NAG tests (7 samples);
- Whole rock chemical assay of solids (15 samples);
- 1:5 solid/liquid leach tests (12 hour duration; 15 samples);
- 1:2 solid/liquid leach tests (12 hour duration; 3 samples).

Most of the analyses were undertaken by Australian Laboratory Services, Brisbane. The intrinsic oxidation rate and the acid-base characteristic curves were measured at the ANSTO laboratories, Lucas Heights.

Appendix 1 summarises the samples studied and gives an overview of the characterisation program.

3 Results

The detailed results are tabulated in Appendices 2 to 6 and are summarised and discussed in the following sections.

3.1 Paste pH and Electroconductivity

The measured paste pH values ranged from acidic (pH 2.7) to quite alkaline (pH 9.2). Figure 1 shows the paste pH plotted as a function of the sulphur content of the sample. As would be expected, there is a trend towards lower pH as the sulphur content increases i.e. oxidation of sulphides would be expected to result in the formation of stored acidity in the form of secondary reaction products. The most acidic paste pH values are associated with some of the extremely sulphur-rich Paraburdoo Lens 2 samples. Acidic pH values also indicate that the samples are relatively reactive and that little or no ANC is present.

Figure 2 shows the electroconductivity plotted as a function of the sulphur content of the samples. The highest electroconductivity measurements are also associated with the sulphur-rich Paraburdoo Lens 2 samples, consistent with the presence of greater quantities of soluble reaction products.

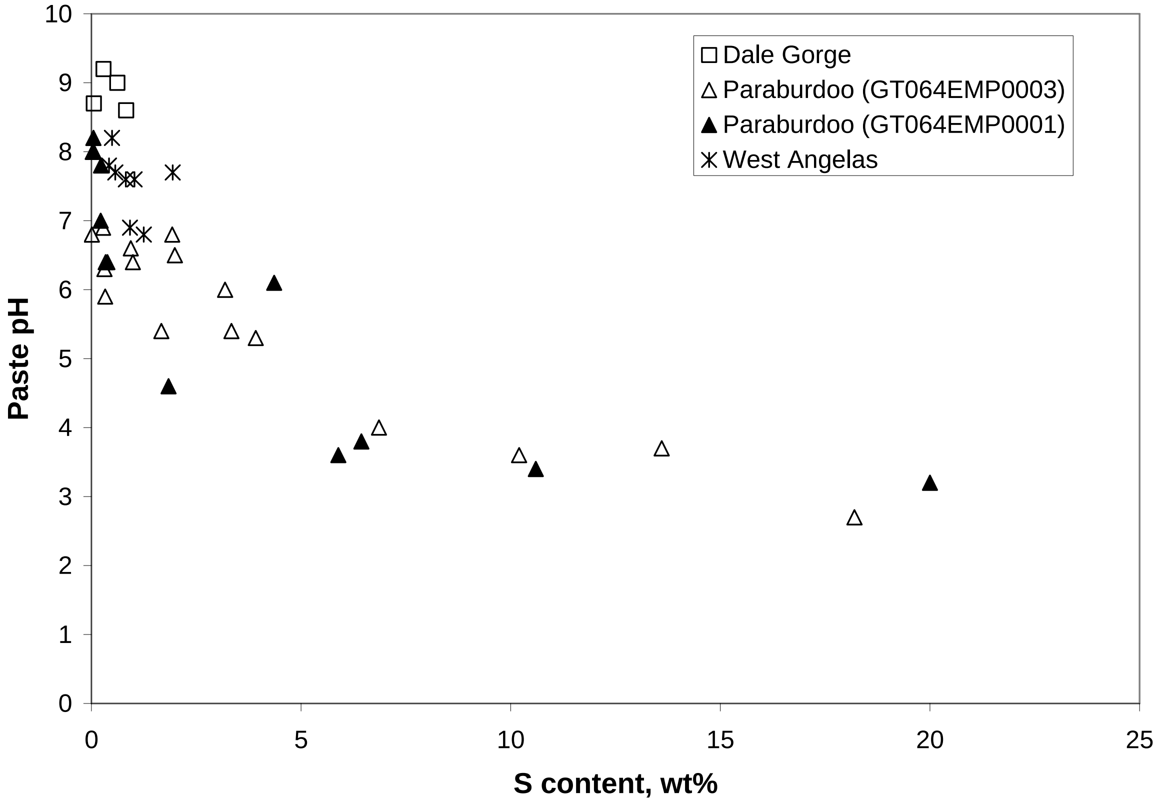


Figure 1: Paste pH plotted as a function of sample sulphur content

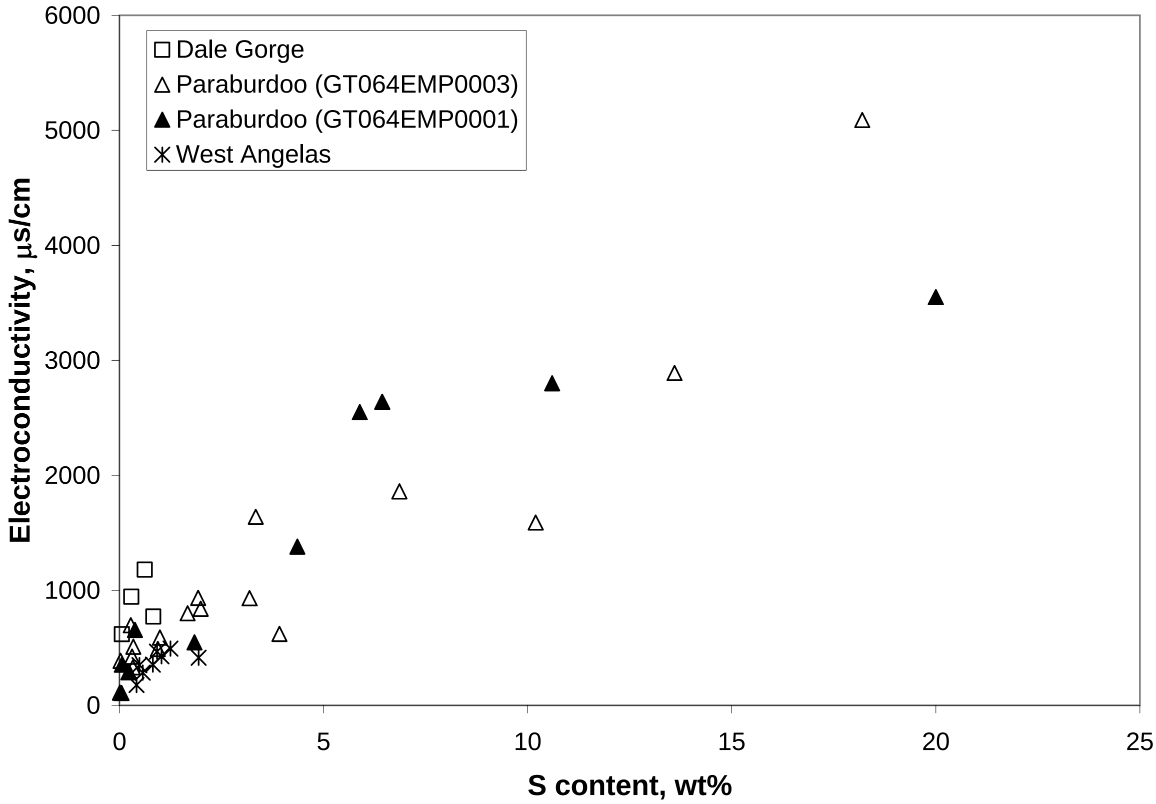


Figure 2: Electroconductivity plotted as a function of sample sulphur content

3.2 Acid-Base Accounting

Acid-base accounting testwork was undertaken on a selection of up to 44 of the samples. The data were analysed according to the methods given in the ARD Test Handbook (AMIRA, 2002).

The calculated maximum potential acidity (MPA) of the samples shows a wide range, from <1 to 612 kgH_2SO_4/t. The acid neutralising capacity (ANC) of the samples also showed a wide range, from <1 to 158 kgH_2SO_4/t. MPA values are calculated based on the measured total sulphur content of the sample. It is assumed that all the sulphur is in the form of reactive sulphide-sulphur and therefore has the potential to oxidise and generate acid. If a significant proportion of the sulphur present is in the form of sulphate (i.e. an oxidised form of sulphur), then the MPA value can be overestimated. For 17 samples, the proportion of S present as sulphate was measured and found to be relatively minor (<10% of the total S). For those samples, the recalculated acid potential (AP) values were found to be very similar to the MPA values and the classification of the samples was unaffected.

Figure 3 and Figure 4 show an acid-base accounting plot and a geochemical classification diagram, respectively. The majority of the Paraburdoo and West Angelas samples plot in regions associated with the potential to generate acid. In contrast, the Dales Gorge samples are associated with significant ANC and often plot in or near non-acid generating regions.

An additional criterion for classifying materials is the net potential ratio (NPR), which is the ratio of ANC to MPA (or, if available, AP). A sample with a NPR less than unity is potentially acid forming. For waste rock, a sample with an NPR greater than 3 is generally considered non-acid forming. A zone of uncertainty remains for values between unity and 3. The calculated NPR values are summarised in Table 1, along with some information taken from drilling logs. In the case of Dales Gorge, three of the four samples studied are classed as non-acid forming. The remaining sample has an NPR value of 1.27 and lies in the zone of uncertainty, but notably has a comparatively low MPA.

Paraburdoo Len 2 samples typically have NPR values less than unity and so are classified as potentially acid-forming. The exceptions are samples from the topmost depth intervals. These intervals appear to represent a transition from the deeper black shales to green and yellow/brown shales. The colour change could be indicative of a transition from unoxidised to oxidised material. There is a coincident reduction in the total sulphur content and, based on the calculated NPR values, these topmost depth intervals are classed as non-acid forming.

Seven of the eight West Angelas samples studied gave NPR values close to, or less than, unity and so are classified as potentially acid-forming. The exception was sample #429, described as silicate banded iron formation, which gave an NPR value of 3.43 and could be considered non-acid forming. However, the ANC is low and offers little buffering capacity in excess of the MPA and therefore could not beneficially be used elsewhere to neutralize acidity from other sources.

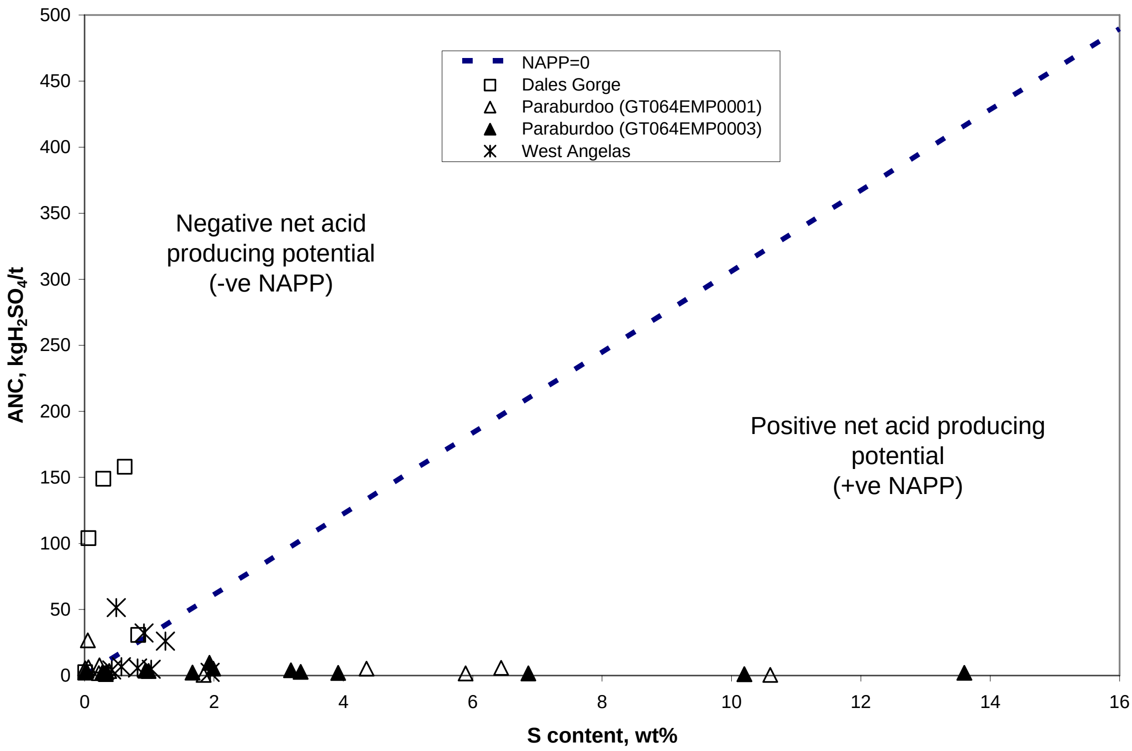


Figure 3: Acid-Base Accounting Plot

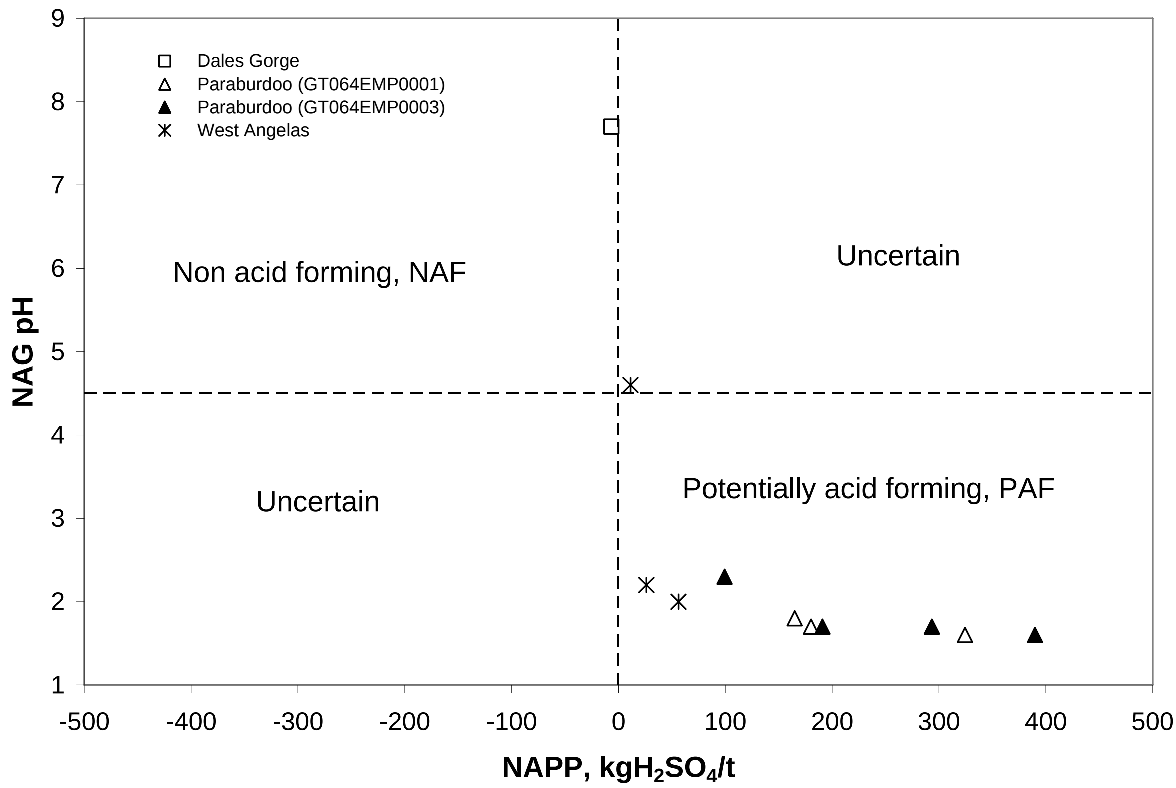


Figure 4: Geochemical Classification Plot

Table 1: Summary of NPR values along with available geological information

Sample #	Depth interval	Lithology	NPR
Dales Gorge (Borehole WB06NTB02) [1]			
1	134-135	Shales from DG1 (possibly DG2) and may banded iron formation. The presence of carbonates is considered likely	9.00
2	140-142		16.79
3	126-128		56.64
4	-	[Sample #4 was a sample of gravel pack, included to ensure that it was not acid generating]	High
5	142-150		1.27
Paraburdoo Lens 2 (Borehole GT064EMP0003) [2]			
1	21.43-21.6	Green brown shales with banded iron formation bands	7.84
2	23-23.2	Black shale	3.92
3	25-25.28	Black shale	0.33
4	27.42-27.6	Black shale	0.11
5	29.25-29.5	Black shale	0.18
6	31-31.24	Black shale	0.26
7	33-33.22	Black shale	0.04
8	35-35.17	Black pyritic shale	0.02
9	36.96-37.14	Black pyritic shale	0.01
10	38.95-39.08	Black pyritic shale	0.00
11	41-41.16	Black pyritic shale	0.01
12	43.03-43.23	Black pyritic shale	0.00
13	44.9-45.1	Black pyritic shale, chert bands	0.04
14	46.89-47.06	Black pyritic shale, chert bands	0.03
15	48.97-49.15	Black pyritic shale, chert bands	0.14
16	51.2-51.34	Black pyritic shale, chert bands	0.16
17	53.97-54.14	Black pyritic shale, chert bands	0.11
18	56-56.13	Black pyritic shale, chert/banded iron formation interbeds	0.09
Paraburdoo Lens 2 (Borehole GT064EMP0001) [2]			
19	182.76-183	Shales, yellow/brown goethitic	High
20	183.99-184.22	Shales, yellow/brown goethitic	High
21	185-185.23	Black shale	3.38
22	187.05-187.19	Black shale	17.39
23	188.97-189.13	Black shale	1.09
24	190.92-191.11	Black shale	0.27
25	193.15-193.34	Black shale, poss. pyrite nodules	0.29
26	195.2-195.38	Black shale, poss. pyrite nodules	Low
27	197-197.15	Black pyritic shale	0.00
28	198.87-199.06	Black pyritic shale	0.01
29	200.93-201.08	Black pyritic shale	0.03
30	202.9-203.04	Black pyritic shale, chert bands, poss. gold?	Low
31	205-205.2	Black pyritic shale, chert bands, vuggy brecciated	0.04
West Angelas (Blast #WEP2/652/902) [3]			
1	428	Banded iron formation	0.70
2	429	Silicate banded iron formation	3.43
3	430	Banded iron formation	1.14
4	431	Shale/silicates	0.23
5	432	Shale/silicates	0.16
6	433	Shale/silicates	0.33
7	434	Shale/silicates	0.38
8	435	Shale/silicates	0.04

[1] Lithological descriptions based on telephone conversations with Tim Kendrick and Mike Stone (Rio Tinto, Dales Gorge), February 2007
[2] Lithological descriptions based on drill log information provided by Daniel Sackers (Rio Tinto, Geological Support), February 2007.
[3] Lithological descriptions based on information provided by Sig Slepecki, in a memorandum to Ros Green (November 2006)

The ANC value for the samples is a measure of role that gangue minerals could play in neutralising acid generated during sulphide oxidation. Comparison of the CarbNP values with the ANC values can give an idea of how much of the neutralising capacity of the sample is due to the presence of carbonates. CarbNP values were calculated for twelve samples. The results are summarised in Table 2.

Table 2: Comparison of ANC and CarbNP values

Sample #	Depth Interval	ANC kgH_2SO_4/t	CarbNP kgH_2SO_4/t	Ratio CarbNP:ANC
Dales Gorge (Borehole WB06NTB02)				
1	134-135	158	196	1.24
2	140-142	149	211	1.41
Paraburdoo Lens 2 (Borehole GT064EMP0003)				
3	25-25.28	2.8	None	Zero
7	33-33.22	4	21	5.31
11	41-41.16	1.6	14	8.67
12	43.03-43.23	1	66	66.12
18	56-56.13	5.2	None	Zero
Paraburdoo Lens 2 (Borehole GT064EMP0001)				
21	185-185.23	6.2	None	Zero
24	190.92-191.11	1.8	25	14.06
28	198.87-199.06	1.6	65	40.82
29	200.93-201.08	5.8	45	7.74
West Angelas (Blast #WEP2/652/902)				
1	428	26.1	135	5.16

Where CarbNP values exceed or equal the ANC values (CarbNP:ANC ratios ≥ 1) it is likely that the neutralising capacity present in the samples is due to carbonates, but that some of the carbonate present is in a form that does not participate in acid neutralising reactions, e.g. siderite. This is the case for the majority of the samples studied. However, for three of the Paraburdoo Len 2 samples there was no detectable carbonate-based neutralisation capacity, suggesting that other minerals, such as aluminosilicates, must be providing the available neutralisation capacity.

For nine samples, neutralisation capacity was studied further by measuring acid buffering characteristic curves (ABCC). ABCCs give an indication of the reactivity of the neutralisation capacity of the samples and provides additional insight to the mineral forms that are involved. The results are illustrated in Figure 5 to Figure 7 and summarised in Table 3. In the case of the two Dales Gorge samples studied, the ABCCs start at quite neutral or alkaline pH values (pH 7 or above) and the pH remains above 6 until 60-80% of the ANC is exhausted, suggestive of control largely by carbonates (calcite and/or dolomite). For both these samples, most of the ANC (73-100%) appears to be available for reaction.

In the case of the Paraburdoo Lens 2 samples, the starting pH for the ABCCs is near-neutral or below and the pH decreases relatively rapidly following addition of acid (Figure 6). This is consistent with the potentially acid forming classification of these samples and their relatively low neutralisation capacities, ANC values range from 5.2 to 26.6 kg H_2SO_4/t. As shown in Table 3, the samples contain little or no calcitic or dolomitic carbonate mineral neutralization capacity, and a significant proportion of the ANC appears unavailable for reaction (more than 50%).

The two West Angelas samples studied show different trends. Sample #429 starts at a relatively alkaline pH value (pH > 8) and remains near-neutral until around 60% of the ANC is exhausted, suggestive of control largely by carbonates. Sample #428, on the other hand, starts at a relatively acid pH (pH < 4.5) and remains acidic throughout the test. It would appear that what ANC may have been present in the sample had been consumed during handling and storage prior to testing.

Table 3: Summary of ABCC data

			% ANC expended while pH above:		
Sample #	**Depth Interval**	**ANC kgH_2SO_4/t**	**pH 7[1]**	**pH 6[2]**	**pH 4.5**
Dales Gorge (Borehole WB06NTB02)					
1	134-135	158	24%	58%	73%
5	142-150	30.7	4%	78%	>100%
Paraburdoo Lens 2 (Borehole GT064EMP0003)					
16	51.2-51.34	9.6	0%	8%	28%
18	56-56.13	5.2	0%	0%	46%
Paraburdoo Lens 2 (Borehole GT064EMP0001)					
22	187.05-187.19	26.6	5%	19%	38%
29	200.93-201.08	5.8	0%	0%	0%
31	205-205.2	5.2	0%	0%	5%
West Angelas (Blast #WEP2/652/902)					
1	428	26.1	0%	0%	0%
2	429	51.4	32%	57%	87%

[1] Typically neutralisation at pH 7 and above is indicative of control by calcite.
[2] Typically neutralisation at pH 6 to 7 is indicative of control by dolomitic carbonate.

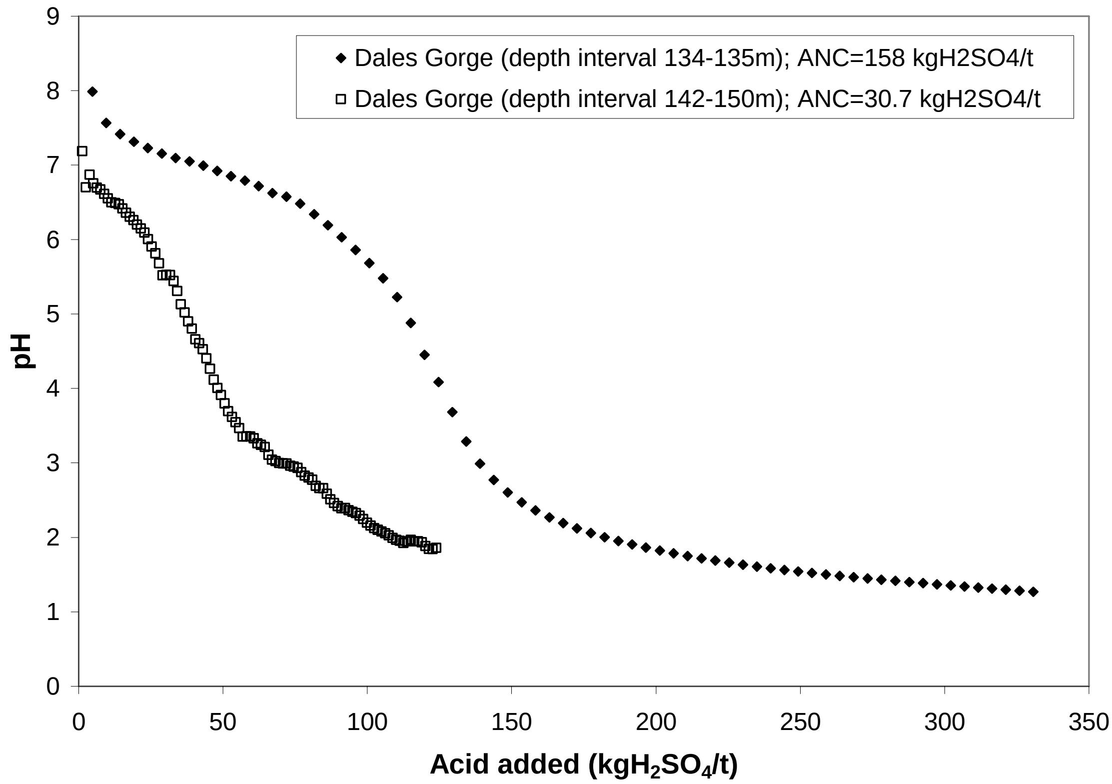
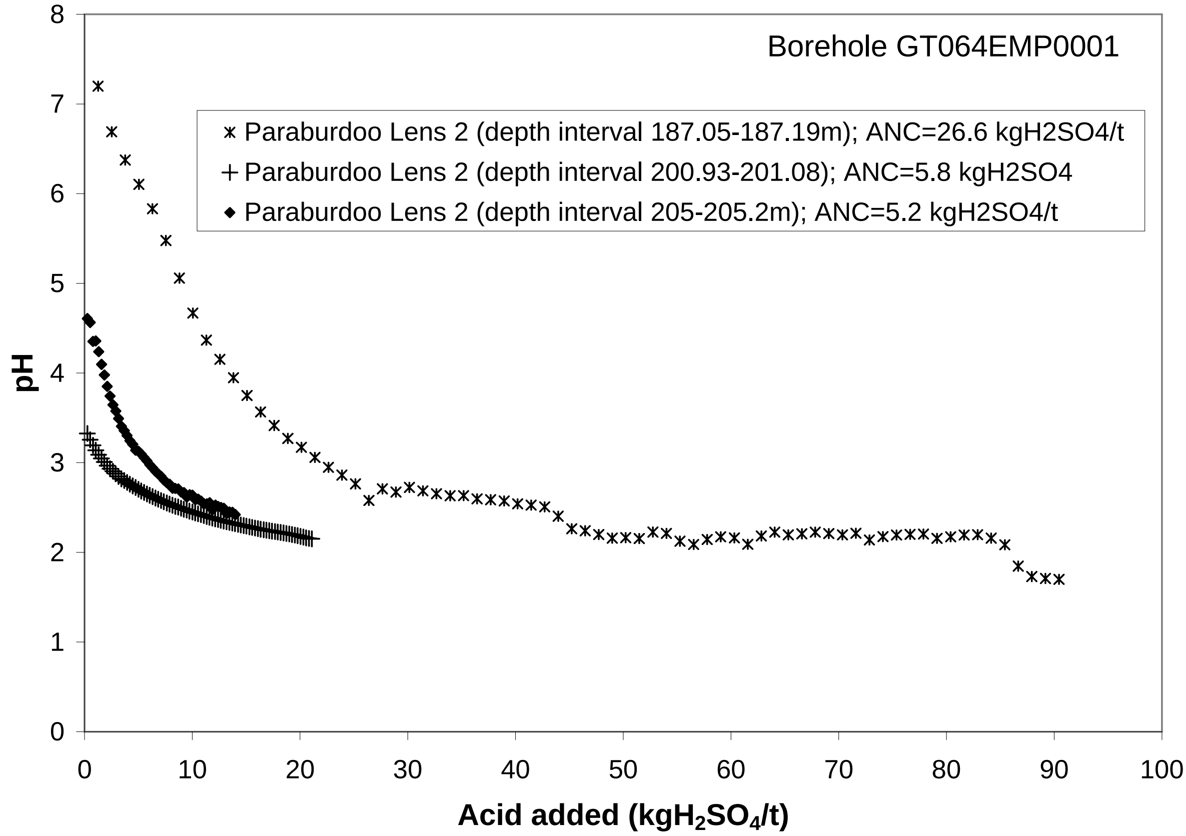


Figure 5: Acid buffering characteristic curves (Dales Gorge samples)



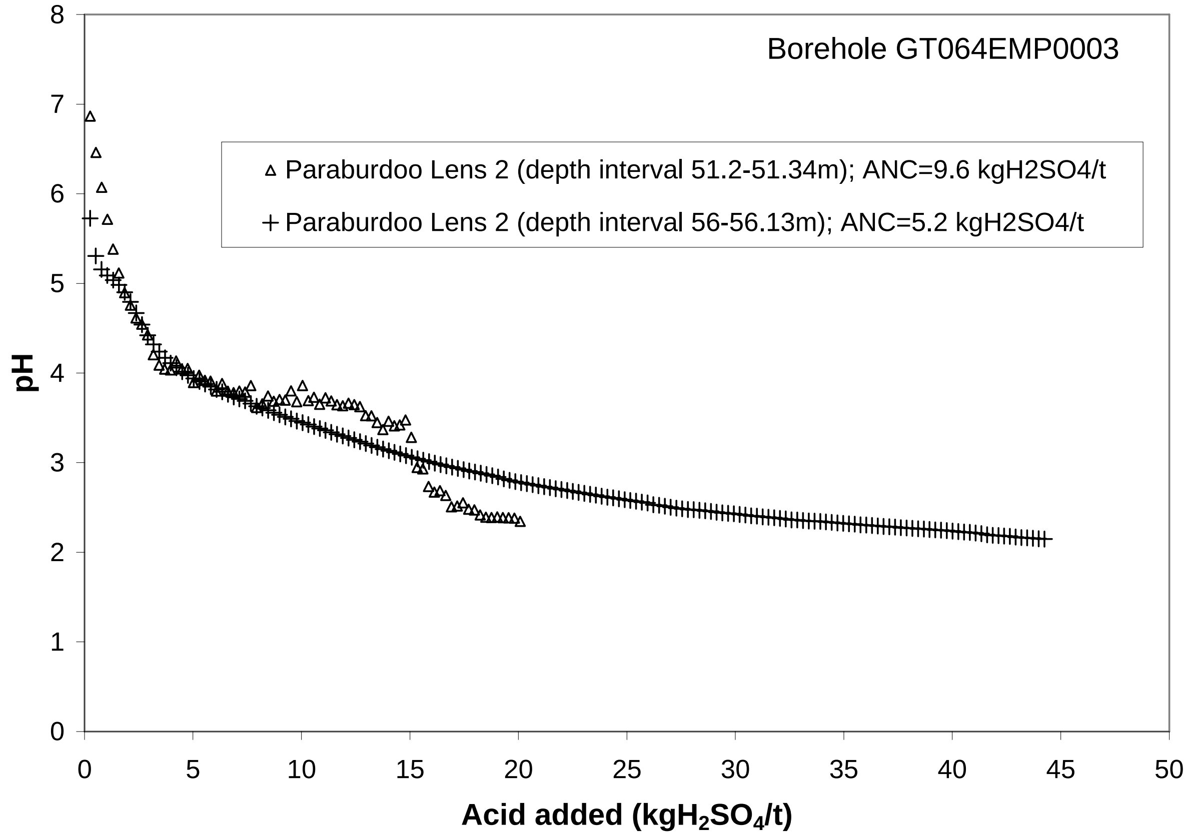


Figure 6: Acid buffering characteristic curves (Paraburdoo Lens 2 samples)

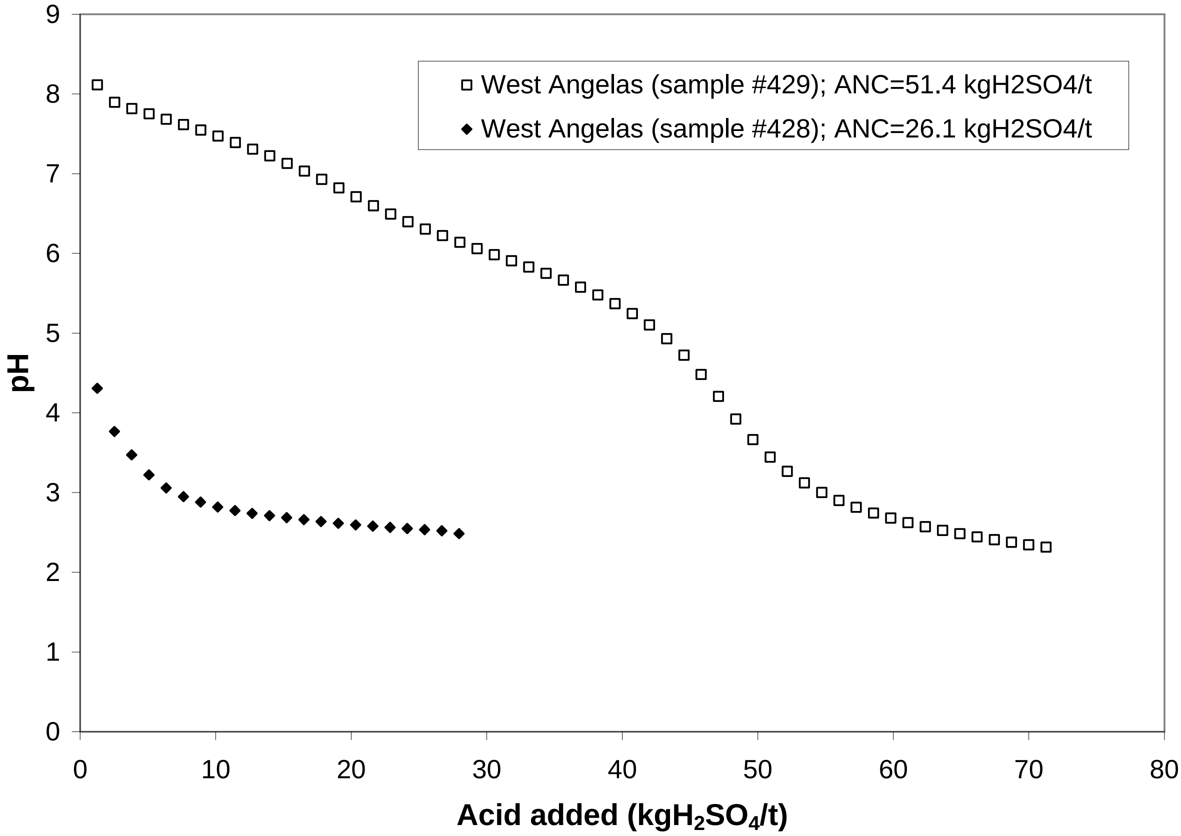


Figure 7: Acid buffering characteristic curves (West Angelas samples)

3.3 Oxidation Rates

Ideally, sample sizes of 2-3kg are required for intrinsic oxidation rate measurements. Unfortunately, in the case of the Dales Gorge and West Angelas samples, insufficient masses of sample remained following the general laboratory testwork. In the case of the Paraburdoo Lens 2 samples, two composite samples were prepared using sulphur-rich material. The details are given in Table 4.

Table 4: Intrinsic oxidation rate measurements, Paraburdoo Lens 2 composites

Composite	Equal parts of the following: sample# (depth interval)	Intrinsic oxidation rate $[kg(O_2)kg(\text{dry material})^{-1}s^{-1}]$
A	9 (36.96-37.14m) 10 (38.95-39.08m) 11 (41-41.16m) 12 (43.03-43.23m)	3.6×10^{-10}
B	26 (195.2-195.38m) 27 (197-197.15m) 28 (198.87-199.06m) 29 (200.93-201.08m)	2.9×10^{-10}

Note:
1) The measurements were conducted on moist samples; the moisture was adjusted to 5wt%, dry basis. It was judged that the samples would not hold 10% moisture (as used in previous measurements).
2) The uncertainty on the measurements can be taken to be ±10%.

The resulting IOR values lie within the range of values obtained in previous studies of samples of pyritic black shale from Rio Tinto Iron Ore sites (e.g. Linklater et al., 2007).

3.4 Net Acid Generation

Net acid generation (NAG) tests measure how a sample behaves under highly oxidising conditions. The sample is contacted with the strong oxidant, hydrogen peroxide. Sulphides contained in the sample oxidise. Neutralising minerals that may be present consume all or part of the acid generated. Following a predetermined contact time, the solution pH is recorded and the NAG acidity of the sample is quantified by titration with a base (sodium hydroxide). For samples with high S contents, a single test may not access all of the reactive sulphides present in the sample. It is therefore advisable to repeat the NAG tests several times (sequential NAG tests). The results of sequential NAG tests (up to 3 stages) are given in Appendix 4.

Of the thirteen samples studied, twelve still had detectable acidity after Stage 3. Of these, ten still gave NAG pH values less than pH 4.5, suggesting that un-oxidised reactive sulphide minerals remained in the samples. The measured acidities however had decreased significantly; typically acidities measured in Stage 3 were less than 10 % of those measured in Stage 1 (for titration to pH 4.5 and to pH 7). Generally, the cumulative NAG acidities calculated for the samples were comparable to, or slightly less than, the NAPP values. In the case of one of the Paraburdoo Lens 2 samples (Borehole GT064EMP0003, depth interval 46.89-47.06m), the cumulative NAG acidity was significantly greater that the NAPP value, up to a factor of 2 (mostly measured in Stage 1). This is probably due to the fact that some of the ANC associated with this sample is not available for reaction (see also discussion in Section 3.2).

The Dales Gorge sample studied (depth interval 142-150m) gave negligible acidities in Stage 1. This sample gave an NPR value of 1.27 and had been categorised as ‘uncertain’ (Section 3.2). The low acidities observed in the NAG test suggest this sample should be classified as non acid forming. One of the Paraburdoo Lens 2 samples, gave low to very low acidities in Stages 2 and 3 (Borehole GT064EMP0003, depth interval 46.89-47.06m). The three West Angelas samples studied were associated with relatively low acidities at all stages (although two of the samples consistently gave NAG pH values less than 4.5).

Titration to pH 4.5 generally accounts for acidity attributable to free acid (H_2SO_4) and ferric iron generated during the oxidation of sulphide minerals (that has not been neutralized by the contained ANC). Titration from pH 4.5 to pH 7 generally accounts for acidity associated with some metals, such as copper, that are soluble at pH 4.5 but practically insoluble at pH 7. Acidity attributed to un-oxidised ferrous iron will also be accounted for in the titration up to pH 7 (ferrous iron remains soluble at pH 4.5; however oxidation to ferric by atmospheric oxygen accelerates as the pH increases).

Figure 8 is a plot showing the ratio (at each stage) of acidity to pH 7 and acidity to pH 4.5. A ratio close to unity shows that the NAG (pH 4.5) and NAG (pH 7) values are equivalent and that therefore there is no significant additional acidity associated with the titration between pH 4.5 and pH 7. In such a case, most of the acidity can be attributed to free acid (H_2SO_4) and ferric irons generated during the sulphide oxidation. Values significantly greater than unity suggest that the relative importance of acidity between pH 4.5 and 7 has increased, i.e. there is an increased contribution associated with metals other than ferric iron.

In Figure 8, it can be seen that for many of the samples, the calculated ratios tend to be close to unity in the early stages (the stages associated with the highest measured acidities) and show a slight increase towards the late stages (the stages associated with lower acidity). The increased ratios at later stages is particularly marked in the case of two of the West Angelas samples, #432 and #435.

These observations would be consistent with the early reaction (and most substantial acid generation) being dominated by oxidation of iron-bearing sulphides. Later reaction is probably confined to oxidation of any un-oxidised ferrous iron and perhaps some small contribution from the oxidation of other sulphides that might be present.

There are some exceptions to this general behaviour:

- In the case of Paraburdoo Lens 2 sample associated with low acidities in Stages 2 and 3 (Borehole GT064EMP0003, depth interval 46.89-47.06m), the ratio of the acidities increases from Stage 1 to 2, but decreases significantly between Stage 2 and 3. Given the low acidities involved, the trends are probably not significant.
- West Angelas sample #428 gives ratios consistently greater than unity: >110 in Stage 1; >5 in Stage 2 and >9 in Stage 3. For this sample, all the measurable acidity was associated with the titration between pH 4.5 and pH 7, suggesting that the acidity generated in this sample is related to metals other ferric iron.

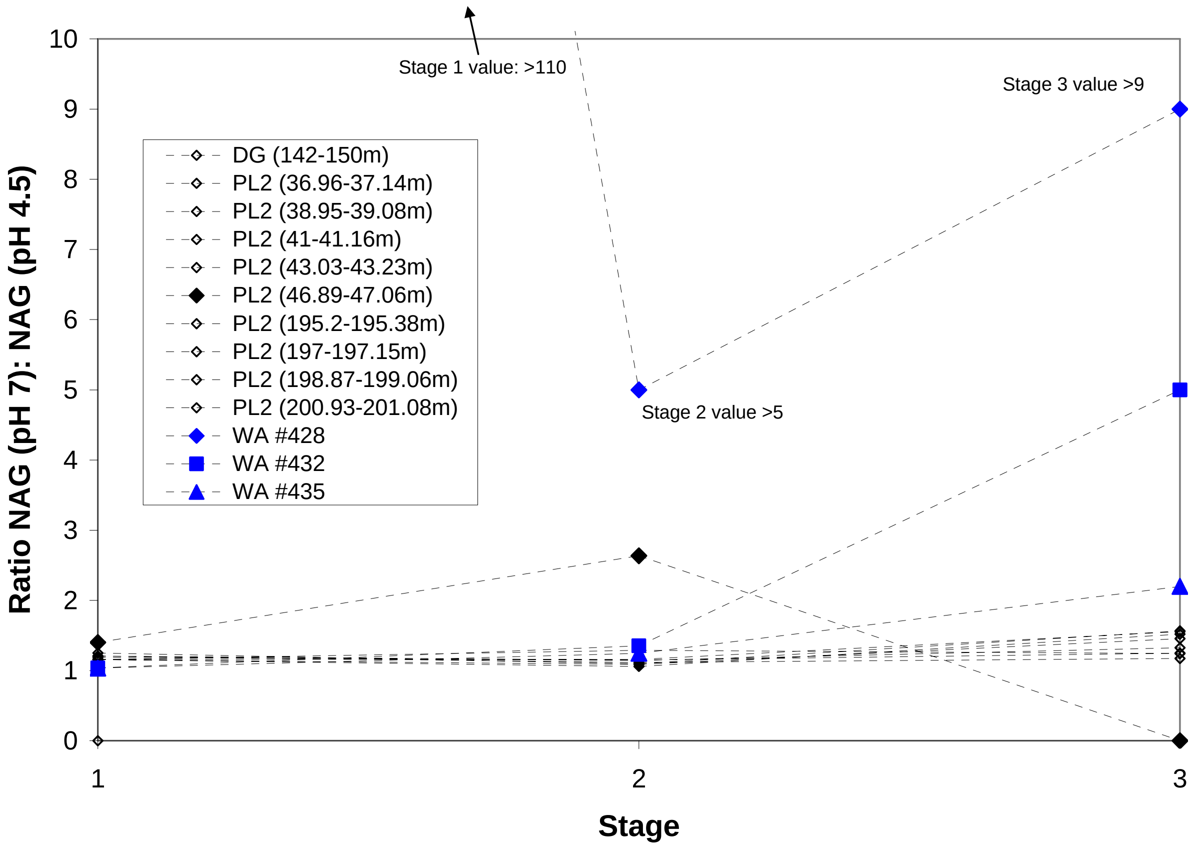


Figure 8: Ratio of NAG (pH 7) to NAG (pH 4.5) in Stages 1, 2 and 3.

Kinetic NAG tests were undertaken on seven samples, five Paraburdoo Lens 2 and two West Angelas. Detailed results are given in Appendix 4.

Four of the five Paraburdoo Lens 2 samples show similar behaviour. There is an immediate drop in pH and a corresponding spike in temperature (generally to more than 80°C but in one case to a more modest 50°C). The pH remains low for the remainder of the test (up to 5 hours). This behaviour is typical of potentially acid forming samples. The temperature spike is consistent with heat release due to oxidation of sulphides. The rapid drop in pH is consistent with the limited neutralisation capacity present in these samples (ANC values, <4 kg H_2SO_4/t). For these samples, it appears that no lag time can be expected before the onset of acidification. This conclusion is further supported by the fact that they exhibited acidic paste pH values.

The fifth Paraburdoo Lens 2 sample (Borehole GT064EMP0003, depth interval 46.89-47.06m) shows a flatter pH profile at around pH 5. There is a drop to pH 4 at around 50 minutes, coinciding with a temperature maximum of 60°C. Shortly after this (at 90 minutes) there is a single increased pH measurement, pH 6, before the profile returns to pH 5 for the remainder of the test. This sample had a lower total S content than the other samples studied (3.34 wt% as opposed to 6.44-18.2 wt%) which probably explains the more gradual heat release and the more modest maximum temperature observed. For this sample, some lag time can be expected before acidification.

The two West Angelas samples studied are also associated with relatively low total S contents (<2 wt%) and also show more gradual heat release and modest maximum temperatures (55 to 70°C). The temperature maxima occur at around 100 minutes and coincide with the expected drop in pH indicative of sulphide oxidation. In the case of these samples, some lag time can be expected before acidification.

3.5 Leachability of Contaminants

Multi-element assays of the samples are given in Appendix 5. The results of the leach tests are given in Appendix 6. It is important to note that the leach extraction tests reflect the potential for metal release from the samples under the conditions current when the samples are tested. For example, a highly oxidized sample will yield a significantly higher release of solutes than a fresh (un-weathered) sample of the same material due to the changes that occur during oxidation and subsequent weathering. Although the tests can be used to infer which contaminants might be released in the longer term, they do not necessarily reflect the leachate concentrations that might be generated by the waste rock as it weathers in situ under field conditions.

The multi-element assays of the samples (solids) showed that the following elements were significantly enriched relative to average ‘crustal’ abundances in at least some of the samples studied (see Appendix 4 for further discussion of geochemical abundance indices):

C, S, As, Au, Bi, Mo, Sb, Se, Sn

From the data presented in Appendices 5 and 6, it was possible to calculate the percentage of element leached from the samples during the leach test. The results of these calculations are given in Table 5. Most data were generated from leach tests undertaken at a 5:1 water-to-rock ratio. Three samples were also studed at a 2:1 water-to-rock ratio. The results obtained at a 2:1 ratio were very similar to those obtained at a 5:1 ratio.

Of the major elements, for some of the samples, significant percentages of Na, K, Ca and Mg present were leached during the test, probably due to a combination of:

(i) dissolution of readily soluble salts (e.g. sulphates, carbonates, chlorides). The probable role of sulphates can be inferred from the observation that high percentages of leachable S are often correlated.
(ii) desorption from exchange sites on mineral surfaces (e.g. these elements often occupy ion exchange sites on clays and are relatively easily displaced following water-rock interactions).

Of the minor elements studied, for some of the samples, significant percentages of B (one sample only), Co, Cr, Mn, Mo, Ni, Se and Zn present were leached during the test. Three samples were associated with the highest percentages of leached minor elements, all were black pyritic shales from the Paraburdoo Lens 2 (GT064EMP0003, depth interval: 38.95 - 39.08m, and GT064EMP0001, depth intervals: 197 - 197.15m; 200.93 - 201.08m). These samples were also associated with a high percentage of leached major elements. It is possible that minor elements be incorporated within readily soluble salt and so could be released following dissolution of those salts. (Note that the salts could have been formed due to oxidation during sample handling and storage.) It is also possible that the minor elements have been released due to desorption from mineral surfaces.

It is notable that, of the elements that were enriched in the samples (with respect to average crustal abundances), only Mo and Se leached in appreciable quantities during the tests.

Table 5: Percentage of element leached during test (5:1 water-to-rock ratio, unless otherwise indicated)

	Dales Gorge		Paraburdoo Lens 2										West Angelas			West Angelas (2:1 ratio)		
Sample#	**1**	**5**	**1**	**3**	**10**	**15**	**18**	**19**	**21**	**27**	**29**	**30**	**1**	**5**	**8**	**1**	**5**	**8**
Borehole/Blast	**WB06NTB02**		**GT064EMP0003**					**GT064EMP0001**					**WEP2/652/902**			**WEP2/652/902**		
Depth interval	**134-135**	**142-150**	**21.43-21.6**	**25-25.28**	**38.95-39.08**	**48.97-49.15**	**56-56.13**	**182.76-183**	**185-185.23**	**197-197.15**	**200.93-201.08**	**202.9-203.04**	**#428**	**#432**	**#435**	**#428**	**#432**	**#435**
Major elements																		
Al	n.c.	n.c.	n.c.	n.c.	4	n.c.	n.c.	n.c.	n.c.	2	1	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.
Ca	0	0	6	14	89	19	16	n.c.	3	16	43	28	4	1	2	2	0	1
Fe	n.c.	n.c.	n.c.	n.c.	2	0	n.c.	0	n.c.	1	1	1	n.c.	0	0	n.c.	n.c.	n.c.
K	5	5	5	1	n.c.	2	2	n.c.	0	n.c.	1	1	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.
Mg	0	0	8	1	14	1	1	0	0	5	5	9	4	0	0	2	0	0
Na	67	33	10	10	n.c.	4	2	4	3	n.c.	2	1	2	1	1	1	0	0
S	3	1	5	7	3	2	2	10	3	1	3	1	3	1	1	1	0	0
Si	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Minor elements																		
Ag	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.
As	n.c.	n.c.	n.c.	n.c.	0	n.c.	n.c.	n.c.	n.c.	0	0	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.
B	n.c.	n.c.	10	n.c.	n.c.	n.c.	n.c.	1	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.
Ba	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.
Bi	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.
Cd	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.
Co	n.c.	n.c.	n.c.	n.c.	69	n.c.	n.c.	n.c.	n.c.	59	59	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.
Cr	n.c.	n.c.	n.c.	n.c.	10	n.c.	n.c.	n.c.	n.c.	0	1	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.
Cu	n.c.	n.c.	n.c.	n.c.	0	n.c.	n.c.	n.c.	n.c.	0	8	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.
F	1	1	3	1	n.c.	1	1	2	0	1	0	1	n.c.	1	1	n.c.	1	1
Hg	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.
Mn	n.c.	n.c.	0	0	23	1	0	n.c.	n.c.	13	17	24	0	n.c.	n.c.	0	n.c.	n.c.
Mo	5	20	n.c.	10	n.c.	2	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.
Ni	n.c.	n.c.	n.c.	n.c.	30	n.c.	n.c.	n.c.	n.c.	21	24	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.
P	n.c.	n.c.	0	0	0	n.c.	n.c.	0	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.
Pb	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.
Sb	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.

	Dales Gorge		Paraburdoo Lens 2										West Angelas			West Angelas (2:1 ratio)		
Sample#	**1**	**5**	**1**	**3**	**10**	**15**	**18**	**19**	**21**	**27**	**29**	**30**	**1**	**5**	**8**	**1**	**5**	**8**
Borehole/Blast	**WB06NTB02**		**GT064EMP0003**					**GT064EMP0001**					**WEP2/652/902**			**WEP2/652/902**		
Depth interval	**134-135**	**142-150**	**21.43-21.6**	**25-25.28**	**38.95-39.08**	**48.97-49.15**	**56-56.13**	**182.76-183**	**185-185.23**	**197-197.15**	**200.93-201.08**	**202.9-203.04**	**#428**	**#432**	**#435**	**#428**	**#432**	**#435**
Se	n.c.	n.c.	n.c.	7	n.c.	n.c.	8	n.c.	11	1	7	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.
Sn	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.
Sr	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.
V	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	0	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.
Zn	n.c.	n.c.	n.c.	n.c.	26	n.c.	n.c.	n.c.	n.c.	16	3	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.

n.c. – not possible to calculate a percentage, usually because the element was indetectable in the solution at the end of the leach test, i.e. percentage leached infinitesimally small.

4 Conclusions and Recommendations

The following conclusions have been reached:

- Acidic paste pH values and high electroconductivities correlated positively with the total S content of the samples. This was interpreted as evidence of the presence of sulphide oxidation reaction products in these samples;
- Measurements on selected samples showed that 90% or more of the sulphur present was in the form unoxidised sulphide sulphur.
- The samples from the different sites showed distinct acid-base accounting characteristics:
    - The Dales Gorge samples were associated with significant ANC and classified as non acid forming. CarbNP estimates and ABCC measurements suggested that the available ANC is in the form of carbonate minerals and readily available for reaction;
    - The majority of the Paraburdoo Lens 2 samples were classified as potentially acid forming. The limited ANC available is likely to be a combination of carbonates and aluminsilicates, and may not all be available for reaction (adding weight to categorisation of the samples as potentially acid forming). Exceptions were samples located in the topmost depth intervals, in a transitional zone between deeper black shales to green and yellow/brown shales, were classified as non-acid forming;
    - Seven of eight West Angelas samples studied were classified as potentially acid forming. CarbNP estimates and ABCC measurements were variable; in some samples ANC appeared to be in the form of readily available carbonates, whereas in other samples the ANC was not readily available.
- IOR values were measured in the case of composite samples of sulphur-rich material from Paraburdoo Lens 2. The values obtained, 3-4 × 10^{-10} kg(O_2)kg(dry material)$^{-1}$s^{-1}, lie within the range of values obtained in previous studies of samples from Rio Tinto Iron Ore sites;
- Sequential NAG tests suggested that for most samples early reaction (and most substantial acid generation) was dominated by oxidation of iron-bearing sulphides. The exception was one of the West Angelas samples (#428, a banded iron formation sample) where all measurable acidity was associated with the titration between pH 4.5 and pH 7, indicative of metals other than ferric iron;
- In all but one of the Paraburdoo Lens 2 samples studied, kinetic NAG tests suggested that sulphide present was readily oxidised with no significant lag time to reaction and acidification. For the remaining Paraburdoo Lens 2 sample, and both West Angelas samples studied, kinetic NAG tests suggested that the onset of acidification would be delayed. Additional kinetic testwork could allow estimation of timescales (see below);
- In at least some of the samples, the following elements were present in quantities that were enriched relative to average crustal abundances: C, S, As, Au, Bi, Mo, Sb, Se, Sn;
- Of these enriched elements, only Mo and Se were readily leachable in the samples. Other (not enriched) minor elements present in readily leachable form were B (one sample only), Co, Cr, Mn, Ni and Zn. Three of the Paraburdoo Lens 2 samples (all black pyritic shales) were associated with the highest percentages of leached minor elements. It should be noted that weathering and acidification reactions could be expected the change the solubility and leachability of several of the trace metals present.

A number of recommendations were made following characterisation of the previous batch of samples (Linklater et al, 2007). Those recommendations remain valid and apply equally to the results presented herein. They are summarised below:

- Undertaking leach tests under a wider range of conditions. For example, using acid solution as the leachant. Given the potentially acid forming nature of many of the Rio Tinto Iron Ore waste materials, it would be insightful to measure the leachability of contaminants under acidic conditions.

- Conducting weathering or kinetic tests in columns to determine reaction kinetics and overall rates and potential for trace element release from the waste rock. These results can be used to complete water and load balance calculations (i) to determine the overall potential for contaminant release from the waste rock dumps and (ii) to determine minimum requirements for closure and ensure that contaminant loads are sustained within acceptable levels.

5 References

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Appendices

Appendix 1: Summary of samples and the program of measurements undertaken

Sample #	Borehole #	Depth Interval	S, C content	ANC	IOR	Sulphate S	Organic C	ABCC	NAG	Kinetic NAG	Multi-element assay	1:2 Leach tests
Dales Gorge												
1	WB06NTB02	134-135	X	X		X	X	X			X	X
2		140-142	X	X			X					
3		126-128	X	X								
4		-	X	X								
5		142-150	X	X		X		X	X		X	X
Paraburdoo Lens 2												
1	GT064EMP0003	21.43-21.6	X	X							X	X
2		23-23.2	X	X								
3		25-25.28	X	X			X				X	X
4		27.42-27.6	X	X								
5		29.25-29.5	X	X								
6		31-31.24	X	X								
7		33-33.22	X	X			X					
8		35-35.17	X	X								
9		36.96-37.14	X	X	X (Composite sample)	X			X			
10		38.95-39.08	X	X		X			X	X	X	X
11		41-41.16	X	X		X	X		X			
12		43.03-43.23	X	X		X	X		X	X		
13		44.9-45.1	X	X								
14		46.89-47.06	X	X					X	X		
15		48.97-49.15	X	X		X					X	X
16		51.2-51.34	X	X				X				
17		53.97-54.14	X	X								
18		56-56.13	X	X		X	X	X			X	X
19	GT064EMP0001	182.76-183	X	X							X	X
20		183.99-184.22	X	X								
21		185-185.23	X	X			X				X	X

Sample #	**Borehole #**	**Depth Interval**	**S, C content**	**ANC**	**IOR**	**Sulphate S**	**Organic C**	**ABCC**	**NAG**	**Kinetic NAG**	**Multi-element assay**	**1:2 Leach tests**
22		187.05-187.19	X	X				X				
23		188.97-189.13	X	X								
24		190.92-191.11	X	X			X					
25		193.15-193.34	X	X								
26		195.2-195.38	X	X	X	X			X			
27		197-197.15	X	X	(Composite	X			X	X	X	X
28		198.87-199.06	X	X	sample)	X	X		X			
29		200.93-201.08	X	X		X	X	X	X	X	X	X
30		202.9-203.04	X	X		X					X	X
31		205-205.2	X	X		X		X				
West Angelas	Blast# WEP2/652/902											
1	428		X	X		X	X	X	X	X	X	X
2	429		X	X				X				
3	430		X	X								
4	431		X	X								
5	432		X	X		X			X		X	X
6	433		X	X								
7	434		X	X								
8	435		X	X		X			X	X	X	x
Total number of measurements			**44**	**44**	**2**	**17**	**12**	**9**	**13**	**7**	**15**	**15**

ANC=acid neutralisation capacity; S=sulphur; C=carbon; NAG=net acid generation tests (up to 3 stages); ABCC=acid base characteristic curve

Appendix 2: Paste pH and Electroconductivity

Sample #	Borehole	Depth interval	Paste pH	Electroconductivity
				µS/cm
Dales Gorge				
1	WB06NTB02	134-135	9	1180
2		140-142	9.2	945
3		126-128	8.7	618
4		-	8.8	219
5		142-150	8.6	772
Paraburdoo Lens 2				
1	GT064EMP0003	21.43-21.6	6.8	110
2		23-23.2	8	388
3		25-25.28	6.9	697
4		27.42-27.6	5.9	329
5		29.25-29.5	6.3	424
6		31-31.24	6.4	510
7		33-33.22	6	932
8		35-35.17	5.3	621
9		36.96-37.14	3.7	2890
10		38.95-39.08	2.7	5090
11		41-41.16	4	1860
12		43.03-43.23	3.6	1590
13		44.9-45.1	5.4	800
14		46.89-47.06	5.4	1640
15		48.97-49.15	6.6	490
16		51.2-51.34	6.8	935
17		53.97-54.14	6.4	589
18		56-56.13	6.5	840
19	GT064EMP0001	182.76-183	6.9	174
20		183.99-184.22	7.1	52
21		185-185.23	8	354
22		187.05-187.19	8.2	107
23		188.97-189.13	7.8	294
24		190.92-191.11	7	287
25		193.15-193.34	6.4	656
26		195.2-195.38	3.4	2800
27		197-197.15	3.2	3550
28		198.87-199.06	3.6	2550
29		200.93-201.08	3.8	2640
30		202.9-203.04	4.6	548
31		205-205.2	6.1	1380
West Angelas	Blast# WEP2/652/902			
1	428		6.8	493
2	429		8.2	350
3	430		6.9	467
4	431		7.6	354
5	432		7.6	426
6	433		7.8	177
7	434		7.7	284
8	435		7.7	414

Appendix 3: Acid-Base Accounting

Table A3.1 Results from acid-base accounting testwork

Sample #	Borehole	Depth interval	Total S	Total C	Sulphate S	Organic C	Inorganic C	ANC	CarbNP	MPA	AP	NAPP	NPR
			%					kgH_2SO_4 equiv.					
Dales Gorge													
	WB06NT												
1	B02	134-135	0.62	2.74	0.05	0.34	2.4	158	196	18.97	17.55	-140.45	9.00
2		140-142	0.29	2.69		0.11	2.58	149	211	8.87		-140.13	16.79
3		126-128	0.06	2.14				104		1.84		-102.16	56.64
4		-	<0.01	0.04				2.5		<0.3		-2.50	High
5		142-150	0.83	1.51	0.04			30.7		25.40	24.09	-6.61	1.27
Paraburdoo Lens 2													
	GT064												
1	EMP0003	21.43-21.6	0.01	1.26				2.4		0.31		-2.09	7.84
2		23-23.2	0.03	2.83				3.6		0.92		-2.68	3.92
3		25-25.28	0.28	4.22		4.37	Negligible	2.8	Negligible	8.57		5.77	0.33
4		27.42-27.6	0.33	1.96				1.1		10.10		9.00	0.11
5		29.25-29.5	0.31	3.73				1.7		9.49		7.79	0.18
6		31-31.24	0.34	4.5				2.7		10.40		7.70	0.26
7		33-33.22	3.19	4.69		4.43	0.26	4	21	97.61		93.61	0.04
8		35-35.17	3.92	4.04				2		119.95		117.95	0.02
9		36.96-37.14	13.6	2.82	0.79			2.1		416.16	391.99	389.89	0.01
10		38.95-39.08	18.2	2.01	0.85			0.8		556.92	530.81	530.01	0.00
11		41-41.16	6.86	6.81	0.57	6.64	0.17	1.6	14	209.92	192.58	190.98	0.01
12		43.03-43.23	10.2	6.76	0.58	5.95	0.81	1	66	312.12	294.37	293.37	0.00
13		44.9-45.1	1.67	1.02				2.2		51.10		48.90	0.04
14		46.89-47.06	3.34	4.39				2.8		102.20		99.40	0.03
15		48.97-49.15	0.94	0.37	0.05			3.7		28.76	27.25	23.55	0.14
16		51.2-51.34	1.93	2.47				9.6		59.06		49.46	0.16

Sample #	**Borehole**	**Depth interval**	**Total S**	**Total C**	**Sulphate S**	**Organic C**	**Inorganic C**	**ANC**	**CarbNP**	MPA	AP	NAPP	**NPR**
17		53.97-54.14	0.99	1.11				3.4		30.29		26.89	0.11
18		56-56.13	1.99	1.71	0.06	1.8	Negligible	5.2	Negligible	60.89	58.97	53.77	0.09
	GT064												
19	EMP0001	182.76-183	<0.01	0.04				5.4		<0.3		-5.40	High
20		183.99-184.22	<0.01	0.04				2.2		<0.3		-2.20	High
21		185-185.23	0.06	5.52		5.61	Negligible	6.2	Negligible	1.84		-4.36	3.38
22		187.05-187.19	0.05	4.17				26.6		1.53		-25.07	17.39
23		188.97-189.13	0.23	2.94				7.7		7.04		-0.66	1.09
24		190.92-191.11	0.22	4.64		4.33	0.31	1.8	25	6.73		4.93	0.27
25		193.15-193.34	0.38	4.68				3.4		11.63		8.23	0.29
26		195.2-195.38	10.6	4.16	0.62			<0.5		324.36	305.29	324.36	Low
27		197-197.15	20	2.48	0.36			1.3		612.00	600.88	599.58	0.00
28		198.87-199.06	5.89	8.05	0.45	7.25	0.8	1.6	65	180.23	166.57	164.97	0.01
29		200.93-201.08	6.44	7.4	0.36	6.85	0.55	5.8	45	197.06	186.05	180.25	0.03
30		202.9-203.04	1.84	0.11	0.02			<0.5		56.30	55.59	56.30	Low
31		205-205.2	4.36	4.86	0.13			5.2		133.42	129.30	124.10	0.04
West Angelas	Blast# WEP2/652/902												
1	#428		1.25	1.68	0.03	0.03	1.65	26.1	135	38.25	37.37	11.27	0.70
2	#429		0.49	0.66				51.4		14.99		-36.41	3.43
3	#430		0.92	1.2				32.2		28.15		-4.05	1.14
4	#431		0.82	0.03				5.7		25.09		19.39	0.23
5	#432		1.03	0.02	0.02			4.8		31.52	30.96	26.16	0.16
6	#433		0.42	0.02				4.2		12.85		8.65	0.33
7	#434		0.57	0.02				6.6		17.44		10.84	0.38
8	#435		1.94	0.01	0.02			2.4		59.36	58.61	56.21	0.04

S=sulphur; C=carbon; ANC=acid neutralisation capacity; CarbNP=carbonate-based acid neutralising capacity, MPA=maximum potential acidity; AP=acid potential (based on estimated sulphidic S content of samples (i.e. having accounted for the amount of S present as sulphate S, i.e. already oxidised); NAPP=net acid producing potential; NPR=net potential ratio (ratio of ANC to MPA, or if available, AP)

Appendix 4: Net Acid Generation Testwork

Net acid generation (NAG) test results are given in Table A4.1. Kinetic NAG tests were also carried out; the results are tabulated in Table A4.2 and illustrated in Figure A4.1.

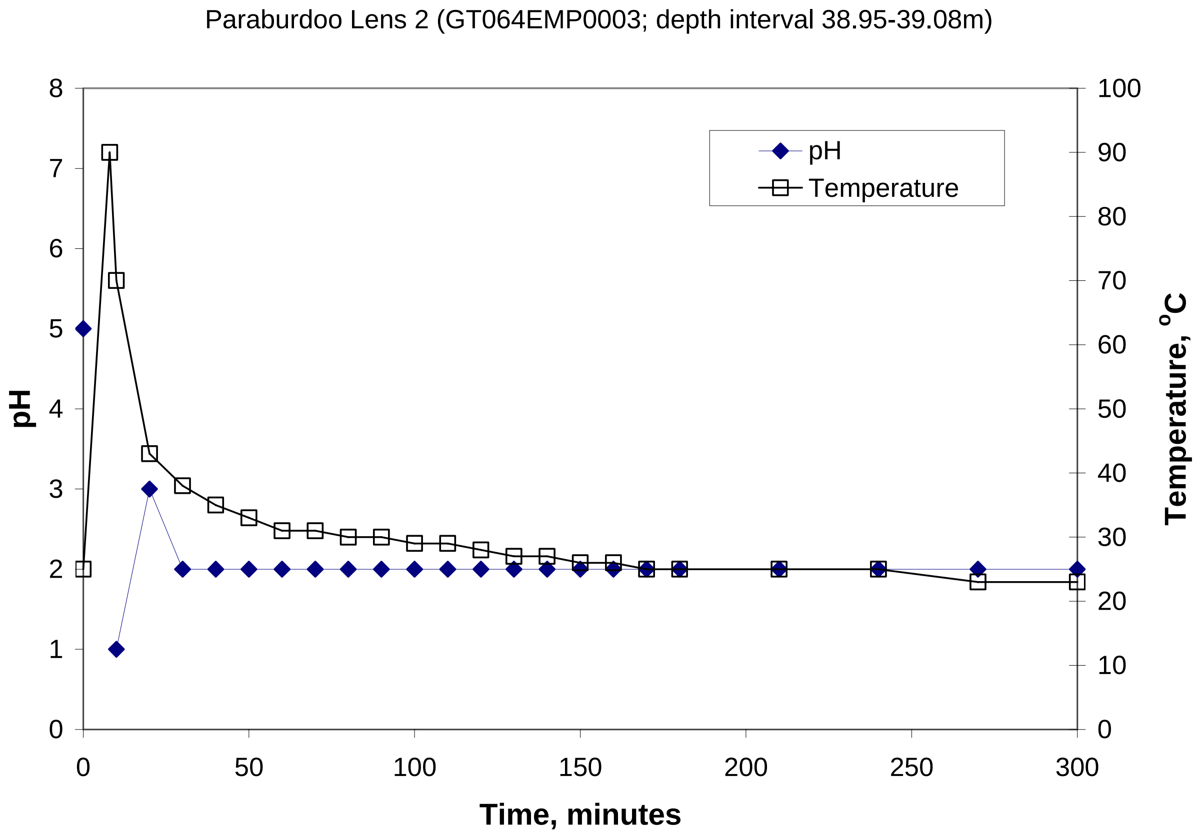
Table A4.1 Results of Net Acid Generation Tests (up to 3 Stages)

			Stage 1			Stage 2			Stage 3			Cumulative Totals	
Sample #	**Borehole**	**Depth interval**	**NAGpH**	**NAG(pH4.5)**	**NAG(pH7)**	**NAGpH**	**NAG(pH4.5)**	**NAG(pH7)**	**NAGpH**	**NAG(pH4.5)**	**NAG(pH7)**	**NAG(pH4.5)**	**NAG(pH7)**
				kg H_2SO_4/t			kg H_2SO_4/t			kg H_2SO_4/t		kg H_2SO_4/t	
Dales Gorge													
5	WB06NTB02	142-150	7.7	<0.1	<0.1							<0.1	<0.1
Paraburdoo Lens 2													
9	GT064 EMP0003	36.96-37.14	1.6	208	260	2.0	64.0	70.2	2.6	12.2	19.1	284	349
10		38.95-39.08	1.5	256	296	1.8	86.4	91.6	2.5	11.0	16.7	354	404
11		41-41.16	1.7	128	148	2.3	27.0	34.8	2.7	9.9	12.3	165	195
12		43.03-43.23	1.7	150	181	2.0	49.6	57.0	2.6	11.7	14.6	211	252
14		46.89-47.06	2.3	135	189	3.3	2.2	5.8	4.8	<0.1	2.2	137	197
26	GT064 EMP0001	195.2-195.38	1.6	204	236	2.0	56.5	61.5	2.6	11.4	16.6	272	314
27		197-197.15	1.6	276	333	1.8	104	116	2.3	26.1	30.6	405	479
28		198.87-199.06	1.8	105	125	2.3	21.5	24.6	2.8	12.6	16.7	139	167
29		200.93-201.08	1.7	117	136	2.3	22.6	26.2	2.8	7.2	11.2	147	173
West Angelas													
1	Blast# WEP2/652/902	#428	4.6	<0.1	11.0	4.6	<0.1	0.5	5.5	<0.1	0.9	<0.1	12.4
5		#432	2.2	20.5	21.3	3.5	1.7	2.3	4.4	0.2	1.0	22.4	24.6
8		#435	2.0	33.3	34.5	2.8	7.7	9.6	3.8	1.0	2.2	42.0	46.3

Table A4.2 Results of Kinetic Net Acid Generation Tests

	Paraburdoo Len 2										West Angelas			
Sample #	**10**		**12**		**14**		**27**		**29**		**1**		**8**	
Borehole/Blast	**GT064EMP0003**						**GT064EMP0001**				**WEP2/652/902**			
Depth Interval	**38.95-39.08**		**43.03-43.23**		**46.89-47.06**		**197-197.15**		**200.93-201.08**		**#428**		**#435**	
Time (minutes)	**pH**	**Temp**	**pH**	**Temp**	**pH**	**Temp**	**pH**	**Temp**	**pH**	**Temp**	**pH**	**Temp**	**pH**	**Temp**
0	5	25	5	25	5	25	5	25	5	25	5	24	5	24
8		90												
9								90						
10	1	70	1	60	5	26	1	60	2	45	5	25	5	24
11				85										
20	3	43	1	49	5	30	2	42	2	51	5	26	6	24
30	2	38	1	40	5	34	2	36	2	40	5	26	5	25
40	2	35	1	36	5	38	2	35	2	35	5	26	5	26
50	2	33	2	33	4	47	2	32	2	34	5	27	5	27
60	2	31	2	32	4	60	2	32	3	32	5	30	5	30
70	2	31	2	31	5	46	2	31	3	32	5	32	5	34
80	2	30	2	31	5	38	2	31	3	31	4	36	4	42
90	2	30	2	30	6	34	2	29	3	30	3	45	3	69
100	2	29	3	29	5	31	2	29	3	28	3	53	3	65
110	2	29	2	28	5	29	2	28	3	28	3	55	3	52
120	2	28	2	27	5	29	2	27	3	28	4	50	3	43
130	2	27	2	27	5	28	2	27	3	27	4	44	3	37
140	2	27	2	26	5	28	2	26	3	27	4	36	3	32
150	2	26	2	26	5	27	2	26	3	26	4	34	3	31
160	2	26	2	26	5	27	2	26	3	26	4	32	4	30
170	2	25	3	26	5	26	2	26	3	25	5	31	5	28
180	2	25	3	25	5	26	2	25	3	25	5	29	3	27
190											5	28	3	26
200											5	26	3	25
210	2	25	3	25	5	25	2	25	3	25	5	25	3	25
220											5	25	3	24

	Paraburdoo Len 2										West Angelas			
Sample #	**10**		**12**		**14**		**27**		**29**		**1**		**8**	
Borehole/Blast	**GT064EMP0003**						**GT064EMP0001**				**WEP2/652/902**			
Depth Interval	**38.95-39.08**		**43.03-43.23**		**46.89-47.06**		**197-197.15**		**200.93-201.08**		**#428**		**#435**	
Time (minutes)	**pH**	**Temp**	**pH**	**Temp**	**pH**	**Temp**	**pH**	**Temp**	**pH**	**Temp**	**pH**	**Temp**	**pH**	**Temp**
230											5	24	3	24
240	2	25	3	24	5	24	2	24	3	24	5	24	4	24
250														
260														
270	2	23	3	24	5	24	2	23	3	24	5	24	4	24
280														
290														
300	2	23	3	23	5	24	2	23	3	24	5	24	4	24
310														
320														
330											5	24	4	24
340														
350														
360											5	24	4	24



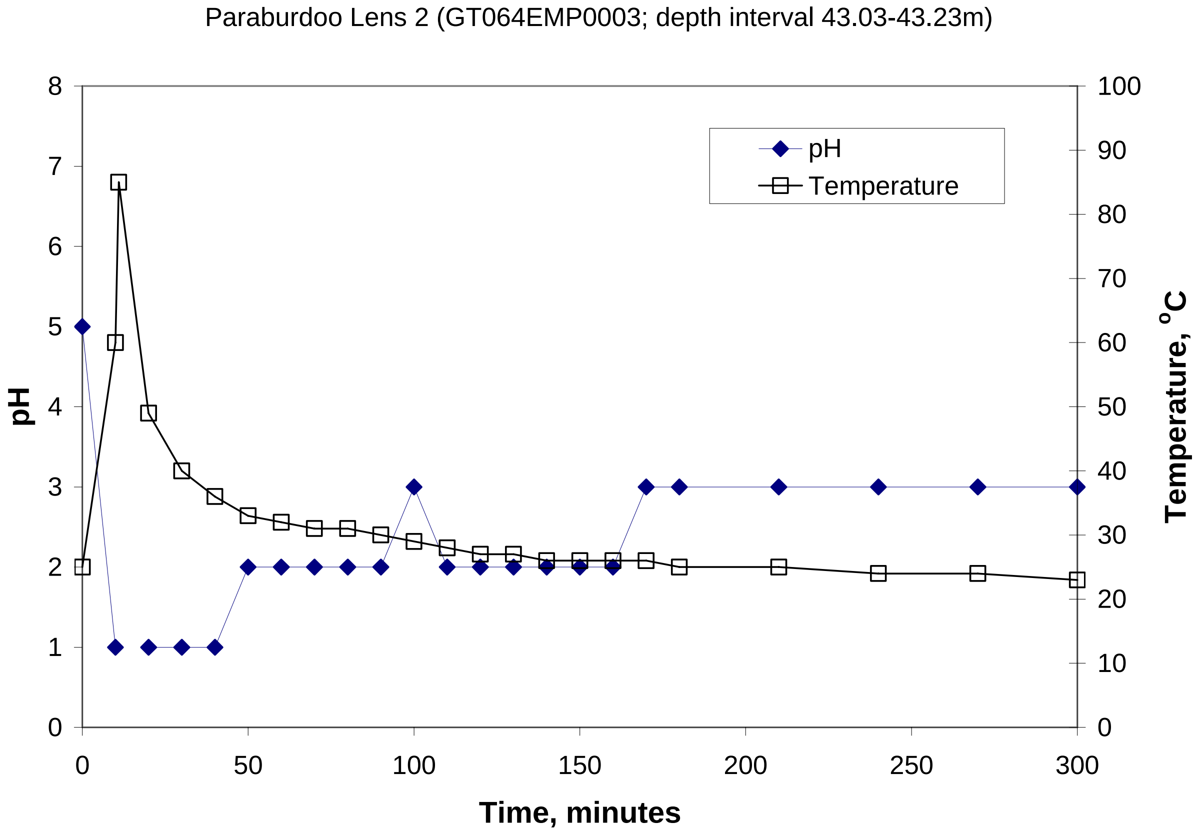
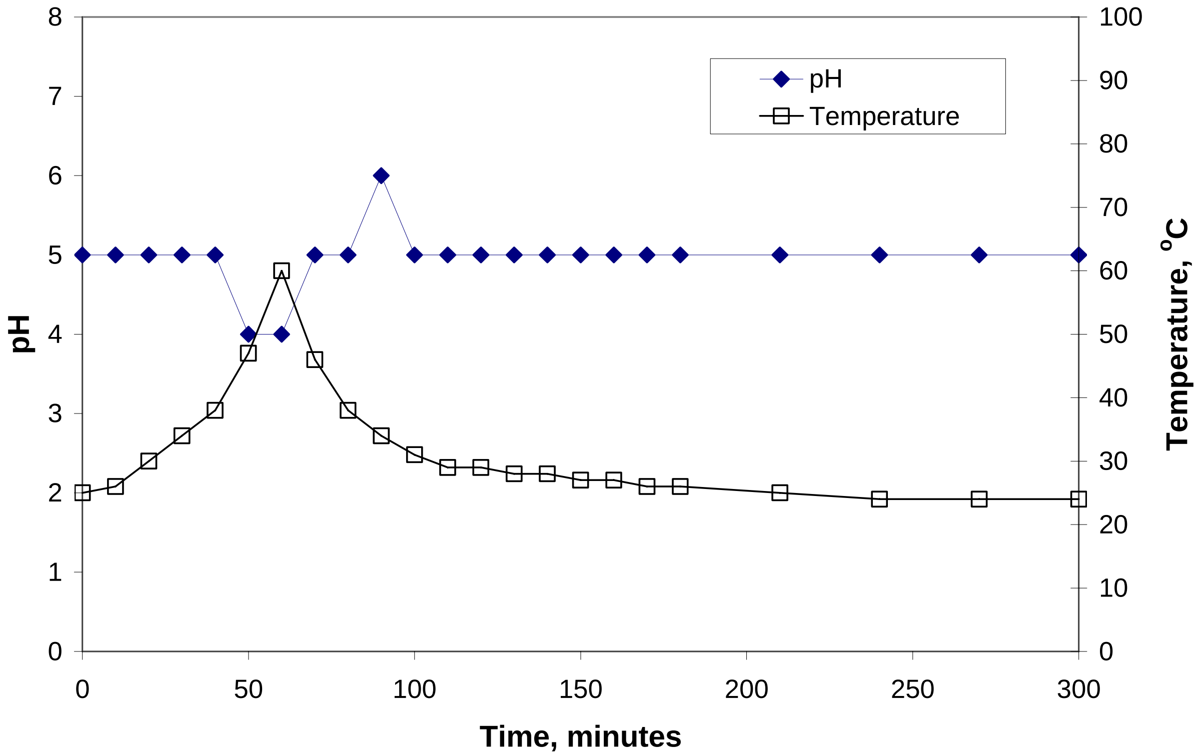


Figure A4.1 Kinetic NAG test results presented graphically

Paraburdoo Lens 2 (GT064EMP0003; depth interval 46.89-47.06m)



Paraburdoo Lens 2 (GT064EMP0001; depth interval 197-197.15m)

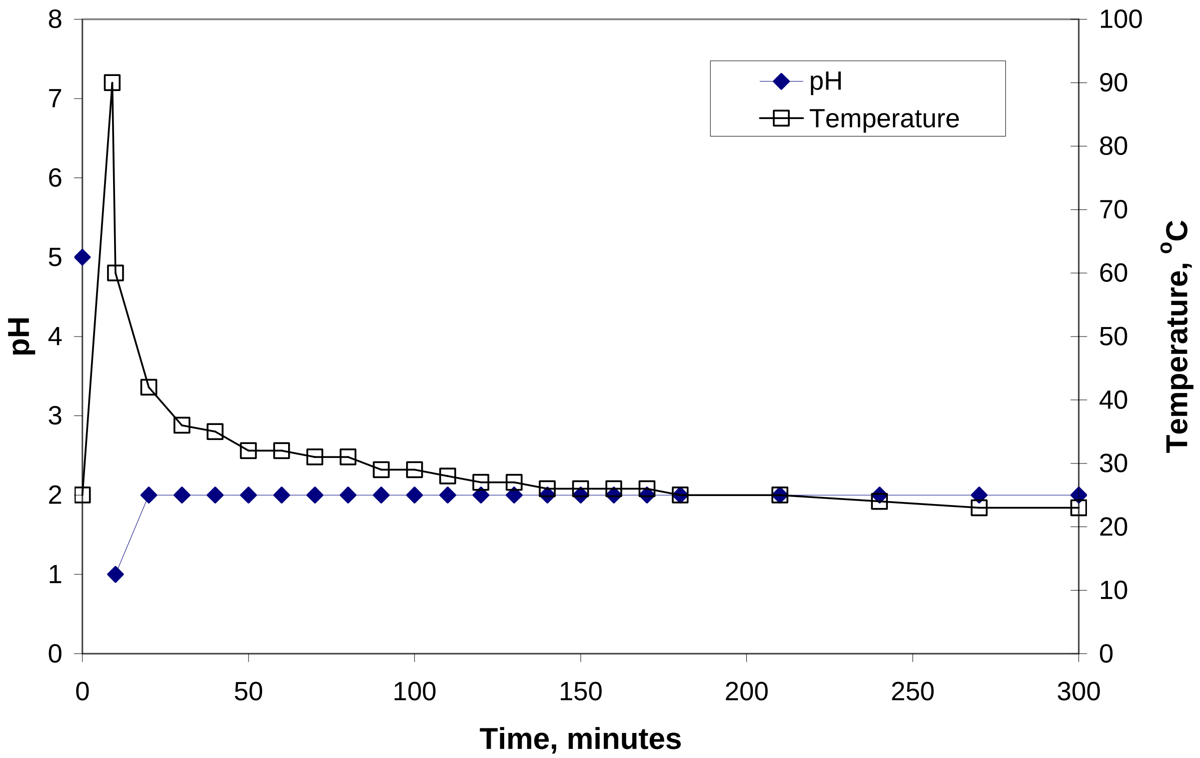
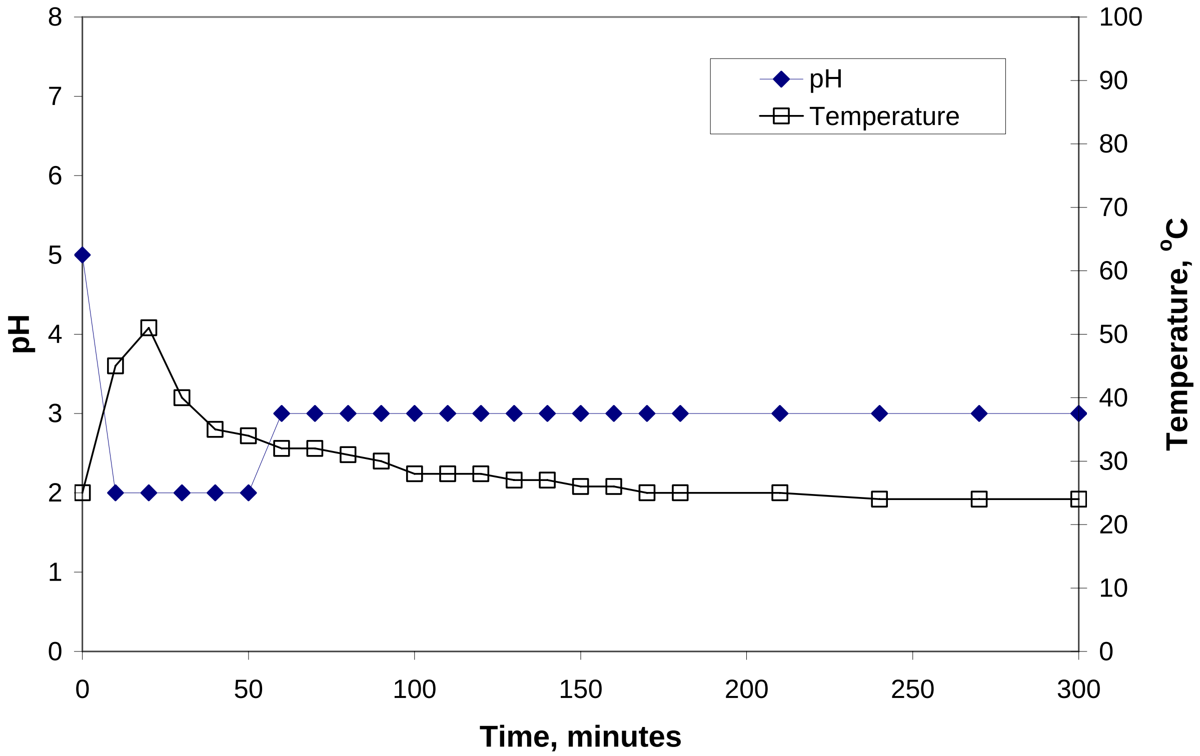


Figure A4.1 (continued) Kinetic NAG test results presented graphically

Paraburdoo Lens 2 (GT064EMP0001; depth interval 200.93-201.08m)



West Angelas (WEP2/652/902; #428)

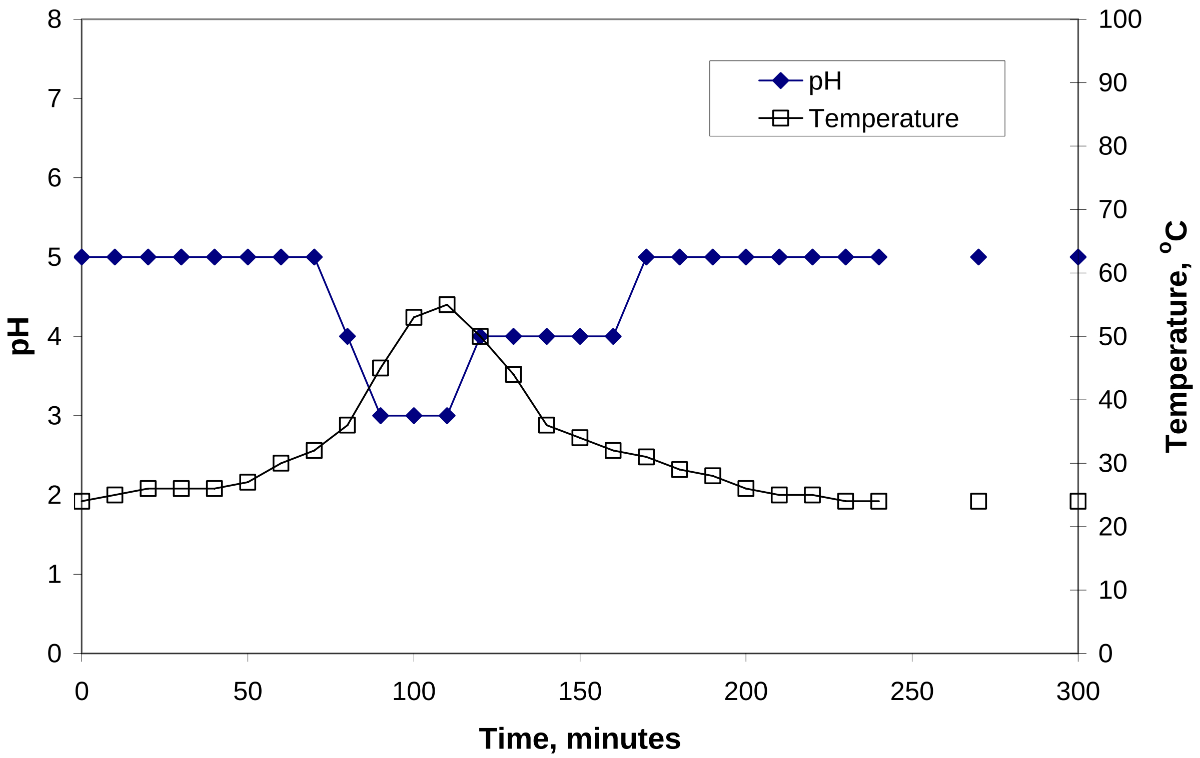


Figure A4.1 (continued) Kinetic NAG test results presented graphically

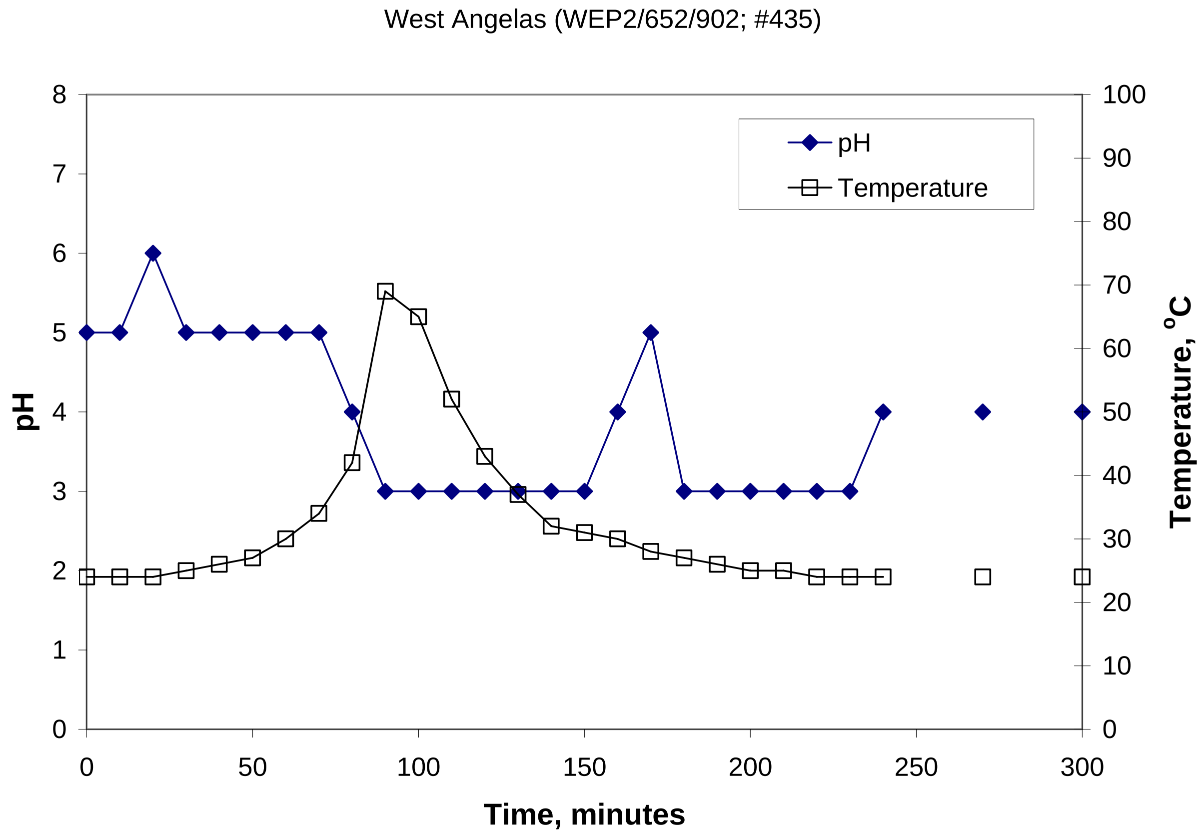


Figure A4.1 (continued) **Kinetic NAG test results presented graphically**

Appendix 5: Multi-Element Assays

Bulk chemical assays were undertaken on a selection of fifteen samples. The following elements were included in the assays:

- Majors – Al, C, Ca, Fe, K, Mg, Na, S, Si, Ti
- Minors – Ag, As, Au, B, Ba, Bi, Cd, Co, Cr, Cu, F, Hg, Mn, Mo, Ni, P, Pb, Sb, Se, Sn, Sr, V, Zn

Results of the analyses are given in Table A5.1. Geochemical abundance indices (GAI) were also calculated and are shown in Table A5.2. GAI values are a comparison of the measured values to 'average' values associated with a particular reference material. They are calculated using the following formula (Förstner, 1993):

$$\text{GAI} = \log_2\left(\frac{\text{MeasuredConcentration}}{1.5 \times \text{AverageAbundance}}\right)$$

where the GAI quantifies an assay result for a particular element in terms of the average-crustal-abundance of that element (Bowen, 1979). Positive GAI values indicate enrichment of the element in the sample when compared to average-crustal abundances. As a general rule, a GAI of 3 or higher signifies enrichment that warrants further evaluation.

Table A5.1: Results of multi-element assays for the Dales Gorge samples

	MULTI-ELEMENT ASSAY		GEOCHEMICAL ABUNDANCE INDEX		
Sample #	**1**	**5**		**1**	**5**
Borehole	**WB06NTB02**			**WB06NTB02**	
Depth Interval	**134-135**	**142-150**	**Average Crustal Abundance***	**134-135**	**142-150**
Major elements (%)					
Al	1.56	3.61	8.2	0	0
C	2.61	1.46	0.048	5	4
Ca	3.24	1.16	4.1	0	0
Fe	41.06	33.22	4.1	2	2
K	0.34	0.15	2.1	0	0
Mg	4.31	5.30	2.3	0	0
Na	0.06	0.08	2.3	0	0
S	0.64	0.86	0.026	4	4
Si	6.9	11.3	27.7	0	0
Ti	0.07	0.14	0.56	0	0
Minor elements (ppm)					
Ag	<0.5	<0.5	0.07	Low	Low
As	17	32	1.5	2	3
Au	<0.01	<0.01	0.0011	Low	Low
B	10	<10	10	0	Low
Ba	50	20	500	0	0
Bi	<2	<2	0.048	Low	Low
Cd	<0.5	<0.5	0.11	Low	Low
Co	8	22	20	0	0
Cr	22	33	100	0	0
Cu	15	14	50	0	0
F	300	460	950	0	0
Hg	0.045	0.052	0.05	0	0
Mn	3460	1850	950	1	0
Mo	2	2	1.5	0	0
Ni	15	30	80	0	0
P	940	830	1000	0	0
Pb	6	7	14	0	0
Sb	<5	<5	0.2	Low	Low
Se	0.6	0.6	0.05	3	3
Sn	<5	8	2.2	Low	1
Sr	9	6	370	0	0
V	21	33	160	0	0
Zn	29	42	75	0	0

* taken from Bowen (1979)
Al, Ca, Fe, K, Mg, Na, Si and Ti by fusion – inductively coupled plasma – atomic emission spectroscopy (ICP-AES); F by specific ion electrode; C, S by Leco method; Au by atomic absorption spectroscopy (AAS); B by HF digest – ICP-AES; Sn by trace level X-ray fluorescence analysis; remaining elements by four-acid digest – ICPMS or ICPAES.

Table A5.2: Results of multi-element assays for Paraburdoo Lens 2 samples

	MULTI-ELEMENT ASSAY									
Sample #	**1**	**3**	**10**	**15**	**18**	**19**	**21**	**27**	**29**	**30**
Borehole	**GT064EMP0003**					**GT064EMP0001**				
Depth Interval	**21.43-21.6**	**25-25.28**	**38.95-39.08**	**48.97-49.15**	**56-56.13**	**182.76-183**	**185-185.23**	**197-197.15**	**200.93-201.08**	**202.9-203.04**
Major elements (%)										
Al	6.83	7.17	2.30	2.08	4.04	11.75	9.53	2.72	6.22	0.19
C	1.23	4.33	1.92	0.38	1.65	0.05	5.53	2.33	7.23	0.12
Ca	0.12	0.05	0.02	0.02	0.04	0.09	0.07	0.06	0.08	0.01
Fe	20.14	10.42	22.87	3.70	7.83	27.28	6.36	18.67	6.04	2.36
K	0.04	2.99	0.27	0.93	0.66	0.14	1.55	0.33	2.54	0.33
Mg	0.10	1.12	0.49	0.57	2.37	0.25	3.17	1.07	1.15	0.07
Na	0.08	0.11	0.11	0.17	0.21	0.21	0.23	0.25	0.24	0.31
S	0.02	0.26	18.05	0.93	2.05	0.01	0.06	18.75	6.03	1.85
Si	22.7	26.3	20.3	40.4	32.2	10.7	24.5	22.4	26.4	43.6
Ti	0.28	0.26	0.08	0.08	0.17	0.45	0.36	0.08	0.23	0.01
Minor elements (ppm)										
Ag	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
As	765	118	1145	22	21	290	155	977	358	57
Au	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
B	10	150	<10	30	40	130	160	90	200	170
Ba	30	90	20	10	50	10	90	10	70	10
Bi	<2	<2	3	<2	<2	<2	<2	<2	3	<2
Cd	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Co	60	8	41	6	15	15	24	35	42	5
Cr	122	75	23	709	43	152	107	140	97	4
Cu	90	31	43	25	47	34	90	44	52	9
F	120	2180	420	810	700	170	1860	320	2450	200
Hg	0.412	0.158	0.475	0.118	0.132	0.044	0.042	0.493	0.49	0.099
Mn	3700	102	87	132	393	387	141	81	33	102
Mo	19	2	21	5	3	5	2	4	6	1
Ni	127	75	102	37	44	142	194	100	115	13
P	860	350	140	90	50	3150	300	360	420	30
Pb	24	16	58	9	9	14	49	66	64	11
Sb	<5	<5	29	<5	<5	5	6	7	8	<5
Se	0.7	1.5	6.5	0.6	1.2	1	0.9	8.4	6.9	0.7
Sn	<5	<5	<5	<5	<5	<5	14	5	40	<5
Sr	14	8	2	3	7	3	14	23	53	1
V	69	65	30	12	57	70	92	30	75	4
Zn	87	33	17	14	79	138	97	28	53	3

Al, Ca, Fe, K, Mg, Na, Si and Ti by fusion – inductively coupled plasma – atomic emission spectroscopy (ICP-AES); F by specific ion electrode; C, S by Leco method; Au by atomic absorption spectroscopy (AAS); B by HF digest – ICP-AES; Sn by trace level X-ray fluorescence analysis; remaining elements by four-acid digest – ICPMS or ICPAES.

Table A5.2 (continued): Results of multi-element assays for Paraburdoo Lens 2 samples

		GEOCHEMICAL ABUNDANCE INDEX									
Sample #		**1**	**3**	**10**	**15**	**18**	**19**	**21**	**27**	**29**	**30**
Borehole		**GT064EMP0003**					**GT064EMP0001**				
Depth Interval	**Average Crustal Abund.***	**21.43-21.6**	**25-25.28**	**38.95-39.08**	**48.97-49.15**	**56-56.13**	**182.76-183**	**185-185.23**	**197-197.15**	**200.93-201.08**	**202.9-203.04**
Major elements (%)											
Al	8.2	0	0	0	0	0	0	0	0	0	0
C	0.048	4	5	4	2	4	0	6	5	6	0
Ca	4.1	0	0	0	0	0	0	0	0	0	0
Fe	4.1	1	0	1	0	0	2	0	1	0	0
K	2.1	0	0	0	0	0	0	0	0	0	0
Mg	2.3	0	0	0	0	0	0	0	0	0	0
Na	2.3	0	0	0	0	0	0	0	0	0	0
S	0.026	0	2	8	4	5	0	0	8	7	5
Si	27.7	0	0	0	0	0	0	0	0	0	0
Ti	0.56	0	0	0	0	0	0	0	0	0	0
Minor elements (ppm)											
Ag	0.07	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low
As	1.5	8	5	8	3	3	7	6	8	7	4
Au	0.0011	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low
B	10	0	3	Low	1	1	3	3	2	3	3
Ba	500	0	0	0	0	0	0	0	0	0	0
Bi	0.048	Low	Low	5	Low	Low	Low	Low	Low	5	Low
Cd	0.11	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low
Co	20	1	0	0	0	0	0	0	0	0	0
Cr	100	0	0	0	2	0	0	0	0	0	0
Cu	50	0	0	0	0	0	0	0	0	0	0
F	950	0	0	0	0	0	0	0	0	0	0
Hg	0.05	2	1	2	0	0	0	0	2	2	0
Mn	950	1	0	0	0	0	0	0	0	0	0
Mo	1.5	3	0	3	1	0	1	0	0	1	0
Ni	80	0	0	0	0	0	0	0	0	0	0
P	1000	0	0	0	0	0	1	0	0	0	0
Pb	14	0	0	1	0	0	0	1	1	1	0
Sb	0.2	Low	Low	6	Low	Low	4	4	4	4	Low
Se	0.05	3	4	6	3	4	3	3	6	6	3
Sn	2.2	Low	Low	Low	Low	Low	Low	2	0	3	Low
Sr	370	0	0	0	0	0	0	0	0	0	0
V	160	0	0	0	0	0	0	0	0	0	0
Zn	75	0	0	0	0	0	0	0	0	0	0

* taken from Bowen (1979)

Table A5.3: Results of multi-element assays for West Angelas samples

	MULTI-ELEMENT ASSAY									GEOCHEMICAL ABUNDANCE INDEX							
Sample #	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Average Crustal Abund.***	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Blast	**WEP2/652/902**									**WEP2/652/902**							
SampleID	**#428**	**#429**	**#430**	**#431**	**#432**	**#433**	**#434**	**#435**		**#428**	**#429**	**#430**	**#431**	**#432**	**#433**	**#434**	**#435**
Major elements (%)																	
Al	0.24	0.26	0.15	0.07	0.05	0.08	0.05	0.04	8.2	0	0	0	0	0	0	0	0
C	1.75	0.66	1.2	0.03	0.02	0.02	0.02	0.01	0.048	4	3	4	0	0	0	0	0
Ca	0.29	1.33	0.21	0.14	0.24	0.24	0.21	0.15	4.1	0	0	0	0	0	0	0	0
Fe	14.13	41.41	20.07	29.31	23.92	15.11	28.75	27.14	4.1	1	2	1	2	1	1	2	2
K	0.02	0.05	<0.08	0.02	0.02	0.05	0.02	0.02	2.1	0	0	Low	0	0	0	0	0
Mg	0.55	1.33	0.47	1.83	2.14	1.22	2.02	2.12	2.3	0	0	0	0	0	0	0	0
Na	0.40	0.21	0.37	2.80	3.25	1.88	3.24	3.15	2.3	0	0	0	0	0	0	0	0
S	1.33	0.49	0.92	0.82	1.02	0.42	0.57	1.82	0.026	5	3	4	4	4	3	3	5
Si	32.7	15.9	30.0	23.3	26.4	33.8	23.1	24.3	27.7	0	0	0	0	0	0	0	0
Ti	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.56	0	0	0	0	0	0	0	0
Minor elements (ppm)																	
Ag	<0.5				<0.5			<0.5	0.07	Low				Low			Low
As	8				29			49	1.5	1				3			4
Au	0.03				0.01			0.03	0.0011	4				2			4
B	<10				<10			20	10	Low				Low			0
Ba	20				10			10	500	0				0			0
Bi	2				<2			<2	0.048	4				Low			Low
Cd	<0.5				<0.5			<0.5	0.11	Low				Low			Low
Co	3				<1			<1	20	0				Low			Low
Cr	13				2			1	100	0				0			0
Cu	21				16			18	50	0				0			0
F	80				120			70	950	0				0			0
Hg	0.025				0.029			0.041	0.05	0				0			0

	MULTI-ELEMENT ASSAY									GEOCHEMICAL ABUNDANCE INDEX							
Sample #	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Average Crustal Abund.***	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Blast	**WEP2/652/902**									**WEP2/652/902**							
SampleID	**#428**	**#429**	**#430**	**#431**	**#432**	**#433**	**#434**	**#435**		**#428**	**#429**	**#430**	**#431**	**#432**	**#433**	**#434**	**#435**
Mn	1550				60			50	950	0				0			0
Mo	<1				<1			<1	1.5	Low				Low			Low
Ni	8				<1			<1	80	0				Low			Low
P	30				440			150	1000	0				0			0
Pb	7				7			6	14	0				0			0
Sb	<5				<5			<5	0.2	Low				Low			Low
Se	0.8				0.4			0.6	0.05	3				2			3
Sn	<5				<5			<5	2.2	Low				Low			Low
Sr	2				<1			<1	370	0				Low			Low
V	2				<1			1	160	0				Low			0
Zn	26				17			13	75	0				0			0

* taken from Bowen (1979)

Al, Ca, Fe, K, Mg, Na, Si and Ti by fusion – inductively coupled plasma – atomic emission spectroscopy (ICP-AES); F by specific ion electrode; C, S by Leco method; Au by atomic absorption spectroscopy (AAS); B by HF digest – ICP-AES; Sn by trace level X-ray fluorescence analysis; remaining elements by four-acid digest – ICPMS or ICPAES.

Appendix 6: Leach Tests

Leach tests were undertaken on a selection of fifteen samples. The leach tests were undertaken at room temperature and a water-to-rock ratio of 5:1. The solution used was de-ionised water. Good contact between solid and solution was ensured by end over end tumbling. The duration of the test was 12 hours.

In the case of three samples, the leach tests were repeated at a water-to-rock ratio of 2:1. These repeats were undertaken to ensure consistency with previous work for the Pilbara geochemical characterisation programme; typically, previous work involved lower water-to-rock ratios, either 2:1 or 3:1.

Following the test, solutions were assayed for the following elements:

- Majors – Al, Ca, Fe, K, Mg, Na, S, Si, Ti
- Minors – Ag, As, B, Ba, Bi, Cd, Co, Cr, Cu, F, Hg, Mn, Mo, Ni, P, Pb, Sb, Se, Sn, Sr, V, Zn

Results of the analyses are given in Table A6.1 and A6.2.

Table A6.1: Results of leach tests (5:1)

	Dales Gorge		Paraburdoo Lens 2										West Angelas		
Sample#	**1**	**5**	**1**	**3**	**10**	**15**	**18**	**19**	**21**	**27**	**29**	**30**	**1**	**5**	**8**
Borehole/Blast	**WB06NTB02**		**GT064EMP0003**						**GT064EMP0001**				**WEP2/652/902**		
Depth interval	**134-135**	**142-150**	**21.43-21.6**	**25-25.28**	**38.95-39.08**	**48.97-49.15**	**56-56.13**	**182.76-183**	**185-185.23**	**197-197.15**	**200.93-201.08**	**202.9-203.04**	**#428**	**#432**	**#435**
Aluminium	<1	<1	<1	<1	804	<1	<1	<1	<1	420	351	<1	<1	<1	<1
Antimony	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Arsenic	<0.1	<0.1	<0.1	<0.1	0.7	<0.1	<0.1	<0.1	<0.1	0.3	0.1	<0.1	<0.1	<0.1	<0.1
Barium	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Bismuth	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.01	<0.01	<0.01
Boron	<1	<1	1	<1	<1	<1	<1	1	<1	<1	<1	<1	<1	<1	<1
Cadmium	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Calcium	60	30	70	70	190	40	70	<10	20	100	340	40	110	20	30
Chromium	<0.1	<0.1	<0.1	<0.1	2.2	<0.1	<0.1	<0.1	<0.1	0.4	0.5	<0.1	<0.1	<0.1	<0.1
Cobalt	<0.1	<0.1	<0.1	<0.1	28.1	<0.1	<0.1	<0.1	<0.1	20.5	24.8	<0.1	<0.1	<0.1	<0.1
Copper	<0.1	<0.1	<0.1	<0.1	0.2	<0.1	<0.1	<0.1	<0.1	0.1	4.0	<0.1	<0.1	<0.1	<0.1
Fluoride	4	6	4	14	<1	7	5	3	4	2	8	2	<1	1	1
Iron	<1	<1	<1	<1	4270	5	<1	2	<1	2640	865	138	<1	2	1
Lead	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Magnesium	120	90	80	120	700	70	240	10	30	530	530	60	210	50	60
Manganese	<0.1	<0.1	0.2	0.2	19.7	0.7	1.2	<0.1	<0.1	10.5	5.6	24.2	2.4	<0.1	<0.1
Mercury	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Molybdenum	0.1	0.4	<0.1	0.2	<0.1	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Nickel	<0.1	<0.1	<0.1	<0.1	30.8	<0.1	<0.1	<0.1	<0.1	21.4	27.5	<0.1	<0.1	<0.1	<0.1
Phosphorus	<0.10	<0.10	0.13	0.10	0.17	<0.10	<0.10	0.29	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Potassium	170	80	20	210	<10	150	130	<10	50	<10	130	40	<10	<10	<10
Selenium	<0.1	<0.1	<0.1	0.1	<0.1	<0.1	0.1	<0.1	0.1	0.1	0.5	<0.1	<0.1	<0.1	<0.1
Silicon													88	165	185
Silver	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Sodium	400	270	80	110	<10	60	50	90	80	<10	40	40	90	180	170
Strontium	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Sulphur	220	90	10	180	4540	190	400	10	20	2770	2080	220	380	130	150

	Dales Gorge		Paraburdoo Lens 2										West Angelas		
Sample#	**1**	**5**	**1**	**3**	**10**	**15**	**18**	**19**	**21**	**27**	**29**	**30**	**1**	**5**	**8**
Borehole/Blast	**WB06NTB02**		**GT064EMP0003**					**GT064EMP0001**					**WEP2/652/902**		
Depth interval	**134-135**	**142-150**	**21.43-21.6**	**25-25.28**	**38.95-39.08**	**48.97-49.15**	**56-56.13**	**182.76-183**	**185-185.23**	**197-197.15**	**200.93-201.08**	**202.9-203.04**	**#428**	**#432**	**#435**
Tin	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Vanadium	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Zinc	<0.1	<0.1	<0.1	<0.1	4.4	<0.1	<0.1	<0.1	<0.1	4.4	1.5	<0.1	<0.1	<0.1	<0.1

Units: mg/kg on a dry weight basis

Table A6.1: Results of leach tests (2:1)

	West Angelas		
Sample#	**1**	**5**	**8**
Borehole/Blast	**WEP2/652/902**		
Depth interval	**#428**	**#432**	**#435**
Aluminium	<1	<1	<1
Antimony	<0.2	<0.2	<0.2
Arsenic	<0.2	<0.2	<0.2
Barium	<2	<2	<2
Bismuth	<0.02	<0.02	<0.02
Boron	<1	<1	<1
Cadmium	<0.2	<0.2	<0.2
Calcium	70	10	10
Chromium	<0.2	<0.2	<0.2
Cobalt	<0.2	<0.2	<0.2
Copper	<0.2	<0.2	<0.2
Fluoride	<1	1	1
Iron	<1	<1	<1
Lead	<0.2	<0.2	<0.2
Magnesium	110	30	30
Manganese	2.1	<0.2	<0.2
Mercury	<0.002	<0.002	<0.002
Molybdenum	<0.2	<0.2	<0.2
Nickel	<0.2	<0.2	<0.2
Phosphorus	<0.1	<0.1	<0.1
Potassium	<10	<10	<10
Selenium	<0.2	<0.2	<0.2
Silicon	37	66	72
Silver	<0.2	<0.2	<0.2
Sodium	50	90	80
Strontium	<2	<2	<2
Sulphur	190	50	60
Tin	<0.2	<0.2	<0.2
Vanadium	<0.2	<0.2	<0.2
Zinc	<0.2	<0.2	<0.2

Units: mg/kg on a dry weight basis

SRK Report Distribution Record

Report Ref.	Final, revised
Copy No.	1
Date	29th January 2008

Name/Title	Company	Copy #
Ros Green	Rio Tinto	1
SRK Library	SRK Consulting	2

Approval Signature:

Dr Ros Green
Geological Support Environmental Specialist
Pilbara Iron
Rosalind.Green@riotinto.com

8 February 2007

Dear Ros

re: **ARD Characterisation of West Angeles Sample**
Pilbara Iron Service Order 4700317716

A single rock of West Angeles shale was sent to ANSTO Minerals for characterisation with respect to acid rock drainage and reactivity. The Pilbara Iron sample identification number was EB0608392-001 and the ANSTO identification was TOMP-200706-1.

The rock sample was prepared for measurement by crushing and pulverising as described by Bennett and Comarmond (2006)[1]. The methods used for geochemical characterisation and the measurement of the intrinsic oxidation rate (IOR) have been described in the same report. The results of the measurements are presented in Table 1.

Table 1. Geochemical characterisation, ARD classification and IOR of West Angeles sample EB0608392-001.

Parameter	**Units**	**Value**
total S	%	0.06
total C	%	0.35
$pH_{1:2}$		8.4
$EC_{1:2}$	µS/cm	55.9
MPA	kg H_2SO_4/t	1.8
ANC	kg H_2SO_4/t	6.5
NAPP	kg H_2SO_4/t	-4.7
ANC/MPA		>3
NAGpH		7.7
NAG(pH4.5)		<0.1
NAG(pH7.0)		<0.1
ARD Classification		NAF
IOR at 5.0% moisture (dry basis)	kg(O_2) kg(dry material)$^{-1}$ s^{-1}	18.4 × 10^{-11}

[1] Bennett, JW and Comarmond MJ (2006) Measurements to determine oxidation rates and rate controls in the North End Box Cut Dump, Mount Tom Price. ANSTO/C869.

Whilst the low sulfur content is consistent with the classification of the material as non-acid forming (see for example Bennett and Comarmond 2007)[2], the IOR is typical of values measured in Brockman black shale (Bennett and Comarmond 2007) and is greater than any values measured by ANSTO in DG2 or Whaleback shale. Such material may be suitable for use as an oxygen consuming layer to surround potentially acid forming black shale materials in waste rock dumps. This concept has been described by Bennett and Comarmond (2006).

This letter completes the requirements of Pilbara Iron service order 4700317716.

Your sincerely

John Bennett
and
Josick Comarmond

[2] Bennett, JW and Comarmond MJ (2007) Characterisation of 78 Brockman black shale samples. ANSTO/C<<aaa>>.

Geochemical Characterisation of Banded Iron Formation Samples from the West Angelas Mine

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Executive Summary

SRK coordinated geochemical characterisation test work on 10 reverse circulation (RC) chip samples of Banded Iron Formation (BIF) material from the West Angelas project area. The samples were selected by Rio Tinto Iron Ore staff. The samples locations were all originally below the natural water table. However, six of the ten samples were de-saturated since 2006 due to the dewatering and lowering of the water table within the mining area.

All samples were subjected to static testing comprising standard acid base account testing, multi-element analysis, mineralogical assessment and leach extraction testing.

The outcomes and conclusions from this study were as follows:

- The paste pH results indicated all samples were in the near neutral to mildly alkaline pH range. The samples also have low soluble salt content as indicated by the low paste electrical conductivity (EC) results.
- The samples have a low maximum potential acidity (MPA), ranging between 4.9 and 23.3 kgH_2SO_4/t, corresponding to a total sulphur content of less than 0.76 %.
- The acid neutralising capacity (ANC) ranged between 37 and 101 kgH_2SO_4/t.
- The acid buffering characteristic curve (ABCC) results suggest that the ANC availability (to buffer the pH in a circum neutral range) may range from 25 % to 60 %.
- Even though classified as non acid forming (NAF) by both the AMIRA[1] and Price[2] (using the ANC value) methods, one sample (ECP402) generated a small amount of acidity during the net acid generation (NAG) test. This appears to bear out the ABCC results. For the remainder of the samples no net acidity was generated with the pH(ox) values at near neutral to mildly alkaline.
- The mineralogical assessment identified pyrite and acid neutralising carbonates (calcite and dolomite).
- The samples were classified as non acid forming (NAF) based by both the AMIRA and Price classification schemes, with the exception of one sample that was classified as uncertain (UC) by the Price method only.
- The multi-element assays of the samples showed that As, Au, B, S and Se are enriched relative to average „crustal" abundances in at least one of the samples.
- Solute release from the as received samples was low.

Whilst the test work to date concludes that the samples would be classified as non acid forming (NAF), the ABCC results suggest that the ANC availability is limited and as a result some of the samples may be classified as uncertain or even potentially acid forming (PAF). Verification of actual availabilities should be determined by ABCC method. Furthermore, the weathering characteristics and rates of oxidation and acid neutralisation at field conditions remain unknown. We recommend that further investigation into the geochemical properties of the materials be considered.

[1] AMIRA see References
[2] Price see References

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Disclaimer

The opinions expressed in this Report have been based on the information supplied to SRK Consulting (Australasia) Pty Ltd (SRK) by Rio Tinto Iron Ore Pty Ltd (RTIO) and Australian Laboratory Services (ALS). The opinions in this Report are provided in response to a specific request from RTIO to do so. SRK has exercised all due care in reviewing the supplied information. Whilst SRK has compared key supplied data with expected values, the accuracy of the results and conclusions from the review are entirely reliant on the accuracy and completeness of the supplied data. SRK does not accept responsibility for any errors or omissions in the supplied information and does not accept any consequential liability arising from commercial decisions or actions resulting from them.

1. Introduction

This report describes the results for ten samples undertaken as part of ongoing programmes of geochemical characterisation in support of the Rio Tinto Iron Ore (RTIO) West Angelas mining operation and resource evaluation studies. The primary objectives of the testing programme were to establish the acid generating potential of the samples. In the longer term, the results will be used to support waste management and planning for the rehabilitation and closure of the mining operations.

This report documents the findings of geochemical test work carried out on reverse circulation (RC) chip samples of Banded Iron Formation (BIF) material from the West Angelas project area. The physical descriptions of the samples as provided by RTIO staff at West Angelas mine are shown in Table 1-1.

Table 1-1: Physical description of sample material

RTIO ID		Depth		Strand	Tag	Logging	S (%)	Proximity to final pit wall	Depth from water table	
Sample	Hole	From	To						Original	Current
	GR09	m	m					m	m	m
ECP051	WAA001	92	94	Macleod	W-BIF	SHC74 BIF24 PYT1 QTZ1	0.437	55	0	22 AWT
ECP052	WAA001	94	96	Macleod	W-BIF	SHC70 BIF29 QTZ1	0.483	57	1 BWT	19 AWT
ECP053	WAA001	96	98	Macleod	W-BIF	SHC77 BIF20 QTZ1 PYT2	0.425	61	4 BWT	17 AWT
ECP054	WAA001	98	100	Macleod	W-BIF	BIF71 SHC25 QTZ3 PYT1	0.546	64	6 BWT	15.5 AWT
ECP164	WAA003	92	94	Macleod	W-BIF	SHC52 BIF45 PYT3	0.651	55	12 BWT	9 AWT
ECP165	WAA003	94	96	Macleod	W-BIF	SHC70 BIF30	0.478	58	14 BWT	6 AWT
ECP281	WAA005	98	100	Macleod	W-BIF	BIF40 SHC60	0.484	56	40.5 BWT	19 BWT
ECP332	WAA006	92	94	Macleod	W-BIF	BMA99 PYT1	0.129	15	35.5 BWT	13 BWT
ECP355	WAA006	134	136	Macleod	W-BIF	SHL85 BIF15	0.378	53	75 BWT	54 BWT
ECP402	WAA007	86	88	Macleod	W-BIF	SHL90 BIF9 PYT1	0.225	57	30 BWT	51 BWT

Notes: Data provided by RTIO staff (10 Dec 09); W-BIF – Waste Banded Iron Formation; SHC – Carbonaceous Shale; PYT = pyrite; QTZ = visible quartz crystals; BMA = magnetic BIF; SHL = shale; AWT – Above Water Table; BWT – Below Water Table.

2. Work Programme

Rio Tinto Iron Ore staff selected and collected ten samples of material for static test work. While the samples were all from below the original water table, dewatering activities that commenced in 2006 lowered the local water table so that six of the ten samples became unsaturated. We understand that the samples were selected based on their sulphur content and proximity to the proposed pit shell (they underlie the proposed pit shell).

The samples were sent to Australian Laboratory Services (ALS) in Perth, who coordinated analyses between their Perth and Brisbane laboratories. ALS prepared samples for intrinsic oxidation rate (IOR) measurements and mineralogical assessment, which were undertaken by SRK Consulting, Sydney and Queensland University of Technology (QUT) respectively.

All samples were submitted for basic static testing (Stage 1), with supplementary testing (Stages 2 and 3) carried out on a subset of samples. The overall test programme is summarised in Table 2-1. The methods are summarised in Appendix 1 and are consistent with those documented in the ARD Test Handbook (AMIRA, 2002).

Table 2-1: Summary of samples and programme of measurements carried out

Stage	Test	ECP051	ECP052	ECP053	ECP054	ECP164	ECP165	ECP281	ECP332	ECP355	ECP402	Totals
1	Paste pH	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	10
	Paste EC	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	10
	ANC	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	10
	Total S	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	10
	Total C	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	10
	Multi Element Assay	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	10
	Single Addition NAG	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	10
2	Sulphate S[1]	✓			✓	✓	✓				✓	5
	TIC/TOC	✓	✓				✓		✓	✓		5
	Leach Test[2]	✓				✓	✓	✓			✓	5
3	Kinetic NAG	✓					✓					2
	ABCC		✓				✓			✓		3
	IOR						✓					1
	Mineralogy (XRD)		✓				✓			✓		3

Notes: [1]HCl digest; [2]2:1 L:S over 12 hr duration; L:S – Liquid to solid ratio; EC – Electrical conductivity; ANC – Acid neutralising capacity; S – Sulphur; C – Carbon; NAG – Net acid generation; TIC/TOC – Total Inorganic Carbon/Total Organic Carbon; ABCC – Acid Buffering Characteristic Curve; IOR – Intrinsic Oxidation Rate; XRD – x-ray diffraction.

3. Results and Discussion

The static test results are tabulated in Appendices 2 to 6 and are summarised in Table 3-1. The table also includes the sample classification. The results are discussed in the following sections.

3.1 Paste pH and Electrical Conductivity

Simple paste tests provide an indication of the abundance of readily soluble salts which may be used to infer the degree of weathering the material had undergone prior to testing. Where the sample originates from a naturally saline environment, an elevated paste EC may simply indicate salinity. However, where natural salinity is low and the sample contains sulphide mineralisation, a high EC would indicate salts from oxidation.

Paste pH indicates if a sample had already become acidic due to sulphide mineral oxidation. Generally, low paste pH values (pH < 5) are indicative of net acid generation and pH values above 7 suggest the presence of reactive neutralising minerals, or, if categorised as potentially acid generating, that the sample has, as yet, not oxidised sufficiently to become acidic.

Plots of the paste pH and paste EC as a function of total sulphur content are shown in Figure 3-1 and Figure 3-2 respectively. Samples that remained below the water table are represented as circles on the plots.

The paste pH results for all samples were in the near neutral to mildly alkaline pH range. Paste EC values generally were low. The results indicate that the samples contain reactive neutralising minerals and a low soluble salt content. No significant difference between the saturated and unsaturated samples could be discerned from the results.

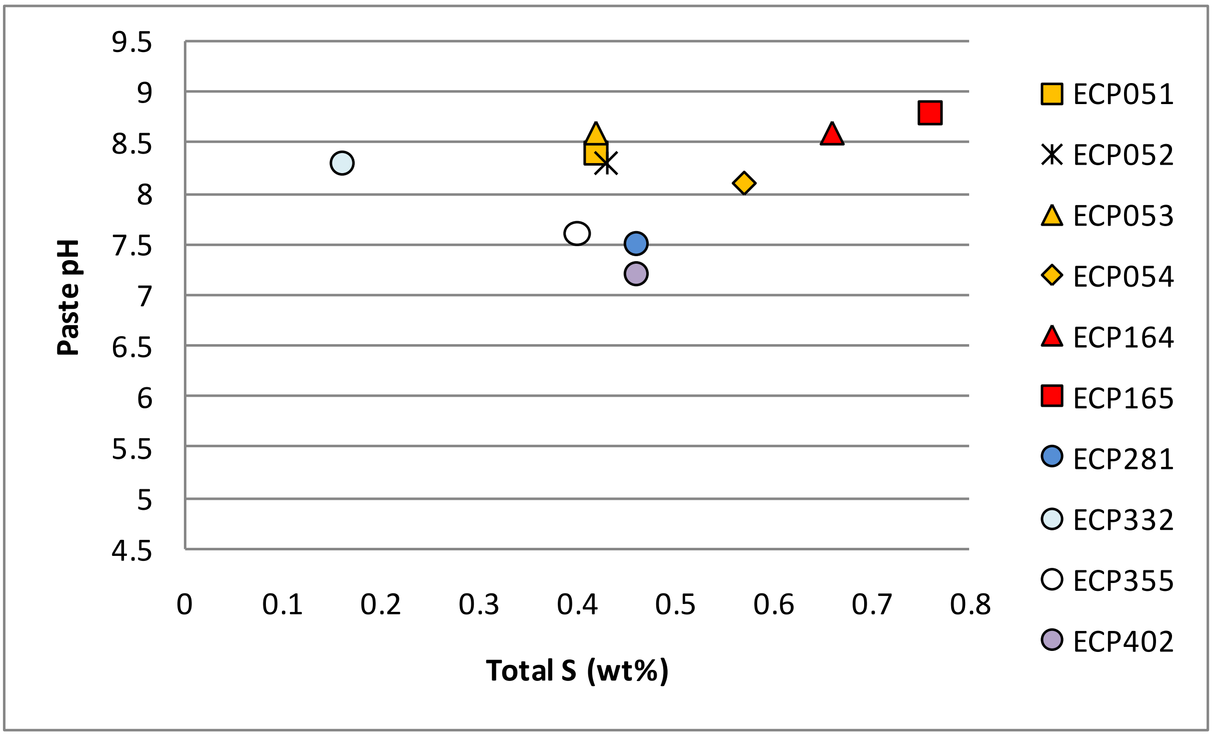

Figure 3-1: Paste pH plotted as a function of total sulphur (wt%)

Table 3-1: Summarised results of static test work

Parameter	Units	LOD	Sample ID									
			ECP051	ECP052	ECP053	ECP054	ECP164	ECP165	ECP281	ECP332	ECP355	ECP402
Paste pH	pH Unit	0.1	8.4	8.3	8.6	8.1	8.6	8.8	7.5	8.3	7.6	7.2
Paste EC	µS/cm	1	462	301	284	302	380	305	358	44	303	416
Total S	%	0.01	0.42	0.43	0.42	0.57	0.66	0.76	0.46	0.16	0.4	0.46
SO_4-S[1]	%	0.01	0.04	-	-	0.04	0.04	0.04	-	-	-	0.14
Sulphide[2]	%	-	0.38	-	-	0.53	0.62	0.72	-	-	-	0.32
MPA	kg H_2SO_4/t	-	12.9	13.2	12.9	17.4	20.2	23.3	14.1	4.9	12.2	14.1
AP	kg H_2SO_4/t	-	11.8	-	-	16.1	18.9	22	-	-	-	9.7
Total C	%	0.02	2.35	2.1	2.32	2.53	2.39	2.61	3.45	0.67	3.46	3.41
TIC	%	0.02	2.06	1.79	-	-	-	2.21	-	0.64	3.08	-
TOC	%	0.02	0.29	0.32	-	-	-	0.4	-	0.03	0.38	-
CarbNP (surr)[3]	kg H_2SO_4/t	-	192	171	189	207	195	213	282	55	282	278
CarbNP	kg H_2SO_4/t	-	168	146	-	-	-	180	-	52	251	-
ANC	kg H_2SO_4/t	0.5	67	82.1	63.9	70	73.5	101	75.4	37.5	55.3	41.7
NAPP[4]	kg H_2SO_4/t	-	-55	-69	-51	-54	-55	-79	-61	-33	-43	-32
NPR[4]	-	-	5.7	6.2	5	4.3	3.9	4.6	5.4	7.7	4.5	4.3
pH (OX)	pH Unit	0.1	7.9	8.2	8	8.1	8.2	8.2	8	9.6	8	5.5
NAG (pH 4.5)	kg H_2SO_4/t	0.1	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
NAG (pH 7.0)	kg H_2SO_4/t	0.1	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	2.7
Classification	Price	-	NAF	NAF	NAF	NAF	NAF	NAF	NAF	NAF	NAF	UC
	AMIRA	-	NAF	NAF	NAF	NAF	NAF	NAF	NAF	NAF	NAF	NAF

Note: [1]Sulphate sulphur determined by HCl digest; [2]Calculated from Total sulphur (wt%) – sulphate sulphur (wt%); set of samples as part of Stage 2 testing; [3]CarbNP(surr) calculated from total carbon; [4]NAPP and NPR were calculated using MPA when AP was not available; LOD – Limit of Detection; MPA – Maximum Potential Acidity; AP – Acid Potential; TIC – Total Inorganic Carbon; TOC – Total Organic Carbon; CarbNP – Carbonate Neutralising Potential; (surr) – surrogate; ANC – Acid Neutralising Capacity; NAPP – Net Acid Production Potential; NPR – Neutralisation Potential Ratio;; NAG – Net Acid Generation; UC - Uncertain; NAF – Non Acid Forming.

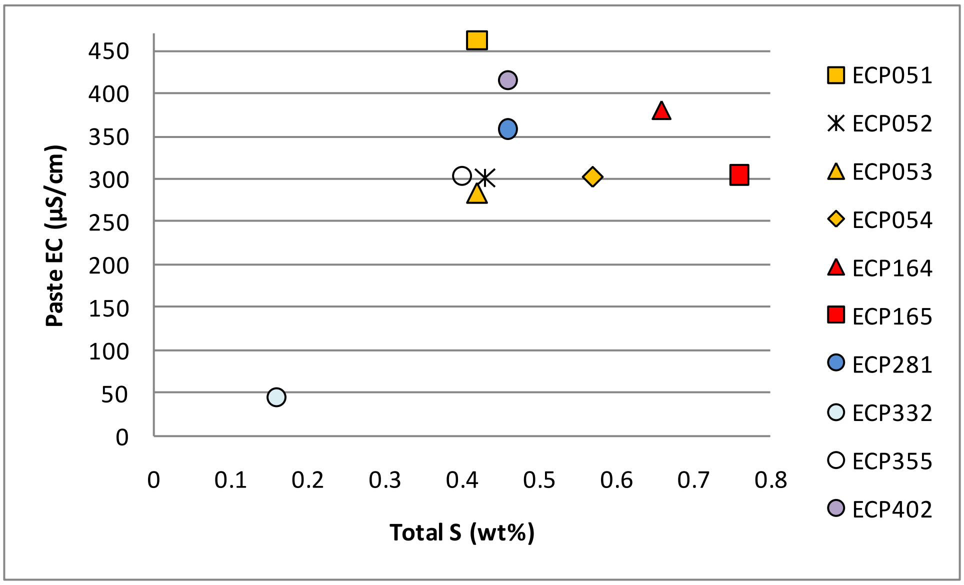

Figure 3-2: Paste EC plotted as a function of total sulphur

3.2 Acid Base Accounting

3.2.1 Acid Generation Potential

The maximum potential acidity (MPA) is calculated from the total sulphur content of a sample and assumes that all sulphur is in the form of pyrite. The MPA may overestimate the actual potential for acid generation if a significant proportion of the sulphur is present as sulphate. Then the acid potential (AP) is a more appropriate measure of the potential for acid generation. The AP calculated from the sulphide content (where sulphide sulphur is the difference between total sulphur and sulphate sulphur).

The total sulphur content of the samples was less than 1% (ranging from 0.16 to 0.76%), resulting in a relatively low maximum potential acidity (MPA) of between 4.9 and 23.3 kgH_2SO_4/t (see Table 3-1). Where measured, the sulphate sulphur values generally were low (<10% total sulphur), except for ECP402 (approximately 30% total sulphur), suggesting that the majority of sulphur is present as sulphide. Low sulphate sulphur indicates a low degree of weathering. This is consistent with the low paste EC.

The MPA generally aggress with the AP, as there is little or no sulphate sulphur present in the samples (see Table 3-1).

3.2.2 Acid Neutralising Capacity

The acid neutralising capacity (ANC) is the combined potential of carbonates (e.g. calcite) and aluminosilicates to neutralise acidity. The ANC of the samples ranged from 37 to 101 kgH_2SO_4/t. The conditions of the ANC test are aggressive (i.e. low pH and elevated temperature) and may result in overestimation of the ANC that is available to buffer leachate solution to within the neutral pH range. For example, minerals such as aluminosilicates may react at the low pH of the ANC test but may not be sufficiently reactive to neutralise acidity at near neutral pH conditions.

The Ca and Mg carbonate minerals are of greatest importance in terms of neutralising acidity as they react rapidly and buffer in the near neutral pH range. The total inorganic carbon (TIC) content (or total carbon where TIC is unavailable) can be used to infer the carbonate mineral content and estimate the carbonate neutralization potential (CarbNP).

The CarbNP ranged from 52 to 252 kgH_2SO_4/t which is in excess of the corresponding measured ANC values. Where the CarbNP exceeds the ANC (CarbNP:ANC ratio > 1) the carbonate minerals that are present may be in a form such as siderite ($FeCO_3$) that does not participate in acid neutralising reactions. The mineralogical assessment (see Section 3.3.2) confirmed this conclusion since siderite was identified in the three samples tested. Hence the CarbNP would overestimate the neutralising potential of the samples.

Acid buffering characteristic curves (ABCC) may be used to assess the proportion of ANC within a sample that is readily available for acid neutralisation. The test involves the slow titration of the sample with hydrochloric acid whilst continuously measuring the pH. The results of the ABCC tests for three samples are shown in Figure 3-3 and tabulated in Appendix 2. The differences between the CarbNP, ANC and ABCC are shown in Table 3-2.

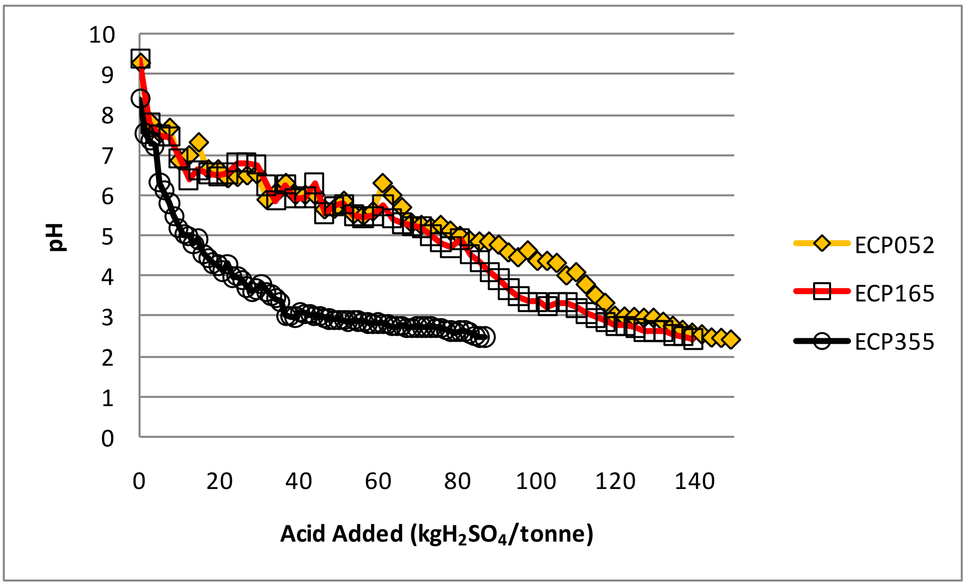

Figure 3-3: Acid buffering characteristic curves

The curve for sample ECP355 is characteristic of a material that contains negligible available neutralising capacity. In this case, the pH decreased rapidly as any neutralising minerals are not sufficiently reactive to buffer the acidity added. The test results for this sample indicated an ANC value 55.3 kgH_2SO_4/t whereas the ABCC test suggests that less than 10 kgH_2SO_4/t neutralisation capacity (or < 20 %) may be available to buffer the pH above a value of about 6.

The curves for samples ECP052 and ECP165 are similar. After an initially rapid decrease in pH, a plateau is observed at pH 6.5 (between 12 and 32 kgH_2SO_4/t) which is indicative of buffering by calcium-magnesium carbonate minerals. The results further suggest that the available ANC to buffer the pH above 6.0 is about 40 to 50 kgH_2SO_4/t (or about 50 to 60 % of the ANC).

Table 3-2: Summary of measured and calculated neutralising potentials

Sample ID	AP	CarbNP	ANC NP	ABCC NP	
	kg H_2SO_4/t			pH 6	pH 4.5
ECP051	11.8	168	67	-	-
ECP052	*13.2*	146	82	40	94
ECP053	*12.9*	*189*	64	-	-
ECP054	16.1	*207*	70	-	-
ECP164	18.9	*195*	73	-	-
ECP165	22	180	101	50	83
ECP281	*14.1*	*282*	75	-	-
ECP332	*4.9*	52	38	-	-
ECP355	*12.2*	251	55	< 10	16
ECP402	9.7	*278*	42	-	-

Note: MPA values (shown in italics) were used where AP values were not available ; CarbNP values in italics based on total carbon.

Whilst there are three possible measurements of the neutralising potential, the discussion above outlines that both the CarbNP and ANC will overestimate the neutralising capacity due to the presence of non acid consuming carbonates and aluminosilicates respectively. Therefore, the ABCC should provide the most reliable measurement of neutralising potential.

3.2.3 Net Acid Production Potential

The net acid producing potential (NAPP) of the samples is a balance of the AP and neutralising potential (i.e. NAPP = AP – ANC) and is shown for all samples in Table 3-1. The negative NAPP values indicate that the samples contain an overall excess of neutralising capacity.

The calculated NAPP values based on the available ABCC estimates are shown in Table 3-3. These values are based on the „readily available‟ ANC (i.e. whilst the pH remains above 6), since this represents the portion of ANC associated with reactive carbonates. The minerals that buffer acidity below pH 6 are less reactive and significantly less effective at mitigating ARD. Once the pH decreases below 6, the solubility of many metals increases exponentially and may lead to unacceptable water quality in leachate from mine materials. Again, negative NAPP values indicate that there is still an excess of neutralising potential to prevent onset of ARD, with the exception of sample ECP355 which could become marginally acidic. Considering the low ANC availability based on the ABCC results, other samples could also be reclassified as uncertain or potentially acid forming.

Table 3-3: Summary of ABCC based NAPP and NPR

Sample ID	AP	CarbNP	ANC NP	ABCC NP	NAPP*	NPR*
	kg H_2SO_4/t			pH 6	AP - ABCC	
ECP052	13.2	146	82	40	-27	3.0
ECP165	22	180	101	50	-28	2.3
ECP355	12.2	251	55	< 10	< 2	> 0.8

Note: * based on ABCC at pH 6.

3.3 Net Acid Generation Tests

Net acid generation (NAG) tests measure how a sample behaves under highly oxidising conditions. The test results reflect the condition under which the test is performed (i.e. fine grained sample) and may not necessarily reflect the outcome for coarse grained material as would be encountered in a waste rock dump. That is why the NPR criteria require an ANC:AP ratio in excess of 3 to provide some factor of safety. The results should therefore be interpreted within the context of the test conditions. During the test the sample is contacted with the strong oxidant, hydrogen peroxide, to oxidise sulphide minerals contained in the sample. Concurrently, neutralising minerals present in the sample consumes the acidity until the ANC is depleted after which the sample pH decreases. Following a predetermined contact time, the solution pH (pH(ox)) is recorded and the acidity of the sample is quantified by titration with a base (sodium hydroxide). The results of the NAG test are presented in Table 3-4.

Table 3-4: Results of single addition NAG test

Sample ID	Parameter						
	Total S	AP	ANC	pH (ox)	NAG (pH 4.5)	NAG (pH 7.0)	NAPP
Units	%	kg H_2SO_4/t	kg H_2SO_4/t	pH Unit	kg H_2SO_4/t	kg H_2SO_4/t	kg H_2SO_4/t
LOD	0.01	0.6	0.5	0.1	0.1	0.1	0.6
ECP051	0.42	12	67	7.9	<0.1	<0.1	-55
ECP052	0.43	*13*	82	8.2	<0.1	<0.1	-69
ECP053	0.42	*13*	64	8	<0.1	<0.1	-51
ECP054	0.57	16	70	8.1	<0.1	<0.1	-54
ECP164	0.66	19	74	8.2	<0.1	<0.1	-55
ECP165	0.76	22	101	8.2	<0.1	<0.1	-79
ECP281	0.46	*14*	75	8	<0.1	<0.1	-61
ECP332	0.16	*5*	38	9.6	<0.1	<0.1	-33
ECP355	0.4	*12*	55	8	<0.1	<0.1	-43
ECP402	0.46	10	42	5.5	<0.1	2.7	-32

Note: MPA values (shown in italics) were used where AP values were not available.

If the sample pH had decreased to below 4.5, titration up to pH 4.5 generally accounts for acidity associated with free acid (H_2SO_4) and ferric iron generated during the oxidation of sulphide minerals (that has not been neutralized by the contained ANC). Titration from pH 4.5 to pH 7 generally accounts for acidity associated with some metals, such as copper, that are soluble at pH 4.5 but practically insoluble at pH 7. Acidity attributed to ferrous iron will also be accounted for in the titration up to pH 7 (ferrous iron remains soluble at pH 4.5; however oxidation to ferric by atmospheric oxygen accelerates as the pH increases).

The results of the NAG test indicate that only sample ECP402 generated a small amount of net acidity, which was associated with dissolved metals. (We note however that sample ECP355 remain circum neutral in pH.) There was no acidity generated in the remaining samples where the pH(ox) values were near neutral to mildly alkaline.

The results of the single addition NAG test indicate that the ANC of the samples (at fine grain size) is sufficient to neutralise any acidity generated by sulphide oxidation. This is consistent with the negative NAPP values, which also implies acidity would not be generated.

3.3.1 Kinetic NAG Test

During the kinetic NAG test, the temperature and pH are measured over time following the addition of hydrogen peroxide, to assess the rate of response to peroxide oxidation (i.e. reactivity of the sample). Sulphide oxidation is an exothermic reaction and will cause a subsequent rise in temperature if the sulphide mineral is sufficiently reactive. A concurrent decrease in pH would indicate the rate of acidification is more rapid than the rate if neutralization.

Samples ECP051 and ECP165 were subjected to kinetic NAG tests as they contained the lowest and highest sulphur content respectively. Both samples were from above the water table. The results of the kinetic NAG tests are similar for both samples as shown in Figure 3-4 and Figure 3-5 (results are tabulated in Appendix 3).

The flat temperature profiles of the NAG solution suggests that the sulphide minerals are relative slow reacting. The relatively constant pH (near neutral) indicates that the rate of neutralisation is sufficient to neutralise acidity concurrently as it is produced.

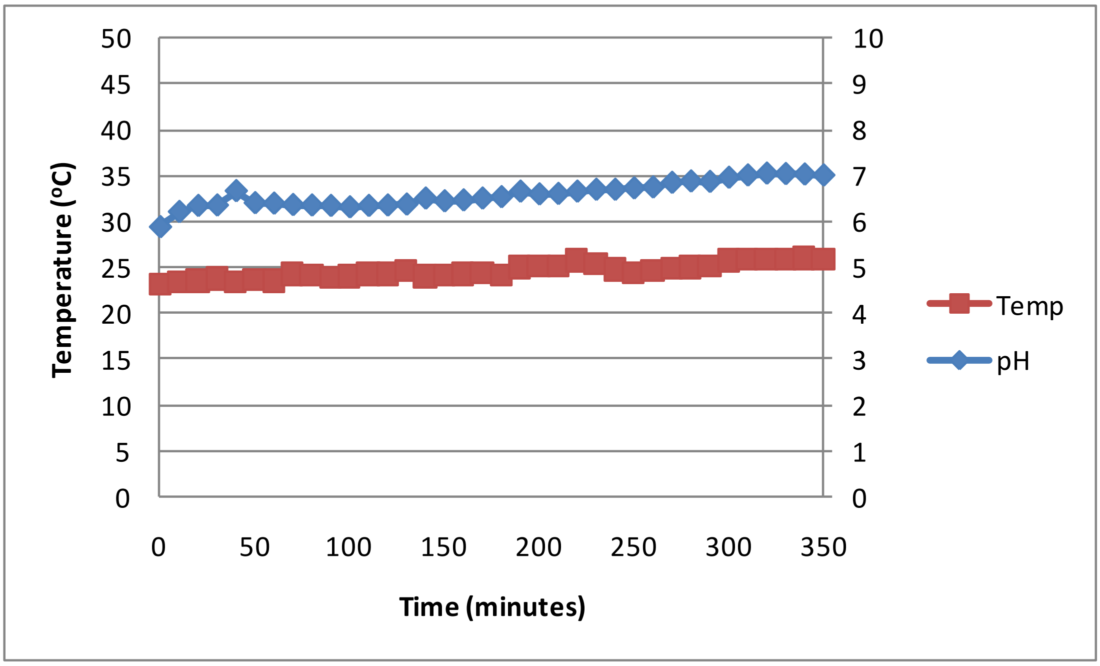

Figure 3-4: Kinetic NAG profile for ECP051 (Total S 0.42 wt %)

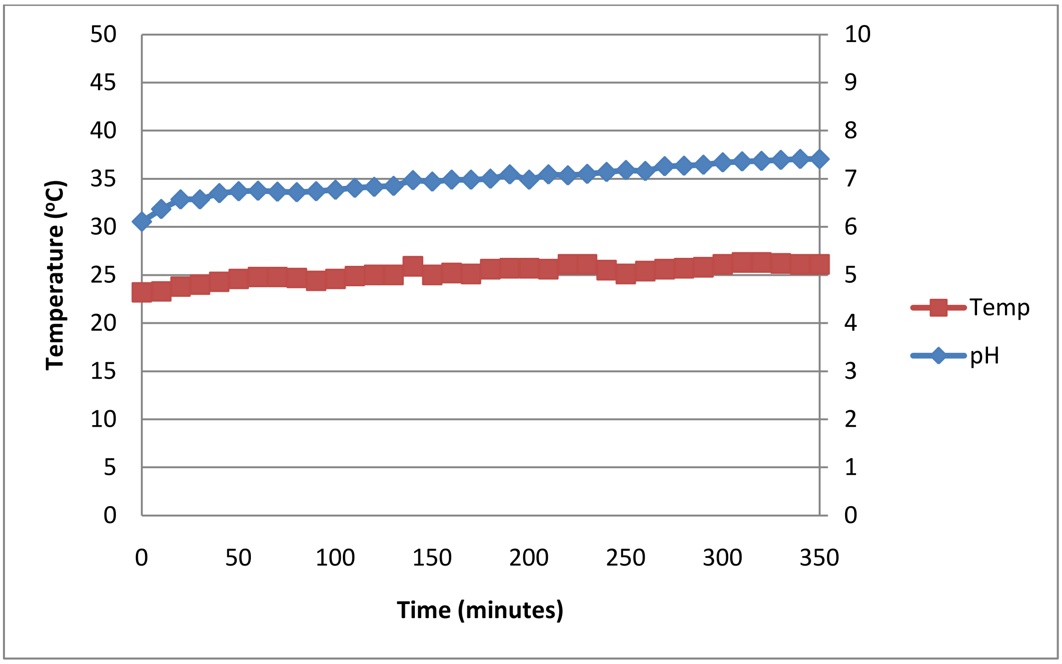

Figure 3-5: Kinetic NAG profile for ECP165 (Total S 0.76 wt %)

3.3.2 Mineralogy

The mineralogical assessment carried out on three samples utilised powder x-ray diffraction (XRD) to identify the primary mineral phases. The procedure included the addition of an internal standard (corundum) to allow quantification of the phases identified. The results are provided in Appendix 4 and are summarised in Table 3-5.

Table 3-5: Summary of mineralogical results

Phase Concentrations Wt% (nominal/absolute)[1]				
Mineral	Approx Formula	Sample ID		
		ECP052	ECP165	ECP355
Calcite	$CaCO_3$	0.2	0.2	0.5
Dolomite	$CaMg(CO_3)_2$	11	10.1	1.4
Siderite	$FeCO_3$	4.3	6.8	24.9
Pyrite	FeS_2	0.3	2	0.3
Goethite	FeO(OH)	3.5	-	3.4
Kaolinite	-	0.4	1	0.8
K-feldspar (Microcline)	$KAlSi_3O_8$	5	1.9	1.7
Mica (Biotite)	$K(Mg,Fe^{2+})_3(Si_3Al)O_{10}(OH)_2$	8.4	12.3	3
Laumonite	$Ca_{3.16}K_{0.76}Na_{0.89}(Al_{7.63}Si_{15.18}O_{48})(H_2O)_{9.05}$	-	4.4	-
Quartz	SiO_2	35.5	14.2	22.5
Stilpnomelane	$Ca_4Fe_{47}Si_{72}O_{180}(OH)_{36}\cdot xH_2O$	15.5	15.2	13
Zeolite[2]	$Na_3Co_{10.5}Al_{25.5}Si_{24}O_{96}(OH)_{4.5}(CO)_3$	1.1	3	4.3
Amorphous/unknown Content[3]	-	15	29	24.2
Calculations[4]	Mineral Phase			
AP	Pyrite	5	33	5
NP	Calcite and dolomite	119	109	20
NAPP	AP - NP	-114	-77	-15

Notes: [1]Some values may not be significant (near estimated standard deviation ~ 0.2 wt%); [2]the phase model is poor for this phase, it is likely it is under-estimated; [3]amorphous/non-diffracting/unknown is calculated by difference; [4]AP and NP calculations are based on the abundance of sulphide minerals (i.e. (wt% pyrite)/(55.85+64)*2*32 x 30.6) and neutralising carbonate minerals (i.e. [(wt% calcite + (wt % dolomite)/(24.3+40+(12+3x16)*2)*2*(40+(12+3x16)*2)] /100*98) respectively (see Table A1-2 in Appendix 1).

The mineralogical assessment confirmed the presence of acid forming sulphide (pyrite) and acid neutralising carbonates (calcite and dolomite). As noted before, the buffering of acidity indicated in the ABCC plots for samples ECP052 and ECP165 is consistent with dolomite as confirmed by the mineralogical assessment.

Sample ECP355 contained the highest abundance of siderite and lowest cumulative abundance of dolomite and calcite. Whilst siderite is a carbonate mineral, it does not provide a net buffering capacity as was confirmed in the ABCC test.

Pyrite is present in varying abundance in all three samples tested.

3.4 Sample classification

The static test results were interpreted according to the methods given in the ARD Test Handbook (AMIRA, 2002) (see also Appendix 1). Table 3-6 summarises the classification scheme adopted.

Within the non-acid forming (NAF) category is the „barren" sub-class. „Barren" in the context of the classification scheme is intended to indicate that this material has no particular value in terms of, for example, excess acid neutralising capacity to mitigate the effects of acid generation in other materials, nor is it likely to generate acid.

Table 3-6: Acid-base accounting classification

Class	Sub-class	Description
NAF	NAF	Samples with a negative NAPP value and a NAG pH(ox) of ≥4.5
	NAF-Barren	As above, and also a low ANC (≤5 kgH_2SO_4/t). Such samples have little value with respect to mitigating the effects of acid production in other mine waste materials
PAF	PAF	Samples with a positive NAPP value and a NAG pH(ox) of <4.5
	PAF-LC	PAF materials associated with low NAG acidities ($NAG_{pH4.5}$ <5 kgH_2SO_4/t)
Uncertain	UC(PAF)	Samples with negative NAPP but giving NAG pH(ox) values <4.5
	UC(NAF)	Samples with positive NAPP but giving NAG pH values ≥4.5. Possibly in these samples some of the sulphur present is in non-pyritic forms

Note: NAF – Non Acid Forming; PAF – Potentially Acid Forming; LC – Low Capacity (to produce acid); ANC – acid neutralisation capacity; NAPP – net acid producing potential; NAG pH – pH measured during net acid generation test.

A geochemical classification plot of the samples is shown in Figure 3-6, and is based on the results of the net acid generation (NAG) test and the NAPP. The negative NAPP (which ranges from approximately -79 to -32 kgH_2SO_4/t) together with pH(ox) values that are greater than 4.5 results in the classification of the samples as NAF.

In addition to the AMIRA scheme, sample classification was assessed based on the ratio of ANC to AP (Price, 1997). Total sulphur in this context is being used to calculate the AP (i.e. MPA) where the sulphate sulphur content is unknown. The ratio of ANC to AP (or MPA as applicable) is known as the net potential ratio (NPR). For waste rock, a sample with a NPR of less than 1 is classified as PAF. A sample with an NPR in excess of 3 is classified as NAF. A zone of uncertainty remains for values between 1 and 3. This zone of uncertainty exists because acid generation and neutralization under actual field conditions are different to those in the laboratory. For example ANC availability may be less for coarser samples than for homogenously fine samples in which case acid generation could still occur even though the theoretical ANC exceeds the AP (or MPA).

An ABA plot showing the ANC as a function of total sulphur is shown in Figure 3-7. The plot includes the divisions between the PAF and UC classification (solid black line, where NPR = 1) and the UC and NAF classification (dotted black line, where NPR = 3). The solid black line also indicates where the ANC and total sulphur give rise to a NAPP equal to 0. Only considering the ANC results and the total sulphur all samples classified as NAF, except for sample ECP402 which is borderline NAF/UC.

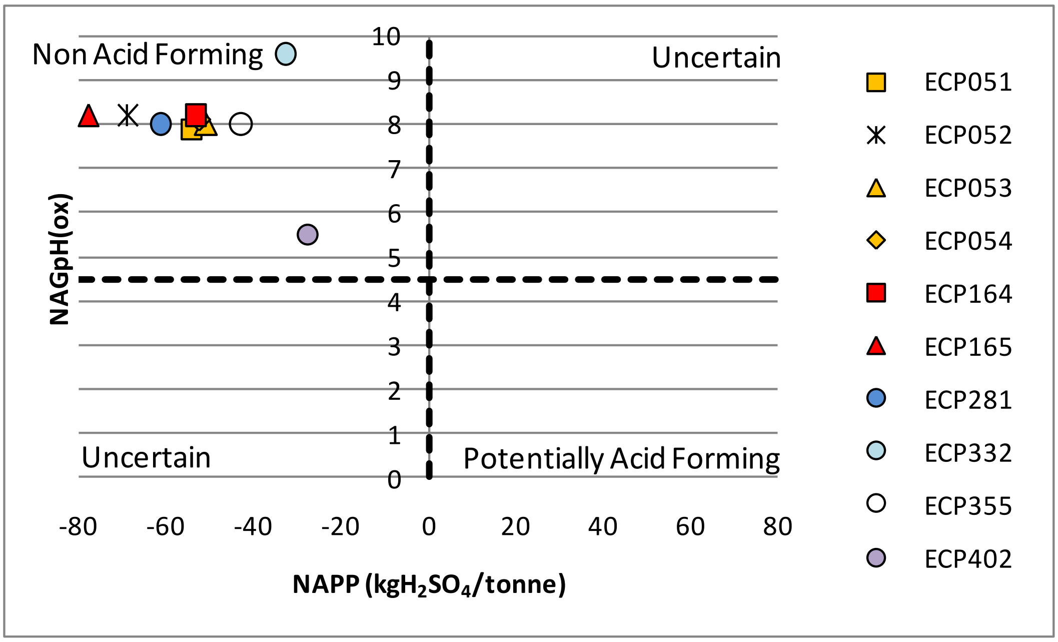

Figure 3-6: Geochemical classification plot

Note in Figure 3-6 that sample ECP164 overlays sample ECP054.

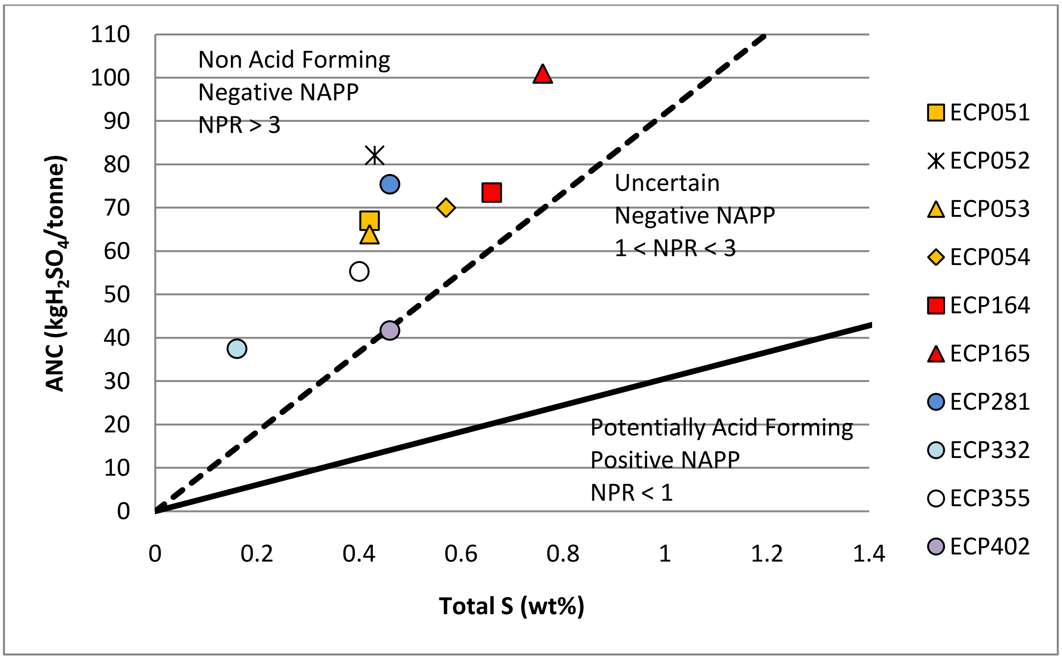

Figure 3-7: Acid base account plot

The similar classification of samples by both schemes, and the balance of evidence from the static tests carried out suggests that the samples will be NAF.

However, the ABCC results indicate that not all of the ANC is available for acid neutralization and buffering the pH to above 6.0. With inferred available ANC ranging from about 25 % to 60 % would cause a number of samples to replot to within the uncertain range, and possibly within the PAF range (see Table 3-3).

3.5 Multi Element Analysis

The results of multi-element analyses, including the calculated global abundance indicators (GAI)), for a subset of samples are provided in Appendix 5. The results show that both Fe and Si are the most abundant elements and are present in almost equal concentrations. Both Fe and Si were common elements in the minerals identified by XRD.

The GAI values are a measure of the elemental abundances compared to average „crustal" abundances. The multi-element assays of the samples showed that As, Au, B, S and Se were significantly enriched relative to average „crustal" abundances in at least one of the samples (see Appendix 5 for further discussion of global abundance indices). Of these, only As and Se would be considered as potentially significant as they could leach at elevated concentrations during extended weathering, even at near neutral pH conditions.

3.6 Metal Leachability

Simple water leach extraction tests were carried out on selected samples to provide an indication of the potential for solutes release. These test results reflect the condition of the samples at the time they were tested and do not represent solution concentrations that may result over time during weathering. Furthermore, since the physical and chemical conditions of the leach test will not be the same as those expected in the „as placed" environment (e.g. solubility constraints, liquid to solid ratio, etc), the leach composition is not expected to be representative of that which may develop in the field. The results therefore cannot be used directly to represent leachate quality expected to seep from a dump of the material. The results may however be useful to provide an indication of the readily leachable elements that may be present, but does not exclude the potential of any element to leach should it not be detected in the leachate.

The results of the leach extraction tests are shown in Appendix 6 and summarised in Table 3-7. The table includes the Australian Drinking Water Guidelines for reference only. Note that while direct comparison with the drinking water standards may identify some parameters of concern (i.e. where they may already exceed these guidelines). Again, it does not necessarily mean that the parameters that remain below these guidelines would not be of concern. The reason for this is that the extraction tests only provide "snapshot" in time and does not represent actual conditions within a waste rock dump that may influence water quality, such as future oxidation, rate of water infiltration (i.e. contact ratio of water to solids) and so on.

The leachability of the elements from all samples is generally very low. Some salinity (sodium chloride) is present in all the samples as indicated by the release of sodium. Sulphur (as sulphate) release also indicates that there are some sulphide mineral oxidation products present in the samples.

Leachable quantities of these elements can be explained by:

i. Dissolution of readily soluble salts (i.e. solutes that are present in the sample and dissolve immediately without the effects of weathering, such as sulphates).
ii. Desorption from exchange sites on mineral surfaces (e.g. elements that occupy ion exchange sites on clays and are relatively easily displaced following water-rock interactions).

The analytical results were used to calculate the fraction leached (as a percentage) of each element. The outcomes are tabulated in Appendix 6 and summarised in Table 3-8 for selected elements.

The results indicate that only Bi, Mo, Na and S were leached in any appreciable quantities (i.e. greater than 10%). The majority of trace elements were present in the leach solutions at concentrations below the limit of detection of the analytical method. While their mobility is unknown for conditions of extended weathering, the results suggest that both As and Se (determined as enriched from the multi element assay) may be present as relatively stable phases.

Table 3-7: Concentration of elements leaching above the limit of detection

Element	Ca	K	Mg	Mn	Na	S	Si	pH Value
Units	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	pH Unit
LOD	5	5	5	0.05	5	5	0.5	0.05
ECP051	35	190	20	<LOD	340	185	14	8.6
ECP164	25	95	30	0.05	360	115	15	8.8
ECP165	15	65	20	<LOD	365	125	14	8.9
ECP281	200	165	195	0.65	55	290	18	7.1
ECP402	330	150	320	2.15	85	550	19	6.9
ADWG[1]								
Health	-	-	-	0.5	-	167[2]	-	-
Aesthetic	-	-	-	0.1	180	83	-	6.5 - 8.5
Stock	1000	-	-	-	-	-	-	-
Element	B	Bi	Mo	U	Cl	F	N	-
Units	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	-
LOD	0.5	0.005	0.05	0.005	5	0.5	10	-
ECP051	<LOD	<LOD	0.1	<LOD	35	1.5	45	-
ECP164	0.5	0.01	0.15	<LOD	30	3.5	50	-
ECP165	<LOD	<LOD	0.1	<LOD	35	5	40	-
ECP281	<LOD	<LOD	<LOD	0.005	30	1.5	25	-
ECP402	<LOD	<LOD	<LOD	<LOD	50	1	40	-
ADWG								
Health	4	-	0.05	0.02	-	1.5	50[3]	-
Aesthetic	-	-	-	-	250	-	-	-
Stock	5	-	0.15	0.2	-	2	400	-

Notes: LOD – Limit of Detection; [1]ADWG – Australian Drinking Water Guideline; [2]guideline for SO4 converted to S assuming all sulphur is present as sulphate (where the SO4 guideline values are 500mg/l (health), 250mg/l (aesthetic) and 1000mg/l (stock)); [3]guideline for NO3 used for N, since NO3 is the most stable ion under oxidising conditions.

Table 3-8: Percentage of element leaching from the solids

	% Element Leaching						
Sample ID	Ca	K	Mg	Mn	Na	S	Si
ECP051	0.63	2.60	0.14	NC	70.5	8.81	0.01
ECP164	0.31	1.38	0.20	0.01	37.3	3.48	0.01
ECP165	0.12	0.68	0.10	NC	30.8	3.29	0.01
ECP281	5.83	2.21	3.08	0.06	3.80	12.6	0.02
ECP402	9.42	2.01	5.01	0.19	4.09	23.9	0.02
Sample ID	B	Bi	F	Mo	U	-	-
ECP051	NC	NC	0.70	26.7	NC	-	-
ECP164	5	16.7	1.67	34.1	NC	-	-
ECP165	NC	NC	1.82	17.1	NC	-	-
ECP281	NC	NC	0.75	NC	1.25	-	-
ECP402	NC	NC	0.54	NC	NC	-	-

Notes: NC – Not calculated as element was <LOD in multi element assay and/or leach test.

3.7 Oxidation Rates

The intrinsic oxidation rate (IOR) measurement provides an indication of the rate at which sulphide minerals in the sample may oxidise (under conditions where supply of oxygen is not a limiting factor). Only one sample was submitted for IOR measurement (as shown in Table 3-9) due to the generally low sulphur content of the sample set.

Also shown in Table 3-9 is the calculated initial sulphate generation rate for the material (Gibson et al, 1994) and the expected depth that oxygen will penetrate via gas diffusion into a dump of the material (i.e. rate of oxygen transport versus rate of consumption). [If oxygen supply via gas convection were to take place, the oxygen penetration depths would differ, and could be significantly greater].

Table 3-9: Intrinsic oxidation rate measurement

Sample ID	Moisture Content	Total S	IOR	Depth of O_2 Penetration	Initial Sulphate Generation Rate
	%	%	kg(O_2)/kg(sample)/s	m	Tonnes/Ha/Yr
ECP165	3.7	0.76	1.6×10^{-10}	3.32	378

Notes: The uncertainty on the IOR measurement can be taken to be ±10%.

Note that the last two columns in the table above assume that:

- The measured IOR is solely due to pyrite oxidation;
- Oxygen can readily diffuse into a dump of the material i.e. the dump is unsaturated to a depth greater than the maximum depth of oxygen penetration; and
- The dry bulk density of the dump material is 1.5×10^3 kg/m^3 and the oxygen diffusion coefficient is 5×10^{-6} m^2/s.

These assumptions could apply during the early stages of oxidation of exposed material. As oxidation proceeds and the pH decreases, the oxidation rate is expected to increase because other reactions such as bacterially catalysed ferric oxidation become more significant.

4. Conclusions

SRK coordinated geochemical characterisation test work on 10 reverse circulation (RC) chip samples of Banded Iron Formation (BIF) material from the West Angelas project area. It is understood that the samples were selected by Rio Tinto Iron Ore staff on the basis of the sulphur content and proximity to the proposed pit shell (where all samples underlie it).

We understand that the samples were all originally located below the natural water table. Dewatering activity that commenced in 2006 has artificially depressed the local groundwater level, exposing six of the ten samples to unsaturated conditions above the new water table.

The following conclusions result from this study:

- The paste results for all samples were in the near neutral to mildly alkaline pH range with low EC, suggesting that they contain reactive neutralising minerals and a low soluble salt content respectively.
- The total sulphur content of the samples was less than 1% (ranging from 0.16 to 0.76%). Where measured, the majority of sulphur was present as sulphide. The maximum potential acidity (MPA) of the samples was low (between 4.9 and 23.3 kgH_2SO_4/t).
- The ANC was moderate (between 37 and 101 kgH_2SO_4/t). The samples contain aluminosilicates that are of low significance in mitigating ARD and carbonates (i.e. siderite) that do not contribute to the neutralising potential. Based on measured ANC, and the NAG test results, generally sufficient neutralising potential was readily available to buffer acidity and prevent acidification.
- The ABCC test results however suggest that only a fraction of the measured ANC may be available for acid neutralisation and pH buffering to above 6.0. The results suggest that the availability may range from as low as 25 % up to 60 % (or more) based on three tests.
- The ABCC test appears to best reflect the actual available ANC for pH buffering within the circum neutral pH range.
- Only a small amount of acidity was generated in the NAG test for sample ECP402, which was associated with dissolved metals (pH(ox) 5.5). This appears to be consistent with the outcomes of the ABCC results. There was no net acidity generated in the remaining samples where the pH(ox) values were near neutral to mildly alkaline. The results indicate that for the finely ground samples the ANC would be sufficient to neutralise acidity generated by sulphide oxidation.
- The mineralogical assessment identified the presence of acid generating sulphide (pyrite) and acid neutralising carbonates (calcite and dolomite) as well as carbonates that do not contribute to the neutralisation capacity (i.e. siderite).
- The samples were classified NAF based on both the AMIRA and Price classification schemes. However sample reclassification to uncertain and potentially PAF would occur if the ABCC indicated availabilities for the ANC are applied to the samples.
- The multi-element assays of the samples showed that As, Au, B, S and Se were enriched relative to average „crustal" abundances in at least one of the samples.
- The leachability of the elements from the „as received" (i.e. relatively unweathered) samples was generally very low, with only Bi, Mo, Na and S leachable in any appreciable quantities (i.e. greater than 10%).

5. Recommendations

Whilst the test work to date concludes that the samples would be classified as non acid forming, the ABCC results indicate that not all of the ANC is available for acid neutralisation. This would mean that some samples could be reclassified as uncertain or even PAF. Furthermore, the rates of oxidation and concurrent acid neutralisation within the environment of a waste rock dump (i.e. weathering characteristics and rate of oxidation) are uncertain. This may be determined by carrying out kinetic test work (such as kinetic columns) on coarser grained samples.

We therefore recommend that further investigation into the geochemical properties of the material be considered. This should include supplementary ABCC testing as well as kinetic testing.

6. References

AMIRA International Limited, ARD Test Handbook: *Project P387A Prediction and Kinetic Control of Acid Mine Drainage*, May 2002.

Bennett, J.W. and Comarmond, M.J, *Measurements to Determine Oxidation Rates and Rate Controls in the North End Box Cut Dump*, Mount Tom Price, ANSTO Technical Report, ANSTO/C869, (2006).

Price, WA, *Draft Guidelines and Recommended Methods for the Prediction of Metal Leaching and Acid Rock Drainage at Minesites in British Columbia*, April 1997.

Appendices

Appendix 1: Summary of test methods

Summary of Test Methods

The tests carried out as part of the geochemical characterisation programme and calculations used to assist in evaluating the acid base accounting parameters of the samples are shown in Tables A1.1 and A1.2 respectively.

Table A1.1: Parameters measured and description of method

Parameter	ALS method code	Description
Paste pH	EA031	The pH of the saturated paste was determined according to USEPA 600/2-78-054 (Sobek et al., 1978).
Paste EC (2:1)	EA032	Electrical conductivity measurements are performed a 1:2 solid/water extract.
Acid neutralising capacity (ANC)	EA013	Determined by adding HCl to the sample, heating it, and then back-titrating the mixture with NaOH in order to determine the amount of HCl that remains on completion of the reaction. The amount of acid consumed in the initial reaction is calculated and expressed as the ANC. Details of the procedure are outlined in the AMIRA International ARD Test Handbook (AMIRA, 2002).
Acid Buffering Characteristic Curve	EA046	The test involves the slow addition of HCl to the sample. The pH is monitored over the duration of the test.
Total sulphur	ED042T	The sample is combusted in oxygen at 1350°C. Sulphur present in the sample is evolved as sulphur dioxide and swept to a measurement cell where it is quantified by infrared detection (LECO).
Sulphate sulphur	ED040T	The sample is dissolved in dilute hydrochloric acid and the solution is bulked to volume. An aliquot of this solution is then analysed by ICPAES to determine the sulphate sulphur content.
Total carbon	EP007	The sample is combusted in oxygen at 1350°C. Carbon present in the sample is evolved as carbon dioxide and swept to a measurement cell where it is quantified by infrared detection (LECO).
Total organic carbon	EP005	Inorganic carbon (carbonates, bicarbonates) is removed by reaction with dilute hydrochloric acid. After drying, the remaining sample is combusted in oxygen at 1350°C. Any organic carbon in the sample present as organic matter or graphite is evolved as carbon dioxide and swept to a cell where it is quantified by infra - red detection (LECO).
Multi element assay	-	Involves the near total dissolution of most elements using a variety of digestion techniques (e.g. aqua regia, four acid digest and lithium borate fusion). Analytical techniques are selected depending on the elements under investigation and include ICP-AES, ICP-MS, AAS, ISE and TGA.
Leach test	-	Simple leach extraction involves dissolution of elements from the solid matrix using de-ionised water. The water and solids are mixed at a ratio of 2:1 (water:solids) and agitated for a period of 12 hours. Analytical techniques are selected depending on the elements under investigation and include ICP-AES and ICP-MS.
Single addition net acid generation (NAG) test	EA011	The NAG test involves addition of hydrogen peroxide to prepared samples (to oxidise any reactive sulphides). The NAG pH is the pH of the final solution. The resultant acidity is then titrated (using NaOH) to pH 4.5 and then to pH 7. Details of the procedure are outlined in the AMIRA International ARD Test Handbook (AMIRA, 2002).
Kinetic NAG test	EA011K	Similar to EA011 except the temperature and pH are recorded at regular intervals over the duration of the test.
Intrinsic Oxidation Rate	-	Intrinsic oxidation rate is calculated based on the consumption of oxygen over a fixed period of time.
Mineralogical Assessment	-	Quantitative XRD carried out on a powdered sample containing an internal standard.

Table A1.2: Calculated ABA data

Parameter	Description
Maximum potential acidity (MPA)	Calculated by multiplying the total sulphur content (wt%) by 30.6. Approach assumes that all sulphur is present as pyrite.
Acid potential (AP)	Calculated by multiplying the sulphide-sulphur content (wt%) by 30.6
Sulphide sulphur	Sulphide sulphur (wt%) = total sulphur (wt%) – sulphate sulphur (wt%)
Surrogate carbonate neutralising potential (CarbNPsurr)	Calculated by multiplying the total carbon content (wt%) by 81.63
Carbonate neutralising potential (CarbNP)	Calculated by multiplying the inorganic carbon content (wt%) by 81.63
Net acid producing potential (NAPP)	NAPP the difference between the AP of the sample and the ANC: NAPP = AP-ANC If AP is not available, then MPA can be used
Net potential ratio (NPR)	NPR is the ratio of the AP and the ANC: NPR = ANC/AP If AP is not available, then MPA can be used
Mineralogical ABA calculations	
Sulphide content in pyrite	S(wt%) = (Mass pyrite(wt%))/(MM(FeS_2)x 2 x (MM(S))
Acid Potential in kg H_2SO_4/t	AP = S(Wt%) x 30.6
Carbon content in calcite	C(wt%) = Mass calcite(wt%) x (MM(C)/MM($CaCO_3$))
Carbon content in dolomite	C(wt%) = Mass dolomite(wt%)/MM($CaMg(CO_3)_2$)) x 2 x (MM (C)
Total Neutralising Carbon	TNC(wt%) = C (calcite) + C (dolomite)
Neutralising Potential in kg H_2SO_4/t	NP = TNC /12 x 98 /100 x 1000

Note: MM = Molecular Mass

Appendix 2: Acid Buffering Characteristic Curves

ABCC Tests

The results of the ABCC test work are shown in Tables A2.1. The test involves the slow addition of HCl to the sample whilst continuously measuring the pH.

Table A2.1: ABCC data

Sample ID		ECP052		ECP165				ECP165			
HCl Molarity (M)		0.5		0.5				0.1			
Increments (mL)		0.2		0.2				0.5			
Weight (g)		2		2				2			
Addition	mL	kg H_2SO_4	pH	Addition	mL	kg H_2SO_4	pH	Addition	mL	kg H_2SO_4	pH
0	0	0	9.27	0	0	0	9.39	0	0	0	8.39
1	0.2	2.45	7.8	1	0.2	2.45	7.78	1	0.5	1.225	7.54
2	0.4	4.9	7.53	2	0.4	4.9	7.49	2	1	2.45	7.35
3	0.6	7.35	7.66	3	0.6	7.35	7.46	3	1.5	3.675	7.24
4	0.8	9.8	6.85	4	0.8	9.8	6.93	4	2	4.9	6.31
5	1	12.25	6.98	5	1	12.25	6.39	5	2.5	6.125	6.11
6	1.2	14.7	7.3	6	1.2	14.7	6.63	6	3	7.35	5.8
7	1.4	17.15	6.63	7	1.4	17.15	6.54	7	3.5	8.575	5.49
8	1.6	19.6	6.63	8	1.6	19.6	6.47	8	4	9.8	5.19
9	1.8	22.05	6.41	9	1.8	22.05	6.54	9	4.5	11.025	5.03
10	2	24.5	6.44	10	2	24.5	6.8	10	5	12.25	4.99
11	2.2	26.95	6.48	11	2.2	26.95	6.8	11	5.5	13.475	4.79
12	2.4	29.4	6.51	12	2.4	29.4	6.76	12	6	14.7	4.9
13	2.6	31.85	5.88	13	2.6	31.85	6.25	13	6.5	15.925	4.54
14	2.8	34.3	6.05	14	2.8	34.3	5.86	14	7	17.15	4.45
15	3	36.75	6.29	15	3	36.75	6.26	15	7.5	18.375	4.31
16	3.2	39.2	6	16	3.2	39.2	5.92	16	8	19.6	4.26
17	3.4	41.65	6	17	3.4	41.65	5.95	17	8.5	20.825	4.11
18	3.6	44.1	6	18	3.6	44.1	6.3	18	9	22.05	4.3
19	3.8	46.55	5.64	19	3.8	46.55	5.55	19	9.5	23.275	3.97
20	4	49	5.65	20	4	49	5.73	20	10	24.5	3.98
21	4.2	51.45	5.85	21	4.2	51.45	5.78	21	10.5	25.725	3.9
22	4.4	53.9	5.52	22	4.4	53.9	5.5	22	11	26.95	3.71
23	4.6	56.35	5.48	23	4.6	56.35	5.45	23	11.5	28.175	3.6
24	4.8	58.8	5.59	24	4.8	58.8	5.49	24	12	29.4	3.66
25	5	61.25	6.29	25	5	61.25	5.75	25	12.5	30.625	3.8
26	5.2	63.7	5.99	26	5.2	63.7	5.42	26	13	31.85	3.6
27	5.4	66.15	5.69	27	5.4	66.15	5.31	27	13.5	33.075	3.51
28	5.6	68.6	5.3	28	5.6	68.6	5.23	28	14	34.3	3.43
29	5.8	71.05	5.25	29	5.8	71.05	5.2	29	14.5	35.525	3.36
30	6	73.5	5.19	30	6	73.5	5	30	15	36.75	3
31	6.2	75.95	5.25	31	6.2	75.95	4.83	31	15.5	37.975	2.99
32	6.4	78.4	5.11	32	6.4	78.4	4.7	32	16	39.2	2.97
33	6.6	80.85	4.98	33	6.6	80.85	4.9	33	16.5	40.425	3.11
34	6.8	83.3	4.87	34	6.8	83.3	4.53	34	17	41.65	3.05

Sample ID		ECP052		ECP165				ECP165			
HCl Molarity (M)		0.5		0.5				0.1			
Increments (mL)		0.2		0.2				0.5			
Weight (g)		2		2				2			
Addition	mL	kg H_2SO_4	pH	Addition	mL	kg H_2SO_4	pH	Addition	mL	kg H_2SO_4	pH
35	7	85.75	4.84	35	7	85.75	4.36	35	17.5	42.875	3.04
36	7.2	88.2	4.84	36	7.2	88.2	4.1	36	18	44.1	3.01
37	7.4	90.65	4.76	37	7.4	90.65	3.91	37	18.5	45.325	2.99
38	7.6	93.1	4.57	38	7.6	93.1	3.67	38	19	46.55	2.96
39	7.8	95.55	4.45	39	7.8	95.55	3.49	39	19.5	47.775	2.92
40	8	98	4.62	40	8	98	3.35	40	20	49	2.91
41	8.2	100.45	4.36	41	8.2	100.45	3.35	41	20.5	50.225	2.91
42	8.4	102.9	4.36	42	8.4	102.9	3.24	42	21	51.45	2.89
43	8.6	105.35	4.31	43	8.6	105.35	3.33	43	21.5	52.675	2.88
44	8.8	107.8	4	44	8.8	107.8	3.33	44	22	53.9	2.89
45	9	110.25	4.08	45	9	110.25	3.21	45	22.5	55.125	2.87
46	9.2	112.7	3.78	46	9.2	112.7	3.07	46	23	56.35	2.85
47	9.4	115.15	3.51	47	9.4	115.15	2.95	47	23.5	57.575	2.82
48	9.6	117.6	3.32	48	9.6	117.6	2.85	48	24	58.8	2.81
49	9.8	120.05	3	49	9.8	120.05	2.76	49	24.5	60.025	2.82
50	10	122.5	2.98	50	10	122.5	2.76	50	25	61.25	2.81
51	10.2	124.95	2.97	51	10.2	124.95	2.71	51	25.5	62.475	2.79
52	10.4	127.4	2.95	52	10.4	127.4	2.6	52	26	63.7	2.74
53	10.6	129.85	2.95	53	10.6	129.85	2.63	53	26.5	64.925	2.74
54	10.8	132.3	2.85	54	10.8	132.3	2.63	54	27	66.15	2.75
55	11	134.75	2.75	55	11	134.75	2.53	55	27.5	67.375	2.71
56	11.2	137.2	2.65	56	11.2	137.2	2.49	56	28	68.6	2.71
57	11.4	139.65	2.58	57	11.4	139.65	2.43	57	28.5	69.825	2.73
58	11.6	142.1	2.54	58	11.6	142.1		58	29	71.05	2.73
59	11.8	144.55	2.46	-	-	-	-	59	29.5	72.275	2.73
60	12	147	2.45	-	-	-	-	60	30	73.5	2.72
61	12.2	149.45	2.41	-	-	-	-	61	30.5	74.725	2.7
-	-	-	-	-	-	-	-	62	31	75.95	2.69
-	-	-	-	-	-	-	-	63	31.5	77.175	2.66
-	-	-	-	-	-	-	-	64	32	78.4	2.63
-	-	-	-	-	-	-	-	65	32.5	79.625	2.59
-	-	-	-	-	-	-	-	66	33	80.85	2.62
-	-	-	-	-	-	-	-	67	33.5	82.075	2.62
-	-	-	-	-	-	-	-	68	34	83.3	2.57
-	-	-	-	-	-	-	-	69	34.5	84.525	2.51
-	-	-	-	-	-	-	-	70	35	85.75	2.48
-	-	-	-	-	-	-	-	71	35.5	86.975	2.47

Appendix 3: Kinetic NAG tests

Kinetic NAG Tests

The results of the kinetic NAG test are shown in Tables A3.1. Measurements of temperature and pH were collected over a period of time after addition of hydrogen peroxide solution to the sample.

Table A3.1: Kinetic ABCC data

Sample ID	ECP052		ECP355	
Time (mins)	pH	Temp (^oC)	pH	Temp (^oC)
0	5.88	23.1	6.11	23.2
10	6.21	23.4	6.37	23.3
20	6.34	23.5	6.57	23.8
30	6.35	23.8	6.6	24
40	6.66	23.4	6.7	24.3
50	6.4	23.6	6.7	24.6
60	6.39	23.5	6.8	24.8
70	6.36	24.3	6.7	24.8
80	6.35	24.1	6.7	24.7
90	6.34	23.9	6.7	24.4
100	6.31	24	6.8	24.6
110	6.34	24.3	6.8	24.9
120	6.35	24.3	6.8	25
130	6.37	24.7	6.9	25
140	6.5	24	7.0	25.9
150	6.44	24.1	6.9	25
160	6.46	24.3	7	25.2
170	6.5	24.4	7	25.1
180	6.53	24.2	7.0	25.6
190	6.65	25	7.1	25.7
200	6.59	25.1	7.0	25.7
210	6.6	25.2	7.1	25.6
220	6.65	25.8	7.1	26.1
230	6.69	25.4	7.1	26.1
240	6.69	24.8	7.1	25.5
250	6.72	24.4	7.2	25.1
260	6.74	24.7	7.2	25.4
270	6.84	24.9	7.3	25.6
280	6.87	25	7.3	25.7
290	6.86	25.1	7.3	25.8
300	6.95	25.8	7.3	26.1
310	7	25.9	7.4	26.3
320	7.04	25.9	7.4	26.3
330	7.03	25.9	7.4	26.2
340	7.02	26	7.4	26.1
350	7	25.9	7.4	26.1
360	7	25.9	7.4	26.1

Appendix 4: Mineralogical assessment

POWDER X-RAY DIFFRACTION ANALYSIS
OF SUBMITTED SAMPLES

QUT Reference : XAF6170
Your Reference: SRK ECP052, ECP165, ECP355
Date: 19 March 2010

INTRODUCTION
The three (3) samples were sent by Mr Alex Watson of SRK Consulting, Sydney via ALS-Brisbane for powder XRD analysis to determine the identity and concentration of the compounds present in the samples. The samples were received on 4 March 2010.

PROCEDURE
The samples were fine powders of about 5g. Sub-samples were weighed and sufficient internal standard (corundum) added to produce specimens that contained 10 wt% internal standard. The specimens were prepared with a McCrone micronising mill using corundum beads and ethanol as a fluid. The ethanol was evaporated from the prepared samples by placing them in a drying oven at 55C overnight. Data was collected using a Panalytical vertical diffractometer, copper $K\alpha$ radiation and the usual conditions. The powder x-ray diffraction data was analysed using Jade (V9.0, Materials Data Inc.) for phase identification and SiroQuant (V3.0, Sietronics Pty Ltd) for quantitative analysis using a Rietveld analysis approach where the x-ray diffraction pattern is modelled using the crystal structures of the identified phases. An internal standard is added to obtain absolute concentration for the modelled phases by back-calculating from the known concentration of the internal standard. The sum of the absolute concentrations is subtracted from 100 wt% to obtain a residual. The residual represents the unexplained portion of the pattern; it may be the non-diffracting content but will also represent unidentified phases.

A small amount of the original samples were dispersed in water for clay analysis.

RESULTS
A table of nominal concentrations is attached.

In the table below the results are given as absolute concentrations. The known concentration of the internal standard is used to back calculate the absolute concentrations of the identified phases. The sum of the absolute concentrations is subtracted from 100 wt% to give a residual. If there exists any poorly diffracting, non-diffracting or unidentified phases, they are estimated in the residual as the amorphous/unidentified portion. A poor modelling of individual phases will lead to a poor estimate of its concentration and a consequential error of the residual. There may exist unidentified minor phases which will be part of the residual.

All samples show minor to trace smectite in the clay scans but this is not modelled in the powder patterns.

Tony Raftery

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Senior Technologist

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Phase concentrations wt% (nominal, absolute) **

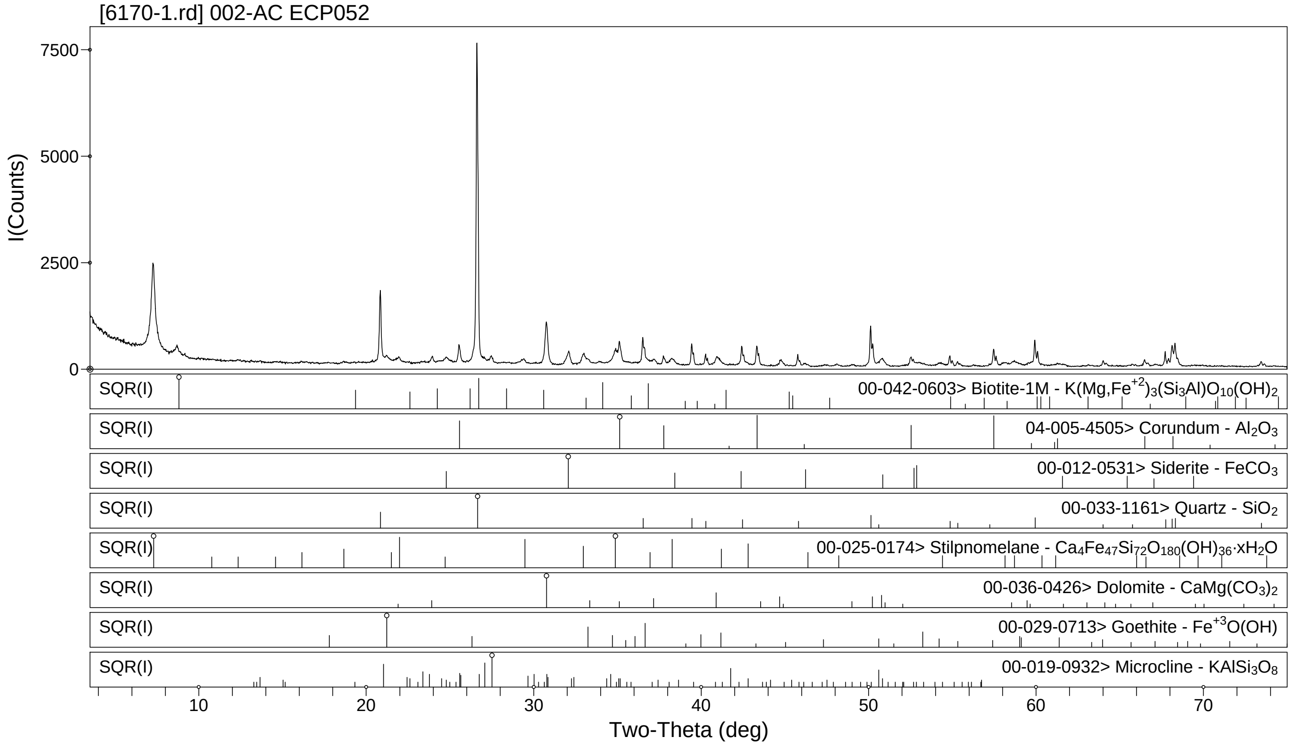
	ECP052	ECP165	ECP355
Amorp./unknown Content*	15	29	24.2
Quartz	35.5	14.2	22.5
Dolomite	11	10.1	1.4
Siderite	4.3	6.8	24.9
Calcite	0.2	0.2	0.5
Kaolinite	0.4	1.0	0.8
Mica (Biotite)	8.4	12.3	3
K-feldspar (Microcline)	5.0	1.9	1.7
Pyrite	0.3	2.0	0.3
Zeolite***	1.1	3	4.3
Goethite	3.5	0	3.4
Stilpnomelane	15.5	15.2	13.0
Laumonite		4.4	

* amorphous/non-diffracting/unknown is calculated by difference

** some values may not be significant (near estimated standard deviation ~ 0.2 wt%)

*** the phase model is poor for this phase, it is likely it is under-estimated

Powder XRD patterns



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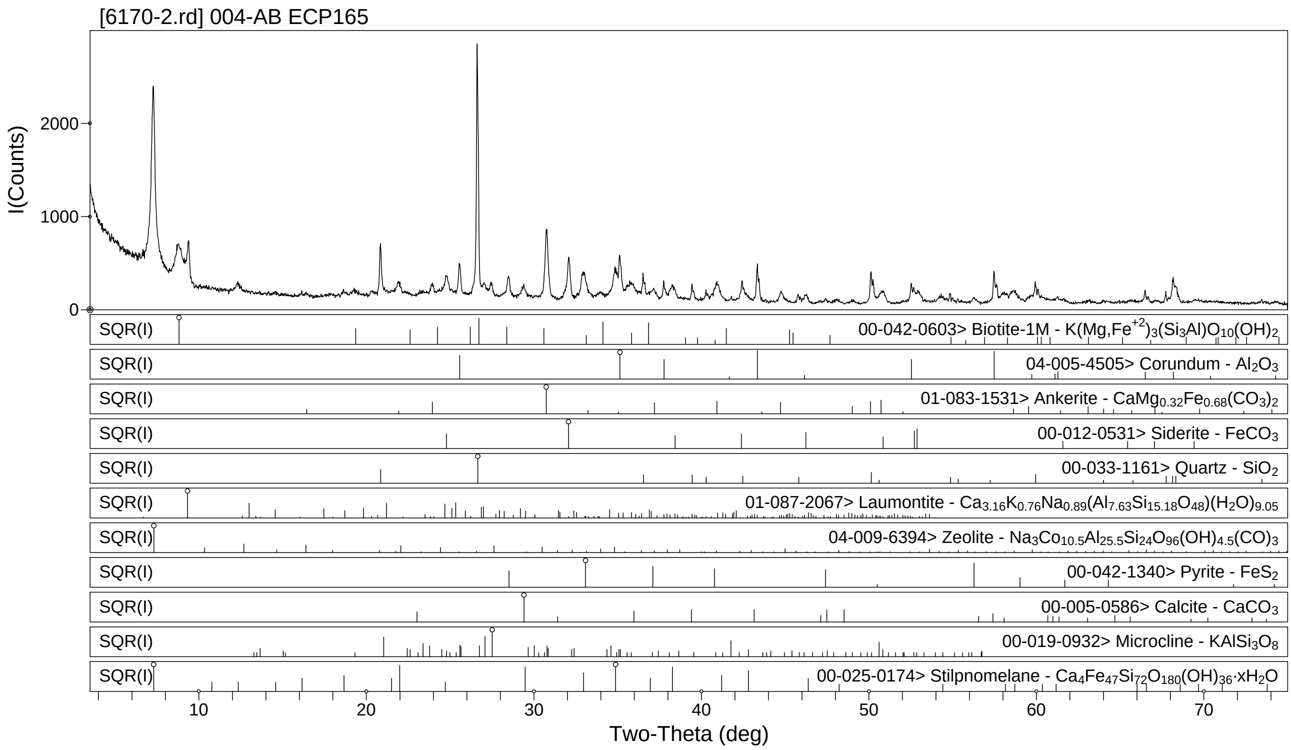

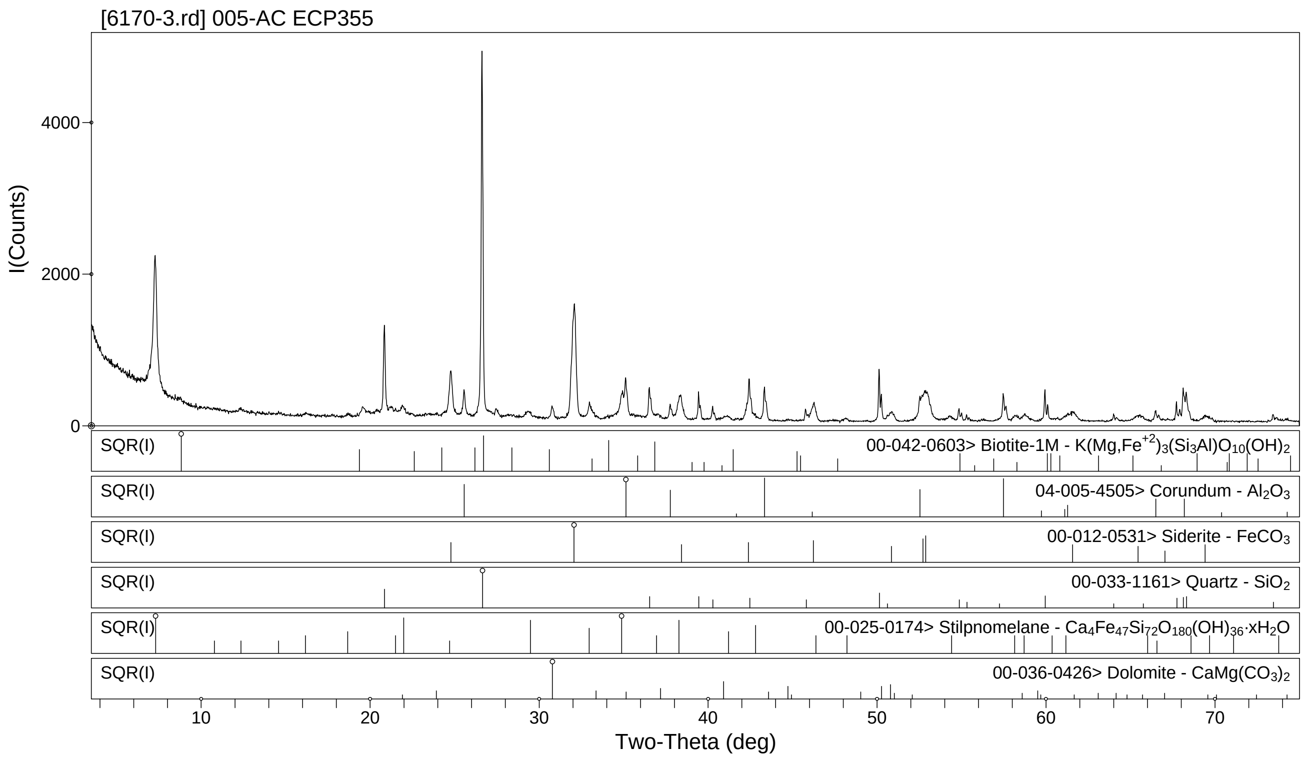

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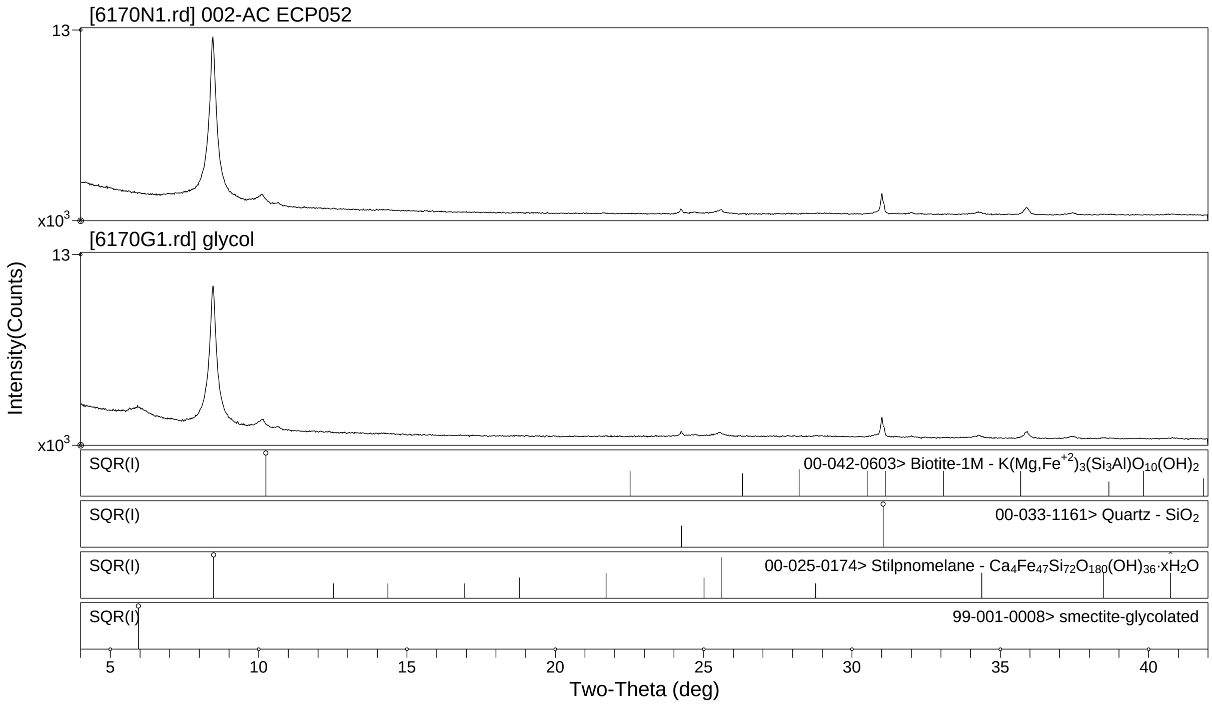
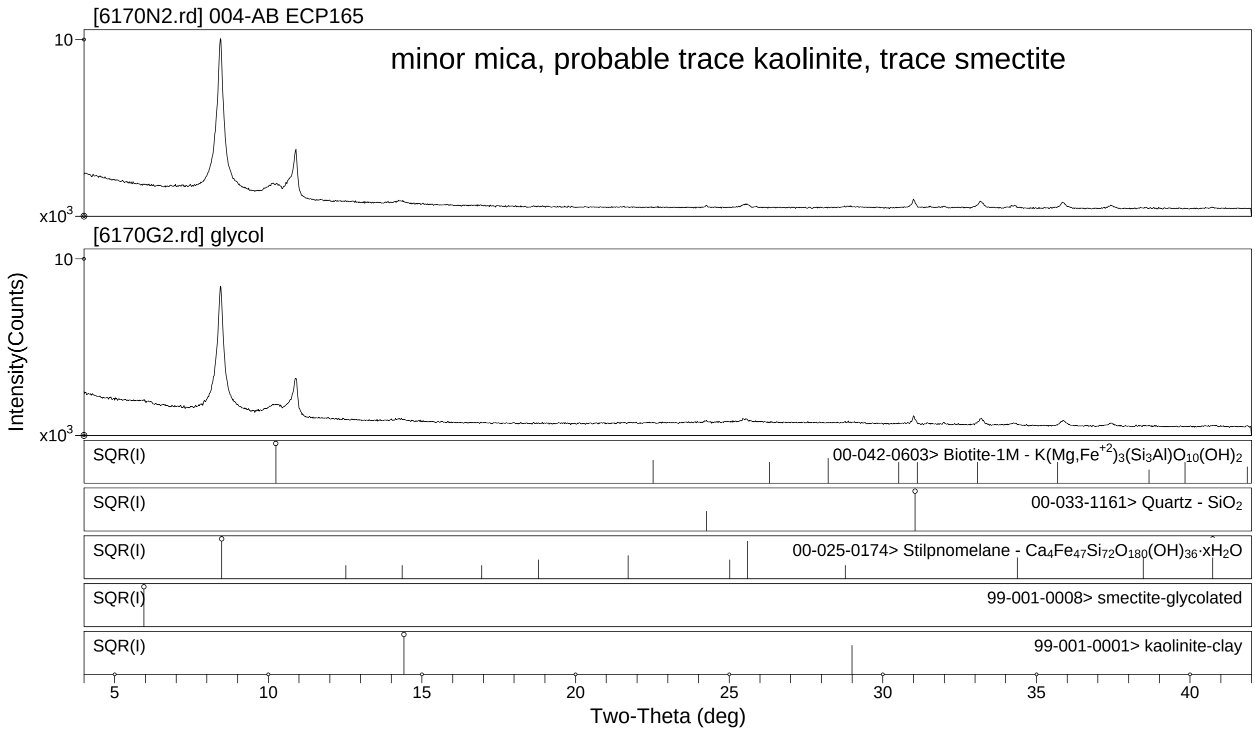
Clay XRD patterns





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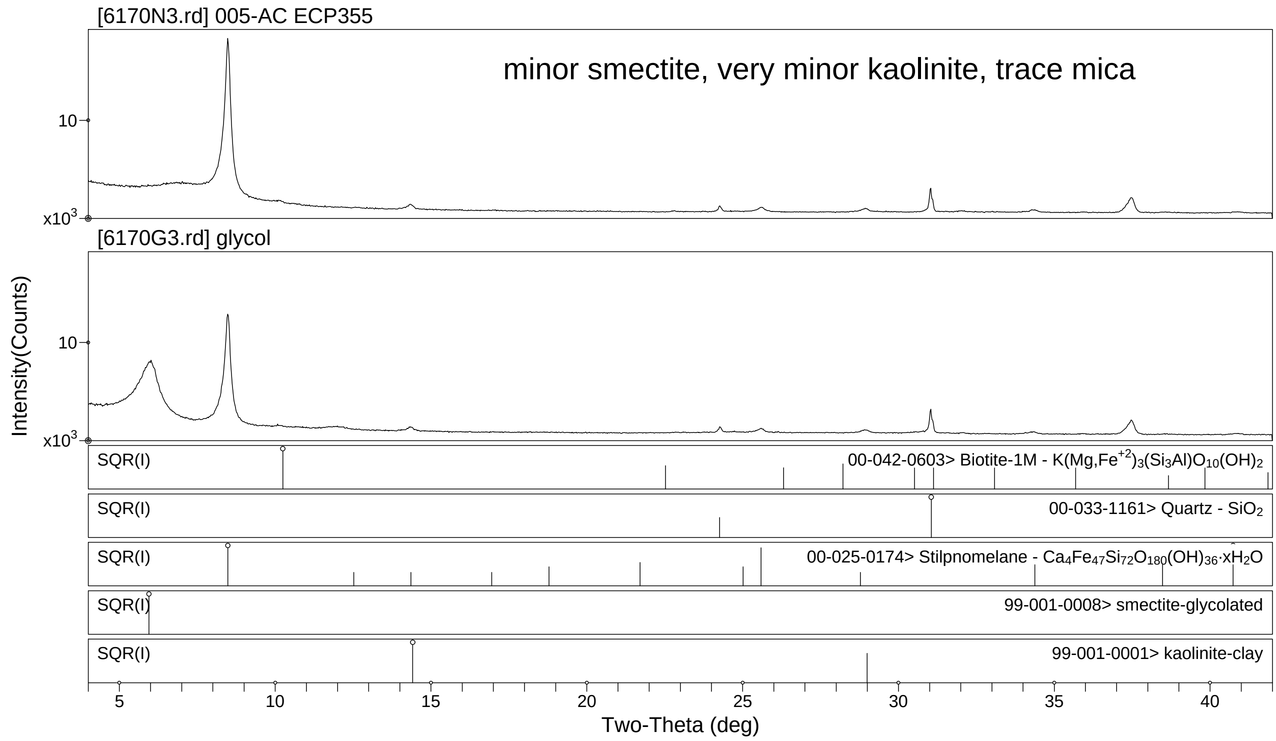

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Appendix 5: Multi-element assay and Global Abundance Indicators

Multi-Element assays

The results of the multi-element assays are shown in Tables A5.1 (major elements) and Table A5.2 (minor elements), where:

- Major elements – Al, Ca, Fe, K, Mg, Mn, Na, P, S, Si and Ti; and
- Minor elements – Ag, As, Au, B, Ba, Be, Bi, Cd, Co, Cr, Cu, F, Hg, Mo, Ni, Pb, Sb, Sc, Se, Sn, Sr, Th, U, V and Zn.

Global Abundance Indicators

The global abundance index (GAI) values are also shown in Table A5.1 and A5.2 and provide a direct comparison of the measured abundances of the elements with the average abundance of elements in the Earth‟s crust (Bowen, 1979). The GAI indicates which elements are „enriched‟ in the sample with respect to the global average and is calculated using the following formula (Förstner, 1993):

$$\text{GAI} = Int\left(\log_2\left(\frac{\text{MeasuredConcentration}}{1.5\times\text{AverageAbundance}}\right)\right)$$

Zero or positive GAI values indicate enrichment of the element in the sample when compared to average-crustal abundances. As a general rule, a GAI of 3 or higher signifies enrichment that warrants further evaluation.

The table below relates GAI values to *n* (the ratio of the measured abundance in the sample to the reference material abundance).

GAI	*n* range
0	$1 < n < 3$
1	$3 \leq n < 6$
2	$6 \leq n < 12$
3	$12 \leq n < 24$

Table A5.1: Multi element assay and Global Abundance Indicators (Major elements)

	1	GAI	1	GAI	1	GAI	1	GAI	1	GAI	1	GAI
Sample ID	Al	Al	Ca	Ca	Cr	Cr	Fe	Fe	K	K	Mg	Mg
LOD/MCA (%)	0.01	8.2	0.01	4.1	0.01	0.01	0.01	4.1	0.01	2.1	0.01	2.3
ECP051	1.6	0	1.11	0	0.01	0	19.6	1	1.46	0	2.95	0
ECP052	1.9	0	2.43	0	0.01	0	15.2	1	1.64	0	2.68	0
ECP053	2.64	0	0.99	0	0.01	0	20.1	1	2.58	0	3.01	0
ECP054	1.25	0	1.37	0	0.01	0	18.7	1	1.17	0	2.04	0
ECP164	1.53	0	1.62	0	0.01	0	19.6	1	1.38	0	3.04	0
ECP165	2.24	0	2.44	0	0.01	0	19.9	1	1.91	0	4.03	0
ECP281	2.17	0	0.69	0	0.01	0	22	1	1.49	0	1.27	0
ECP332	0.14	0	1.07	0	<LOD	0	28.1	2	0.06	0	1.28	0
ECP355	1.86	0	0.52	0	0.01	0	21.2	1	1.05	0	2.08	0
ECP402	2.09	0	0.7	0	0.01	0	22	1	1.49	0	1.28	0

	1	GAI	1	GAI	1	GAI	2	GAI	1	GAI	1	GAI
Sample ID	Mn	Mn	Na	Na	P	P	S	S	Si	Si	Ti	Ti
LOD/MCA (%)	0.01	0.095	0.01	2.3	0.004	0.1	0.01	0.026	0.005	27.7	0.01	0.56
ECP051	0.12	0	0.1	0	0.026	0	0.42	3	23.9	0	0.1	0
ECP052	0.12	0	0.09	0	0.031	0	0.43	3	26	0	0.12	0
ECP053	0.11	0	0.12	0	0.026	0	0.42	3	22.1	0	0.16	0
ECP054	0.09	0	0.1	0	0.022	0	0.57	3	25.6	0	0.08	0
ECP164	0.09	0	0.19	0	0.026	0	0.66	4	23.6	0	0.1	0
ECP165	0.1	0	0.24	0	0.022	0	0.76	4	20.5	0	0.14	0
ECP281	0.22	0	0.29	0	0.017	0	0.46	3	21.7	0	0.12	0
ECP332	0.03	0	0.34	0	0.079	0	0.16	2	24.9	0	0.01	0
ECP355	0.25	0	0.38	0	0.022	0	0.4	3	22	0	0.11	0
ECP402	0.23	0	0.42	0	0.013	0	0.46	3	21.7	0	0.11	0

Notes: GAI results that are „enriched" are indicated with grey shading; LOD – limit of detection; MCA – mean crustal abundance; Method 1 = ME-ICP85 (silicates by fusion followed by inductively coupled plasma – atomic emission spectroscopy (ICPAES) analysis); Method 2 = Leco.

Table A5.2: Multi element assay and Global Abundance Indicators (Minor elements)

Method/GAI	1	GAI	1	GAI	2	GAI	3	GAI	1	GAI	1	GAI	1	GAI	1	GAI
Sample ID	Ag	Ag	As	As	Au	Au	B	B	Ba	Ba	Bi	Bi	Cd	Cd	Co	ppm
LOD/MCA (ppm)	0.01	0.07	0.2	1.5	0.01	0.0011	10	10	10	500	0.01	0.048	0.02	0.11	0.1	20
ECP051	0.11	0	7.5	1	<LOD	0	10	0	90	0	0.09	0	0.27	0	8	0
ECP052	0.07	0	10.1	2	0.04	4	30	1	80	0	0.12	0	0.11	0	8.9	0
ECP053	0.08	0	18	3	0.01	2	50	1	180	0	0.15	1	0.08	0	13.2	0
ECP054	0.07	0	6.3	1	0.02	3	70	2	40	0	0.08	0	0.08	0	6.1	0
ECP164	0.08	0	10.2	2	0.01	2	20	0	50	0	0.12	0	0.08	0	9.7	0
ECP165	0.08	0	22.6	3	0.01	2	10	0	90	0	0.21	1	0.06	0	15.4	0
ECP281	0.11	0	14.6	2	<LOD	0	60	2	140	0	0.23	1	0.28	0	13.4	0
ECP332	0.07	0	<LOD	0	<LOD	0	100	2	20	0	0.02	0	<LOD	0	1.5	0
ECP355	0.09	0	7.2	1	<LOD	0	150	3	130	0	0.1	0	0.11	0	7.6	0
ECP402	0.1	0	14	2	0.01	2	<LOD	0	140	0	0.22	1	0.28	0	12.9	0
Method/GAI	1	GAI	4	GAI	5	GAI	1	GAI	1	GAI	1	GAI	1	GAI	1	GAI
Sample ID	Cu	Cu	F	F	Hg	Hg	Mo	Mo	Ni	Ni	Pb	Pb	Sb	Sb	Se	Se
LOD/MCA (ppm)	0.2	50	20	950	0.005	0.05	0.05	1.5	0.2	80	0.5	14	0.05	0.2	1	0.05
ECP051	31.4	0	430	0	0.017	0	0.75	0	24.4	0	13.3	0	1	1	1	3
ECP052	16.2	0	520	0	0.025	0	1.09	0	29.5	0	7.3	0	0.54	0	1	3
ECP053	13.5	0	370	0	0.025	0	1.12	0	35.4	0	4.3	0	0.62	1	1	3
ECP054	15.6	0	310	0	0.018	0	0.97	0	17.7	0	3	0	0.69	1	1	3
ECP164	18.7	0	420	0	0.019	0	0.88	0	22.5	0	2.9	0	0.68	1	1	3
ECP165	20.9	0	550	0	0.02	0	1.17	0	33.6	0	2.9	0	0.8	1	2	4
ECP281	32.4	0	400	0	0.026	0	1.76	0	38.3	0	9.4	0	0.84	1	2	4
ECP332	2.9	0	170	0	0.015	0	0.97	0	3.7	0	1.1	0	0.17	0	1	3
ECP355	24.4	0	330	0	0.025	0	0.89	0	23.3	0	5.9	0	0.68	1	1	3
ECP402	33.8	0	370	0	0.024	0	1.64	0	34.8	0	8.5	0	0.77	1	2	4

Notes: GAI results that are „enriched" are indicated with grey shading; LOD – limit of detection; MCA – mean crustal abundance; Method 1 = ME-ICP61 (four acid digest followed by inductively coupled plasma – atomic emission spectroscopy (ICPAES) analysis); Method 2 = Au-ICP21 (Au by fire assay and ICPAES); Method 3 = B-ICP69 (B by HF digest and ICPAES); Method 4= F-ELE81a (F by specific ion electrode); Method 5 = ME-MS42 (Hg. by aqua regia digest followed by ICPMS (mass spectroscopy) analysis).

Table A5.2: Multi element assay and Global Abundance Indicators (Minor elements) - Continued

Method/GAI	1	GAI	1	GAI	1	GAI	1	GAI	1	GAI	1	GAI
Sample ID	Sn	Sn	Sr	Sr	Th	Th	U	U	V	V	Zn	Zn
LOD/MCA (ppm)	0.2	2.2	0.2	370	0.2	12	0.1	2.4	1	160	2	75
ECP051	0.6	0	16.2	0	2	0	0.5	0	27	0	72	0
ECP052	0.7	0	19.5	0	2.4	0	0.5	0	38	0	53	0
ECP053	0.8	0	12.9	0	3.4	0	0.9	0	46	0	35	0
ECP054	0.7	0	11.1	0	1.5	0	0.4	0	24	0	42	0
ECP164	0.6	0	16.4	0	2	0	0.5	0	28	0	17	0
ECP165	0.8	0	12.5	0	2.9	0	0.7	0	37	0	39	0
ECP281	0.9	0	8.2	0	2.9	0	0.8	0	36	0	78	0
ECP332	0.2	0	10.9	0	0.2	0	<LOD	0	3	0	7	0
ECP355	0.7	0	9.5	0	2.2	0	0.5	0	32	0	44	0
ECP402	0.9	0	8.2	0	3	0	0.8	0	34	0	77	0

Notes: GAI results that are „enriched" are indicated with grey shading; LOD – limit of detection; MCA – mean crustal abundance; Method 1 = ME-ICP61 (four acid digest followed by inductively coupled plasma – atomic emission spectroscopy (ICPAES) analysis).

Appendix 6: Leachate composition and percentage of elements leaching from the solid

Leach Tests

Leach tests were undertaken on four of the seven samples. The leach tests were undertaken at room temperature and using de-ionised water at a water-to-rock ratio of 2:1. End over end tumbling over a period of 12 hours ensured good contact between the solid and solution.

Following the test, solutions were assayed for the elements shown in Table A6.1.

Table A6.2 shows the calculated percentage of elements leaching.

Table A6.1: Leach test results

Sample ID	Al	Ca	Cr	Fe	K	Mg	Mn	Na	S	Si	P	pH Value	
Units	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	pH Unit	
LOD	0.5	5	0.05	0.5	5	5	0.05	5	5	0.5	5	0.05	
ECP051	<LOD	35	<LOD	<LOD	190	20	<LOD	340	185	14	<LOD	8.6	
ECP164	<LOD	25	<LOD	<LOD	95	30	0.05	360	115	15	<LOD	8.8	
ECP165	<LOD	15	<LOD	<LOD	65	20	<LOD	365	125	14	<LOD	8.9	
ECP281	<LOD	200	<LOD	<LOD	165	195	0.65	55	290	18	<LOD	7.1	
ECP402	<LOD	330	<LOD	<LOD	150	320	2.15	85	550	19	<LOD	6.9	
Sample ID	**Ag**	**As**	**B**	**Ba**	**Bi**	**Cd**	**Co**	**Cu**	**Hg**	**Mo**	**Ni**	**Pb**	**Sb**
Units	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
LOD	0.05	0.05	0.5	0.5	0.005	0.05	0.05	0.05	0.0003	0.05	0.05	0.05	0.05
ECP051	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	0.1	<LOD	<LOD	<LOD
ECP164	<LOD	<LOD	0.5	<LOD	0.01	<LOD	<LOD	<LOD	<LOD	0.15	<LOD	<LOD	<LOD
ECP165	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	0.1	<LOD	<LOD	<LOD
ECP281	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
ECP402	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
Sample ID	**Se**	**Sn**	**Sr**	**Th**	**Ti**	**Tl**	**U**	**V**	**Zn**	**Cl**	**F**	**N**	**-**
Units	mg/L	mg/L	mg/L	mg/L	mg/L	Mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	-
LOD	0.05	0.05	0.5	0.005	0.5	0.5	0.005	0.05	0.05	5	0.5	10	-
ECP051	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	35	1.5	45	-
ECP164	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	30	3.5	50	-
ECP165	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	35	5	40	-
ECP281	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	0.005	<LOD	<LOD	30	1.5	25	-
ECP402	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	50	1	40	-

Note: LOD – limit of detection.

Table A6.2: Calculated percentage of elements leaching

	Major Elements (%)										
Sample ID	Al	Ca	Cr	Fe	K	Mg	Mn	Na	P	S	Si	Ti
ECP051	NC	0.63	NC	NC	2.60	0.14	NC	70.5	NC	8.81	0.01	NC
ECP164	NC	0.31	NC	NC	1.38	0.20	0.01	37.3	NC	3.48	0.01	NC
ECP165	NC	0.12	NC	NC	0.68	0.10	NC	30.8	NC	3.29	0.01	NC
ECP281	NC	5.83	NC	NC	2.21	3.08	0.06	3.80	NC	12.6	0.02	NC
ECP402	NC	9.42	NC	NC	2.01	5.01	0.19	4.09	NC	23.9	0.02	NC
	Minor Elements (%)											
Sample ID	Ag	As	B	Ba	Bi	Cd	Co	Cu	F	Hg	Mo	Ni
ECP051	NC	NC	NC	NC	NC	NC	NC	NC	0.70	NC	26.7	NC
ECP164	NC	NC	5	NC	16.7	NC	NC	NC	1.67	NC	34.1	NC
ECP165	NC	NC	NC	NC	NC	NC	NC	NC	1.82	NC	17.1	NC
ECP281	NC	NC	NC	NC	NC	NC	NC	NC	0.75	NC	NC	NC
ECP402	NC	NC	NC	NC	NC	NC	NC	NC	0.54	NC	NC	NC
Sample ID	Pb	Sb	Se	Sn	Sr	Th	U	V	Zn	-	-	-
ECP051	NC	NC	NC	NC	NC	NC	NC	NC	NC	-	-	-
ECP164	NC	NC	NC	NC	NC	NC	NC	NC	NC	-	-	-
ECP165	NC	NC	NC	NC	NC	NC	NC	NC	NC	-	-	-
ECP281	NC	NC	NC	NC	NC	NC	1.25	NC	NC	-	-	-
ECP402	NC	NC	NC	NC	NC	NC	NC	NC	NC	-	-	-

Notes: NC – not calculated as the element was below the limit of detection in the multi element assay and/or the leach solution.

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West Angelas

GEOCHEMICAL ASSESSMENT OF SAMPLES FROM WEST ANGELAS

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1.0 Introduction

Environmental Geochemistry International Pty Ltd (EGi) was commissioned by Rio Tinto Iron Ore to carryout geochemical testing of samples from the West Angelas B, D and A West deposits, located approximately 110 kilometres north west of Newman in the Hamersley Range.

The aim of the test work was to:

- Determine the acid forming characteristics of waste rock and provide a preliminary assessment of the likelihood of occurrence of potentially acid forming rock types.
- Assess the reactivity of any sulphide mineralisation to provide preliminary estimates of the likely geochemical behaviour and lag times for acidification to occur under field conditions.
- Identify any elemental enrichments that could be environmentally significant, and to assess the potential for mobilisation of elements that could adversely impact the quality of waste dump seepage.
- Provide recommendations for kinetic testing in the form of column leach testing to determine lag periods and leaching characteristics of waste materials if required.

This report presents the methodology and results of the testing program, and discusses the likely implications for the handling and management of waste rock for ARD control.

2.0 Testing Program

One hundred and thirty five (135) individual samples were received by EGi in August 2013 and consisted of the following:

- 37 detrital samples;
- 4 clay samples;
- 3 pisolite/ detrital samples;
- 29 West Angela Member samples;
- 30 Newman samples;
- 24 MacLeod Member samples; and
- 8 Nammuldi Member samples.

All samples underwent the following tests:

- $pH_{1:2}$ and $EC_{1:2}$ determination;
- Total S analysis; and
- Acid neutralising capacity (ANC) determination.

Selected samples also underwent:

- Net acid generation (NAG) testing.
- Carbon forms testing;
- Sulphur speciation testing;
- ABCC;
- Kinetic NAG;
- Sequential NAG;
- Multi-element scans on solids;
- Multi-element scans on water extracts.

The total S assays were carried out by Sydney Environmental and Soil Laboratory (SESL); multi-element analyses of liquors were conducted by Australian Laboratory Services (ALS) in Sydney; multi-element analyses of solids samples, SO_4-S, chromium reducible S and carbon forms analysis was conducted by ALS in Brisbane; KCl extractable S was conducted by Levay & Co. Environmental Services in SA; and all other test work was carried out by EGi in Sydney.

A description of the test procedures in presented in Appendix A. A map showing the location of the samples is provided in Appendix B.

3.0 Results

3.1 Acid Forming Characteristics and ARD Classification

The acid forming characteristics of the samples are presented in Table 1, comprising $pH_{1:2}$ and $EC_{1:2}$, total S, maximum potential acidity (MPA), ANC, NAPP, ANC/MPA ratio, single addition NAG and ARD classification.

The $pH_{1:2}$ and $EC_{1:2}$ results were determined by equilibrating the sample in deionised water for approximately 16 hours, at a solid to water ratio of 1:2 (w/w). This gives an indication of the inherent acidity and salinity of the waste material when initially exposed in a waste emplacement area.

Figure 1 is an acid-base account plot of ANC and total S. The NAPP zero line is shown which defines the NAPP positive and NAPP negative domains and lines for ANC/MPA ratio values of 2 and 3 are also plotted. Note that the NAPP = 0 line is equivalent to an ANC/MPA ratio of l. The ANC/MPA ratio is used as an indication of the relative factor of safety within the NAPP negative domain. Usually a ratio of 2 indicates a high factor of safety that the material will remain circum-neutral in pH and thereby should not be problematic with respect to ARD.

The NAPP value is an acid-base account calculation using measured total S and ANC values. It represents the balance between the MPA and ANC. A negative NAPP value indicates that the sample may have sufficient ANC to prevent acid generation. Conversely, a positive NAPP value indicates that the material may be acid generating.

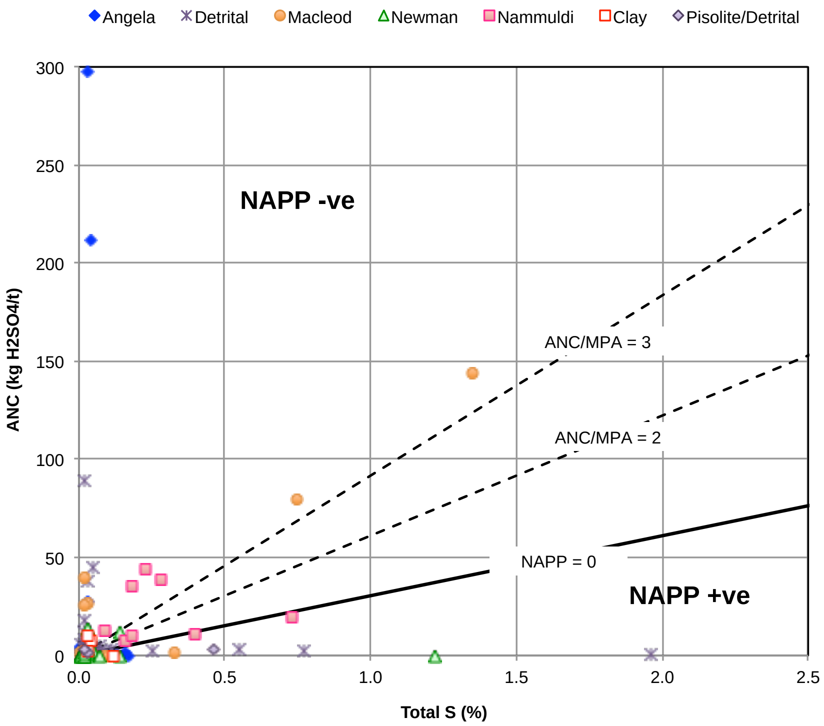


Figure 1a: Acid base account plot of total S versus ANC

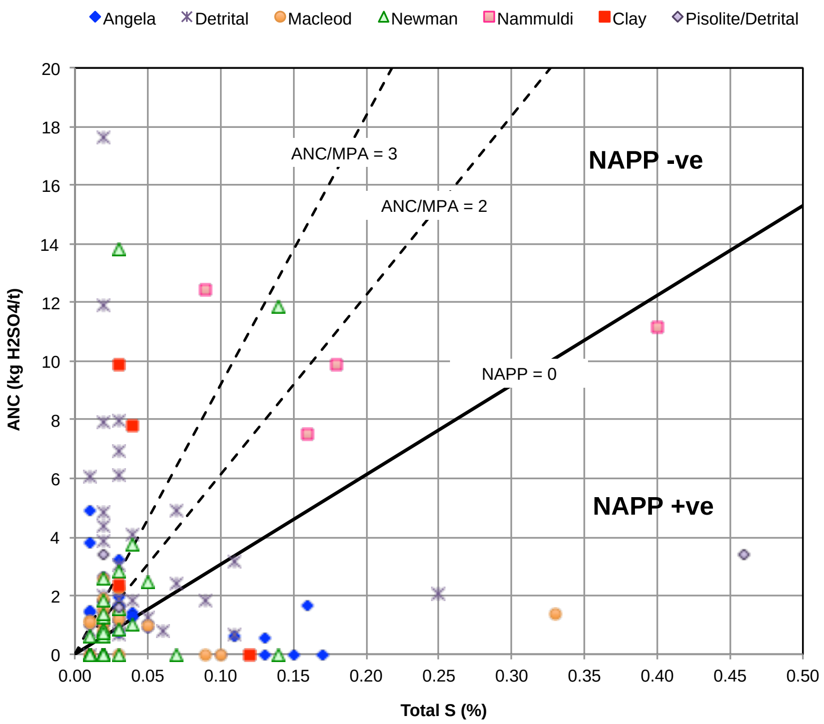


Figure 1b: Same as 1a but with an expanded total S and ANC scale.

The results show that 64% of the samples have a total S content less than 0.1%S and ANC less than 5 kg H_2SO_4/t. The majority of the samples have a negative NAPP and roughly 45% of the samples have an ANC/MPA ratio greater than 2, indicating a high factor of safety with respect to the prevention of acid generation.

The NAPP value is used in conjunction with single addition net acid generation (NAG) test results to geochemically classify samples in relation to their ARD potential. Samples are classified as barren, non-acid forming (NAF), potentially acid forming (PAF) and uncertain (UC) according to the following characteristics:

- Barren: Total S < 0.1%S and ANC ≤ 5 kg H_2SO_4/t.
- NAF: Non-Acid Forming. NAPP negative and NAGpH greater than or equal to 4.5.
- PAF: Potentially Acid Forming. NAPP positive, NAGpH less than 4.5 and NAG acidity greater than 5 kg H_2SO_4/t.
- PAF-LC: Potentially Acid Forming -Lower Capacity. NAPP positive, NAGpH less than 4.5 and NAG acidity to pH 4.5 less than or equal to 5 kg H_2SO_4/t.
- UC: Uncertain. Conflicting NAPP and NAG results (i.e., NAPP positive and NAGpH greater than 4.5 or NAPP negative and NAGpH less than 4.5).

Figure 2 is an ARD classification plot of NAGpH and NAPP for the 32 samples with total S ≥ 0.1%S. Samples with total S < 0.1%S were barren or NAF with a high factor of safety and were not tested. However, 3 samples (FRK397, FNH063 and FRH214) with total S <0.1%S were included to confirm that these low S samples would not generate acid. The results are discussed further in the following sections.

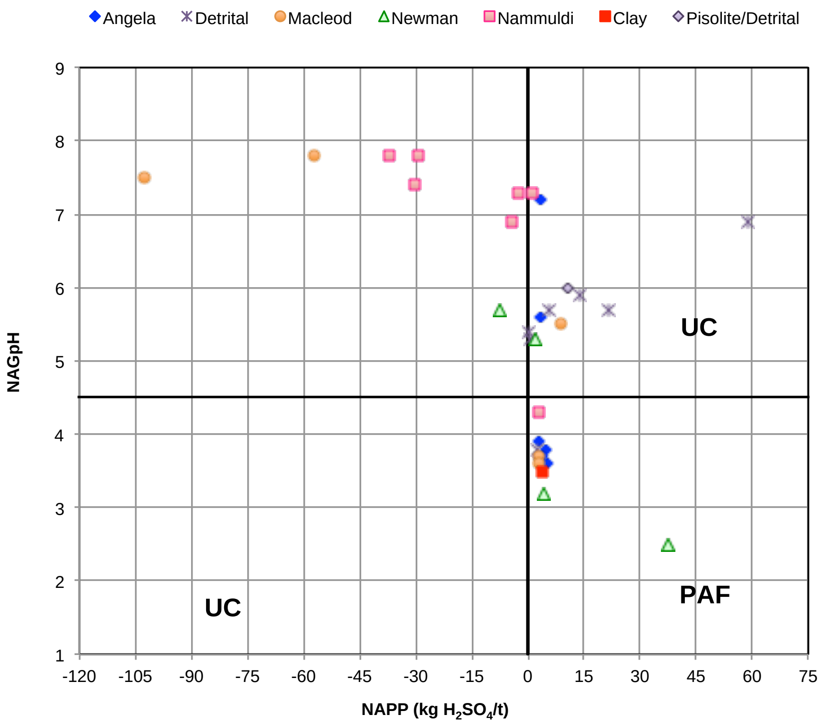


Figure 2: ARD classification plot.

3.1.1 Detrital

Thirty-seven (37) detrital samples were provided for testing. The samples had circum-neutral to alkaline $pH_{1:2}$ ranging from 6.3 to 8.2 and $EC_{1:2}$ values that ranged from 0.12 to 1.15 dS/m. About 78% of the detrital samples were non-saline with $EC_{1:2}$ less than 0.5 dS/m. All but one of the remaining samples were slightly saline with $EC_{1:2}$ between 0.5 and 1.0 dS/m. Sample ELO107 was moderately saline with an $EC_{1:2}$ of 1.15 dS/m.

The total S content of the samples ranged from 0.01 to 1.96%S with a median of 0.03%S. All but three samples had a total S content less than 0.3%S, these being FQD687, FQD908 and FOM528, which had total S contents of 0.77, 0.55 and 1.96%S, respectively.

The samples had an ANC ranging from 0 to 89 kg H_2SO_4/t, with a median of 2 kg H_2SO_4/t. Roughly 85% of the detrital samples had a low ANC less than 10 kg H_2SO_4/t.

Eleven (11) of the samples were NAPP positive and 26 were NAPP negative (see Figure 1). The samples had NAPP values ranging from -89 to +59 kg H_2SO_4/t with a median value of -1 kg H_2SO_4/t.

Twenty-one (21) samples had an ANC/MPA ratio of 2 or more indicating a high factor of safety. Sixteen samples had an ANC/MPA ratio less than 2, however, 10 of these samples were barren with respect to acid generation and neutralisation (total S <0.1%S and ANC ≤ 5 kg H_2SO_4/t).

Seven (7) NAPP positive samples were selected for NAG testing and 5 of the samples had a NAGpH greater than 4.5 and were classified as uncertain (UC). Three of these samples (FQR914, FQD851 and FED908) had total S contents of 0.11, 0.25 and 0.55%S, respectively and hence all the sulphide sulphur within these samples is likely to have oxidised in the single addition NAG test and these samples are expected to be non-acid forming, UC(NAF). The other two samples, FQD687 and FOM528 had total S content of 0.77 and 1.96%S, respectively. These two samples underwent further testing (S speciation and sequential NAG testing discussed in Section 3.2 and 34) that confirmed the samples as NAF.

Sample (FRK397) had total S content of 0.09%S and ANC of 2 kg H_2SO_4/t and was classified as barren. Sample FTI114, had a NAGpH of 3.8 and was classified PAF-LC as the NAG value to pH 4.5 was less than 5 kg H_2SO_4/t.

For the remaining samples, 20 were classified as barren with a total S content less than 0.1%S and ANC $\leq$ 5 kg H_2SO_4/t. Ten samples were classified as NAF with total S content $\leq$ 0.05%S and ANC > 5 kg H_2SO_4/t. All the NAF samples had a negative NAPP.

Overall, only 1 of the detrital samples was classified as PAF-LC, 21 were barren, 10 were NAF and 5 were UC(NAF).

3.1.2 Clay and Pisolite/Detrital

Four clay samples and three pisolite/detrital samples were provided for testing. The samples had neutral $pH_{1:2}$ ranging from 7.3 to 7.5 and were non-saline with $EC_{1:2}$ ranging from 0.14 to 0.42 dS/m.

The clay samples had total S contents ranging from 0.03 to 0.12%S, with three samples having a value less than 0.05%S. The ANC ranged from 0 to 10 kg H_2SO_4/t and three of the samples had a negative NAPP of -9 to -1 kg H_2SO_4/t. One sample, FNC936, had a positive NAPP value of 4 kg H_2SO_4/t. This sample had a NAGpH of 3.5, indicating that it was PAF-LC.

Two of the clay samples (EYT775 and EYT782) were classified as NAF and one sample (EYT925) was barren with respect to acid generation and neutralisation.

Two of the pisolite/detrital samples (FRL157 and FRL097) had total S contents less than 0.05%S, ANC less than 5 kg H_2SO_4/t and had negative NAPP values. These two samples were classified as barren.

One sample (FRD872) had a total S content of 0.46%S, a low ANC of 3 kg H_2SO_4/t and a positive NAPP value of 11 kg H_2SO_4/t. The sample underwent NAG testing and had a NAGpH of 6.0 indicating that it was UC. Sulphur speciation testing (Section 3.2) confirmed that the sulphur is present in non-acid generating form and hence the sample is classified UC(NAF).

The results of testing indicate that two clay samples are classified as NAF, one is barren and one classified as PAF-LC. Two of the pisolite/detrital samples are classified as barren and one sample is UC(NAF).

3.1.3 West Angela Member

Twenty nine (29) West Angela Member samples were provided for testing. The $pH_{1:2}$ of the samples ranged from 5.1 to 7.7, with all except one sample (FNC939) having a pH of 6 or higher. The $EC_{1:2}$ values ranged from 0.13 to 0.26 dS/m, indicating that all samples were non-saline (less than 0.5 dS/m).

The samples had a total S content ranging from 0.01 to 0.17%S with a median of 0.03%S. The acid neutralising capacity (ANC) ranged from 0 to 297 kg H_2SO_4/t, with a median of 1 kg H_2SO_4/t. All but three of the samples had a low ANC of less than 10 kg H_2SO_4/t. Samples FRI220, EYT840 and FOM940 had ANC values of 27, 212 and 297 kg H_2SO_4/t, respectively.

The NAPP values raged from -297 to +5 kg H_2SO_4/t and 22 of the 29 samples were NAPP negative, with 7 NAPP positive (see Figure 1b).

The NAPP positive samples were selected for net acid generation (NAG) testing. These samples had total S contents of 0.1 to 0.17%S. Five of the samples had a positive NAPP value and NAGpH less than 4.5 (Figure 2) and were classified as potentially acid forming (PAF) but with only a low acid generating capacity (PAF-LC). The remaining 2 samples had positive NAPP values of +3 kg H_2SO_4/t, but NAGpH greater than 4.5, indicating that they had an uncertain (UC) classification. It is likely that all the sulphide sulphur within these two samples (0.13 and 0.16%S) would be oxidised in the single addition NAG test and these samples have been classified as uncertain, but likely to be non-acid forming, i.e., UC(NAF).

Nineteen (19) of the 22 NAPP negative West Angela Member samples, were classified as barren as they had a total S content < 0.1%S and ANC ≤ 5 kg H_2SO_4/t and 3 samples were classified as NAF, with total S content <0.05%S and ANC greater than 20 kg H_2SO_4/t.

Overall, the results indicate that 5 samples are classified as PAF-LC, 19 samples are barren, 3 samples are NAF and 2 are UC(NAF).

3.1.4 Newman Member

Thirty (30) Newman Member samples were provided for testing. The $pH_{1:2}$ of the samples was circum-neutral to alkaline ranging from 6.1 to 8.3, and the samples were non-saline with $EC_{1:2}$ between 0.12 and 0.25 dS/m.

The total S contents of the samples ranged from 0.01 to 1.22%S, with a median of 0.02%S. All but three samples had a total S less than 0.1%S. Samples FQR487 and

FRM113 both had total S contents of 0.14%S and sample FRQ860 had a total S content of 1.22%S.

The ANC of the samples ranged from 0 to 14 kg H_2SO_4/t, with a median of 1 kg H_2SO_4/t. All but two samples had an ANC less than 5 kg H_2SO_4/t. These samples were FRM103 (14 kg H_2SO_4/t) and FRM113 (12 kg H_2SO_4/t).

Twenty six (26) of the 30 samples were devoid of S and ANC and were classified barren.

Two (2) samples (FQR487 and FQR860) had a positive NAPP and NAGpH < 4.5 (Figure 2). Sample FQR487 was classified PAF-LC and FQR860 classified PAF.

The remaining 2 samples (FRM103 and FRM113) had the highest ANC of the Newman Member samples and were classified NAF.

Overall, 26 of the Newman Member samples were barren, 2 were classified as NAF, one PAF and one PAF-LC.

3.1.5 MacLeod Member

Twenty four (24) MacLeod Member samples were provided for testing. The $pH_{1:2}$ of these samples ranged from 6.7 to 8.1, indicating that they were circum-neutral to alkaline. The samples were also non-saline with $EC_{1:2}$ values ranging from 0.13 to 0.44 dS/m.

The total S contents of the samples ranged from 0.01 to 1.35%S, with a median of 0.02%S. All but three samples had a total S content of 0.1%S or less. Samples FOG111, FOH843 and FOD662 had a total S content of 1.35, 0.75 and 0.33%S, respectively.

The ANC of the samples ranged from 0 to 144 kg H_2SO_4/t, with a median of 1 kg H_2SO_4/t. Nineteen out of the 24 samples (approximately 80%) had an ANC less than 5 kg H_2SO_4/t. The remaining samples had values greater than 25 kg H_2SO_4/t.

The NAPP values ranged from -103 to +9 kg H_2SO_4/t, with 18 samples being NAPP negative and 6 samples NAPP positive (see Figure 1). Five (5) samples were selected for NAG testing and had total S contents of 0.09 to 1.35%S. Two samples (Figure 2), (FNH063 and FRK393), had positive NAPP values and NAGpH < 4.5. Sample FRK393 has a total S content of 0.1%S and is devoid of ANC. The results suggest that this sample is PAF-LC, however the low S content indicates that it is essentially barren with respect to acid generating capacity similar to sample FNH063, which is classified as barren. It is most likely that the low NAGpH in the samples maybe due to the reaction of iron during the NAG test. Elevated iron content is characteristic of samples from the Pilbara region of WA and samples from this study have iron contents ranging from 19% to 43% (Section 3.6). It is postulated that the acidification process might involve both dissolution and oxidation of some iron to a higher oxidation state (*i.e*. Fe^{2+} oxidised to Fe^{3+}) during the NAG test, then re-precipitation of the metal during the back-titration step. If such is the case, then some (and possibly all) of the acid produced by these samples during the NAG test could be artifacts of the analytical procedure and not related to pyrite oxidation.

The remaining three samples had NAGpH greater than 4.5. Samples FOG111 and FOH843 had negative NAPP values and are classified as NAF. Sample FOD662 had a positive NAPP value of 3 kg H_2SO_4/t and is classified as UC. The sample had a total S content of 0.33%S and is therefore classified as uncertain, but likely to be non-acid forming, i.e., UC(NAF)

Overall 17 samples were classified as barren, five were NAF, one PAF-LC and one UC(NAF).

3.1.6 Nammuldi Member

Eight (8) Nammuldi samples were provided for testing and had circum-neutral $pH_{1:2}$ ranging from 6.7 to 7.4. The samples were also non-saline with $EC_{1:2}$ varying from 0.13 to 0.3 dS/m.

The total S contents of the samples ranged from 0.09 to 0.73%S, with half of the samples having a value greater than 0.2%S. The ANC of the samples ranged from 8 to 44 kg H_2SO_4/t and the samples had NAPP values of -37 to +3 kg H_2SO_4/t.

Seven of the eight samples were selected for NAG testing. Sample FOH848 did not undergo NAG testing as this sample had a low total S content of 0.09%S, ANC of 12 kg H_2SO_4/t and negative NAPP of -10 kg H_2SO_4/t. This sample was classified NAF.

Figure 2 shows that 5 samples had a negative NAPP value and NAGpH greater than 4.5, indicating that they were NAF, one sample (FOH416) had a positive NAPP value and NAGpH of 4.3, indicating that the sample was PAF-LC and one sample (FOH851) had a positive NAPP value and NAGpH of 7.3, indicating that it was UC. The sample had a total S content of 0.4%S and is therefore classified as uncertain, but likely to be non-acid forming, i.e., UC(NAF).

Overall, 6 samples were NAF, one sample was PAF-LC and one was classified as UC(NAF).

3.1.7 Summary

The results indicate a general lack of existing acidity and salinity in materials represented by these samples. Testing also indicates that 79% of the samples have a low total S content less than 0.1%S and 71% have a low acid neutralising capacity (ANC) less than 5 kg H_2SO_4/t. The net acid producing potential (NAPP) of the samples ranged from -297 to +59 kg H_2SO_4/t, with a median value of -1 kg H_2SO_4/t. About two thirds of the samples (66%) were NAPP negative and one third (34%) were NAPP positive.

The table below summarises the ARD classifications split by each member group. Overall, 92% of the samples are classified as barren or non-acid forming (NAF) and 8% potentially acid forming (PAF or PAF-LC).

Member Group	Number of Samples	% Barren	% NAF	%PAF	%PAF-LC
West Angela	29	66%	17%	-	17%
Detrital	37	57%	40%	-	3%
MacLeod	24	71%	25%	-	4%
Newman	30	87%	7%	3%	3%
Nammuldi	8	-	88%	-	12%
Clay	4	25%	50%	-	25%
Pisolite/Detrital	3	67%	33%	-	-
TOTAL	**135**	**64%**	**28%**	**1%**	**7%**

3.2 Carbon Forms and Sulphur Speciation

The carbon (C) forms are presented in Table 2 and the sulphur (S) speciation results are presented in Table 3. The inorganic C content is calculated by the difference between the total C and organic C content.

Figure 3 is a comparison of total %C and total inorganic %C. The line represents the 1:1 trend where the total %C is equal to the total inorganic %C. The results show almost all carbon is present as inorganic C in most of the samples. There are 4 samples where inorganic C is significantly less that total C, particularly sample EYT782 (Clay), represented by the red circle, which had a total C content of 0.61%C and most was in the form of organic C (0.5%C_{org}).

The carbonate neutralising value (CNV) of the samples is also shown in Table 2. The CNV is an indirect measure of the inherent buffering capacity within a sample based on carbon content. CNVs were calculated from the inorganic C content of the samples as follows:

$$\text{CNV (kg } H_2SO_4\text{/t)} = \text{\% Total Inorganic C x 81.67}$$

Figure 4 shows good correlation between ANC and CNV for samples with an ANC less than 50 kg H_2SO_4/t and occasional samples with ANC greater than 50 kg H_2SO_4/t. However for most samples with higher ANC, the CNV calculation is significantly greater than the measured ANC content.

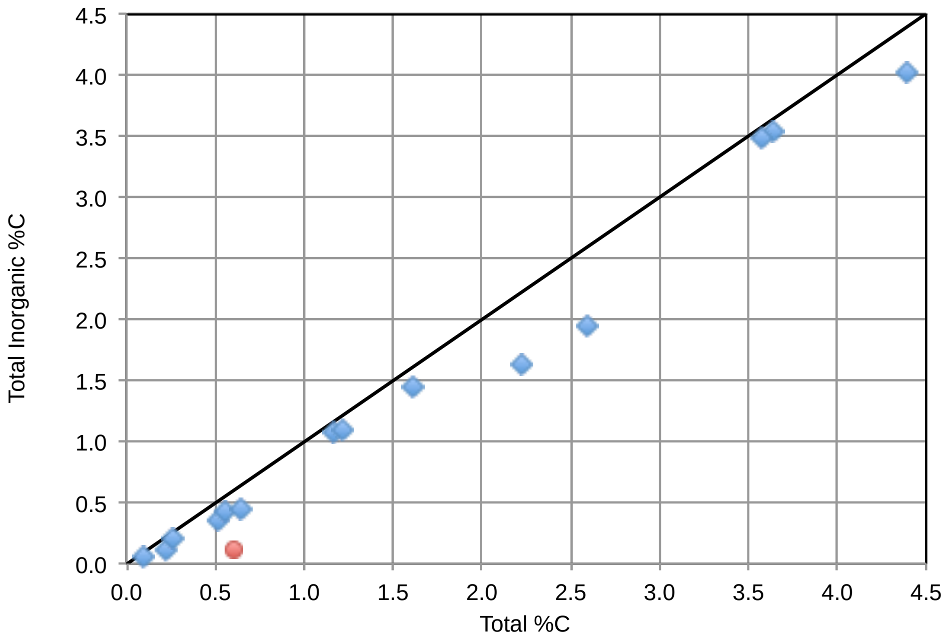


Figure 3: Comparison of total %C with total inorganic %C.

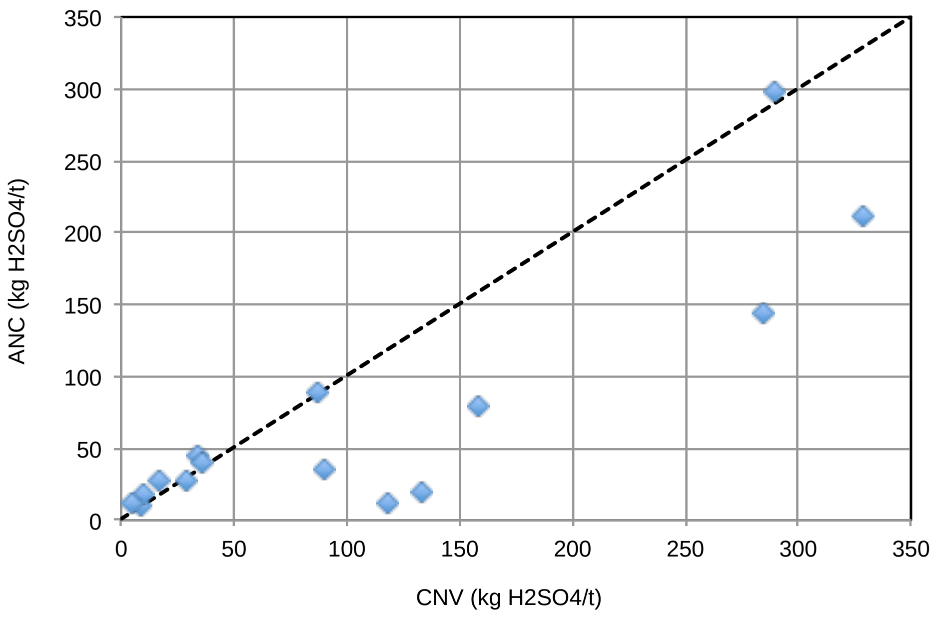


Figure 4: Relationship between CNV and ANC of selected samples.

To further evaluate this difference, the table below presents a comparison of the measured ANC, CNV and acid buffering characteristic curve (ABCC) results (discussed in Section 3.3). The results show that where the CNV value is significantly higher than the measured ANC (blue highlighted values), the results of ABCC testing support the lower measured ANC values and therefore the measured ANC is a more reliable indicator of the available neutralising capacity of the samples than the CNV.

The results suggest that the total C or total inorganic C content of these samples is unlikely to be useful for identifying high ANC rock types during operation.

Sample ID	ANC	CNV	ABCC to pH 4
	(kg H_2SO_4/t)		
EYT840	212	328	-
FOM940	297	289	261
FRI220	27	29	21
EYT782	10	9	8
FNC563	45	34	36
ELO107	18	10	-
FRD062	89	87	96
FNC467	40	36	34
FOG111	**144**	**284**	**65**
FQP332	27	17	-
FOH843	**80**	**158**	**37**
FOH852	**11**	**118**	**17**
FOH858	**35**	**90**	**33**
FOH416	**20**	**133**	**13**
FRM113	12	5	5

Sulphur speciation testing was carried out on 15 selected samples and the results are shown on Table 3. Note that the pyritic S value should only be treated as a guide to the pyrite content in the sample due to issues with repeatability in the chromium reducible sulphur (CRS) method[1]. Partial oxidation of pyrite may occur in samples prior to testing, and some of the S originally present as pyrite may be in the form of acid sulphate salts. Hence the total acid generating S proportion of the sample is the sum of the pyritic S (from CRS) and the acid sulphate S.

The results show that in all but one of the samples, the total acid generating S forms was low (<0.1%S). All samples, except FQR860 (Newman), had a pyritic S content of less than 0.02%S and a low acid sulphate S content of less than 0.1%S. Sample FRQ860 had a pyritic S content of 1.06%S, confirming that the majority of the sulphur within the sample is in the form of reactive pyrite.

Two detrital samples, FQD687 and FOM528, were classified as uncertain (see Section 3.1.1) and had total S contents of 0.77 and 1.96%S, respectively. Sulphur speciation testing indicates that the acid generating sulphur forms in the samples only accounted for 0.01 and 0.02%S in the samples and that the majority of the sulphur in the two samples was in the form of non-acid generating sulphur. The S speciation results confirm the

[1] Environmental Geochemistry International, Levay and Co. and ACeSSS, 2008. *ACARP Project C15034: Development of ARD Assessment for Coal Process Wastes*, EGi Document No. 3207/817, July 2008. www.acarp.com.au.

NAG test results and both samples are therefore classified as uncertain, but likely to be non-acid forming, i.e., UC(NAF).

These results indicate that the total sulphur content alone can not be used as a criteria for identifying PAF material types at the West Angela Mine. Likewise, total C is not likely to be useful in identifying high ANC materials for acid neutralisation.

3.3 Acid Buffering Characteristic Curve (ABCC)

An acid buffering characteristic curve (ABCC) is produced by slow titration of a sample with acid, and provides an indication of the relative reactivity of the measured ANC. The acid buffering of a sample to pH 4 can be used as an estimate of the proportion of readily available ANC. Calcite, dolomite, ferroan dolomite and siderite standard curves are used for reference. Calcite and dolomite readily dissolve in acid and exhibit strongly buffered pH curves in the ABCC test, rapidly dropping once the ANC value is reached. Siderite provides very poor acid buffering, exhibiting a steep pH curve in the ABCC test. Ferroan dolomite is between siderite and dolomite in acid buffering availability.

Sixteen (16) samples were selected for ABCC testing and the results are presented in Figures 5 to 13. Note that different sample types that have similar ANC have been grouped together on the same plot. Samples were selected to cover a range of ANC and material types.

3.3.1 Detrital

The ABCC plots for the detrital samples are presented in Figures 7 to 9.

The ABCC plot of sample FRM221, which has an ANC of 12 kg H_2SO_4/t is presented in Figure 7. The curve of the sample is represented by the purple circles and shows that there is a small pH plateau above 7, before the pH decreases rapidly. The sample curve plots close to the calcite standard curve and all of the ANC of this sample is readily available.

Samples FNC563 (purple circle curve) and FQR817 (light blue circle curve), which have ANC values of 45 and 38 kg H_2SO_4/t, respectively, are presented in Figure 8. The results show that both sample curves have a small pH plateau above pH 7 and plot between the calcite and dolomite standard curves. Between 80 and 100% of the ANC of these samples is readily available.

Figure 9, presents the ABCC plot of sample FRD062, which has an ANC of 89 kg H_2SO_4/t. The results show that the sample curve has a pH plateau above pH 7 and plots close to the calcite standard curve. All of the ANC of this sample is readily available.

The results suggest that generally the ANC of the detrital samples is comprised of carbonate forms that are similar to calcite and dolomite, with 80 to 100% of the ANC being readily available.

3.3.2 Clay

The ABCC plot of the clay sample (EYT782) is presented in Figure 7. The sample has an ANC of 10 kg H_2SO_4/t and is represented by the black dashed pH curve. The pH drops from the beginning of the test and the curve plots close to the ferroan dolomite and dolomite standard. Approximately 75% of the ANC of this sample is readily available.

3.3.3 West Angela

Figure 5 presents an acid buffering characteristic curve (ABCC) of West Angela sample FOM940 with an ANC of 297 kg H_2SO_4/t. The results show that the sample curve plots close to the ferroan dolomite standard curve, suggesting that the ANC of this sample is dominated by ferroan dolomite. Approximately 90% of the ANC of this sample is readily available.

The ABCC of West Angela sample FRI220, with an ANC of 27 kg H_2SO_4/t, is presented in Figure 6 (represented by the red diamond curve). The pH curve decreases from the beginning of the test and the curve plots between the ferroan dolomite and siderite standard curves. Approximately 75% of the ANC of the sample is readily available.

The results suggest that the ANC of the two West Angela Member samples is comprised of carbonate similar to ferroan dolomite with approximately 75 to 90% of the ANC being readily available.

3.3.4 Newman

The ABCC plot of sample FRM113, which has an ANC of 12 kg H_2SO_4/t, is presented in Figure 7 (represented by the light blue squares) and shows that the pH dropped from the beginning of the test. The sample plots close to the ferroan dolomite standard curve and approximately 40% of the ANC of the sample is readily available.

3.3.5 MacLeod

The ABCC plots for MacLeod Member samples, FOH824, FNC467, FOG111 and FOH843 are presented in Figures 6, 8, 10 and 11, respectively.

Figure 6 presents the ABCC of sample FOH824, which has an ANC of 27 kg H_2SO_4/t and is represented by the orange diamond curve. The pH curve decreases from the beginning of the test and plots between the ferroan dolomite and siderite standard curves. Approximately 25% of the ANC of this sample is readily available.

Figure 8 presents the ABCC plot of sample FNC467, which has an ANC of 40 kg H_2SO_4/t and is represented by the orange diamond curve. The pH curve plots between the dolomite and ferroan dolomite standard curves and has a small pH plateau above 6. Approximately 85% of the ANC of this sample is readily available.

Figure 10 and 11 present the ABCC plots of sample FOG111 (ANC of 144 kg H_2SO_4/t) and FOH843 (ANC of 80 kg H_2SO_4/t), respectively. The pH curve of the samples decreases from the beginning of the test and the results show that about 45 and 47% of the ANC of these samples, respectively, is readily available.

The results suggest that the ANC of the MacLeod Member samples comprises variable carbonate forms. For the samples that had ANC dominated by ferroan dolomite/ siderite, the readily available portion was less than 50% of the total measured ANC. For the sample that had ANC dominated by dolomite/ ferroan dolomite, about 85% of the ANC was readily available.

3.3.6 Nammuldi

The ABCC plots of samples FOH852, FOH853, FOH858 and FOH416 are presented in Figures 7, 8, 12 and 13, respectively. The samples have an ANC of 11, 44, 35 and 20 kg H_2SO_4/t, respectively and are represented in the plots by green triangles.

Figure 7 presents the ABCC plot of sample FOH852, that has an ANC of 11 kg H_2SO_4/t. The results show that the pH curve drops from the beginning of the test and plots close to the dolomite standard curve. All of the ANC of this sample is readily available.

The ABCC plot of sample FOH853 is presented in Figure 8 and shows that the sample has a pH plateau above 6 before decreasing. The sample pH curve plots close to the dolomite standard curve and the results indicate that all of the ANC of this sample is readily available.

Figure 12 presents the ABCC plot of sample FOH858, which has an ANC of 35 kg H_2SO_4/t. The pH curve of the sample plots close to the ferroan dolomite standard curve and the results suggest that 95% of the ANC of this sample is readily available.

Figure 13 presents the ABCC plot of sample FOH416, which has an ANC of 20 kg H_2SO_4/t. The pH curve drops from the beginning of the test and plots between the ferroan dolomite and siderite standards. About 65% of the ANC of this sample was readily available.

The results suggest that the carbonates in the Nammuldi Member samples are dominated by minerals similar to ferroan dolomite and dolomite. Between 65 and 100% of the measured ANC of these samples is readily available.

3.3.7 Summary

Generally at least 70% of the ANC of the West Angela Member, detrital, Nammuldi Member and clay samples was readily available and the ANC of the samples was similar to carbonates such as calcite, dolomite and ferroan dolomite. Generally less than 50% of the ANC of the MacLeod Member and Newman samples was readily available, with carbonates being similar to ferroan dolomite and siderite.

3.4 Sequential Net Acid Generation (NAG)

When testing samples with high sulphide contents it is common for oxidation to be incomplete in the single addition NAG test. Sequential NAG testing overcomes this limitation to an extent through successive additions of peroxide to the same sample.

Four samples with total S contents ranging from 0.55 to 1.96%S, underwent sequential NAG testing and the results are presented in Table 4.

Three of the samples were detrital samples (FQD687, FQD908 and FOM528) and had positive NAPP values, but NAGpH greater than 4.5, indicating that they were uncertain. The samples did not acidify even after four stages and have been classified as uncertain, but likely to be non-acid forming, i.e., UC(NAF). The sequential NAG test results for samples FQD687 and FOM528 support the S speciation results, which indicated that the majority of the sulphur within these two samples was not in the form of reactive pyrite.

One Newman sample, FQR860, had a total S content of 1.22%S. The sample underwent four sequential NAG stages, with most of the acidity being generated in the first stage. The cumulative sequential NAG acidity to pH 7.0 to NAPP ratio is 1.3. This suggests that all the sulphur within the sample is in the form of reactive pyrite.

3.5 Sulphide Reactivity

The kinetic NAG procedure was used to gain an insight into the reactivity of sulphides within a selection of samples classified as PAF and PAF-LC. Whilst kinetic NAG testing is not a replacement for column leach tests, the profiles obtained by the accelerated procedure provide a qualitative estimate of the lag period[2] to the extent that acidification of PAF rock is likely to occur rapidly (weeks to months), within the short term (many months to one or two years), or medium to long term (many years).

Four (4) PAF-LC and 1 PAF sample were selected for kinetic NAG testing and the results are presented in Figures 14 to 18.

2 The lag times provided in this report should be used as a guide only and are based on correlations previously derived by EGi from comparison of kinetic NAG profiles with results from real time testing of the same materials (*e.g.* leach column tests) and field observations across a wide range of rock types at actual mine sites.

Figures 14 presents the kinetic NAG plot for sample FRK244 (West Angela Member), which has a total S content of 0.17%S. The results show that the pH curve starts below 4, suggesting that materials represented by this sample will have a short lag period of months to a year before onset of acid conditions. The shape of the curve suggests that the sulphides within the sample are only slowly reactive.

Figures 15 and 16 present the kinetic NAG plot of samples FT114 and FRK393, respectively. Both samples have a low total S content of 0.1%S. The pH profile of sample FT114 remained above a pH of 4 for the duration of the test, suggesting that materials represented by this sample will likely have a long lag period. The pH curve of sample FRK393 starts below a pH of 4. Due to the low total S content of these samples, the results suggest that although these samples may develop low pH conditions, the acid load would be negligible.

Figure 17 presents the kinetic NAG plot of PAF sample FQR860 (Newman Member) and shows that the pH curve quickly drops below pH 4 at the beginning of the test. The results suggest that materials represented by this sample will have a lag period of weeks to months before onset of acid conditions. The shape of the pH and temperature curve also suggest that materials represented by this sample are moderately reactive.

Figure 18 presents the kinetic NAG plot of sample FOH416 (Nammuldi Member). The results show that pH curve remained between 4 to 4.5 for the duration of the testing procedure, suggesting that materials represented by this sample would likely have a long lag period of two or more years before onset of acid conditions.

3.6 Elemental Composition

To provide some relativity to the multi-element data, the compositions of the solids were compared to typical background concentrations reported for soil and the Earth's crust. The purpose of this comparison was to highlight any elements that were significantly enriched, especially elements that are generally regarded as environmentally important. The comparison is expressed as a Geochemical Abundance Index (GAI), which relates enrichment to the median soil abundance value using the formula:

$$GAI = \log_2 [C / (1.5*S)]$$

where C is the concentration of the element in the sample and S is the median soil[3] content for that element. GAIs are truncated to integer increments (0 through to 6, respectively) where a GAI of 0 indicates the element is present at a concentration similar to, or less than, median soil abundance and a GAI of 6 indicates approximately a 100-fold, or

[3] References for median soil data were: (1) Bowen, H.J.M. (1997) Environmental Chemistry of the Elements. Academic Press, London. (2) Berkman, D.A. (1976) Field Geologists' Manual, The Australian Institute of Mining and Metallurgy, Parkville, Victoria, Australia

greater, enrichment above median soil abundance. The enrichment ranges for the GAI are as follows:

Little or No Enrichment	GAI=0	< 3 times median soil
Minor Enrichment	GAI=1	3 to <6 times median soil
	GAI=2	6 to <12 times median soil
Significant Enrichment	GAI=3	12 to <24 times median soil
	GAI=4	24 to <48 times median soil
	GAI=5	48 to <96 times median soil
	GAI=6	≥ 96 times median soil

Twenty (20) samples were selected for elemental assays and covered the different sample types, S contents, ANC, NAPP values and ARD classifications. Table 5 presents the elemental composition of the solids, Table 6 presents the GAI with results compared against the median soil abundance and Table 7 presents the GAI with results compared against mean crustal abundance.

The table below presents a summary of the elements that are significantly enriched (GAI ≥ 3) in at least one of the samples compared with median soil and mean crustal abundance.

The results show that As, Be, Fe, S, Tl and V are significantly enriched in at least one of the samples tested when compared with median soil abundance and that As, Bi, Fe, S, Sb and Se are significantly enriched in at least one of the samples tested when compared with mean crustal abundance.

Other metals and metalloids in which at least one sample had minor enrichment (GAI = 1 or 2) compared with median soil and mean crustal abundance included Ag, Cd, Co, Cr, Cs, Cu, Ge, Hg, In, Hg, Li, Mn, Mn, Na, Ni, Pb, Sc, Tl, U, V, W and Zn.

Overall, the elements of potential environmental concern that are likely to be significantly enriched in West Angelas waste rock are As, Sb and Se.

Iron (Fe) was also significantly enriched, but the application of world soil and crustal abundances data for Fe in the Pilbara region is unrepresentative of regional soils and surface materials and hence this enrichment is of no local environmental concern. Ideally, element enrichment is based on data for regional soils, but in the absence of these data it is necessary to use the published values.

Strand	Numbers of Samples Assayed	Median Soil (GAI ≥ 3)	Mean Crustal (GAI ≥ 3)
Detrital	5	As, Fe, S and V	As, Bi, Fe, S, Sb and Se
Clay	1	Be and Fe	As, Bi, Fe, Sb, and Se
Pisolite/Detrital	1	Fe	As, Fe, Sb and Se
West Angela	4	As and Fe	As, Bi, Fe, Sb and Se
Newman	4	Fe, S and Tl	As, Fe, S, Sb and Se
MacLeod	3	Fe and S	As, Fe, S and Se
Nammuldi	2	S	S and Se

To evaluate element solubility, the same samples that underwent multi-element scans on solids also underwent multi-element analyses of water extracts to provide an indication of the immediate solubility of environmentally important elements.

The results are presented in Table 8 and show that all samples except West Angela sample FRK244 had a circum-neutral to alkaline $pH_{1:2}$ ranging from 6.7 to 8.4. Sample FRK244 had a pH of 5.8. The samples were also non-saline to slightly saline with $EC_{1:2}$ of 0.13 to 0.73 dS/m.

At the time of testing there was some solubility of Co, Fe, Mn, Ni and Zn generally in samples that were classified as PAF and PAF-LC. Sample FQR487 (Newman Member, PAF-LC) had slight solubility of Co (0.6 mg/l), Cu (0.1 mg/l), Fe (1.5 mg/l), Mn (1.6 mg/l), Ni (0.7 mg/l) and Zn (1.0 mg/l).

Newman sample FQR860 is classified as PAF and had slight solubility of Co (0.2 mg/l), Cu (0.03 mg/l), Fe (0.1 mg/l), Mn (0.1 mg/l) Ni (0.1 mg/l) and Zn (0.2 mg/l).

Manganese was also slightly soluble in PAF-LC samples FRK244 (West Angela – 0.4 mg/l) and FNC936 (Clay – 1.4 mg/l). Sample FRK244, also had slightly soluble Zn (0.17 mg/l).

Concentrations of Fe in samples FOD662 (MacLeod) and FRD872 (Pisolite/detrital) were 0.2 and 0.3 mg/l, respectively. Both these samples were classified as UC(NAF).

Note that Al, Cu, Fe, Ni and Zn are not usually soluble at circum-neutral to alkaline pH. It is likely that the concentrations observed in the samples are colloidal forms and not dissolved. Generally the concentration of environmentally important elements were at low concentrations or below the detection limit. In all samples, the major cations in solution were Ca, Mg and Na and the major anions were Cl and SO_4.

4.0 Criteria for Identifying PAF Material Types

The results indicate that 8% of the samples tested were potentially acid forming (PAF and PAF-LC) and that all these samples had a total S content greater than or equal to 0.1%S. If a total S cut off of 0.1%S was used for operational identification of PAF material types, there would be the potential to misclassify a large proportion of non-acid forming material types as PAF. Approximately 62% of the samples classified as PAF using this cut off criteria would actually be NAF.

Figure 19 presents a box plot of total S split by ARD classification (note that all UC(NAF) samples have been grouped in with the NAF classification). The plot shows a full overlap in total S values for the PAF/PAF-LC samples and the NAF samples. This indicates that using total sulphur as the sole criteria for identifying PAF material types would be overly conservative and unreliable. This is in part due to the high content of non-acid forming sulphur forms in the samples tested (see Section 3.2).

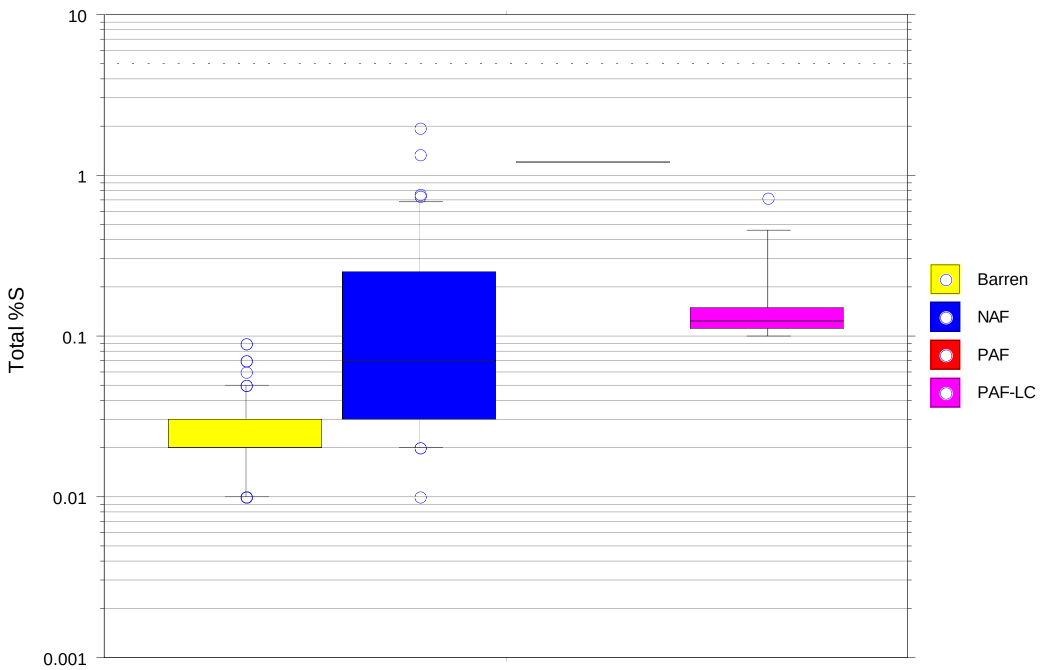


Figure 19: Total S content split by ARD classification.

Figure 20 is a plot of total S vs NAGpH, with samples split by ARD classification. A line showing where the NAGpH = 4.5 is also plotted. Note that all UC(NAF) samples have been included in the NAF classification. The results show that above a NAGpH of 4.5, all the samples are either barren or NAF. Below a NAGpH of 4.5, all but one of the samples is classified as PAF or PAF-LC. Using this NAGpH cut off reduces the misclassification of material types markedly. Roughly 8% of the samples classified as PAF using this NAGpH cutoff would be non-acid generating.

The results indicate that NAGpH can be used for operational identification of PAF material types at West Angelas Mine. The criteria can be further refined by applying a total S grade as follows:

- Barren: Total %S < 0.1%S;
- NAF: Total %S ≥ 0.1%S AND NAGpH ≥ 4.5;
- PAF-LC: 0.1%S < Total %S ≤ 1%S AND NAGpH <4.5;
- PAF: Total %S > 1%S AND NAGpH <4.5.

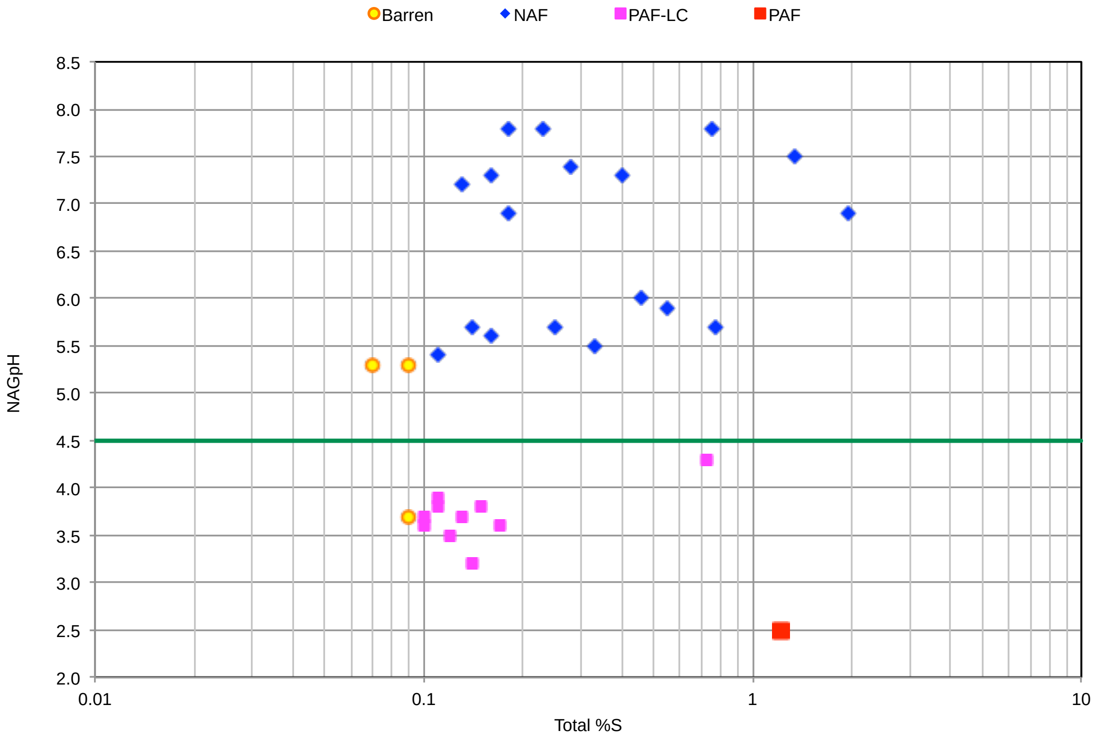


Figure 20: Total S vs NAGpH, split by ARD classification.

5.0 Discussion and Recommendations

Testing has been conducted on seven different waste rock types from two deposits of the West Angelas Mine and indicates that 79% of the samples have a low total S content less than 0.1%S and 71% have a low acid neutralising capacity (ANC) less than 5 kg H_2SO_4/t. About two thirds of the samples (66%) were NAPP negative and one third (34%) were NAPP positive.

The majority of the samples lacked ANC, however, the readily available portion of ANC for samples with greater than 10 kg H_2SO_4/t was variable. Testing of selected samples showed that generally, between 70 to 100% of the ANC the West Angela Member, detrital and Nammuldi Member samples was readily available. The readily available portion of ANC of the MacLeod and Newman Member samples was less than 50%.

Sulphur speciation testing also indicated that for all but one of the samples selected, the majority of the sulphur occurs in non-acid generating forms. Results suggested that the total S content of samples from West Angela Mine can not be used reliably as a criteria for identifying PAF material types at the West Angela Mine.

Similarly, comparison of ANC with CNV (calculated from total inorganic C), showed good correlation between ANC and CNV for samples with an ANC less than 50 kg H_2SO_4/t and occasional samples with ANC greater than 50 kg H_2SO_4/t. However for most samples with higher ANC, the CNV calculation is significantly greater than the measured ANC content. The results indicated that the carbon content of the samples could not be reliably used to identify high ANC material types during operation.

Materials represented by the samples may have elevated concentrations of As, Be, Fe, S, Tl and V, however, the solubility of most of these elements at circum-neutral pH was low for the samples that were tested.

Due to the low acid generating capacity of the PAF-LC samples, and low solubility of environmentally important elements, it is unlikely that column leach testing will yield any additional information for waste management operations.

Overall, 92% of the samples are classified as barren or non-acid forming (NAF) and 8% potentially acid forming (PAF or PAF-LC).

The following criteria may be used for operational identification of PAF material types:

- Barren: Total %S $<$ 0.1%S;
- NAF: Total %S $\geq$ 0.1%S AND NAGpH $\geq$ 4.5;
- PAF-LC: 0.1%S $<$ Total %S $\leq$ 1%S AND NAGpH $<$ 4.5;
- PAF: Total %S $>$ 1%S AND NAGpH $<$ 4.5.

It is recommended that a program of identification, segregation and selective placement be carried out for PAF/PAF-LC material types. If identified as occurring in-pit the material should be selectively placed and encapsulated using appropriate design techniques.

Table 1: Acid forming characteristics of samples from the West Angelas Deposits.

Sample ID	Hole ID	Strand	$pH_{1:2}$	$EC_{1:2}$	ACID-BASE ANALYSIS					NAG TEST			ARD Classification
					Total %S	MPA	ANC	NAPP	ANC/MPA	NAGpH	$NAG_{(pH4.5)}$	$NAG_{(pH7.0)}$	
FNH400	GC12WAB0011	ANG	6.2	0.20	0.05	2	1	1	0.6				Barren
FOH880	GR12WAB0015	ANG	6.5	0.19	0.04	1	1	-0.2	1.2				Barren
FNH979	GR12WAB0016	ANG	6.4	0.18	0.03	1	1	0.2	0.8				Barren
FQP208	GR12WAB0019	ANG	6.7	0.17	0.13	4	1	3	0.1	7.2	0	0	UC (NAF)
FOG166	PZ12WAB0003	ANG	7.2	0.19	0.02	1	1	-1	1.9				Barren
EYT840	RC12WAB0001	ANG	7.3	0.17	0.04	1	212	-210	172.9				NAF
EYT978	RC12WAB0002	ANG	7.5	0.17	0.03	1	2	-1	1.7				Barren
FOH147	RC12WAB0004	ANG	6.2	0.17	0.03	1	2	-1	1.8				Barren
FOG458	RC12WAB0019	ANG	6.0	0.16	0.03	1	3	-2	3.5				Barren
FNC939	RC12WAB0044	ANG	5.1	0.17	0.15	5	0	5	0.0	3.8	1	3	PAF-LC
FRK244	RC12WAB0057	ANG	6.7	0.20	0.17	5	0	5	0.0	3.6	1	7	PAF-LC
FRK412	RC12WAB0061	ANG	6.8	0.21	0.13	4	0	4	0.0	3.7	1	7	PAF-LC
FRK702	RC12WAB0066	ANG	7.2	0.15	0.11	3	1	3	0.2	3.9	0.2	6	PAF-LC
FRK778	RC12WAB0067	ANG	7.5	0.14	0.10	3	0	3	0.0	3.7	1	7	PAF-LC
FQC572	RC12WAD0071	ANG	7.4	0.14	0.02	1	3	-2	4.3				Barren
FQR337	RC12WAD0082	ANG	7.2	0.13	0.02	1	1	-0.4	1.6				Barren
FQD245	RC12WAD0180	ANG	7.3	0.13	0.16	5	2	3	0.3	5.6	0	6	UC (NAF)
FOM740	RC12WAD0241	ANG	6.6	0.23	0.03	1	2	-1	2.1				Barren
FOM940	RC12WAD0244	ANG	6.7	0.20	0.03	1	297	-297	324.1				NAF
FOM276	RC12WAD0245	ANG	6.8	0.26	0.01	0	1	-1	4.6				Barren
FRI027	RC12WAD0250	ANG	7.3	0.18	0.01	0	1	-1	4.8				Barren
FRC036	RC12WAD0302	ANG	7.2	0.17	0.01	0	5	-5	16.0				Barren
FRN248	RC12WAD0337	ANG	7.4	0.18	0.04	1	1	0.0	1.0				Barren
FRI159	RC12WAD0351	ANG	7.5	0.17	0.03	1	1	-0.2	1.3				Barren
FRI220	RC12WAD0352	ANG	7.2	0.19	0.03	1	27	-26	29.7				NAF
FQP163	RC12WAD0379	ANG	7.3	0.19	0.01	0	4	-4	12.5				Barren
FRL667	RC12WAD0392	ANG	7.2	0.18	0.04	1	1	-0.1	1.1				Barren
FRM291	RC12WAD0403	ANG	7.1	0.14	0.02	1	2	-1	2.9				Barren
FQI265	RC12WAD0121	ANG	7.7	0.13	0.02	1	1	-0.1	1.2				Barren

Table 1: Acid forming characteristics of samples from the West Angelas Deposits.

Sample ID	Hole ID	Strand	$pH_{1:2}$	$EC_{1:2}$	ACID-BASE ANALYSIS					NAG TEST			ARD Classification
					Total %S	MPA	ANC	NAPP	ANC/MPA	NAGpH	$NAG_{(pH4.5)}$	$NAG_{(pH7.0)}$	
FNH002	GC12WAB0010	DET	7.5	0.38	0.06	2	1	1	0.4				Barren
FNC563	GR12WAB0007	DET	7.4	0.56	0.05	2	45	-43	29.2				NAF
EYT986	RC12WAB0003	DET	6.6	0.82	0.07	2	5	-3	2.3				Barren
FOH078	RC12WAB0004	DET	7.2	0.73	0.03	1	6	-5	6.6				NAF
FOH267	RC12WAB0006	DET	6.8	0.61	0.04	1	4	-3	3.3				Barren
FOG706	RC12WAB0016	DET	6.8	0.98	0.07	2	2	-0.3	1.1				Barren
FOG751	RC12WAB0020	DET	6.7	0.98	0.03	1	7	-6	7.5				NAF
ELO107	RC12WAB0023	DET	7.5	1.15	0.02	1	18	-17	28.8				NAF
FNH447	RC12WAB0046	DET	7.3	0.35	0.05	2	1	0.3	0.8				Barren
FRK397	RC12WAB0061	DET	7.5	0.23	0.09	3	2	1	0.7	5.3	0	1	Barren
FTI114	RC12WAB0071	DET	7.2	0.24	0.11	3	1	3	0.2	3.8	0.3	5	PAF-LC
FOD371	RC12WAD0015	DET	7.4	0.25	0.01	0	6	-6	19.8				NAF
FQU141	RC12WAD0036	DET	6.5	0.27	0.02	1	2	-1	3.3				Barren
FQU511	RC12WAD0047	DET	7.3	0.29	0.02	1	5	-4	7.9				Barren
FQH537	RC12WAD0063	DET	7.4	0.20	0.03	1	8	-7	8.6				NAF
FQR817	RC12WAD0089	DET	7.2	0.19	0.03	1	38	-37	41.4				NAF
FQR914	RC12WAD0090	DET	7.3	0.18	0.11	3	3	0.2	0.9	5.4	0	6	UC (NAF)
FRD062	RC12WAD0092	DET	6.7	0.34	0.02	1	89	-89	146.1				NAF
FQL196	RC12WAD0103	DET	6.8	0.28	0.02	1	8	-7	13.0				NAF
FQL391	RC12WAD0106	DET	7.4	0.13	0.04	1	2	-1	1.5				Barren
FQL434	RC12WAD0107	DET	6.6	0.43	0.02	1	4	-4	7.2				Barren
FQI466	RC12WAD0124	DET	7.3	0.18	0.01	0	0	0.3	0.0				Barren
FQI876	RC12WAD0132	DET	6.8	0.38	0.03	1	1	0.2	0.7				Barren
FQI965	RC12WAD0133	DET	6.7	0.39	0.02	1	1	-1	2.0				Barren
FQD642	RC12WAD0189	DET	6.6	0.29	0.03	1	3	-2	3.3				Barren
FQD687	RC12WAD0190	DET	6.3	0.18	0.77	24	2	22	0.1	5.7	0	5	UC (NAF)
FQD851	RC12WAD0194	DET	6.6	0.38	0.25	8	2	6	0.3	5.7	0	6	UC (NAF)
FQD908	RC12WAD0195	DET	6.7	0.38	0.55	17	3	14	0.2	5.9	0	4	UC (NAF)
FOM528	RC12WAD0237	DET	6.5	0.44	1.96	60	1	59	0.0	6.9	0	0	UC (NAF)
FRH604	RC12WAD0260	DET	6.8	0.52	0.03	1	1	-0.4	1.4				Barren
FQQ766	RC12WAD0284	DET	7.5	0.14	0.01	0	1	-0.5	2.5				Barren

Table 1: Acid forming characteristics of samples from the West Angelas Deposits.

Sample ID	Hole ID	Strand	$pH_{1:2}$	$EC_{1:2}$	ACID-BASE ANALYSIS					NAG TEST			ARD Classification
					Total %S	MPA	ANC	NAPP	ANC/MPA	NAGpH	$NAG_{(pH4.5)}$	$NAG_{(pH7.0)}$	
FRI928	RC12WAD0331	DET	6.7	0.30	0.03	1	1	-0.2	1.2				Barren
FRM221	RC12WAD0402	DET	7.5	0.17	0.02	1	12	-11	19.4				NAF
FQD434	RC12WAD0185	DET	8.2	0.17	0.03	1	1	-0.1	1.1				Barren
FQI158	RC12WAD0120	DET	7.6	0.13	0.02	1	2	-1	2.7				Barren
FRF768	RC12WAD0290	DET	7.6	0.20	0.03	1	2	-1	2.1				Barren
FRG099	RC12WAD0320	DET	8.1	0.19	0.02	1	4	-3	6.3				Barren
FNC467	GR12WAB0005	MAC	7.6	0.18	0.02	1	40	-39	65.1				NAF
FOG016	GR12WAB0010	MAC	7.7	0.19	0.02	1	1	-0.1	1.1				Barren
FOG079	GR12WAB0011	MAC	7.8	0.19	0.03	1	0	1	0.0				Barren
FOG111	GR12WAB0011	MAC	8.1	0.44	1.35	41	144	-103	3.5	7.5	0	0	NAF
FRF052	GR12WAB0017	MAC	7.9	0.38	0.02	1	2	-1	3.1				Barren
FRF127	GR12WAB0018	MAC	7.4	0.39	0.02	1	1	-1	1.8				Barren
FQP332	GR12WAB0020	MAC	7.5	0.39	0.03	1	27	-26	29.2				NAF
FTI083	GR12WAB0040	MAC	7.6	0.28	0.02	1	3	-2	4.2				Barren
FOH824	PZ12WAB0002	MAC	7.8	0.29	0.02	1	26	-25	41.8				NAF
FOH843	PZ12WAB0002	MAC	7.7	0.15	0.75	23	80	-57	3.5	7.8	0	0	NAF
FOH357	RC12WAB0007	MAC	7.8	0.23	0.03	1	2	-1	2.5				Barren
FOH454	RC12WAB0009	MAC	7.6	0.21	0.02	1	1	-0.3	1.4				Barren
FNH063	RC12WAB0041	MAC	7.7	0.15	0.09	3	0	3	0.0	3.7	1	6	Barren *
FRK393	RC12WAB0060	MAC	7.5	0.16	0.10	3	0	3	0.0	3.6	1	9	PAF-LC
FOD662	RC12WAD0023	MAC	7.4	0.14	0.33	10	1	9	0.1	5.5	0	4	UC (NAF)
FQU326	RC12WAD0041	MAC	7.3	0.13	0.01	0	0	0.3	0.0				Barren
FQU497	RC12WAD0046	MAC	7.4	0.15	0.01	0	1	-1	3.7				Barren
EYA261	RC12WAD0156	MAC	7.5	0.13	0.03	1	1	-1	1.6				Barren
FQD428	RC12WAD0184	MAC	7.1	0.13	0.01	0	1	-1	3.5				Barren
FRE007	RC12WAD0222	MAC	7.2	0.14	0.02	1	1	-1	2.1				Barren
FRE033	RC12WAD0223	MAC	7.3	0.15	0.02	1	1	-0.5	1.8				Barren
FRE144	RC12WAD0228	MAC	7.4	0.14	0.05	2	1	1	0.6				Barren
FRH588	RC12WAD0259	MAC	6.7	0.18	0.03	1	1	-0.3	1.3				Barren
FRH384	RC12WAD0254	MAC	7.6	0.16	0.02	1	2	-1	2.6				Barren

Table 1: Acid forming characteristics of samples from the West Angelas Deposits.

Sample ID	Hole ID	Strand	$pH_{1:2}$	$EC_{1:2}$	ACID-BASE ANALYSIS					NAG TEST			ARD Classification
					Total %S	MPA	ANC	NAPP	ANC/MPA	NAGpH	$NAG_{(pH4.5)}$	$NAG_{(pH7.0)}$	
FOH925	RC12WAB0014	N2L	6.8	0.19	0.02	1	2	-1	3.0				Barren
FTI134	RC12WAB0071	N2L	6.1	0.19	0.02	1	1	0.0	1.0				Barren
FQC173	RC12WAD0051	N2L	7.6	0.15	0.04	1	4	-2	3.0				Barren
FRM591	RC12WAD0410	N2L	7.5	0.16	0.01	0	0	0.3	0.0				Barren
FOG379	RC12WAB0018	N2U	7.7	0.16	0.02	1	1	-1	2.1				Barren
FQR487	RC12WAD0084	N2U	7.8	0.16	0.14	4	0	4	0.0	3.2	3	5	PAF-LC
FQI655	RC12WAD0127	N2U	7.6	0.19	0.01	0	1	-0.3	2.1				Barren
FRE655	RC12WAD0211	N2U	8.3	0.18	0.04	1	1	0.2	0.8				Barren
FRE775	RC12WAD0214	N2U	7.4	0.22	0.01	0	0	0.3	0.0				Barren
FRI612	RC12WAD0360	N2U	7.5	0.25	0.02	1	3	-2	4.2				Barren
FNJ868	RC12WAB0031	NE1	7.5	0.14	0.03	1	1	0.1	0.9				Barren
FNJ933	RC12WAB0035	NE1	6.6	0.15	0.03	1	0	1	0.0				Barren
FRK375	RC12WAB0059	NE1	6.7	0.15	0.02	1	0	1	0.0				Barren
FRK446	RC12WAB0061	NE1	6.5	0.16	0.02	1	0	1	0.0				Barren
FRN514	RC12WAD0346	NE1	6.4	0.18	0.02	1	1	-0.2	1.3				Barren
FNC423	GR12WAB0004	NEW	6.5	0.19	0.02	1	1	-0.2	1.3				Barren
FNC425	GR12WAB0004	NEW	7.3	0.14	0.01	0	0	0.3	0.0				Barren
FOH244	RC12WAB0005	NEW	7.4	0.13	0.03	1	2	-1	1.7				Barren
FOG272	RC12WAB0015	NEW	7.2	0.12	0.02	1	1	-0.1	1.2				Barren
EYJ632	RC12WAB0054	NEW	7.1	0.14	0.02	1	0	1	0.0				Barren
FTI023	RC12WAB0074	NEW	7.6	0.15	0.02	1	0	1	0.0				Barren
FQC936	RC12WAD0076	NEW	7.5	0.16	0.01	0	0	0.3	0.0				Barren
FQR860	RC12WAD0089	NEW	7.3	0.17	1.22	37	0	37	0.0	2.5	21	34	PAF
FRD106	RC12WAD0092	NEW	7.2	0.13	0.05	2	2	-1	1.6				Barren
EYA807	RC12WAD0169	NEW	7.2	0.14	0.02	1	0	1	0.0				Barren
EYA871	RC12WAD0171	NEW	7.4	0.15	0.03	1	3	-2	3.0				Barren
FQD221	RC12WAD0179	NEW	7.7	0.13	0.02	1	1	-1	2.3				Barren
FRH214	RC12WAD0251	NEW	8.2	0.13	0.07	2	0	2	0.0	5.3	0	5	Barren
FRM103	RC12WAD0295	NEW	7.8	0.14	0.03	1	14	-13	15.0				NAF
FRM113	RC12WAD0295	NEW	7.9	0.15	0.14	4	12	-8	2.8	5.7	0	0	NAF

Table 1: Acid forming characteristics of samples from the West Angelas Deposits.

Sample ID	Hole ID	Strand	pH$_{1:2}$	EC$_{1:2}$	ACID-BASE ANALYSIS					NAG TEST			ARD Classification
					Total %S	MPA	ANC	NAPP	ANC/MPA	NAGpH	NAG$_{(pH4.5)}$	NAG$_{(pH7.0)}$	
FOH848	PZ12WAB0002	NAM	7.6	0.25	0.09	3	12	-10	4.5				NAF
FOH851	PZ12WAB0002	NAM	7.4	0.30	0.28	9	39	-30	4.6	7.4	0	0	NAF
FOH852	PZ12WAB0002	NAM	6.8	0.19	0.40	12	11	1	0.9	7.3	0	0	UC (NAF)
FOH853	PZ12WAB0002	NAM	7.3	0.18	0.23	7	44	-37	6.3	7.8	0	0	NAF
FOH857	PZ12WAB0002	NAM	7.2	0.18	0.16	5	8	-3	1.5	7.3	0	0	NAF
FOH858	PZ12WAB0002	NAM	6.7	0.16	0.18	6	35	-29	6.3	7.8	0	0	NAF
FOH416	RC12WAB0008	NAM	7.4	0.13	0.73	22	20	3	0.9	4.3	0.2	3	PAF-LC
FOH417	RC12WAB0008	NAM	7.2	0.13	0.18	6	10	-4	1.8	6.9	0	0	NAF
EYT775	RC12WAB0001	CLA	7.5	0.14	0.04	1	8	-7	6.4				NAF
EYT782	RC12WAB0001	CLA	7.3	0.39	0.03	1	10	-9	10.8				NAF
EYT925	RC12WAB0002	CLA	7.4	0.42	0.03	1	2	-1.43	2.6				Barren
FNC936	RC12WAB0044	CLA	7.3	0.33	0.12	4	0	4	0.0	3.5	1	5	PAF-LC
FRD872	RC12WAD0270	PI	7.5	0.21	0.46	14	3	11	0.2	6.0	0	4	UC (NAF)
FRL157	RC12WAD0385	PI	7.5	0.17	0.03	1	2	-0.69	1.7				Barren
FRL097	RC12WAD0384	PI	7.4	0.34	0.02	1	3	-3	5.6				Barren

KEY

pH$_{1:2}$ = pH of 1:2 extract

EC$_{1:2}$ = Electrical Conductivity of 1:2 extract (dS/m)

MPA = Maximum Potential Acidity (kgH$_2$SO$_4$/t)

ANC = Acid Neutralising Capacity (kgH$_2$SO$_4$/t)

NAPP = Net Acid Producing Potential (kgH$_2$SO$_4$/t)

ANG = West Angela Member

CLA = Clay

DET = Detrital

MAC = Macleod Member

NAM = Nammuldi Member

PI = Pisolite/Detrital

N2L, N2U, NE1, NEW = Newman Member

NAGpH = pH of NAG liquor

NAG$_{(pH4.5)}$ = Net Acid Generation capacity to pH 4.5 (kgH$_2$SO$_4$/t)

NAG$_{(pH7.0)}$ = Net Acid Generation capacity to pH 7.0 (kgH$_2$SO$_4$/t)

NAF = Non-Acid Forming

Barren = Total S < 0.1%S and ANC ≤ 5 kg H2SO4/t

Barren* = Total S < 0.1%S and ANC ≤ 5 kg H2SO4/t, Low NAGpH (NAGpH < 4.5) due to dissolution and oxidation of iron (see section 3.3.1)

PAF = Potentially Acid Forming

PAF-LC = PAF - lower capacity

UC = Uncertain Classification

(expected classification in brackets)

Table 2: Carbon forms results for selected samples.

Sample ID	Hole ID	Strand	Carbon Forms Results				
			Total %C	Organic %C	Total Inorg %C	CNV (kg H_2SO_4/t)	ANC (kg H_2SO_4/t)
EYT840	RC12WAB0001	ANG	4.39	0.37	4.02	328	212
FOM940	RC12WAD0244	ANG	3.64	0.10	3.54	289	297
FRI220	RC12WAD0352	ANG	0.52	0.17	0.35	29	27
EYT782	RC12WAB0001	CLA	0.61	0.50	0.11	9	10
FNC563	GR12WAB0007	DET	0.56	0.14	0.42	34	45
ELO107	RC12WAB0023	DET	0.22	0.10	0.12	10	18
FRD062	RC12WAD0092	DET	1.17	0.10	1.07	87	89
FNC467	GR12WAB0005	MAC	0.64	0.20	0.44	36	40
FOG111	GR12WAB0011	MAC	3.57	0.09	3.48	284	144
FQP332	GR12WAB0020	MAC	0.26	0.05	0.21	17	27
FOH843	PZ12WAB0002	MAC	2.59	0.65	1.94	158	80
FOH852	PZ12WAB0002	NAM	1.61	0.16	1.45	118	11
FOH858	PZ12WAB0002	NAM	1.22	0.12	1.10	90	35
FOH416	RC12WAB0008	NAM	2.22	0.59	1.63	133	20
FRM113	RC12WAD0295	NEW	0.09	0.03	0.06	5	12

Table 3: Sulphur speciation results for selected samples

EGi Sample Number	Sample ID	Strand	Total %S	Pyritic S (%)	Acid Sulphate %S	Total Acid Generating S (%)	Other S Forms (%)
6672	FRK244	ANG	0.17	<0.02	0.07	0.08	0.09
6704	FTI114	DET	0.12	<0.02	0.01	0.02	0.10
6719	FQD687	DET	0.77	<0.02	0.00	0.01	0.76
6722	FOM528	DET	1.96	<0.02	0.01	0.02	1.94
6741	FOD662	MAC	0.28	<0.02	0.00	0.01	0.27
6780	FQR860	NEW	1.22	1.06	0.02	1.08	0.14
6791	FRD872	PI	0.17	<0.02	0.00	0.01	0.16

Pyritic S (%) = CRS (%)

Acid Sulphate S = KCl Acid Sulphate S

Total Acid Generating S = Pyritic S + Acid Sulphate S

Other S Forms = Total S - Total Acid Generating S

Table 4: Sequential NAG test results.

Client Code	Total S (%)	ANC	NAPP	STAGE 1			STAGE 2			STAGE 3			STAGE 4			Total Seq. NAG to pH 4.5	Total Seq. NAG to pH 7.0	Total Seq. NAG to NAPP Ratio
				NAGpH	$NAG_{(pH4.5)}$	$NAG_{(pH7.0)}$	NAGpH	$NAG_{(pH4.5)}$	$NAG_{(pH7.0)}$	NAGpH	$NAG_{(pH4.5)}$	$NAG_{(pH7.0)}$	NAGpH	$NAG_{(pH4.5)}$	$NAG_{(pH7.0)}$			
		(kg H_2SO_4/t)			(kg H_2SO_4/t)			(kg H2SO4/t)			(kg H2SO4/t)			(kg H2SO4/t)		(kg H2SO4/t)		
FQD687	0.77	2	22	5.7	-	-	5.5	-	-	5.6	-	-	5.5	-	-	-	-	-
FQD908	0.55	3	14	5.8	-	-	5.6	-	-	5.5	-	-	5.4	-	-	-	-	-
FOM528	1.96	1	59	6.9	-	-	6.2	-	-	5.8	-	-	5.4	-	-	-	-	-
FQR860	1.22	0	37	2.5	22	32	3.0	2	4	3.7	1	4	4.2	0.2	7	25	47	1.3

Table 5: Multi-element composition of selected solids samples (mg/kg except where shown).

Element	Detection Limit	Elemental Composition - Strand/ Sample Code																			
		Detrital					Clay	Pisolite/ Detrital	West Angela Member				Newman Member				MacLeod Member			Nammuldi Member	
		DET	DET	DET	DET	DET	CLA	PI	ANG	ANG	ANG	ANG	N2U	NE1	NEW	NEW	MAC	MAC	MAC	NAM	NAM
		FTI114	FQR817	FQD908	FOM528	FRG099	FNC936	FRD872	FOG458	FRK244	FOM940	FRI220	FQR487	FNJ868	FQR860	FRM113	FOG111	FOH824	FOD662	FOH857	FOH416
Ag	0.01	0.26	0.21	0.1	0.12	0.11	0.08	0.11	0.07	0.37	0.08	0.12	0.03	0.04	0.09	0.05	0.04	0.05	0.08	0.03	0.21
Al	0.01%	3.77%	6.51%	6.89%	7.69%	8.34%	4.61%	5.83%	5.05%	4.77%	2.03%	3.86%	10.65%	0.66%	7.17%	6.26%	0.42%	0.24%	2.73%	0.38%	1.19%
As	0.2	86.9	18.2	10.2	23.7	8.4	31.3	14.1	28.1	57.1	58.7	25.0	8.2	2.0	21.7	0.5	2.9	2.0	20.2	2.4	5.9
Ba	10	30	40	30	90	60	30	40	40	30	10	40	<10	<10	10	60	10	10	160	10	50
Be	0.05	1.59	0.49	0.22	0.75	0.65	2.96	0.47	2.3	0.86	0.92	0.64	0.94	0.39	1.1	0.32	1.14	0.92	1.62	1.24	2.16
Bi	0.01	0.42	0.24	0.18	0.63	0.19	0.58	0.27	0.56	0.47	0.29	0.52	0.19	0.1	0.31	0.03	0.06	0.01	0.07	0.09	0.24
Ca	0.01%	0.02%	1.03%	0.16%	0.07%	0.24%	0.01%	0.16%	0.09%	0.01%	5.57%	0.55%	0.03%	0.01%	0.13%	5.75%	2.48%	0.13%	0.10%	0.20%	0.19%
Cd	0.02	0.04	0.83	<0.02	<0.02	0.22	0.09	0.03	0.13	0.02	0.02	0.04	<0.02	0.11	0.36	0.18	0.09	0.04	0.03	0.04	0.08
Ce	0.01	59.9	17.1	4.19	20.6	18.9	62.6	8.02	97.1	21.7	16.3	36.7	10.05	8.49	37.4	12.95	5.92	9.65	10.3	8.81	16.4
Co	0.1	21.8	43.9	6.4	11.0	41.1	18.1	5.5	40.7	9.4	3.5	8.1	9.6	6.8	43.1	52.6	1.9	1.8	4.7	2.2	7.0
Cr	1	46	446	417	111	340	52	218	109	41	66	40	441	7	149	38	7	5	25	11	28
Cs	0.05	0.90	0.14	0.18	0.15	0.85	0.65	0.70	1.10	0.40	0.57	0.22	0.26	0.05	2.09	3.66	4.84	2.15	0.13	4.16	8.14
Cu	0.2	94.5	186	37.8	29.7	165.5	42.6	16.6	44.7	47.5	14.8	18.1	27.3	8.3	76.8	153	13.1	4.3	26.9	7.3	21.7
Fe	0.01%	47.1%	21.8%	37.8%	31.8%	16.1%	43.8%	48.7%	25.1%	44.7%	35.3%	45.2%	2.0%	40.8%	1.7%	11.5%	19.1%	18.9%	43.8%	23.5%	21.4%
Ga	0.05	10.7	34	26	25.9	24.2	11.85	21.2	16.3	13.15	6.27	10.55	24.2	1.22	15.5	14.95	1.79	0.78	2.72	1.12	3.35
Ge	0.05	1.99	0.47	1.09	1.57	0.22	3.69	2.45	1.52	2.14	3.02	7.92	0.05	0.27	0.1	0.18	0.19	0.18	2.36	0.23	0.2
Hf	0.1	1.8	3.3	2.7	4.9	2.8	2.2	2.7	3.2	1.9	0.9	2.3	2.7	0.3	2.4	2.6	0.9	0.2	0.5	0.4	0.8
Hg	0.005	0.04	0.013	0.008	0.036	0.006	0.015	0.007	0.037	0.022	0.049	0.032	0.068	0.013	0.075	0.026	0.01	0.037	0.015	0.028	0.13
In	0.005	0.04	0.329	0.103	0.121	0.187	0.058	0.115	0.058	0.059	0.043	0.048	0.147	0.007	0.106	0.095	0.007	<0.005	0.06	0.009	0.017
K	0.01%	0.15%	0.08%	0.07%	0.22%	0.22%	0.48%	0.06%	0.79%	0.23%	0.01%	0.03%	0.01%	<0.0001	0.07%	1.10%	0.44%	0.06%	0.06%	0.40%	1.10%
La	1	40.0	7.5	2.3	5.8	7.0	36.7	3.5	53.9	5.9	7.4	7.0	5.7	2.5	24.2	4.9	3.4	6.0	4.8	4.6	7.8
Li	0.2	4.0	9.0	4.9	63.6	18.3	5.4	5.0	18.8	2.1	4.5	12.8	29.1	1.2	38.8	13.1	1.2	1.7	1.5	2.1	2.1
Mg	0.01%	0.10%	0.86%	0.16%	0.08%	0.31%	0.15%	0.22%	0.25%	0.10%	3.27%	0.36%	0.02%	0.01%	0.20%	3.33%	1.33%	0.67%	0.09%	1.67%	1.41%
Mn	5	3230	946	125	1180	717	4080	65	6440	1500	300	2330	378	467	30	1490	649	274	198	546	786
Mo	0.05	0.83	1.32	1.92	2.12	1.05	1.44	2.24	0.86	1.15	1.59	0.78	0.47	0.45	1.53	0.34	0.43	0.36	0.52	0.66	0.77
Na	0.01%	0.03%	0.10%	0.20%	0.60%	0.24%	0.02%	0.08%	0.02%	0.02%	0.02%	0.02%	0.03%	0.01%	0.02%	1.53%	0.09%	0.02%	0.11%	0.02%	0.04%
Nb	0.1	3.1	6.8	6.5	8.8	7.1	3.2	7.6	4.1	3.5	2	4.3	6.2	0.7	5.1	3.4	0.7	0.4	1.5	0.7	1.7
Ni	0.2	54	88	39	42	121	66	30	108	38	12	23	45	11	141	51	5	8	22	7	20
P	10	540	280	200	300	270	850	280	840	520	310	510	20	410	50	500	130	310	230	230	140
Pb	0.5	39.3	14.4	11.6	20.1	13.3	18.7	18.4	23.9	23.7	15.8	14.8	9.4	4.0	14.3	1.8	1.9	2.1	11.2	2.2	9.3
Rb	0.1	8.3	2.4	1.4	1.0	7.9	25.7	1.7	21.1	10.4	1.2	1.5	1.1	0.4	7.4	88.8	61.5	27.8	2.7	54.5	154.0
S	0.01%	0.12%	0.03%	0.57%	1.96%	0.01%	0.12%	0.19%	0.01%	0.17%	0.01%	0.02%	0.13%	0.02%	1.33%	0.16%	0.78%	0.01%	0.32%	0.24%	0.89%
Sb	0.05	3.04	1.55	1.12	4.06	0.83	3.06	1.77	3.19	4.46	2.77	2.33	0.75	0.43	1.74	0.10	0.48	0.70	1.55	0.59	0.81
Sc	0.1	19.1	39.9	27.6	24.1	37.8	10.8	20.4	11.5	15.1	9.4	9.6	20.7	1.2	20.2	49.4	1.4	0.9	7.5	1.5	4.3
Se	1	2	3	1	3	1	1	1	1	1	1	1	1	<1	2	1	1	<1	1	<1	1
Sn	0.2	1.4	2.7	1.6	2.6	2.2	1.4	1.9	1.8	1.4	0.7	1.3	1.9	0.2	1.7	0.9	0.3	<0.2	0.7	0.3	0.6
Sr	0.2	3.2	25.6	57.7	233	25.8	8.5	58.3	3.9	1.8	24.7	6.8	1.4	0.3	5.7	96.3	32.4	5.8	54.2	3.6	7.5
Ta	0.05	0.26	0.46	0.47	0.74	0.54	0.28	0.58	0.41	0.29	0.14	0.38	0.47	0.05	0.41	0.22	<0.05	<0.05	0.09	0.05	0.15
Th	0.2	8.9	3.3	4.2	15.8	2.6	8.5	6.5	7.1	9.4	4.4	9.1	3	0.7	4.9	0.3	0.5	0.4	1.8	0.6	1.8
Ti	0.005%	0.13%	0.89%	0.62%	0.48%	0.77%	0.13%	0.47%	0.16%	0.15%	0.07%	0.14%	0.65%	0.03%	0.42%	0.71%	0.02%	0.01%	0.06%	0.03%	0.08%
Tl	0.02	0.08	0.48	<0.02	0.1	0.26	0.13	<0.02	0.16	0.1	<0.02	0.16	0.13	<0.02	4.47	0.23	0.12	<0.02	0.04	0.2	0.43
U	0.10	2.4	0.6	0.8	1.6	0.7	7.3	1	3	2.4	1.4	1.6	1.4	0.4	2	0.1	0.1	0.2	0.8	0.3	0.5
V	1	54	808	424	284	373	60	185	90	74	54	64	332	9	118	352	7	4	26	10	24
W	0.1	1.5	0.5	0.7	3.4	0.7	1.2	1.3	1.4	1.4	0.9	1.8	1.3	1.3	2.3	0.4	0.7	0.3	0.5	1	0.5
Y	0.1	40.5	22.6	2	4.7	15.9	23.1	2.9	32.6	11.2	9.5	10.2	6.5	3.5	31.5	31	7.8	7.3	6.6	6.1	7
Zn	2	29	189	5	8	194	72	15	243	39	34	32	75	49	174	142	12	19	52	27	51
Zr	0.5	65.5	115	94.1	180	91.6	84.4	95.8	120	74.5	37.5	87	93.7	11.9	89.2	97.2	46.3	8.9	20.2	17	33.9

< element at or below analytical detection limit.

Table 6: Geochemical abundance indices (GAI) of selected solids samples - Comparison with MEDIAN SOIL ABUNDANCE.

Element	Median Soil Abundance*	Geochemcial Abundance Indices (GAI) - Strand/ Sample Code																			
		Detrital					Clay	Pisolite/ Detrital	West Angela Member				Newman Member				MacLeod Member			Nammuldi Member	
		DET	DET	DET	DET	DET	CLA	PI	ANG	ANG	ANG	ANG	N2U	NE1	NEW	NEW	MAC	MAC	MAC	NAM	NAM
		FTI114	FQR817	FQD908	FOM528	FRG099	FNC936	FRD872	FOG458	FRK244	FOM940	FRI220	FQR487	FNJ868	FQR860	FRM113	FOG111	FOH824	FOD662	FOH857	FOH416
Ag	0.05	2	1	-	1	1	-	1	-	2	-	1	-	-	-	-	-	-	-	-	1
Al	7.1%	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
As	6	**3**	1	-	1	-	2	1	2	**3**	**3**	1	-	-	1	-	-	-	1	-	-
Ba	500	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Be	0.3	2	-	-	1	1	**3**	-	2	1	1	1	1	-	1	-	1	1	2	1	2
Bi	0.2	-	-	-	1	-	1	-	1	1	-	1	-	-	-	-	-	-	-	-	-
Ca	1.5%	-	-	-	-	-	-	-	-	-	1	-	-	-	-	1	-	-	-	-	-
Cd	0.35	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ce	50	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Co	8	1	2	-	-	2	1	-	2	-	-	-	-	-	2	2	-	-	-	-	-
Cr	70	-	2	2	-	2	-	1	-	-	-	-	2	-	1	-	-	-	-	-	-
Cs	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cu	30	1	2	-	-	2	-	-	-	-	-	-	-	-	1	2	-	-	-	-	-
Fe	4.0%	**3**	2	**3**	2	1	**3**	**3**	2	**3**	**3**	**3**	-	**3**	-	1	2	2	**3**	2	2
Ga	20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ge	1	-	-	-	-	-	1	1	-	1	1	2	-	-	-	-	-	-	1	-	-
Hf	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hg	0.06	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
In	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
K	1.4%	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
La	40	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Li	25	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mg	0.5%	-	-	-	-	-	-	-	-	-	2	-	-	-	-	2	1	-	-	1	1
Mn	1000	1	-	-	-	-	1	-	2	-	-	1	-	-	-	-	-	-	-	-	-
Mo	1.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Na	0.5%	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-
Nb	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ni	50	-	-	-	-	1	-	-	1	-	-	-	-	-	1	-	-	-	-	-	-
P	800	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pb	35	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Rb	150	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
S	0.07%	-	-	2	**4**	-	-	1	-	1	-	-	-	-	**4**	1	**3**	-	2	1	**3**
Sb	1	1	-	-	1	-	1	-	1	2	1	1	-	-	-	-	-	-	-	-	-
Sc	7	1	2	1	1	2	-	1	-	1	-	-	1	-	1	2	-	-	-	-	-
Se	0.4	2	2	1	2	1	1	1	1	1	1	1	1	1	2	1	1	1	1	1	1
Sn	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sr	250	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ta	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Th	9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ti	0.50%	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tl	0.2	-	1	-	-	-	-	-	-	-	-	-	-	-	**4**	-	-	-	-	-	1
U	2	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
V	90	-	**3**	2	1	1	-	-	-	-	-	-	1	-	-	1	-	-	-	-	-
W	1.5	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Y	40	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Zn	90	-	-	-	-	1	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
Zr	400	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

*Bowen H.J.M.(1979) Environmental Chemistry of the Elements.

Table 7: Geochemical abundance indices (GAI) of selected solids samples - Comparison with CRUSTAL ABUNDANCE.

Element	Mean Crustal Abundance*	Geochemcial Abundance Indices (GAI) - Strand/ Sample Code																		
		Detrital					Clay	Pisolite/ Detrital	West Angela Member				Newman Member				MacLeod Member			Nammuldi Member	
		DET	DET	DET	DET	DET	CLA	PI	ANG	ANG	ANG	ANG	N2U	NE1	NEW	NEW	MAC	MAC	MAC	NAM	NAM
		FTI114	FQR817	FQD908	FOM528	FRG099	FNC936	FRD872	FOG458	FRK244	FOM940	FRI220	FQR487	FNJ868	FQR860	FRM113	FOG111	FOH824	FOD662	FOH857	FOH416
Ag	0.07	1	1	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	1
Al	8.2%	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
As	1.5	**5**	**3**	2	**3**	2	**4**	**3**	**4**	**5**	**5**	**3**	2	-	**3**	-	-	-	**3**	-	1
Ba	500	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Be	2.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bi	0.048	**3**	2	1	**3**	1	**3**	2	**3**	**3**	2	**3**	1	-	2	-	-	-	-	-	2
Ca	4.0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cd	0.11	-	2	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-
Ce	68	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Co	20	-	1	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-	-	-
Cr	100	-	2	1	-	1	-	1	-	-	-	-	2	-	-	-	-	-	-	-	-
Cs	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Cu	50	-	1	-	-	1	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-
Fe	4.1%	**3**	2	**3**	2	1	**3**	**3**	2	**3**	**3**	**3**	-	**3**	-	1	2	2	**3**	2	2
Ga	18	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ge	1.8	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-
Hf	5.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hg	0.05	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
In	0.049	-	2	-	1	1	-	1	-	-	-	-	1	-	1	-	-	-	-	-	-
K	2.1%	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
La	32	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Li	20	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mg	2.3%	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mn	950	1	-	-	-	-	2	-	2	-	-	1	-	-	-	-	-	-	-	-	-
Mo	1.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Na	2.3%	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nb	20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ni	80	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
P	1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pb	14	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Rb	90	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
S	0.03%	1	-	**4**	**5**	-	1	2	-	2	-	-	2	-	**5**	2	**4**	-	**3**	2	**4**
Sb	0.2	**3**	2	2	**4**	1	**3**	**3**	**3**	**4**	**3**	**3**	1	1	**3**	-	1	1	2	1	1
Sc	16	-	1	-	-	1	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-
Se	0.05	**5**	**5**	**4**	**5**	**4**	**4**	**4**	**4**	**4**	**4**	**4**	**4**	**4**	**5**	**4**	**4**	**4**	**4**	**4**	**4**
Sn	2.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sr	370	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ta	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Th	12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ti	0.56%	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tl	0.6	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-
U	2.4	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
V	160	-	2	1	-	1	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-
W	1	-	-	-	1	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-
Y	30	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Zn	75	-	1	-	-	1	-	-	1	-	-	-	-	-	1	-	-	-	-	-	-
Zr	190	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

*Bowen H.J.M.(1979) Environmental Chemistry of the Elements.

Table 8: Chemical composition of water extracts of selected samples*

Parameter		Detection Limit	Member Group/ Sample Code/ ARD Classification																			
			Detrital					Clay	Pisolite/ Detrital	West Angela Member				Newman				Macleod			Nammuldi Member	
			DET	DET	DET	DET	DET	CLA	PI	ANG	ANG	ANG	ANG	N2U	NE1	NEW	NEW	MAC	MAC	MAC	NAM	NAM
			FTI114	FQR817	FQD908	FOM528	FRG099	FNC936	FRD872	FOG458	FRK244	FOM940	FRI220	FQR487	FNJ868	FQR860	FRM113	FOG111	FOH824	FOD662	FOH857	FOH416
			PAF-LC	NAF	UC (NAF)	UC (NAF)	Barren	PAF-LC	UC(NAF)	Barren	PAF-LC	NAF	NAF	PAF-LC	Barren	PAF	NAF	NAF	NAF	UC(NAF)	NAF	PAF-LC
pH		0.01	6.7	7.4	7.3	7.1	7.8	7.2	7.8	7.2	5.8	7.3	7.5	6.7	7.4	6.8	8.4	8.1	7.9	7.8	7.5	7.6
EC	dS/m	0.01	0.49	0.23	0.30	0.47	0.28	0.48	0.18	0.29	0.35	0.23	0.20	0.38	0.19	0.50	0.17	0.57	0.35	0.13	0.27	0.73
Ag	mg/l	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Al	mg/l	0.01	<0.01	0.01	0.04	<0.01	<0.01	0.02	0.28	<0.01	0.04	<0.01	<0.01	0.20	<0.01	0.05	0.04	<0.01	0.01	0.05	<0.01	<0.01
As	mg/l	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	<0.001	0.019	<0.001	<0.001	<0.001	<0.001	<0.001	0.001
B	mg/l	0.05	0.24	0.06	0.09	0.06	0.1	0.11	0.09	0.08	0.21	<0.05	0.08	0.26	<0.05	0.3	<0.05	<0.05	0.07	0.05	0.05	<0.05
Ba	mg/l	0.001	0.18	0.41	0.47	0.37	0.48	0.14	0.40	0.40	0.18	0.19	0.40	0.08	0.40	0.09	0.34	0.08	0.39	0.41	0.43	0.07
Be	mg/l	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.003	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Ca	mg/l	1	16	10	11	23	11	20	4	24	13	15	14	56	10	48	6	90	9	3	9	38
Cd	mg/l	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0001	<0.0001	<0.0001	0.0008	<0.0001	0.0002	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Cl	mg/l	1	89	23	25	69	40	53	12	27	52	28	7	59	31	49	7	6	41	12	16	28
Co	mg/l	0.001	0.001	<0.001	<0.001	<0.001	<0.001	0.005	<0.001	<0.001	0.004	<0.001	<0.001	0.55	<0.001	0.18	<0.001	<0.001	<0.001	<0.001	0.00	<0.001
Cr	mg/l	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.003	<0.001	0.009	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Cu	mg/l	0.001	0.007	0.001	<0.001	0.002	0.002	0.007	<0.001	0.002	0.011	0.002	0.001	0.13	<0.001	0.028	0.001	0.003	0.002	<0.001	0.004	0.002
F	mg/l	0.1	<0.1	0.2	0.3	<0.1	0.6	<0.1	0.5	0.3	<0.1	0.1	0.2	0.3	<0.1	<0.1	<0.1	<0.1	0.3	0.2	<0.1	<0.1
Fe	mg/l	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.32	<0.05	<0.05	<0.05	<0.05	1.49	<0.05	0.08	<0.05	<0.05	<0.05	0.18	0.05	<0.05
Hg	mg/l	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
K	mg/l	1	6	3	3	4	10	6	3	2	6	2	2	5	2	4	8	5	3	3	8	65
Mg	mg/l	1	24	5	6	15	8	26	2	21	21	12	11	44	7	51	2	34	24	2	11	68
Mn	mg/l	0.001	0.093	0.003	0.003	0.049	0.012	1.41	0.001	0.004	0.39	0.008	0.003	1.61	0.007	0.134	0.00	0.012	0.002	0.001	0.01	0.031
Mo	mg/l	0.001	<0.001	<0.001	<0.001	<0.001	0.001	<0.001	<0.001	<0.001	<0.001	0.001	<0.001	<0.001	<0.001	0.006	0.005	0.004	0.002	0.002	0.007	0.001
Na	mg/l	1	49	22	25	40	37	33	17	21	35	15	11	37	11	37	16	23	29	14	22	56
Ni	mg/l	0.001	0.002	<0.001	<0.001	<0.001	<0.001	0.006	<0.001	<0.001	0.004	<0.001	<0.001	0.73	<0.001	0.113	<0.001	<0.001	<0.001	<0.001	0.01	0.002
P	mg/l	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Pb	mg/l	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Sb	mg/l	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.006	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Se	mg/l	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Si	mg/l	0.1	2.6	7.7	3.4	5.1	10.8	2.2	4.1	2.6	3.6	2.0	3.8	3.6	2.2	2.7	1.7	1.1	2.8	3.6	1.6	1.2
Sn	mg/l	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
SO4	mg/l	1	111	33	47	77	64	143	22	82	112	37	15	310	42	290	17	363	82	19	62	445
Sr	mg/l	0.001	0.15	0.03	0.03	0.11	0.04	0.05	0.01	0.06	0.07	0.04	0.04	0.17	0.03	0.11	0.01	0.08	0.05	0.02	0.02	0.19
Th	mg/l	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
U	mg/l	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Zn	mg/l	0.005	0.09	0.01	0.01	0.03	0.03	0.13	0.01	0.02	0.17	0.01	0.02	1.02	0.02	0.24	<0.005	0.01	0.01	0.01	0.02	0.01

* Extracts conducted on a 1 part sample to 2 parts deionised water mixture. Extract filtered with 0.45μm filter paper prior to being anlaysed.

< element at or below analytical detection limit.

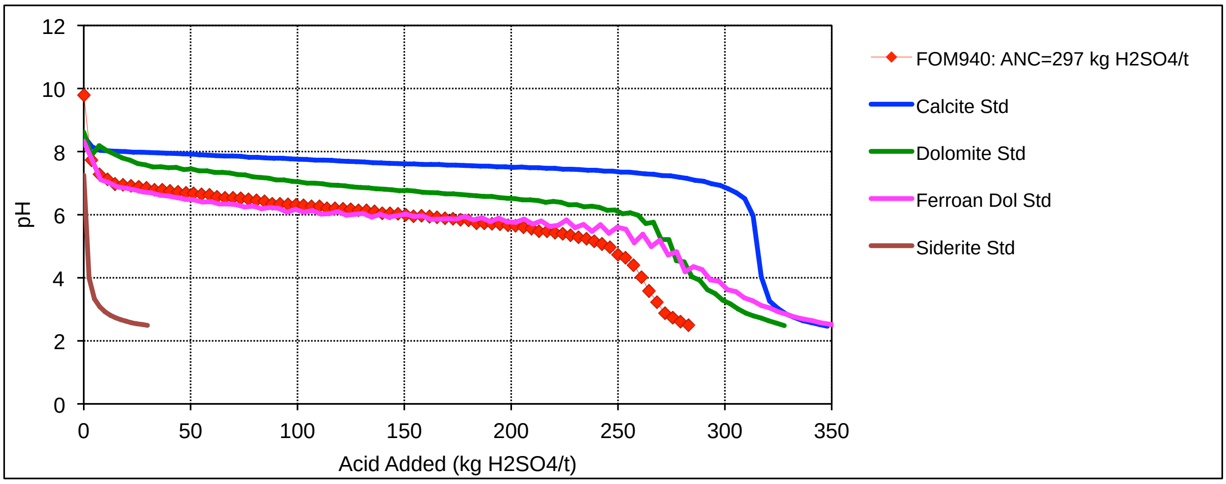


Figure 5: ABCC plot of sample FOM940 with ANC of 297 kg H_2SO_4/t (West Angela). Carbonate standard curves are included for reference.

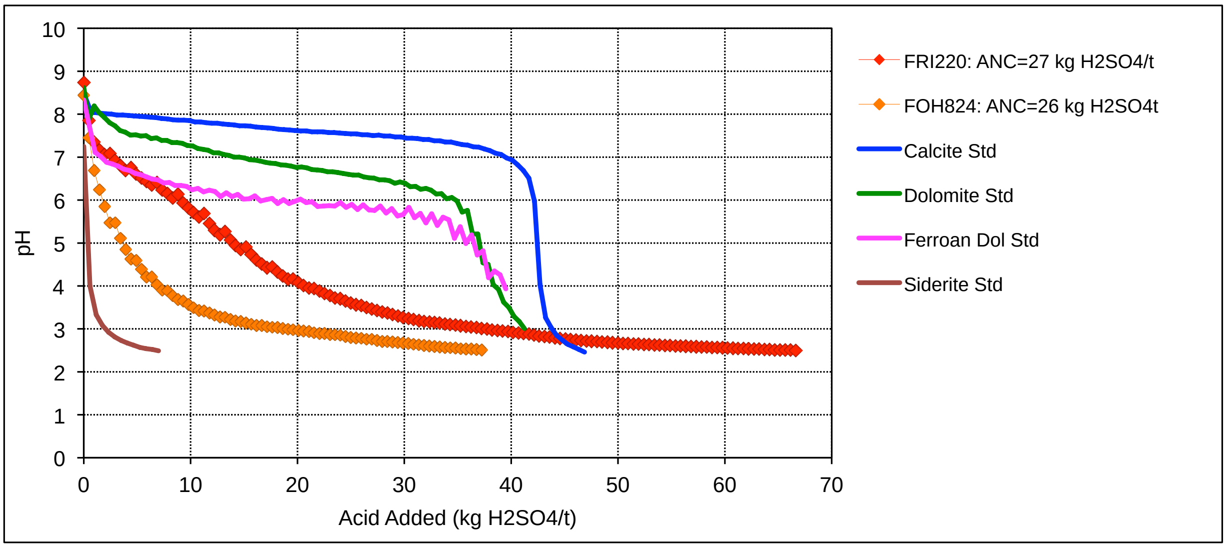


Figure 6: ABCC plot of samples FRI220 (West Angela) and FOH824 (Macleod) with ANC close to 25 kg H_2SO_4/t. Carbonate standard curves are included for reference.

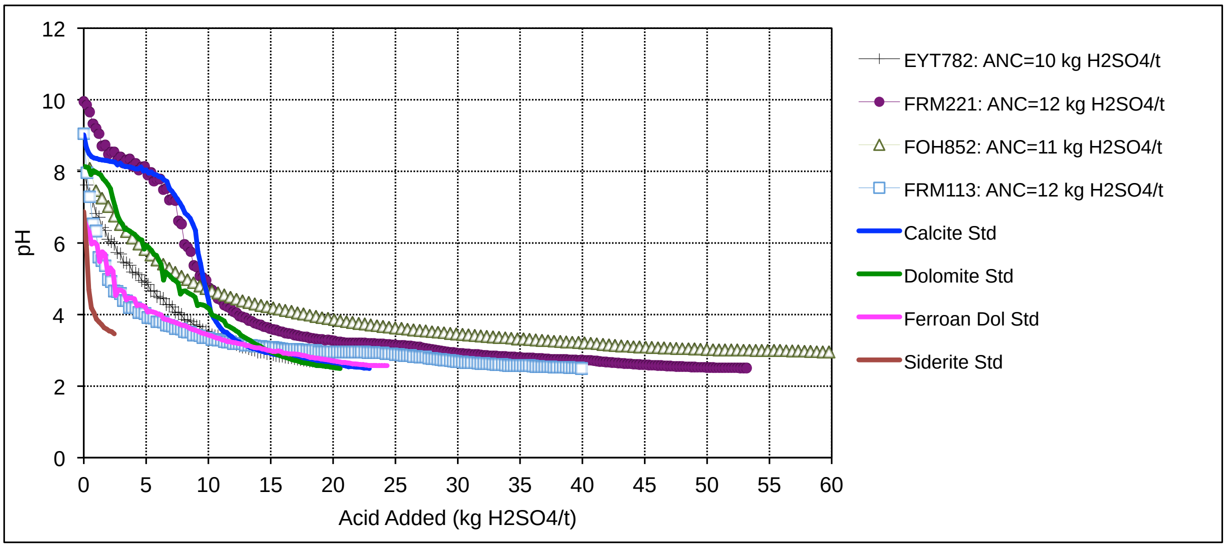


Figure 7: ABCC plot of samples EYT782 (Clay), FRM221 (Detrital), FOH852 (Nammuldi) and FRM113 (Newman) with ANC close to 10 kg H_2SO_4/t. Carbonate standard curves are included for reference.

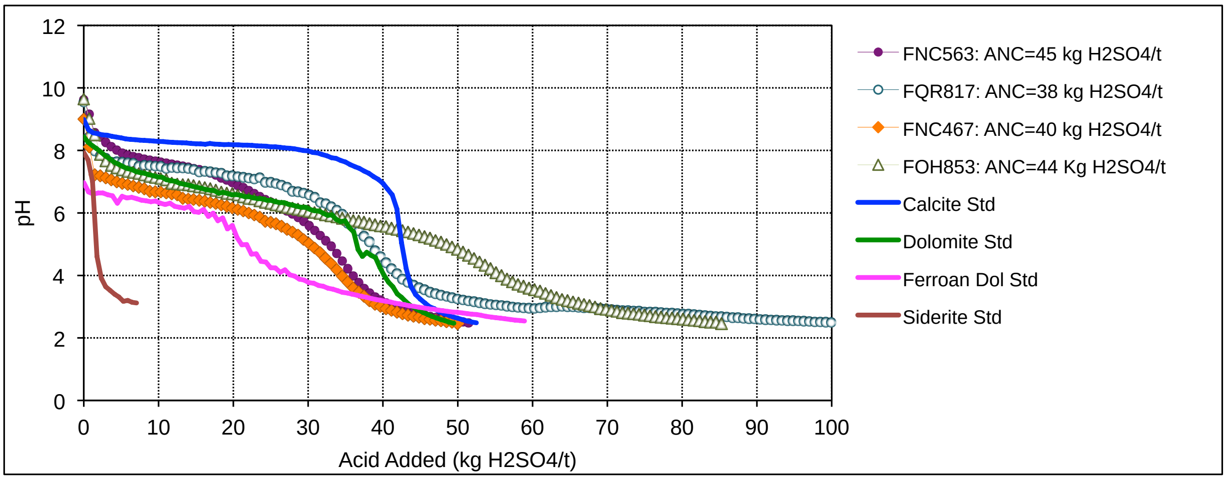


Figure 8: ABCC plot of samples FNC563 (Detrital), FQR817 (Detrital), FNC467 (Macleod) and FOH853 (Nammuldi) with ANC close to 40 kg H_2SO_4/t. Carbonate standard curves are included for reference.

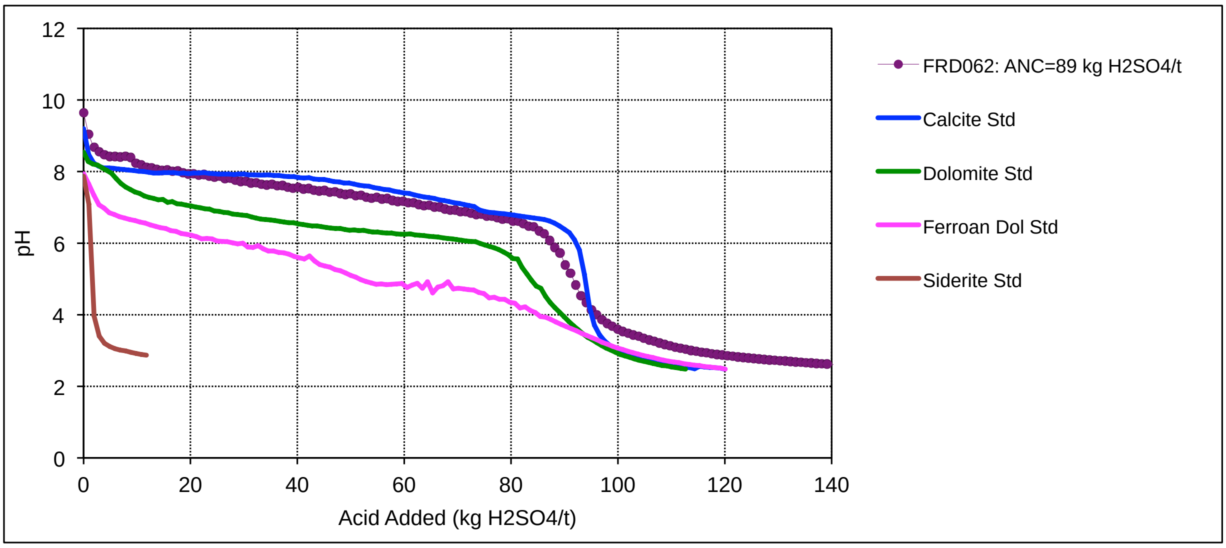


Figure 9: ABCC plot of sample FRD062 with ANC of 89 kg H_2SO_4/t (Detrital). Carbonate standard curves are included for reference.

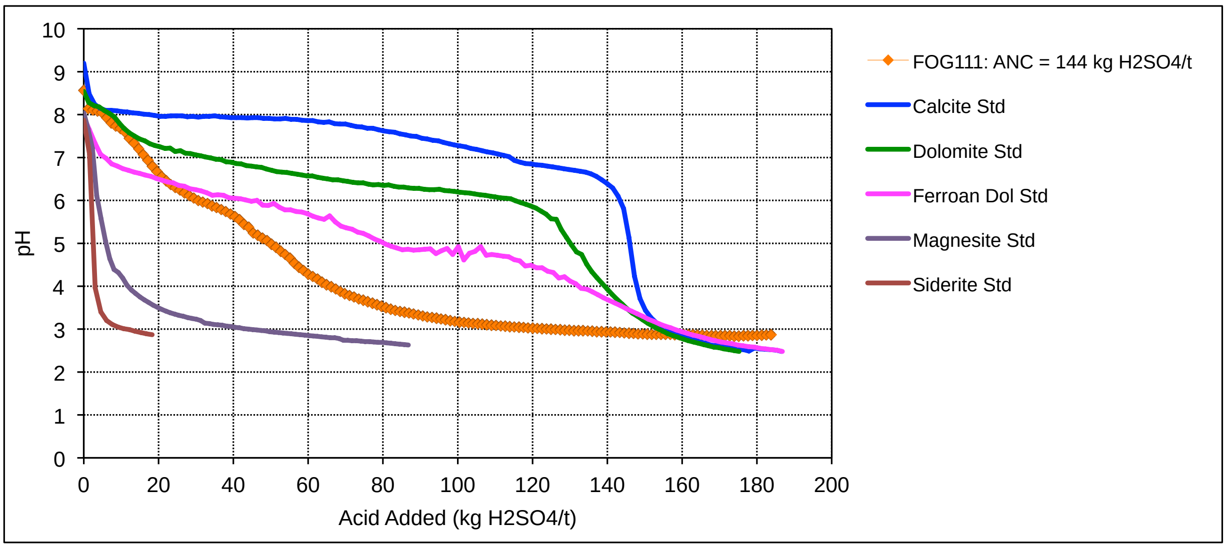


Figure 10: ABCC plot of sample FOG111 with ANC of 144 kg H_2SO_4/t (Macleod). Carbonate standard curves are included for reference.

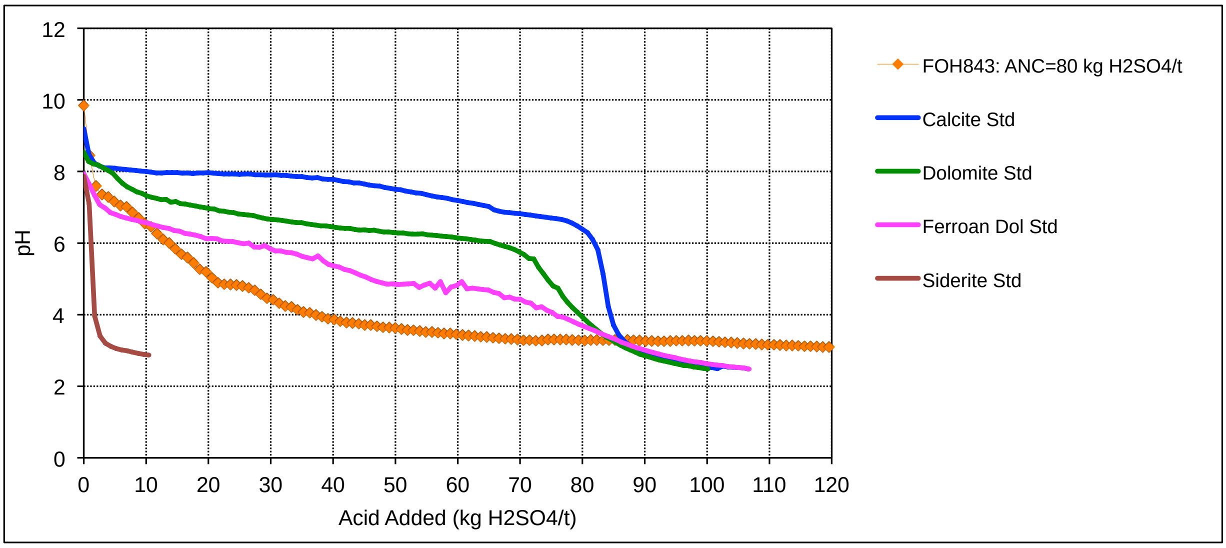


Figure 11: ABCC plot of sample FOH843 with ANC of 80 kg H_2SO_4/t (Macleod). Carbonate standard curves are included for reference.

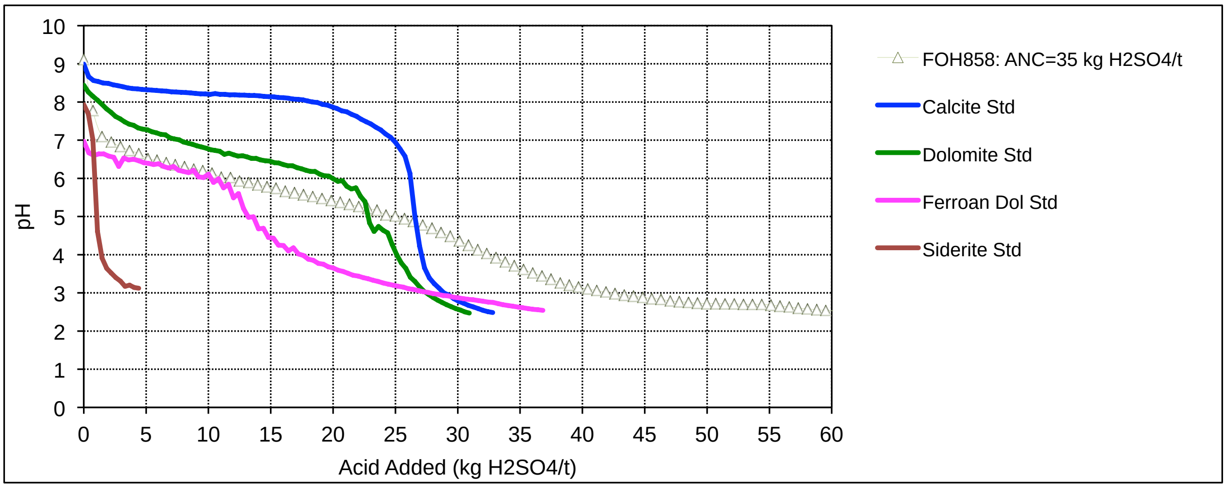


Figure 12: ABCC plot of sample FOH858 with ANC of 35 kg H_2SO_4/t (Nammuldi). Carbonate standard curves are included for reference.

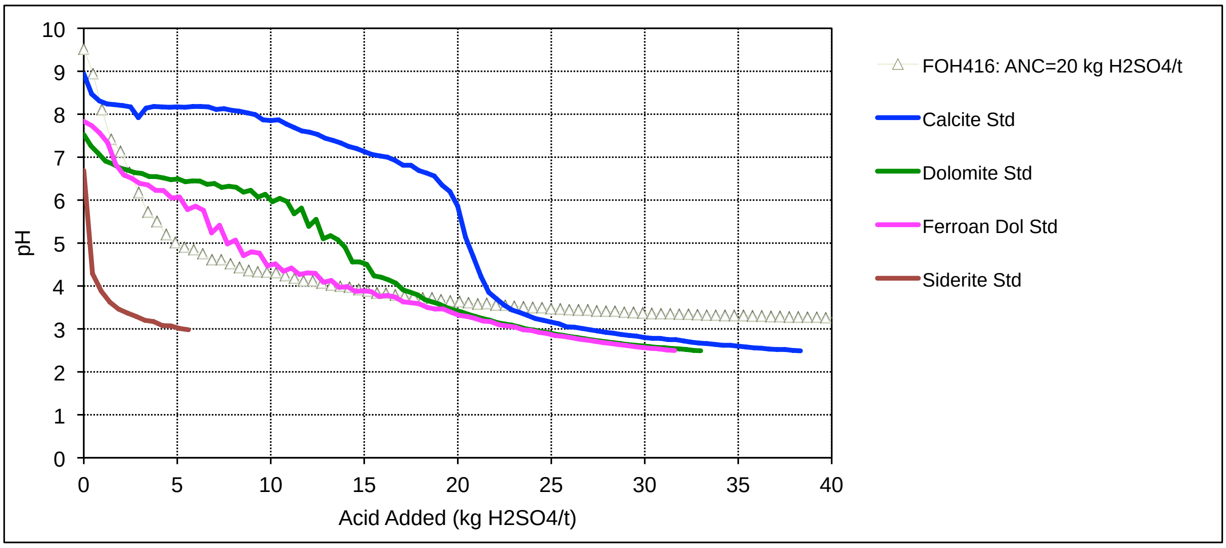
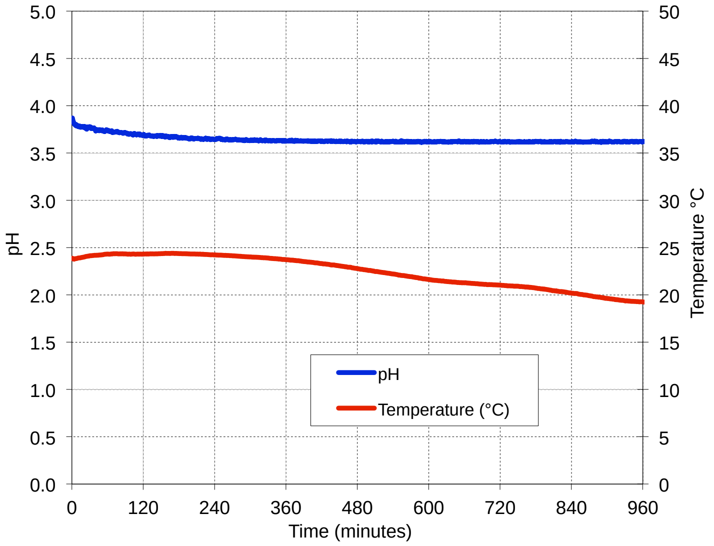


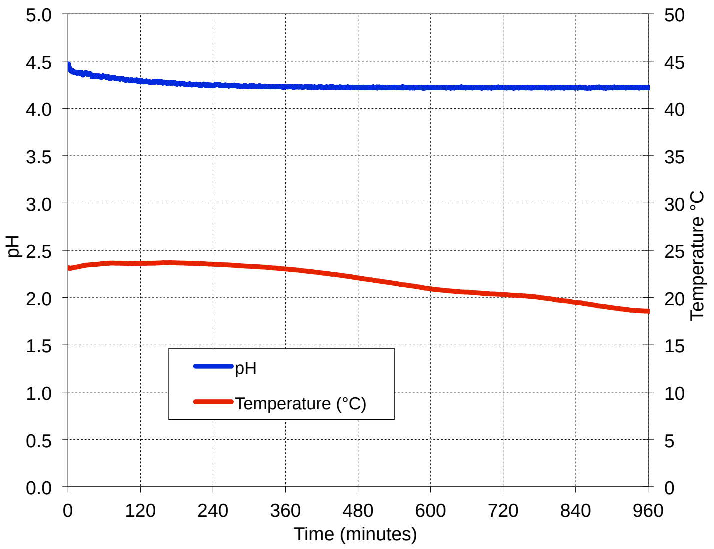
Figure 13: ABCC plot of sample FOH416 with ANC of 20 kg H_2SO_4/t (Nammuldi). Carbonate standard curves are included for reference.



Sample Characteristics

Total %S = 0.17
ANC (kg H_2SO_4/t) = 0
NAPP (kg H_2SO_4/t) = 5
NAGpH = 3.6
$NAG_{(pH4.5)}$ (kg H_2SO_4/t) = 1
$NAG_{(pH7.0)}$ (kg H_2SO_4/t) = 7

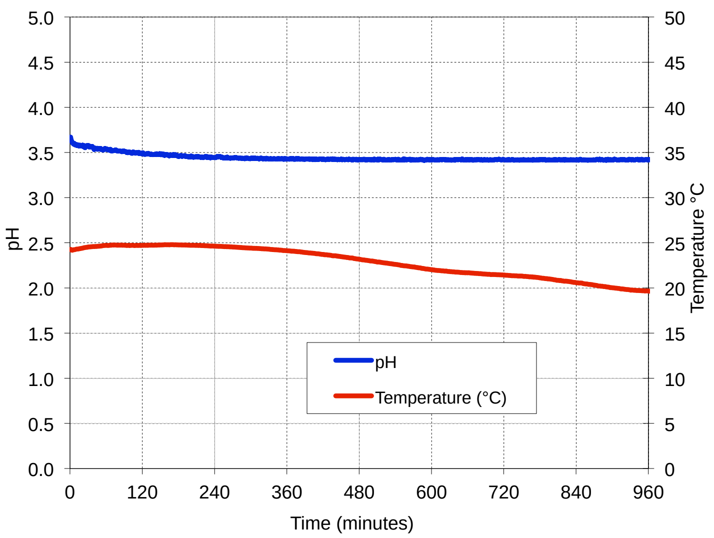
Figure 14: Kinetic NAG plot of West Angela Member sample FRK244.



Sample Characteristics

Total %S = 0.11
ANC (kg H_2SO_4/t) = 1
NAPP (kg H_2SO_4/t) = 3
NAGpH = 3.8
$NAG_{(pH4.5)}$ (kg H_2SO_4/t) = 0
$NAG_{(pH7.0)}$ (kg H_2SO_4/t) = 5

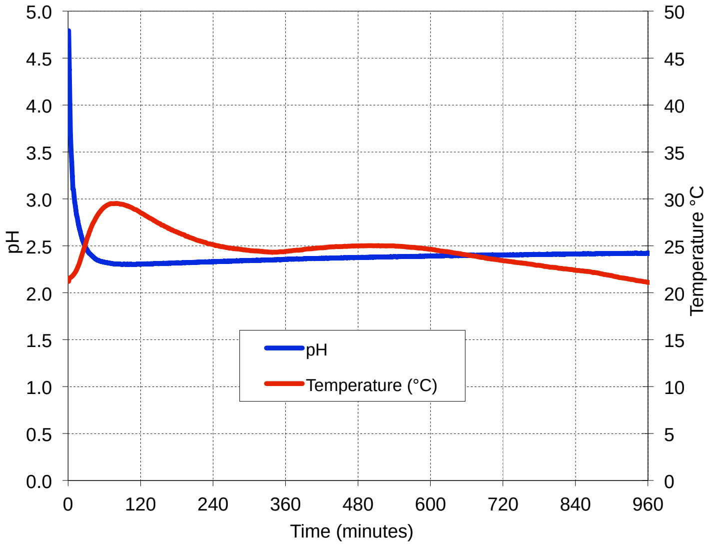
Figure 15: Kinetic NAG plot of Detrital sample FTI114.



Sample Characteristics

Total %S = 0.1
ANC (kg H_2SO_4/t) = 0
NAPP (kg H_2SO_4/t) = 3
NAGpH = 3.6
$NAG_{(pH4.5)}$ (kg H_2SO_4/t) = 1
$NAG_{(pH7.0)}$ (kg H_2SO_4/t) = 9

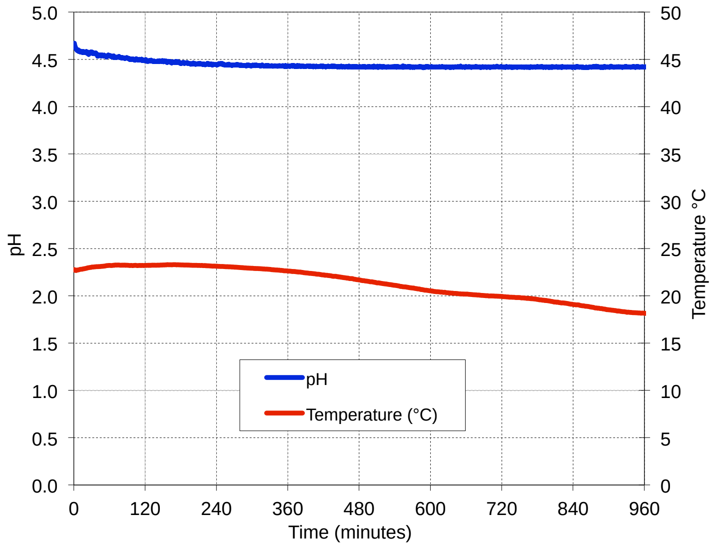
Figure 16: Kinetic NAG plot of Macleod Member sample FRK393.



Sample Characteristics

Total %S	=	1.22
ANC (kg H_2SO_4/t)	=	0
NAPP (kg H_2SO_4/t)	=	37
NAGpH	=	2.5
$NAG_{(pH4.5)}$ (kg H_2SO_4/t)	=	21
$NAG_{(pH7.0)}$ (kg H_2SO_4/t)	=	34

Figure 17: Kinetic NAG plot of Newman Member sample FQR860.



Sample Characteristics

Total %S	=	0.73
ANC (kg H_2SO_4/t)	=	20
NAPP (kg H_2SO_4/t)	=	3
NAGpH	=	4.3
$NAG_{(pH4.5)}$ (kg H_2SO_4/t)	=	0
$NAG_{(pH7.0)}$ (kg H_2SO_4/t)	=	3

Figure 18: Kinetic NAG plot of Nammuldi Member sample FOH416.

APPENDIX A

Assessment of Acid Forming Characteristics

Assessment of Acid Forming Characteristics

Introduction

Acid rock drainage (ARD) is produced by the exposure of sulphide minerals such as pyrite to atmospheric oxygen and water. The ability to identify in advance any mine materials that could potentially produce ARD is essential for timely implementation of mine waste management strategies.

A number of procedures have been developed to assess the acid forming characteristics of mine waste materials. The most widely used methods are the Acid-Base Account (ABA) and the Net Acid Generation (NAG) test. These methods are referred to as static procedures because each involves a single measurement in time.

Acid-Base Account

The acid-base account involves static laboratory procedures that evaluate the balance between acid generation processes (oxidation of sulphide minerals) and acid neutralising processes (dissolution of alkaline carbonates, displacement of exchangeable bases, and weathering of silicates).

The values arising from the acid-base account are referred to as the potential acidity and the acid neutralising capacity, respectively. The difference between the potential acidity and the acid neutralising capacity value is referred to as the net acid producing potential (NAPP).

The chemical and theoretical basis of the ABA are discussed below.

Potential Acidity

The potential acidity that can be generated by a sample is calculated from an estimate of the pyrite (FeS_2) content and assumes that the pyrite reacts under oxidising conditions to generate acid according to the following reaction:

$$FeS_2 + 15/4\ O_2 + 7/2\ H_2O \Rightarrow Fe(OH)_3 + 2\ H_2SO_4$$

Based on the above reaction, the potential acidity of a sample containing 1 %S as pyrite would be 30.6 kilograms of H_2SO_4 per tonne of material (i.e. kg H_2SO_4/t). The pyrite content estimate can be based on total S and the potential acidity determined from total S is referred to as the maximum potential acidity (MPA), and is calculated as follows:

$$\text{MPA (kg } H_2SO_4/t) = (\text{Total \%S}) \times 30.6$$

The use of an MPA calculated from total sulphur is a conservative approach because some sulphur may occur in forms other than pyrite. Sulphate-sulphur, organic sulphur and native sulphur, for example, are non-acid generating sulphur forms. Also, some sulphur may occur as other metal sulphides (e.g. covellite, chalcocite, sphalerite, galena) which yield less acidity than pyrite when oxidised or, in some cases, may be non-acid generating. The total sulphur content is commonly used to assess potential acidity because of the difficulty, costs and uncertainty involved in routinely determining the speciation of sulphur forms within samples, and determining reactive sulphide-sulphur contents. However, if the sulphide mineral forms are known then allowance can be made for non- and lesser acid generating forms to provide a better estimate of the potential acidity.

Acid Neutralising Capacity (ANC)

The acid formed from pyrite oxidation will to some extent react with acid neutralising minerals contained within the sample. This inherent acid buffering is quantified in terms of the ANC.

The ANC is commonly determined by the Modified Sobek method. This method involves the addition of a known amount of standardised hydrochloric acid (HCl) to an accurately weighed sample, allowing the sample time to react (with heating), then back-titrating the mixture with standardised sodium hydroxide (NaOH) to determine the amount of unreacted HCl. The amount of acid consumed by reaction with the sample is then calculated and expressed in the same units as the MPA (kg H_2SO_4/t).

Net Acid Producing Potential (NAPP)

The NAPP is a theoretical calculation commonly used to indicate if a material has potential to produce acidic drainage. It represents the balance between the capacity of a sample to generate acid (MPA) and its capacity to neutralise acid (ANC). The NAPP is also expressed in units of kg H_2SO_4/t and is calculated as follows:

$$\text{NAPP} = \text{MPA} - \text{ANC}$$

If the MPA is less than the ANC then the NAPP is negative, which indicates that the sample may have sufficient ANC to prevent acid generation. Conversely, if the MPA exceeds the ANC then the NAPP is positive, which indicates that the material may be acid generating.

ANC/MPA Ratio

The ANC/MPA ratio is frequently used as a means of assessing the risk of acid generation from mine waste materials. The ANC/MPA ratio is another way of looking at the acid base account. A positive NAPP is equivalent to an ANC/MPA ratio less than 1, and a negative NAPP is equivalent to an ANC/MPA ratio greater than 1. A NAPP of zero is equivalent to an ANC/MPA ratio of 1.

The purpose of the ANC/MPA ratio is to provide an indication of the relative margin of safety (or lack thereof) within a material. Various ANC/MPA values are reported in the literature for indicating safe values for prevention of acid generation. These values typically range from 1 to 3. As a general rule, an ANC/MPA ratio of 2 or more signifies that there is a high probability that the material will remain circum-neutral in pH and thereby should not be problematic with respect to acid rock drainage.

Acid-Base Account Plot

Sulphur and ANC data are often presented graphically in a format similar to that shown in Figure A-1. This figure includes a line indicating the division between NAPP positive samples from NAPP negative samples. Also shown are lines corresponding to ANC/MPA ratios of 2 and 3.

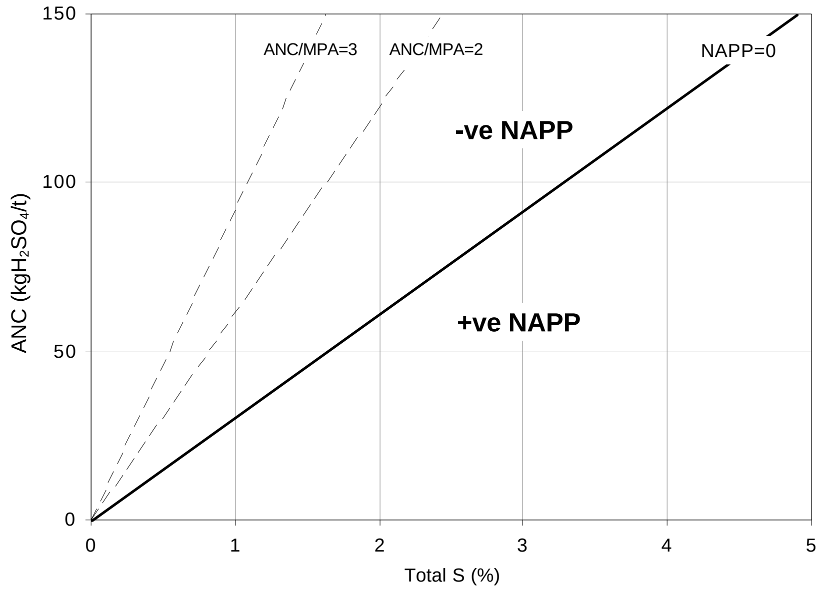


Figure A-1: Acid-base account (ABA) plot

Net Acid Generation (NAG) Test

The NAG test is used in association with the NAPP to classify the acid generating potential of a sample. The NAG test involves reaction of a sample with hydrogen peroxide to rapidly oxidise any sulphide minerals contained within a sample. During the NAG test both acid generation and acid neutralisation reactions can occur simultaneously. The end result represents a direct measurement of the net amount of acid generated by the sample. The final pH is referred to as the NAGpH and the amount of acid produced is commonly referred to as the NAG capacity, and is expressed in the same units as the NAPP (kg H_2SO_4/t).

Several variations of the NAG test have been developed to accommodate the wide geochemical variability of mine waste materials. The four main NAG test procedures currently used by EGi are the single addition NAG test, the sequential NAG test, the kinetic NAG test, and the extended boil and calculated NAG test.

Single Addition NAG Test

The single addition NAG test involves the addition of 250 ml of 15% hydrogen peroxide to 2.5 g of sample. The peroxide is allowed to react with the sample overnight and the following day the sample is gently heated to accelerate the oxidation of any remaining sulphides, then vigorously boiled for several minutes to decompose residual peroxide. When cool, the NAGpH and NAG capacity are measured.

An indication of the form of the acidity is provided by initially titrating the NAG liquor to pH 4.5, then continuing the titration up to pH 7. The titration value at pH 4.5 includes acidity due to free acid (i.e. H_2SO_4) as well as soluble iron and aluminium. The titration value at pH 7 also includes metallic ions that precipitate as hydroxides at between pH 4.5 and 7.

Sequential NAG Test

When testing samples with high sulphide contents it is not uncommon for oxidation to be incomplete in the single addition NAG test. This can sometimes occur when there is catalytic breakdown of the hydrogen peroxide before it has had a chance to oxidise all of the sulphides in a sample. To overcome this limitation, a sequential NAG test is often carried out. This test may also be used to assess the relative geochemical lag of PAF samples with high ANC.

The sequential NAG test is a multi-stage procedure involving a series of single addition NAG tests on the one sample (i.e. 2.5 g of sample is reacted two or more times with 250 ml aliquots of 15% hydrogen peroxide). At the end of each stage, the sample is filtered and the solution is used for measurement of NAGpH and NAG capacity. The NAG test is then repeated on the solid residue. The cycle is repeated until such time that there is no further catalytic decomposition of the peroxide, or when the NAGpH is greater than pH 4.5. The overall NAG capacity of the sample is then determined by summing the individual acid capacities from each stage.

Kinetic NAG Test

The kinetic NAG test is the same as the single addition NAG test except that the temperature and pH of the liquor are recorded. Variations in these parameters during the test provide an indication of the kinetics of sulphide oxidation and acid generation. This, in turn, can provide an insight into the behaviour of the material under field conditions. For example, the pH trend gives an estimate of relative reactivity and may be related to prediction of lag times and oxidation rates similar to those measured in leach columns. Also, sulphidic samples commonly produce a temperature excursion during the NAG test due to the decomposition of the peroxide solution, catalysed by sulphide surfaces and/or oxidation products.

Extended Boil and Calculated NAG Test

Organic acids may be generated in NAG tests due to partial oxidation of carbonaceous materials[1] such as coal washery wastes. This can lead to low NAGpH values and high acidities in standard single addition NAG tests unrelated to acid generation from sulphides. Organic acid effects can therefore result in misleading NAG values and misclassification of the acid forming potential of a sample.

The extended boil and calculated NAG tests can be used to account for the relative proportions of pyrite derived acidity and organic acidity in a given NAG solution, thus providing a more reliable measure of the acid forming potential of a sample. The procedure involves two steps to differentiating pyritic acid from organic derived acid:

Extended Boil NAG	decompose the organic acids and hence remove the influence of non-pyritic acidity on the NAG solution.
Calculated NAG	calculate the net acid potential based on the balance of cations and anions in the NAG solution, which will not be affected by organic acid.

The extended boiling test is carried out on the filtered liquor of a standard NAG test, and involves vigorous boiling of the solution on a hot plate for 3-4 hours. After the boiling step the solution is cooled and the pH measured. An extended boil NAGpH less than 4.5 confirms the sample is potentially acid forming (PAF), but a pH value greater than 4.5 does not necessarily mean that the sample is non acid forming (NAF), due to some loss of free acid during the extended boiling procedure. To address this issue, a split of the same filtered NAG solution is assayed for concentrations of S, Ca, Mg, Na, K and Cl, from which a calculated NAG value is determined[2].

The concentration of dissolved S is used to calculate the amount of acid (as H_2SO_4) generated by the sample and the concentrations of Ca, Mg, Na and K are used to estimate the amount of acid neutralised (as H_2SO_4). The concentration of Cl is used to correct for soluble cations associated with Cl salts, which may be present in the sample and unrelated to acid generating and acid neutralising reactions.

The calculated NAG value is the amount of acid neutralised subtracted from the amount of acid generated. A positive value indicates that the sample has excess acid generation and is likely to be PAF, and a zero or negative value indicates that the sample has excess neutralising capacity and is likely to be NAF.

---

[1] Stewart, W., Miller, S., Thomas, J.E., and Smart R. (2003), 'Evaluation of the Effects of Organic Matter on the Net Acid Generation (NAG) Test', in *Proceedings of the Sixth International Conference on Acid Rock drainage (ICARD), Cairns, 12-18th July 2003*, 211-222.

[2] Environmental Geochemistry International, Levay and Co. and ACeSSS, 2008. *ACARP Project C15034: Development of ARD Assessment for Coal Process Wastes*, EGi Document No. 3207/817, July 2008.

Sample Classification

The acid forming potential of a sample is classified on the basis of the acid-base and NAG test results into one of the following categories:

- Barren;
- Non-acid forming (NAF);
- Potentially acid forming (PAF); and
- Uncertain (UC).

Barren

A sample classified as barren essentially has no acid generating capacity and no acid buffering capacity. This category is most likely to apply to highly weathered materials. In essence, it represents an 'inert' material with respect to acid generation. The criteria used to classify a sample as barren may vary between sites, but for hard rock mines it generally applies to materials with a total sulphur content ≤ 0.1 %S and an ANC ≤ 5 kg H_2SO_4/t.

Non-acid forming (NAF)

A sample classified as NAF may, or may not, have a significant sulphur content but the availability of ANC within the sample is more than adequate to neutralise all the acid that theoretically could be produced by any contained sulphide minerals. As such, material classified as NAF is considered unlikely to be a source of acidic drainage. A sample is usually defined as NAF when it has a negative NAPP and the final NAG pH ≥ 4.5.

Potentially acid forming (PAF)

A sample classified as PAF always has a significant sulphur content, the acid generating potential of which exceeds the inherent acid neutralising capacity of the material. This means there is a high risk that such a material, even if pH circum-neutral when freshly mined or processed, could oxidise and generate acidic drainage if exposed to atmospheric conditions. A sample is usually defined as PAF when it has a positive NAPP and a final NAGpH < 4.5.

Uncertain (UC)

An uncertain classification is used when there is an apparent conflict between the NAPP and NAG results (i.e. when the NAPP is positive and NAGpH > 4.5, or when the NAPP is negative and NAGpH ≤ 4.5). Uncertain samples are generally given a tentative classification that is shown in brackets e.g. UC(NAF).

Figure A-2 shows the format of the classification plot that is typically used for presentation of NAPP and NAG data. Marked on this plot are the quadrats representing the NAF, PAF and UC classifications.

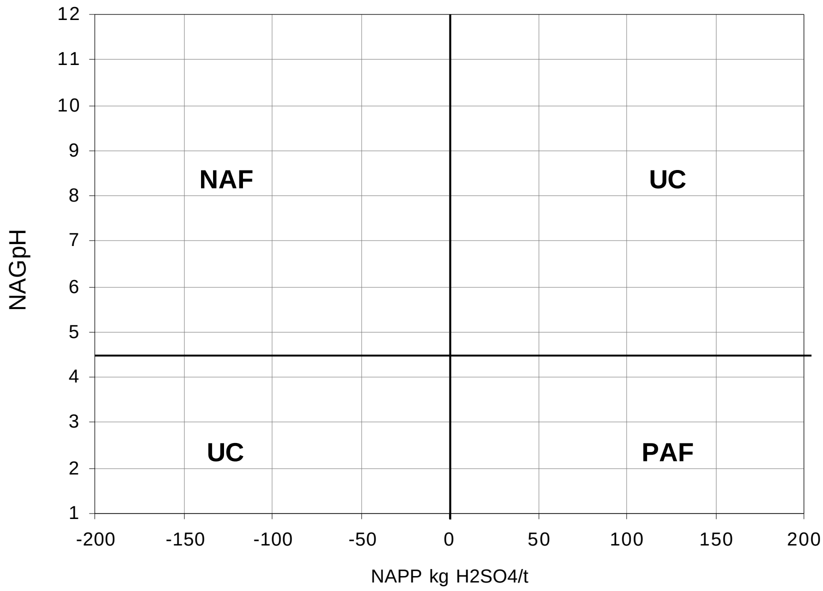


Figure A-2 ARD classification plot

Other Methods

Other test procedures may be used to define the acid forming characteristics of a sample.

pH and Electrical Conductivity

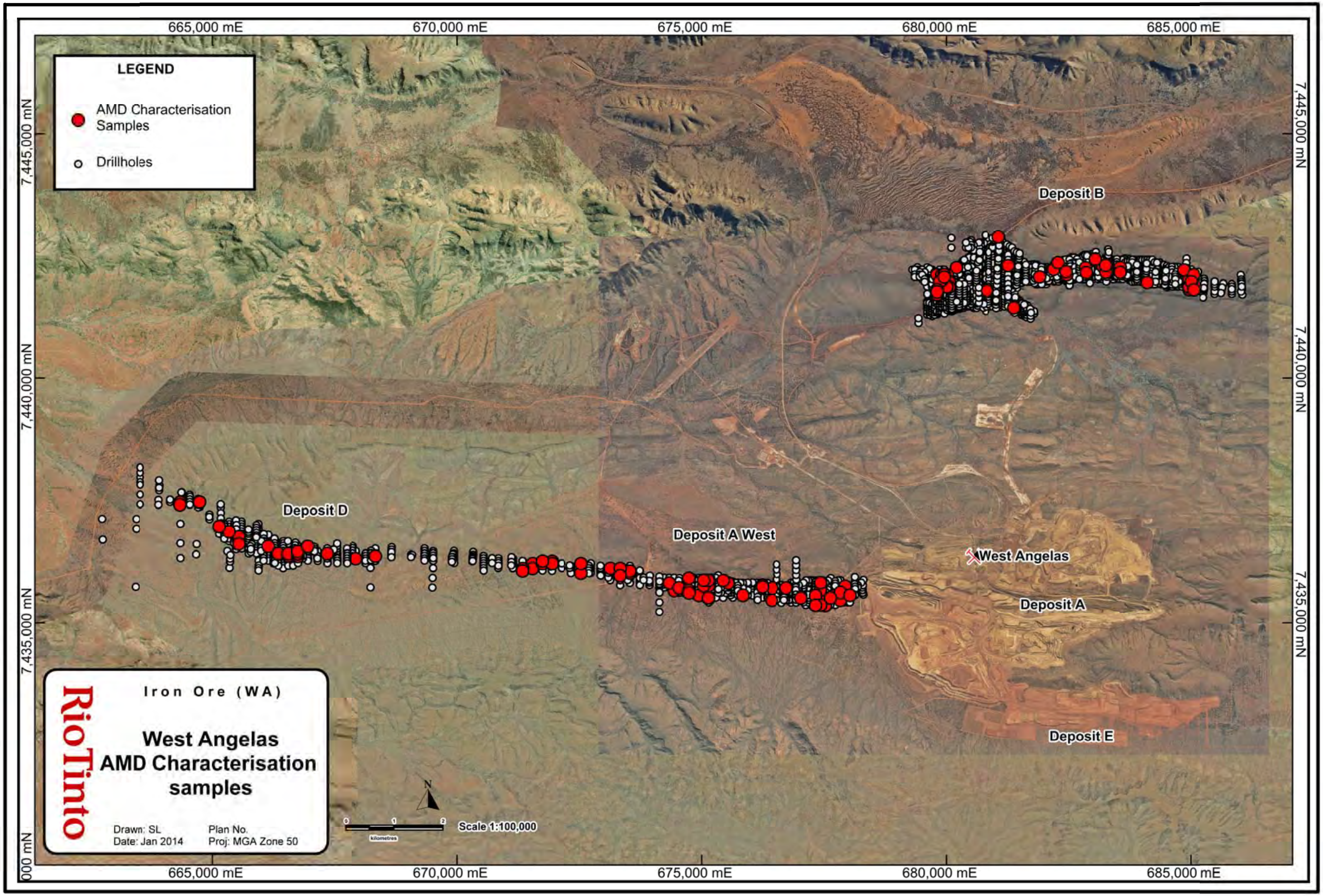
The pH and electrical conductivity (EC) of a sample is determined by equilibrating the sample in deionised water for a minimum of 12 hours (or overnight), typically at a solid to water ratio of 1:2 (w/w). This gives an indication of the inherent acidity and salinity of the waste material when initially exposed in a waste emplacement area.

Acid Buffering Characteristic Curve (ABCC) Test

The ABCC test involves slow titration of a sample with acid while continuously monitoring pH. These data provides an indication of the portion of ANC within a sample that is readily available for acid neutralisation.

APPENDIX B

Map Showing Sample Locations



665,000 mE
670,000 mE
675,000 mE
680,000 mE
685,000 mE
7,445,000 mN
7,440,000 mN
7,435,000 mN
LEGEND
AMD Characterisation Samples
Drillholes
Deposit B
Deposit D
Deposit A West
West Angelas
Deposit A
Deposit E
Iron Ore (WA)
West Angelas
AMD Characterisation samples
Drawn: SL
Date: Jan 2014
Plan No.
Proj: MGA Zone 50
Scale 1:100,000
kilometres
N

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West Angelas Deposit F

GEOCHEMICAL CHARACTERISATION OF WASTE ROCK
FROM WEST ANGELAS DEPOSIT F

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1.0 Introduction

Environmental Geochemistry International Pty Ltd (EGi) was commissioned by Rio Tinto Iron Ore to carryout geochemical testing of samples from West Angelas Deposit F. Previous geochemical characterisation of samples from deposits B, D and A was carried out by EGi in 2013.

The aim of the test work was to:

- Determine the acid forming characteristics of waste rock and provide a preliminary assessment of the likelihood of occurrence of potentially acid forming rock types.
- Identify any elemental enrichments that could be environmentally significant, and to assess the potential for mobilisation of elements that could adversely impact the quality of waste dump seepage.
- Compare results from current testing with those of previous testing of deposits B, D and A.

This report presents the methodology and results of the testing program, and discusses the likely implications for the handling and management of waste rock for ARD control.

1.1 Findings from Testing of Samples from Deposits B, D and A

Previous testing of samples from West Angelas was conducted in 2013. A total of 135 samples from 7 waste rock types were provided for testing.

The results indicated that 79% of the samples had a low total S content less than 0.1%S and 71% had low acid neutralising capacity (ANC) of less than 5 kg H_2SO_4/t. About two thirds of the samples were NAPP negative and one third were NAPP positive.

Overall, 92% of the samples were classified as barren or non-acid forming (NAF) and only 8% were potentially acid forming (PAF or PAF-LC).

Materials represented by the samples may have elevated concentrations of As, Be, Fe, S, Tl and V compared with mean crustal and median soil abundance. However, the solubility of most of these elements at circum-neutral pH was low for the samples that were tested.

2.0 Testing Program

Fifty (50) individual samples were received by EGi in May 2014 and consisted of the following:

- 17 detrital samples;
- 8 West Angela Member samples;
- 19 Newman samples; and
- 6 MacLeod Member samples.

All samples underwent the following tests:

- $pH_{1:2}$ and $EC_{1:2}$ determination;
- Total S analysis; and
- Acid neutralising capacity (ANC) determination.

Selected samples also underwent:

- Net acid generation (NAG) testing.
- Acid buffering characteristic curve (ABCC) testing;
- Multi-element scans on solids; and
- Multi-element scans on water extracts.

The total S assays were carried out by Sydney Environmental and Soil Laboratory (SESL); multi-element analyses of liquors were conducted by Australian Laboratory Services (ALS) in Sydney; multi-element analyses of solids samples was conducted by ALS in Brisbane; and all other test work was carried out by EGi in Sydney.

A description of the test procedures in presented in Appendix A.

3.0 Results

3.1 Acid Forming Characteristics and ARD Classification

Table 1 presents the acid forming characteristics and ARD classification of the samples. The $pH_{1:2}$ and $EC_{1:2}$ results were determined by equilibrating the sample in deionised water for approximately 16 hours, at a solid to water ratio of 1:2 (w/w). This gives an indication of the inherent acidity and salinity of the waste material when initially exposed in a waste emplacement area. All the samples had a neutral to alkaline pH ranging from 7.2 to 8.2, and were non-saline to slightly saline with $EC_{1:2}$ of 0.016 to 0.57 dS/m.

The total S contents of the samples range from <0.01%S to 0.49%S, and all but 6 of the samples have a low total S content below 0.1%S. The majority of the samples (86%) have an ANC less than 5 kg H_2SO_4/t and four samples (8%) have an ANC above 20 kg H_2SO_4/t.

Figure 1a is an acid-base account plot of ANC and total S and Figure 1b is the same as Figures 1a, but with an expanded total S and ANC scale. The NAPP zero line is shown which defines the NAPP positive and NAPP negative domains and lines for ANC/MPA ratio values of 2 and 3 are also plotted. Note that the NAPP = 0 line is equivalent to an ANC/MPA ratio of l. The ANC/MPA ratio is used as an indication of the relative factor of safety within the NAPP negative domain. Usually a ratio of 2 indicates a high factor of safety that the material will remain circum-neutral in pH and thereby should not be problematic with respect to ARD.

The NAPP value is an acid-base account calculation using measured total S and ANC values. It represents the balance between the MPA and ANC. A negative NAPP value indicates that the sample may have sufficient ANC to prevent acid generation. Conversely, a positive NAPP value indicates that the material may be acid generating.

About 82% of the samples had negative NAPP values and approximately 64% of the samples have an ANC/MPA ratio greater than 2, indicating a high factor of safety with respect to the prevention of acid generation.

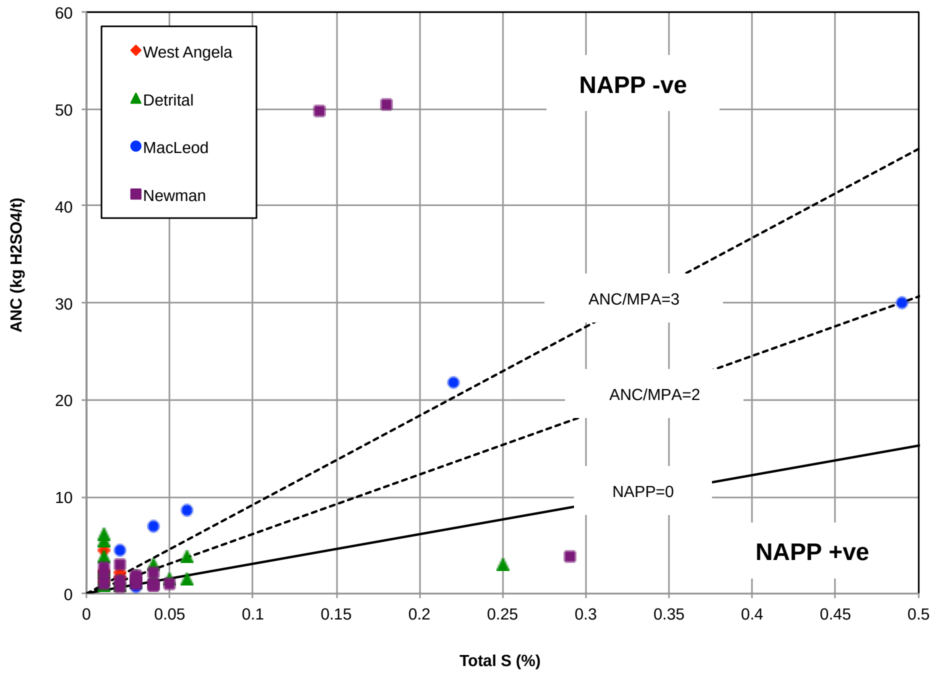

Figure 1a: Acid base account plot of total S versus ANC

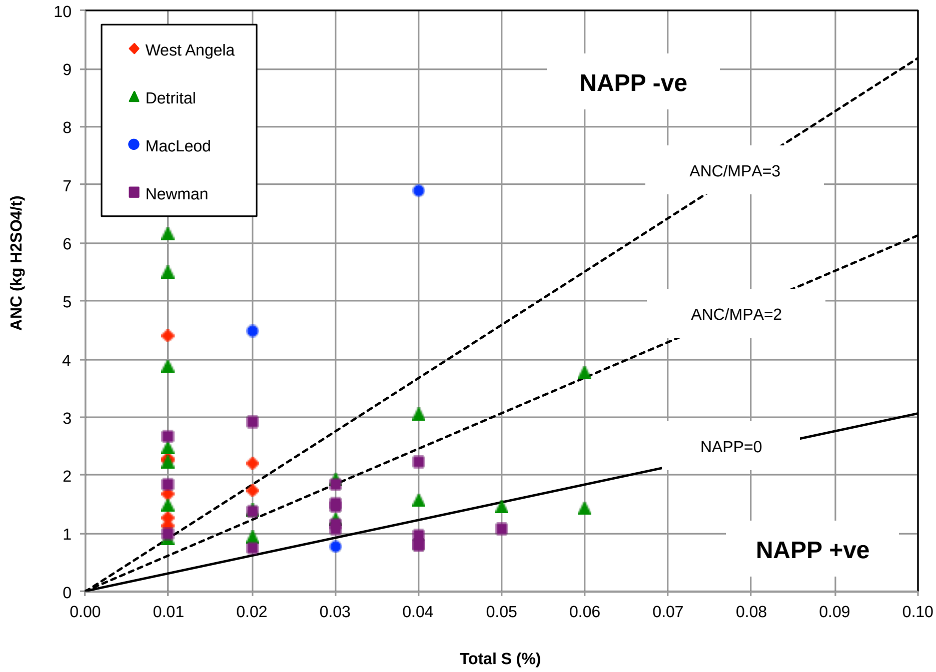

Figure 1b: Same as Figure 1a, but with an expanded total S and ANC scale.

The NAPP value is used in conjunction with single addition net acid generation (NAG) test results to geochemically classify samples in relation to their ARD potential. Samples are classified as barren, non-acid forming (NAF), potentially acid forming (PAF) and uncertain (UC) according to the following characteristics:

• Barren:		Total S < 0.1%S and ANC ≤ 5 kg H_2SO_4/t.
• NAF:	Non-Acid Forming.	NAPP negative and NAGpH greater than or equal to 4.5.
• PAF:	Potentially Acid Forming.	NAPP positive, NAGpH less than 4.5 and NAG acidity greater than 5 kg H_2SO_4/t.
• PAF-LC:	Potentially Acid Forming -Lower Capacity.	NAPP positive, NAGpH less than 4.5 and NAG acidity to pH 4.5 less than or equal to 5 kg H_2SO_4/t.
• UC:	Uncertain.	Conflicting NAPP and NAG results (i.e., NAPP positive and NAGpH greater than 4.5 or NAPP negative and NAGpH less than 4.5).

Note that net acid generation (NAG) testing was only conducted on the six samples with total S greater than or equal to 0.1%S. Samples with total S less than 0.1%S are classified as barren with respect to acid generation.

In total, 41 of the 50 samples are classified as barren. Three samples (FWP116, FWP075, FWP167), had total S contents less than 0.1%S but ANC > 5 kg H_2SO_4/t, and were classified as non-acid forming (NAF).

Four of the six samples with total S > 0.1%S were NAPP negative and the NAGpH was greater than 4.5. These samples were classified NAF.

Newman sample, FWP071, had a positive NAPP value of 5 kg H_2SO_4/t and NAGpH of 2.9, indicating that it was potentially acid forming (PAF).

One sample, FYN787 (detrital), had a positive NAPP value of 5 kg H_2SO_4/t, and NAGpH of 5.6 and was classified as uncertain. It is likely that this sample is NAF, as any sulphides within the sample would have been fully oxidised in the NAG test and hence the sample is classified as uncertain, but likely to be non-acid forming, UC (NAF).

The table below provides a breakdown of ARD classification in relation to each rock type member group.

Stratigraphy	Number of Samples	% Barren	% NAF	% PAF	% UC
West Angela	8	100%	0	0	0
Detrital	17	88%	6%	0	6%
MacLeod	6	33%	67%	0	0
Newman	19	84%	11%	5%	0
TOTAL	50	82%	14%	2%	2%

The results show that all of the West Angela Member samples are classified as barren. Eighty-eight percent (88%) of the detrital samples were classified as barren, 6% were non-acid forming (NAF) and 6% classified as uncertain. Two thirds of the MacLeod Member samples were classified as NAF and one third as barren. The majority of the Newman samples (84%) were classified as barren, 11% were NAF and one sample (5%) classified as potentially acid forming (PAF).

Overall, 41 samples (82%) were classified as barren, 7 samples (14%) were NAF, one sample (2%) was PAF and one sample (2%) classified as UC (NAF).

3.2 Acid Buffering Characteristic Curve (ABCC)

An acid buffering characteristic curve (ABCC) is produced by slow titration of a sample with acid, and provides an indication of the relative reactivity of the measured ANC. Calcite, dolomite, ferroan dolomite and siderite standard curves are used for reference. Calcite and dolomite readily dissolve in acid and exhibit strongly buffered pH curves in the ABCC test, rapidly dropping once the ANC value is reached. Siderite provides very poor acid buffering, exhibiting a steep pH curve in the ABCC test. Ferroan dolomite is between siderite and dolomite in acid buffering availability.

Four samples were selected for ABCC testing and the results are presented in Figures 2 to 4. All four samples had an ANC greater than 20 kg H_2SO_4/t.

Figures 2 and 3 present the ABCC plots of MacLeod Member samples FWP080 and FWP092, which have an ANC of 30 and 22 kg H_2SO_4/t, respectively. The sample curves plot between the ferroan dolomite and siderite standard curves, suggesting that the ANC of the samples is slowly reactive.

Figure 4 presents the ABCC plots of Newman samples FNY843 and FWP156, which both have an ANC of 50 kg H_2SO_4/t. Sample FNY843 plots close to the dolomite standard curve and indicates that most of the ANC of this sample is readily available. Sample FWP156 plots between the calcite and dolomite standard curve and suggest that all of the ANC of this sample is readily available. The shape of the curves indicate that the ANC of both samples is reactive and able to strongly buffer the pH above 6.

3.3 Elemental Composition

To provide some relativity to the multi-element data, the compositions of the solids were compared to typical background concentrations reported for soil and the Earth's crust. The purpose of this comparison was to highlight any elements that were significantly enriched, especially elements that are generally regarded as environmentally important. The comparison is expressed as a Geochemical Abundance Index (GAI), which relates enrichment to the median soil abundance value using the formula:

$$GAI = \log_2 [C / (1.5*S)]$$

where C is the concentration of the element in the sample and S is the median soil[1] content for that element. GAIs are truncated to integer increments (0 through to 6, respectively) where a GAI of 0 indicates the element is present at a concentration similar to, or less than, median soil abundance and a GAI of 6 indicates approximately a 100-fold, or greater, enrichment above median soil abundance. The enrichment ranges for the GAI are as follows:

[1] References for median soil data were: (1) Bowen, H.J.M. (1997) Environmental Chemistry of the Elements. Academic Press, London. (2) Berkman, D.A. (1976) Field Geologists' Manual, The Australian Institute of Mining and Metallurgy, Parkville, Victoria, Australia

Little or No Enrichment	GAI=0	< 3 times median soil
Minor Enrichment	GAI=1	3 to <6 times median soil
	GAI=2	6 to <12 times median soil
Significant Enrichment	GAI=3	12 to <24 times median soil
	GAI=4	24 to <48 times median soil
	GAI=5	48 to <96 times median soil
	GAI=6	≥ 96 times median soil

Ten (10) samples were selected for elemental assays and covered the different sample types, S contents, ANC, NAPP values and ARD classifications. Table 2 presents the elemental composition of the solids, Table 3 presents the GAI with results compared against the median soil abundance and Table 4 presents the GAI with results compared against mean crustal abundance.

The table below presents a summary of the elements that are significantly enriched (GAI ≥ 3) in at least one of the samples compared with median soil and mean crustal abundance.

Strand	Numbers of Samples Assayed	Median Soil (GAI ≥ 3)	Mean Crustal (GAI ≥ 3)
West Angela	1	Fe	As, Fe, Sb and Se
Detrital	2	Fe	As, Fe, S, Sb and Se
MacLeod	3	-	As, S and Se
Newman	4	Fe	Fe, S and Se

The results show that Fe is the only element that is significantly enriched when compared with median soil abundance. There was minor enrichment (GAI = 1 or 2) of Ag, As, Be, Cr, Cs, Mg, Mn, Mo, S, Sb, Sc, Se and W.

Arsenic (As), Fe, S, Sb and Se are significantly enriched in at least one of the samples when compared with mean crustal abundance. At least one of the samples also had minor enrichment (GAI=1 or 2) of Ag, Bi, Cd, Cs, Mn, Mo, and W.

Although Fe was significantly enriched, the application of world soil and crustal abundances data for Fe in the Pilbara region is misleading due to natural high concentrations in regional soils and surface materials and hence this enrichment is of no local environmental concern.

Overall, the elements of potential environmental concern in West Angelas Deposit F waste rock are As, Sb and Se.

To further evaluate this issue, the same samples that underwent multi-element scans on solids underwent multi-element analyses of water extracts to provide an indication of the immediate solubility of environmentally important elements.

Table 5 presents the water extraction results and shows that the samples had a neutral to alkaline $pH_{1:2}$ ranging from 7.5 to 8.3. The samples were non-saline to slightly saline with $EC_{1:2}$ of 0.02 to 0.89 dS/m.

At the time of testing, the environmentally important elements including As, Sb and Se were either at low concentrations of below the detection limit. There was minor release of Fe from sample FYN908, however, at neutral pH, it is likely that the Fe is present as colloidal forms.

The results show that at the time of testing, the solubility of environmentally important elements was low in all samples including the one PAF sample (FWP071).

4.0 Comparison of Deposit F with Deposit B, D and A Waste Rock

Figure 5 presents a box plot comparing the total S content of the Deposit F samples with the Deposits B, D and A samples. The 10^{th}, 25^{th}, 50^{th} (median), 75^{th} and 90^{th} percentiles are marked. The results show that whilst the total S range for Deposit F is less than Deposits B, D and A, the 25^{th}, 50^{th} and 75^{th} percentiles are similar.

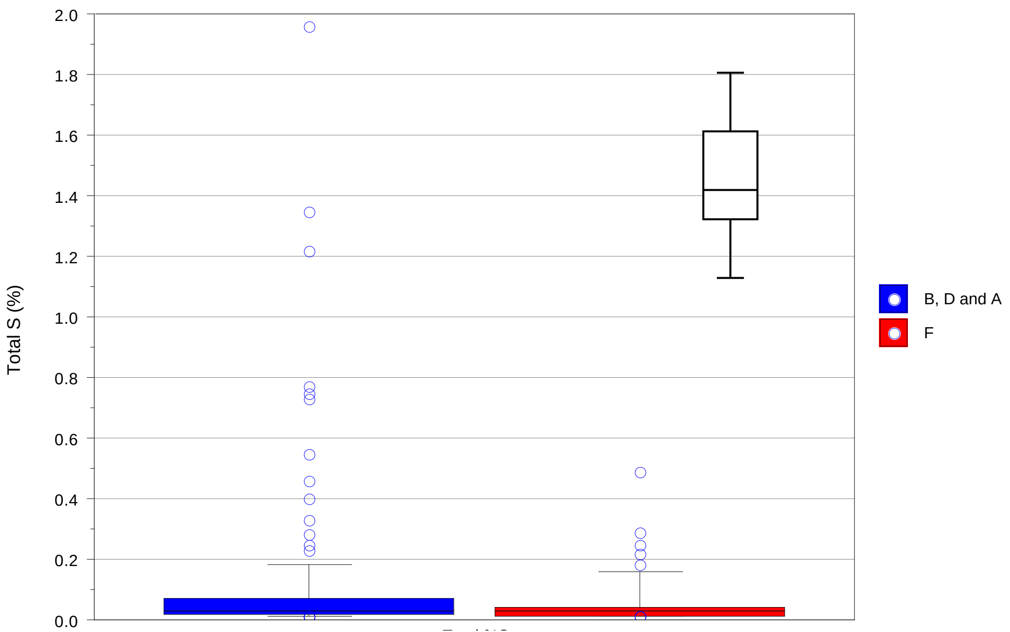

Figure 5: Comparison of Deposit F total S results with Deposits B, D and A results.

Figure 6 presents a box plot comparing the ANC of Deposit F with Deposits B, D and A and shows that the range in ANC for Deposits B, D and A was wider than that of Deposit F and although the 75th percentile is greater, the median values are similar.

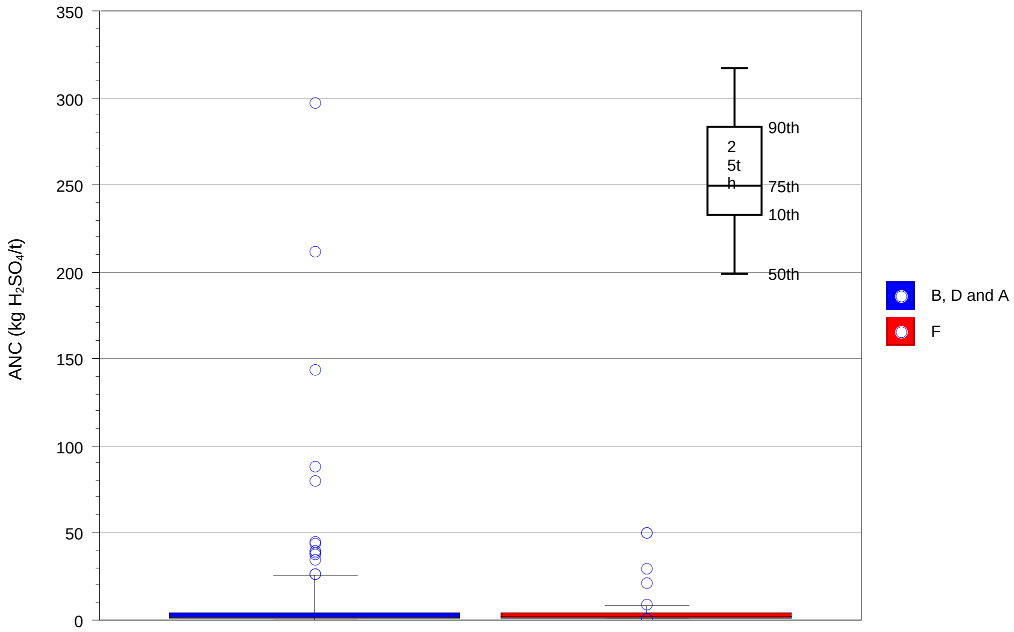

Figure 6: Comparison of Deposit F ANC results with Deposits B, D and A results.

Figure 7 shows a comparison between the NAPP results for the deposits. The 10th, 25th, 50th (median), 75th and 90th percentiles are marked. Again, the results show a wider range for Deposits B, D and A, with Deposit F data falling well within the range with a similar median value.

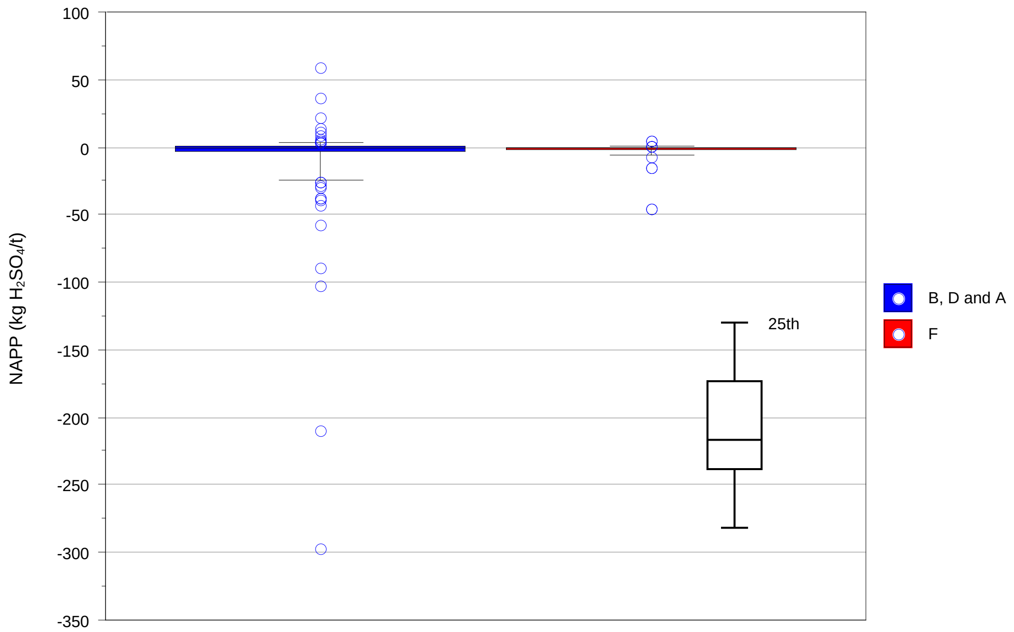

Figure 7: Comparison of Deposit F NAPP results with Deposits B, D and A results.

The table below presents the minimum, maximum, average and median total S, ANC and NAPP values for Deposit F and Deposits B, D and A.

Parameter	Deposit F				Deposit B, D and A			
	Min	Max	Average	Median	Min	Max	Average	Median
Total S (%)	<0.01	0.49	0.06	0.03	<0.01	1.96	0.11	0.03
ANC (kg H_2SO_4/t)	1	50	5	2	0	297	11	2
NAPP (kg H_2SO_4/t)	-46	5	-4	-1	-297	59	-8	-1

The highest total S content for Deposit F was 0.49%S, compared with 1.96%S for Deposits B, D and A, and the highest ANC was 50 kg H_2SO_4/t for Deposit F compared to 297 kg H_2SO_4/t for Deposits B, D and A.

The NAPP range, varied greatly between the deposits with the range for Deposit F being -46 to +5 kg H_2SO_4/t and for Deposits B, D and A being -297 to +59 kg H_2SO_4/t.

The average total S, ANC and NAPP values varied slightly between the deposits, whereas the median values were identical.
The results show that whilst the total S, ANC and NAPP ranges may differ between the Deposit F and Deposits B, D and A samples, the Deposit F data fall well within the range for Deposits B, D and A, with identical median values, but significantly lower maximum NAPP values indicating lower ARD risk.

The table below provides a breakdown of samples in each ARD classification group. The results show that 98% of the samples from Deposit F are barren or NAF and 92% of samples from Deposits B, D and A are barren or NAF.

Deposit	Barren/NAF/ UC(NAF)	PAF/ PAF-LC
F	98%	2%
B, D and A	92%	8%

5.0 Discussion and Recommendations

Testing has been conducted on four different waste rock types from Deposit F of the West Angelas Mine and indicates that 88% of the samples have a total S content less than 0.1%S and 86% have an acid neutralising capacity (ANC) less than 5 kg H_2SO_4/t. The majority of the samples (82%) were NAPP negative with a good to high factor of safety.

Overall, 41 samples (82%) were classified as barren, 7 samples (14%) were NAF, one sample (2%) was PAF and one sample (2%) classified as UC (NAF).

The elements of potential environmental concern that are likely to be significantly enriched in West Angelas Deposit F waste rock are As, Sb and Se. However, the solubility of these elements at circum-neutral pH was low for the samples that were tested.

Based on the samples tested, the ARD risk from waste rock at the West Angelas Deposit F is likely to be low. However, it is recommended that a program of operational monitoring is conducted to confirm the low ARD risk and to identify any units that may require special handling so as not to compromise the long term geochemistry of the waste rock dump.

The results show that whilst the total S, ANC and NAPP ranges may differ between the Deposit F and Deposits B, D and A samples, the Deposit F data fall well within the range for Deposits B, D and A, with identical median values, but significantly lower maximum NAPP values indicating lower ARD risk.

Table 1: Acid forming characteristics of waste rock samples from West Angelas Deposit F.

Sample ID	Hole ID	Sample Type	Stratigraphy Maj	Geozone	Depth (m)		Interval (m)	$pH_{1:2}$	$EC_{1:2}$	ACID-BASE ANALYSIS					NAG TEST			ARD Classification
					From	To				Total %S	MPA	ANC	NAPP	ANC/MPA	NAGpH	$NAG_{(pH4.5)}$	$NAG_{(pH7.0)}$	
FWP214	MB13WAF0005	RCCHIPS	ANG	705	78	80	2.0	7.6	0.034	<0.01	0	2	-1	5.5				Barren
FYN808	MB13WAF0001	RCCHIPS	ANG	702	68	70	2.0	7.5	0.029	<0.01	0	2	-2	7.4				Barren
FYN801	MB13WAF0001	RCCHIPS	ANG	701	54	56	2.0	7.4	0.021	0.02	1	2	-2	3.6				Barren
FYN805	MB13WAF0001	RCCHIPS	ANG	701	62	64	2.0	7.2	0.045	<0.01	0	2	-2	7.5				Barren
FYN891	MB13WAF0002	RCCHIPS	ANG	701	84	86	2.0	7.5	0.071	<0.01	0	1	-1	4.1				Barren
FYN896	MB13WAF0002	RCCHIPS	ANG	701	94	96	2.0	8.1	0.124	<0.01	0	1	-1	3.7				Barren
FWP017	MB13WAF0003	RCCHIPS	ANG	701	88	90	2.0	7.3	0.025	<0.01	0	4	-4	14.4				Barren
FWP331	MB13WAF0006	RCCHIPS	ANG	701	90	92	2.0	7.5	0.016	0.02	1	2	-1	2.9				Barren
FWP127	MB13WAF0004	RCCHIPS	DET	705	58	60	2.0	7.4	0.09	0.01	0	2	-2	7.3				Barren
FWP012	MB13WAF0003	RCCHIPS	DET	701	78	80	2.0	7.3	0.041	<0.01	0	1	-1	4.9				Barren
FYN787	MB13WAF0001	RCCHIPS	DET	12	28	30	2.0	7.6	0.024	0.25	8	3	5	0.4	5.6	0	6	UC (NAF)
FYN886	MB13WAF0002	RCCHIPS	DET	12	76	78	2.0	7.4	0.026	0.03	1	1	0	1.3				Barren
FWP204	MB13WAF0005	RCCHIPS	DET	12	60	62	2.0	8.0	0.029	0.06	2	1	0	0.8				Barren
FYN779	MB13WAF0001	RCCHIPS	DET	11	12	14	2.0	7.2	0.032	0.01	0	2	-2	8.1				Barren
FYN854	MB13WAF0002	RCCHIPS	DET	11	14	16	2.0	7.3	0.038	<0.01	0	1	-1	3.0				Barren
FYN863	MB13WAF0002	RCCHIPS	DET	11	32	34	2.0	7.5	0.031	0.01	0	4	-4	12.6				Barren
FYN975	MB13WAF0003	RCCHIPS	DET	11	10	12	2.0	7.2	0.032	0.02	1	1	-1	2.3				Barren
FWP173	MB13WAF0005	RCCHIPS	DET	11	0	2	2.0	7.4	0.026	0.04	1	2	0	1.3				Barren
FWP196	MB13WAF0005	RCCHIPS	DET	11	44	46	2.0	7.3	0.039	0.02	1	1	0	1.5				Barren
FWP287	MB13WAF0006	RCCHIPS	DET	11	8	10	2.0	7.2	0.025	0.03	1	2	-1	2.1				Barren
FWP311	MB13WAF0006	RCCHIPS	DET	11	52	54	2.0	7.4	0.041	0.01	0	5	-5	17.9				Barren
FYN979	MB13WAF0003	RCCHIPS	DET	7	18	20	2.0	7.3	0.032	0.05	2	1	0	1.0				Barren
FYN996	MB13WAF0003	RCCHIPS	DET	7	50	52	2.0	7.5	0.052	0.04	1	3	-2	2.5				Barren
FWP116	MB13WAF0004	RCCHIPS	DET	7	36	38	2.0	7.4	0.087	0.01	0	6	-6	20.1				NAF
FWP185	MB13WAF0005	RCCHIPS	DET	7	24	26	2.0	8.1	0.116	0.06	2	4	-2	2.1				Barren
FWP075	MB13WAF0003	RCCHIPS	MAC	761	196	198	2.0	8.2	0.112	0.06	2	9	-7	4.7				NAF
FWP080	MB13WAF0003	RCCHIPS	MAC	761	206	208	2.0	7.8	0.568	0.49	15	30	-15	2.0	4.8	0	4	NAF
FWP092	MB13WAF0003	RCCHIPS	MAC	761	228	230	2.0	8.0	0.196	0.22	7	22	-15	3.2	6.9	0	0	NAF
FWP167	MB13WAF0004	RCCHIPS	MAC	761	132	134	2.0	7.9	0.107	0.04	1	7	-6	5.6				NAF
FWP172	MB13WAF0004	RCCHIPS	MAC	761	140	142	2.0	7.7	0.111	0.02	1	4	-4	7.3				Barren
FWP281	MB13WAF0005	RCCHIPS	MAC	751	204	206	2.0	7.6	0.103	0.03	1	1	0	0.8				Barren

Table 1: Acid forming characteristics of waste rock samples from West Angelas Deposit F.

Sample ID	Hole ID	Sample Type	Stratigraphy Maj	Geozone	Depth (m)		Interval (m)	$pH_{1:2}$	$EC_{1:2}$	ACID-BASE ANALYSIS					NAG TEST			ARD Classification
					From	To				Total %S	MPA	ANC	NAPP	ANC/MPA	NAGpH	$NAG_{(pH4.5)}$	$NAG_{(pH7.0)}$	
FYN832	MB13WAF0001	RCCHIPS	N2L	752	110	112	2.0	7.8	0.087	0.04	1	2	-1	1.8				Barren
FWP338	MB13WAF0006	RCCHIPS	N2L	732	102	104	2.0	7.5	0.069	0.01	0	2	-2	6.1				Barren
FWP142	MB13WAF0004	RCCHIPS	N2L	731	84	86	2.0	7.6	0.052	0.03	1	1	0	1.3				Barren
FYN908	MB13WAF0002	RCCHIPS	N2U	722	118	120	2.0	7.7	0.045	0.04	1	1	0	0.7				Barren
FYN911	MB13WAF0002	RCCHIPS	N2U	722	122	124	2.0	7.8	0.039	0.03	1	1	0	1.2				Barren
FWP231	MB13WAF0005	RCCHIPS	N2U	722	108	110	2.0	7.6	0.042	0.04	1	1	0	0.8				Barren
FWP039	MB13WAF0003	RCCHIPS	N2U	721	128	130	2.0	7.4	0.048	0.05	2	1	0	0.7				Barren
FWP040	MB13WAF0003	RCCHIPS	N2U	721	130	132	2.0	7.6	0.069	0.04	1	1	0	0.7				Barren
FYN843	MB13WAF0001	RCCHIPS	NE1	751	132	134	2.0	8.2	0.262	0.18	6	50	-45	9.2	7.6	0	0	NAF
FYN931	MB13WAF0002	RCCHIPS	NE1	751	158	160	2.0	7.8	0.176	0.03	1	1	-1	1.6				Barren
FWP071	MB13WAF0003	RCCHIPS	NE1	751	188	190	2.0	7.4	0.211	0.29	9	4	5	0.4	2.8	9	11	PAF
FWP153	MB13WAF0004	RCCHIPS	NE1	751	104	106	2.0	7.5	0.104	0.01	0	1	-1	3.2				Barren
FWP156	MB13WAF0004	RCCHIPS	NE1	751	110	112	2.0	8.2	0.159	0.14	4	50	-46	11.6	7.2	0	0	NAF
FWP163	MB13WAF0004	RCCHIPS	NE1	751	124	126	2.0	7.8	0.062	0.03	1	2	-1	2.0				Barren
FWP352	MB13WAF0006	RCCHIPS	NE1	751	128	130	2.0	7.5	0.055	0.02	1	3	-2	4.8				Barren
FWP355	MB13WAF0006	RCCHIPS	NE1	751	134	136	2.0	7.4	0.042	0.02	1	1	-1	2.3				Barren
FWP362	MB13WAF0006	RCCHIPS	NE1	751	148	150	2.0	7.2	0.038	0.02	1	1	0	1.2				Barren
FWP371	MB13WAF0006	RCCHIPS	NE1	751	164	166	2.0	7.3	0.035	0.03	1	2	-1	1.7				Barren
FWP252	MB13WAF0005	RCCHIPS	NE1	732	148	150	2.0	7.6	0.039	0.01	0	3	-2	8.7				Barren

KEY

$pH_{1:2}$ = pH of 1:2 extract

$EC_{1:2}$ = Electrical Conductivity of 1:2 extract (dS/m)

MPA = Maximum Potential Acidity (kgH_2SO_4/t)

ANC = Acid Neutralising Capacity (kgH_2SO_4/t)

NAPP = Net Acid Producing Potential (kgH_2SO_4/t)

NAGpH = pH of NAG liquor

$NAG_{(pH4.5)}$ = Net Acid Generation capacity to pH 4.5 (kgH_2SO_4/t)

$NAG_{(pH7.0)}$ = Net Acid Generation capacity to pH 7.0 (kgH_2SO_4/t)

NAF = Non-Acid Forming

PAF = Potentially Acid Forming

PAF-LC = PAF - lower capacity

UC = Uncertain Classification

(expected classification in brackets)

Table 2: Multi-element composition of selected solids samples (mg/kg except where shown).

Element	Detection Limit	ELEMENTAL COMPOSITION									
		FYN896	FYN787	FWP287	FWP080	FWP092	FWP281	FYN908	FYN843	FWP071	FWP156
		ANG	DET	DET	MAC	MAC	MAC	N2U	NE1	NE1	NE1
Ag	0.01	0.19	0.15	0.14	0.16	0.13	0.1	0.2	0.09	0.07	0.08
Al	0.01%	2.30%	4.38%	7.12%	2.23%	0.67%	0.12%	0.35%	0.13%	0.36%	0.11%
As	0.2	27.6	16.8	17.3	19.2	2.5	0.8	2.6	0.5	0.9	0.8
Ba	10	10	60	170	240	10	10	10	10	10	10
Be	0.05	0.99	0.12	1.07	1.14	1.87	0.43	0.37	0.45	0.94	0.42
Bi	0.01	0.23	0.31	0.39	0.14	0.06	0.04	0.05	0.04	0.09	0.05
Ca	0.01%	0.02%	0.08%	0.06%	0.24%	0.34%	0.01%	0.01%	1.51%	0.12%	1.66%
Cd	0.02	0.02	0.03	0.06	0.24	0.09	0.02	0.02	0.04	0.02	0.02
Ce	0.01	22.1	3.78	29.8	24.1	14.2	3.8	7.44	2.12	5.2	1.74
Co	0.1	7.1	1.5	6.9	11.8	2.1	1.2	1.4	1.1	1.6	1.1
Cr	1	49	87	152	45	10	2	1	3	6	2
Cs	0.05	0.05	0.1	2.76	10.95	7.52	0.06	0.05	0.9	0.54	0.87
Cu	0.2	7.2	9.3	51.6	15.6	6.6	3.2	3.7	3.7	5.4	2.1
Fe	0.01%	>50%	49.5%	17.3%	22.9%	21.0%	29.2%	>50%	28.4%	27.1%	25.1%
Ga	0.05	7.43	19.15	19.5	5.62	2.19	0.39	0.89	0.47	1.15	0.4
Ge	0.05	3.28	2.05	0.3	0.31	0.28	0.47	2.28	0.32	0.33	0.3
Hf	0.005	0.9	2	3.7	1.2	0.6	0.7	0.1	0.5	0.6	0.4
Hg	0.005	0.027	0.016	0.007	0.057	0.021	0.01	0.016	0.01	0.023	0.013
K	0.01%	0.01%	0.19%	0.34%	2.08%	0.56%	0.01%	<0.01%	0.05%	0.05%	0.02%
La	0.5	7.4	3	17.7	12.4	7.2	2.1	2.3	1.3	2.8	1
Li	0.2	3.7	1.9	18.8	2.4	2.5	4.9	1.8	4.1	4.7	5.6
Mg	0.01%	0.04%	0.03%	0.10%	1.19%	1.64%	0.02%	0.02%	1.43%	0.15%	1.08%
Mn	5	45	105	349	3620	953	97	262	191	183	240
Mo	0.05	1.46	3.68	1.51	1.08	0.98	0.77	0.27	0.31	0.66	0.5
Na	0.01%	0.01%	0.11%	0.04%	0.06%	0.02%	<0.01%	0.01%	0.05%	0.01%	0.13%
Nb	0.1	2.6	11.6	10.5	3	1.4	0.4	1.1	0.5	0.8	0.4
Ni	0.2	21.4	8.7	27.6	30	9.2	2.3	5	2.7	5.3	2.2
P	10	160	360	370	60	120	290	510	650	460	330
Pb	0.5	12.7	16.2	21.9	13.7	5.8	2.3	2.7	7.8	2.7	2.3
Rb	0.1	0.4	1.8	34.1	165.5	97.5	1	0.3	6.3	7.1	3.3
S	0.01%	0.01%	0.54%	0.02%	0.58%	0.25%	<0.01%	<0.01%	0.11%	0.32%	0.11%
Sb	0.05	1.75	2.46	1.51	0.79	1.11	0.27	0.46	0.37	0.4	0.28
Sc	0.1	6.4	6	18.5	6.9	2.2	0.6	0.9	0.5	1	0.4
Se	1	1	2	2	1	<1	<1	<1	<1	<1	<1
Sn	0.2	0.8	2.6	2.8	0.8	0.5	0.2	0.2	0.2	0.3	0.2
Sr	0.2	1.8	83.8	29.2	2.4	3.7	0.8	0.9	40.7	2.9	15.1
Ta	0.05	0.18	0.92	0.91	0.26	0.11	0.05	0.05	0.05	0.05	0.05
Th	0.2	3.4	6	11.5	3.2	1.6	0.2	0.3	0.2	0.7	0.2
Ti	0.01%	0.10%	0.52%	0.50%	0.14%	0.03%	0.01%	0.01%	0.01%	0.02%	0.01%
Tl	0.02	0.02	0.02	0.35	0.36	0.2	0.02	0.02	0.03	0.05	0.02
U	0.1	1.8	0.7	2	0.9	0.4	0.1	0.3	0.2	0.2	0.2
V	1	55	102	163	42	8	3	8	3	6	2
W	0.1	1.3	2.9	2.3	1.1	1.5	3.7	0.8	2.7	3.8	2.5
Y	0.1	11.5	1.6	11.3	13.5	7	2.1	4.8	4.7	5.3	3.5
Zn	2	5	9	73	68	34	10	8	17	15	10
Zr	0.5	35	79	135.5	52.3	25.8	38.1	5.7	24.2	29.4	18.1

r below analytical detection limit.

Table 3: Geochemical Abundance Index (GAI) of selected solids samples - MEDIAN SOIL ABUNDANCE

Element	Median Soil Abundance*	MEDIAN SOIL ABUNDANCE									
		FYN896	FYN787	FWP287	FWP080	FWP092	FWP281	FYN908	FYN843	FWP071	FWP156
		ANG	DET	DET	MAC	MAC	MAC	N2U	NE1	NE1	NE1
Ag	0.05	1	1	1	1	1	-	1	-	-	-
Al	7.1%	-	-	-	-	-	-	-	-	-	-
As	6	2	1	1	1	-	-	-	-	-	-
Ba	500	-	-	-	-	-	-	-	-	-	-
Be	0.3	1	-	1	1	2	-	-	-	1	-
Bi	0.2	-	-	-	-	-	-	-	-	-	-
Ca	1.5%	-	-	-	-	-	-	-	-	-	-
Cd	0.35	-	-	-	-	-	-	-	-	-	-
Ce	50	-	-	-	-	-	-	-	-	-	-
Co	8	-	-	-	-	-	-	-	-	-	-
Cr	70	-	-	1	-	-	-	-	-	-	-
Cs	4	-	-	-	1	-	-	-	-	-	-
Cu	30	-	-	-	-	-	-	-	-	-	-
Fe	4.0%	**>3**	**3**	2	2	2	2	**>3**	2	2	2
Ga	20	-	-	-	-	-	-	-	-	-	-
Ge	1	1	-	-	-	-	-	1	-	-	-
Hf	6	-	-	-	-	-	-	-	-	-	-
Hg	0.06	-	-	-	-	-	-	-	-	-	-
K	1.4%	-	-	-	-	-	-	-	-	-	-
La	40	-	-	-	-	-	-	-	-	-	-
Li	25	-	-	-	-	-	-	-	-	-	-
Mg	0.5%	-	-	-	1	1	-	-	1	-	1
Mn	1000	-	-	-	1	-	-	-	-	-	-
Mo	1.2	-	1	-	-	-	-	-	-	-	-
Na	0.5%	-	-	-	-	-	-	-	-	-	-
Nb	10	-	-	-	-	-	-	-	-	-	-
Ni	50	-	-	-	-	-	-	-	-	-	-
P	800	-	-	-	-	-	-	-	-	-	-
Pb	35	-	-	-	-	-	-	-	-	-	-
Rb	150	-	-	-	-	-	-	-	-	-	-
S	0.1%	-	2	-	2	1	-	-	-	2	-
Sb	1	-	1	-	-	-	-	-	-	-	-
Sc	7	-	-	1	-	-	-	-	-	-	-
Se	0.4	1	2	2	1	<1	<1	<1	<1	<1	<1
Sn	4	-	-	-	-	-	-	-	-	-	-
Sr	250	-	-	-	-	-	-	-	-	-	-
Ta	2	-	-	-	-	-	-	-	-	-	-
Th	9	-	-	-	-	-	-	-	-	-	-
Ti	0.5%	-	-	-	-	-	-	-	-	-	-
Tl	0.2	-	-	-	-	-	-	-	-	-	-
U	2	-	-	-	-	-	-	-	-	-	-
V	90	-	-	-	-	-	-	-	-	-	-
W	1.5	-	-	-	-	-	1	-	-	1	-
Y	40	-	-	-	-	-	-	-	-	-	-
Zn	90	-	-	-	-	-	-	-	-	-	-
Zr	400	-	-	-	-	-	-	-	-	-	-

*Bowen H.J.M.(1979) Environmental Chemistry of the Elements.

Table 4: Geochemical Abundance Index (GAI) of selected solids samples - MEAN CRUSTAL ABUNDANCE ABUNDANCE

Element	Mean Crustal Abundance*	MEAN CRUSTAL ABUNDANCE									
		FYN896	FYN787	FWP287	FWP080	FWP092	FWP281	FYN908	FYN843	FWP071	FWP156
		ANG	DET	DET	MAC	MAC	MAC	N2U	NE1	NE1	NE1
Ag	0.07	1	1	-	1	-	-	1	-	-	-
Al	8.2%	-	-	-	-	-	-	-	-	-	-
As	1.5	**4**	**3**	**3**	**3**	-	-	-	-	-	-
Ba	500	-	-	-	-	-	-	-	-	-	-
Be	2.6	-	-	-	-	-	-	-	-	-	-
Bi	0.048	2	2	2	1	-	-	-	-	-	-
Ca	4.0%	-	-	-	-	-	-	-	-	-	-
Cd	0.11	-	-	-	1	-	-	-	-	-	-
Ce	68	-	-	-	-	-	-	-	-	-	-
Co	20	-	-	-	-	-	-	-	-	-	-
Cr	100	-	-	-	-	-	-	-	-	-	-
Cs	3	-	-	-	1	1	-	-	-	-	-
Cu	50	-	-	-	-	-	-	-	-	-	-
Fe	4.1%	**>3**	**3**	1	2	2	2	**>3**	2	2	2
Ga	18	-	-	-	-	-	-	-	-	-	-
Ge	1.8	-	-	-	-	-	-	-	-	-	-
Hf	5.3	-	-	-	-	-	-	-	-	-	-
Hg	0.05	-	-	-	-	-	-	-	-	-	-
K	2.1%	-	-	-	-	-	-	-	-	-	-
La	32	-	-	-	-	-	-	-	-	-	-
Li	20	-	-	-	-	-	-	-	-	-	-
Mg	2.3%	-	-	-	-	-	-	-	-	-	-
Mn	950	-	-	-	1	-	-	-	-	-	-
Mo	1.5	-	1	-	-	-	-	-	-	-	-
Na	2.3%	-	-	-	-	-	-	-	-	-	-
Nb	20	-	-	-	-	-	-	-	-	-	-
Ni	80	-	-	-	-	-	-	-	-	-	-
P	1000	-	-	-	-	-	-	-	-	-	-
Pb	14	-	-	-	-	-	-	-	-	-	-
Rb	90	-	-	-	-	-	-	-	-	-	-
S	0.03%	-	**4**	-	**4**	2	-	-	1	**3**	1
Sb	0.2	**3**	**3**	2	1	2	-	1	-	-	-
Sc	16	-	-	-	-	-	-	-	-	-	-
Se	0.05	**4**	**5**	**5**	**4**	**<4**	**<4**	**<4**	**<4**	**<4**	**<4**
Sn	2.2	-	-	-	-	-	-	-	-	-	-
Sr	370	-	-	-	-	-	-	-	-	-	-
Ta	2	-	-	-	-	-	-	-	-	-	-
Th	12	-	-	-	-	-	-	-	-	-	-
Ti	0.56%	-	-	-	-	-	-	-	-	-	-
Tl	0.6	-	-	-	-	-	-	-	-	-	-
U	2.4	-	-	-	-	-	-	-	-	-	-
V	160	-	-	-	-	-	-	-	-	-	-
W	1	-	1	1	-	-	1	-	1	1	1
Y	30	-	-	-	-	-	-	-	-	-	-
Zn	75	-	-	-	-	-	-	-	-	-	-
Zr	190	-	-	-	-	-	-	-	-	-	-

*Bowen H.J.M.(1979) Environmental Chemistry of the Elements.

Table 5: Chemical composition of water extracts of selected samples.

Parameter		Detection Limit	Elemental Composition									
			FYN896	FYN787	FWP287	FWP080	FWP092	FWP281	FYN908	FYN843	FWP071	FWP156
			ANG	DET	DET	MAC	MAC	MAC	N2U	NE1	NE1	NE1
pH		0.01	7.9	7.6	7.5	7.7	8.0	7.9	7.8	8.2	7.6	8.3
EC	dS/m	0.01	0.11	0.07	0.02	0.89	0.26	0.10	0.04	0.26	0.20	0.16
Ag	mg/l	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Al	mg/l	0.01	0.02	0.03	0.03	<0.01	<0.01	<0.01	0.04	<0.01	<0.01	<0.01
As	mg/l	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001
B	mg/l	0.05	<0.05	0.1	0.06	<0.05	<0.05	0.07	<0.05	<0.05	<0.05	<0.05
Ba	mg/l	0.001	0.13	0.41	0.08	0.07	0.43	0.24	0.27	0.44	0.42	0.40
Be	mg/l	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Ca	mg/l	1	<1	2	<1	24	8	1	1	7	8	6
Cd	mg/l	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Cl	mg/l	1	2	21	2	10	7	2	3	26	9	5
Co	mg/l	0.001	<0.001	<0.001	<0.001	0.002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Cr	mg/l	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Cu	mg/l	0.001	0.005	0.002	<0.001	0.008	0.002	0.003	0.002	0.005	0.006	0.003
F	mg/l	0.1	0.1	0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Fe	mg/l	0.05	0.05	<0.05	<0.05	<0.05	<0.05	0.20	0.83	<0.05	<0.05	<0.05
Hg	mg/l	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
K	mg/l	1	<1	4	<1	65	12	<1	<1	8	5	2
Mg	mg/l	1	<1	1	<1	22	8	<1	1	8	7	7
Mn	mg/l	0.001	0.012	<0.001	0.002	0.038	0.003	0.018	0.003	0.003	0.009	0.004
Mo	mg/l	0.001	<0.001	<0.001	<0.001	0.004	0.013	0.002	<0.001	0.006	0.003	0.011
Na	mg/l	1	3	17	4	79	14	3	3	20	6	7
Ni	mg/l	0.001	<0.001	<0.001	<0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
P	mg/l	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Pb	mg/l	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Sb	mg/l	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Se	mg/l	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Si	mg/l	0.1	3.0	4.2	5.5	1.2	2.0	2.9	1.2	2.5	3.0	5.2
Sn	mg/l	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
SO_4	mg/l	1	2	18	2	384	67	2	5	36	45	9
Sr	mg/l	0.001	0.00	0.01	0.00	0.03	0.02	0.01	0.01	0.03	0.02	0.02
Th	mg/l	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
U	mg/l	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Zn	mg/l	0.005	0.01	0.03	0.02	0.05	0.02	0.01	0.01	0.01	0.03	0.01

< element at or below analytical detection limit.

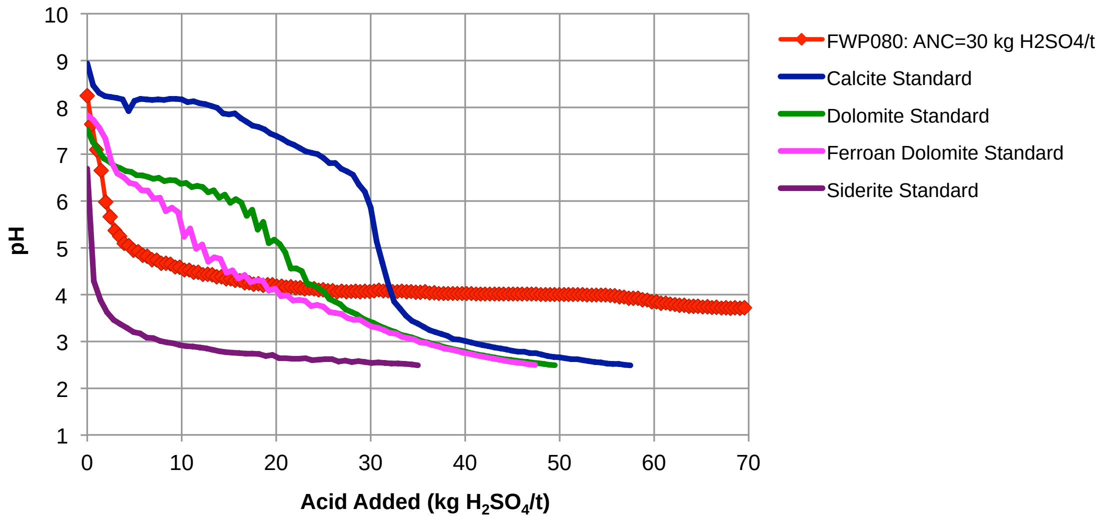

Figure 2: ABCC of MacLeod sample FWP080, with ANC of 30 kg H_2SO_4/t. Carbonate standard curves plotted for reference.

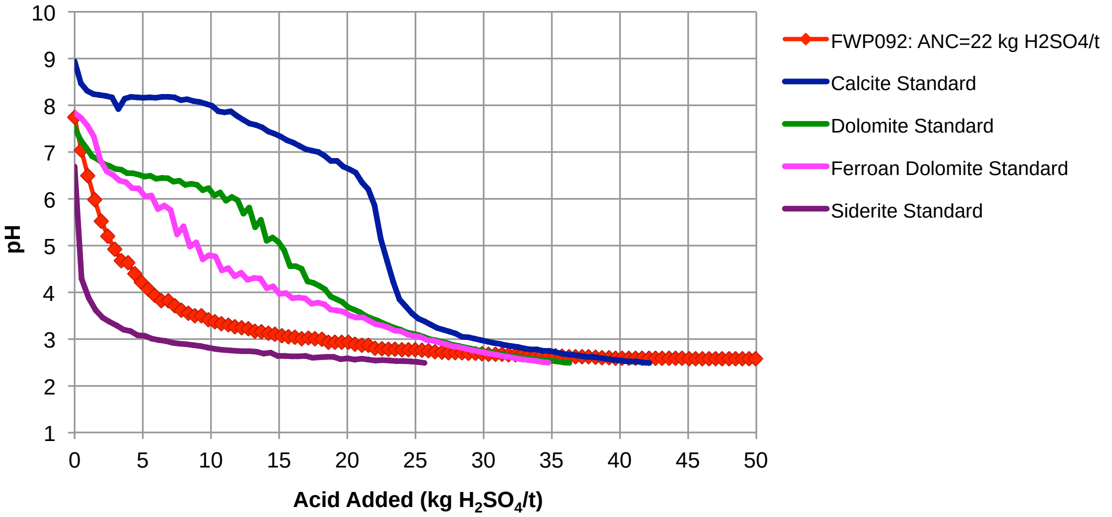

Figure 3: ABCC of MacLeod sample FWP092, with ANC of 22 kg H_2SO_4/t. Carbonate standard curves plotted for reference.

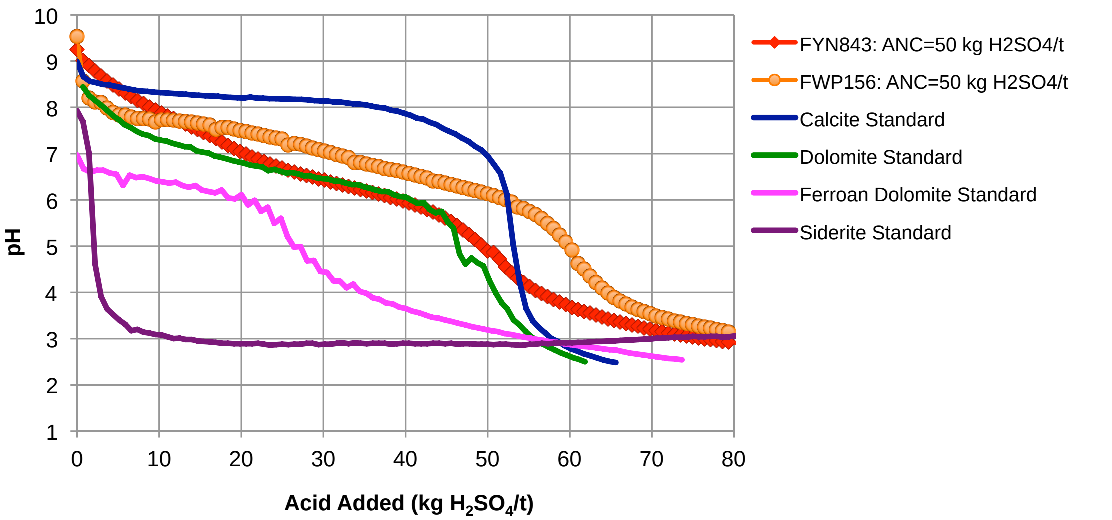

Figure 4: ABCC of Newman samples FYN843 and FWP156, with an ANC of 50 kg H_2SO_4/t. Carbonate standard curves plotted for reference.

APPENDIX A

Assessment of Acid Forming Characteristics

Assessment of Acid Forming Characteristics

Introduction

Acid rock drainage (ARD) is produced by the exposure of sulphide minerals such as pyrite to atmospheric oxygen and water. The ability to identify in advance any mine materials that could potentially produce ARD is essential for timely implementation of mine waste management strategies.

A number of procedures have been developed to assess the acid forming characteristics of mine waste materials. The most widely used methods are the Acid-Base Account (ABA) and the Net Acid Generation (NAG) test. These methods are referred to as static procedures because each involves a single measurement in time.

Acid-Base Account

The acid-base account involves static laboratory procedures that evaluate the balance between acid generation processes (oxidation of sulphide minerals) and acid neutralising processes (dissolution of alkaline carbonates, displacement of exchangeable bases, and weathering of silicates).

The values arising from the acid-base account are referred to as the potential acidity and the acid neutralising capacity, respectively. The difference between the potential acidity and the acid neutralising capacity value is referred to as the net acid producing potential (NAPP).

The chemical and theoretical basis of the ABA are discussed below.

Potential Acidity

The potential acidity that can be generated by a sample is calculated from an estimate of the pyrite (FeS_2) content and assumes that the pyrite reacts under oxidising conditions to generate acid according to the following reaction:

$$FeS_2 + 15/4\ O_2 + 7/2\ H_2O \Rightarrow Fe(OH)_3 + 2\ H_2SO_4$$

Based on the above reaction, the potential acidity of a sample containing 1 %S as pyrite would be 30.6 kilograms of H_2SO_4 per tonne of material (i.e. kg H_2SO_4/t). The pyrite content estimate can be based on total S and the potential acidity determined from total S is referred to as the maximum potential acidity (MPA), and is calculated as follows:

$$\text{MPA (kg } H_2SO_4\text{/t)} = (\text{Total \%S}) \times 30.6$$

The use of an MPA calculated from total sulphur is a conservative approach because some sulphur may occur in forms other than pyrite. Sulphate-sulphur, organic sulphur and native sulphur, for example, are non-acid generating sulphur forms. Also, some sulphur may occur as other metal sulphides (e.g. covellite, chalcocite, sphalerite, galena) which yield less acidity than pyrite when oxidised or, in some cases, may be non-acid generating. The total sulphur content is commonly used to assess potential acidity because of the difficulty, costs and uncertainty involved in routinely determining the speciation of sulphur forms within samples, and determining reactive sulphide-sulphur contents. However, if the sulphide mineral forms are known then allowance can be made for non- and lesser acid generating forms to provide a better estimate of the potential acidity.

Acid Neutralising Capacity (ANC)

The acid formed from pyrite oxidation will to some extent react with acid neutralising minerals contained within the sample. This inherent acid buffering is quantified in terms of the ANC.

The ANC is commonly determined by the Modified Sobek method. This method involves the addition of a known amount of standardised hydrochloric acid (HCl) to an accurately weighed sample, allowing the sample time to react (with heating), then back-titrating the mixture with standardised sodium hydroxide (NaOH) to determine the amount of unreacted HCl. The amount of acid consumed by reaction with the sample is then calculated and expressed in the same units as the MPA (kg H_2SO_4/t).

Net Acid Producing Potential (NAPP)

The NAPP is a theoretical calculation commonly used to indicate if a material has potential to produce acidic drainage. It represents the balance between the capacity of a sample to generate acid (MPA) and its capacity to neutralise acid (ANC). The NAPP is also expressed in units of kg H_2SO_4/t and is calculated as follows:

$$\text{NAPP} = \text{MPA} - \text{ANC}$$

If the MPA is less than the ANC then the NAPP is negative, which indicates that the sample may have sufficient ANC to prevent acid generation. Conversely, if the MPA exceeds the ANC then the NAPP is positive, which indicates that the material may be acid generating.

ANC/MPA Ratio

The ANC/MPA ratio is frequently used as a means of assessing the risk of acid generation from mine waste materials. The ANC/MPA ratio is another way of looking at the acid base account. A positive NAPP is equivalent to an ANC/MPA ratio less than 1, and a negative NAPP is equivalent to an ANC/MPA ratio greater than 1. A NAPP of zero is equivalent to an ANC/MPA ratio of 1.

The purpose of the ANC/MPA ratio is to provide an indication of the relative margin of safety (or lack thereof) within a material. Various ANC/MPA values are reported in the literature for indicating safe values for prevention of acid generation. These values typically range from 1 to 3. As a general rule, an ANC/MPA ratio of 2 or more signifies that there is a high probability that the material will remain circum-neutral in pH and thereby should not be problematic with respect to acid rock drainage.

Acid-Base Account Plot

Sulphur and ANC data are often presented graphically in a format similar to that shown in Figure A-1. This figure includes a line indicating the division between NAPP positive samples from NAPP negative samples. Also shown are lines corresponding to ANC/MPA ratios of 2 and 3.

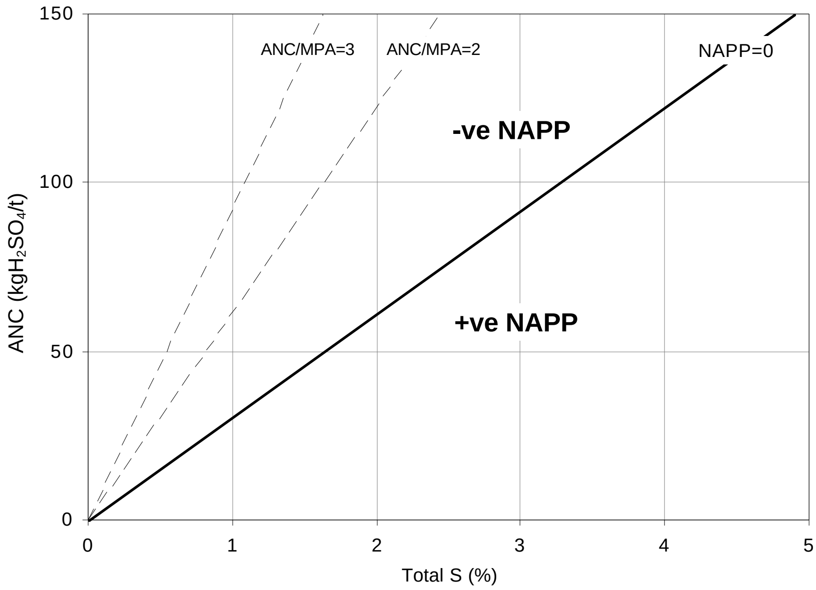

Figure A-1: Acid-base account (ABA) plot

Net Acid Generation (NAG) Test

The NAG test is used in association with the NAPP to classify the acid generating potential of a sample. The NAG test involves reaction of a sample with hydrogen peroxide to rapidly oxidise any sulphide minerals contained within a sample. During the NAG test both acid generation and acid neutralisation reactions can occur simultaneously. The end result represents a direct measurement of the net amount of acid generated by the sample. The final pH is referred to as the NAGpH and the amount of acid produced is commonly referred to as the NAG capacity, and is expressed in the same units as the NAPP (kg H_2SO_4/t).

Several variations of the NAG test have been developed to accommodate the wide geochemical variability of mine waste materials. The four main NAG test procedures currently used by EGi are the single addition NAG test, the sequential NAG test, the kinetic NAG test, and the extended boil and calculated NAG test.

Single Addition NAG Test

The single addition NAG test involves the addition of 250 ml of 15% hydrogen peroxide to 2.5 g of sample. The peroxide is allowed to react with the sample overnight and the following day the sample is gently heated to accelerate the oxidation of any remaining sulphides, then vigorously boiled for several minutes to decompose residual peroxide. When cool, the NAGpH and NAG capacity are measured.

An indication of the form of the acidity is provided by initially titrating the NAG liquor to pH 4.5, then continuing the titration up to pH 7. The titration value at pH 4.5 includes acidity due to free acid (i.e. H_2SO_4) as well as soluble iron and aluminium. The titration value at pH 7 also includes metallic ions that precipitate as hydroxides at between pH 4.5 and 7.

Sequential NAG Test

When testing samples with high sulphide contents it is not uncommon for oxidation to be incomplete in the single addition NAG test. This can sometimes occur when there is catalytic breakdown of the hydrogen peroxide before it has had a chance to oxidise all of the sulphides in a sample. To overcome this limitation, a sequential NAG test is often carried out. This test may also be used to assess the relative geochemical lag of PAF samples with high ANC.

The sequential NAG test is a multi-stage procedure involving a series of single addition NAG tests on the one sample (i.e. 2.5 g of sample is reacted two or more times with 250 ml aliquots of 15% hydrogen peroxide). At the end of each stage, the sample is filtered and the solution is used for measurement of NAGpH and NAG capacity. The NAG test is then repeated on the solid residue. The cycle is repeated until such time that there is no further catalytic decomposition of the peroxide, or when the NAGpH is greater than pH 4.5. The overall NAG capacity of the sample is then determined by summing the individual acid capacities from each stage.

Kinetic NAG Test

The kinetic NAG test is the same as the single addition NAG test except that the temperature and pH of the liquor are recorded. Variations in these parameters during the test provide an indication of the kinetics of sulphide oxidation and acid generation. This, in turn, can provide an insight into the behaviour of the material under field conditions. For example, the pH trend gives an estimate of relative reactivity and may be related to prediction of lag times and oxidation rates similar to those measured in leach columns. Also, sulphidic samples commonly produce a temperature excursion during the NAG test due to the decomposition of the peroxide solution, catalysed by sulphide surfaces and/or oxidation products.

Extended Boil and Calculated NAG Test

Organic acids may be generated in NAG tests due to partial oxidation of carbonaceous materials[1] such as coal washery wastes. This can lead to low NAGpH values and high acidities in standard single addition NAG tests unrelated to acid generation from sulphides. Organic acid effects can therefore result in misleading NAG values and misclassification of the acid forming potential of a sample.

The extended boil and calculated NAG tests can be used to account for the relative proportions of pyrite derived acidity and organic acidity in a given NAG solution, thus providing a more reliable measure of the acid forming potential of a sample. The procedure involves two steps to differentiating pyritic acid from organic derived acid:

Extended Boil NAG	decompose the organic acids and hence remove the influence of non-pyritic acidity on the NAG solution.
Calculated NAG	calculate the net acid potential based on the balance of cations and anions in the NAG solution, which will not be affected by organic acid.

The extended boiling test is carried out on the filtered liquor of a standard NAG test, and involves vigorous boiling of the solution on a hot plate for 3-4 hours. After the boiling step the solution is cooled and the pH measured. An extended boil NAGpH less than 4.5 confirms the sample is potentially acid forming (PAF), but a pH value greater than 4.5 does not necessarily mean that the sample is non acid forming (NAF), due to some loss of free acid during the extended boiling procedure. To address this issue, a split of the same filtered NAG solution is assayed for concentrations of S, Ca, Mg, Na, K and Cl, from which a calculated NAG value is determined[2].

The concentration of dissolved S is used to calculate the amount of acid (as H_2SO_4) generated by the sample and the concentrations of Ca, Mg, Na and K are used to estimate the amount of acid neutralised (as H_2SO_4). The concentration of Cl is used to correct for soluble cations associated with Cl salts, which may be present in the sample and unrelated to acid generating and acid neutralising reactions.

The calculated NAG value is the amount of acid neutralised subtracted from the amount of acid generated. A positive value indicates that the sample has excess acid generation and is likely to be PAF, and a zero or negative value indicates that the sample has excess neutralising capacity and is likely to be NAF.

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[1] Stewart, W., Miller, S., Thomas, J.E., and Smart R. (2003), 'Evaluation of the Effects of Organic Matter on the Net Acid Generation (NAG) Test', in *Proceedings of the Sixth International Conference on Acid Rock drainage (ICARD), Cairns, 12-18th July 2003*, 211-222.

[2] Environmental Geochemistry International, Levay and Co. and ACeSSS, 2008. *ACARP Project C15034: Development of ARD Assessment for Coal Process Wastes*, EGi Document No. 3207/817, July 2008.

Sample Classification

The acid forming potential of a sample is classified on the basis of the acid-base and NAG test results into one of the following categories:

- Barren;
- Non-acid forming (NAF);
- Potentially acid forming (PAF); and
- Uncertain (UC).

Barren

A sample classified as barren essentially has no acid generating capacity and no acid buffering capacity. This category is most likely to apply to highly weathered materials. In essence, it represents an 'inert' material with respect to acid generation. The criteria used to classify a sample as barren may vary between sites, but for hard rock mines it generally applies to materials with a total sulphur content ≤ 0.1 %S and an ANC ≤ 5 kg H_2SO_4/t.

Non-acid forming (NAF)

A sample classified as NAF may, or may not, have a significant sulphur content but the availability of ANC within the sample is more than adequate to neutralise all the acid that theoretically could be produced by any contained sulphide minerals. As such, material classified as NAF is considered unlikely to be a source of acidic drainage. A sample is usually defined as NAF when it has a negative NAPP and the final NAG pH ≥ 4.5.

Potentially acid forming (PAF)

A sample classified as PAF always has a significant sulphur content, the acid generating potential of which exceeds the inherent acid neutralising capacity of the material. This means there is a high risk that such a material, even if pH circum-neutral when freshly mined or processed, could oxidise and generate acidic drainage if exposed to atmospheric conditions. A sample is usually defined as PAF when it has a positive NAPP and a final NAGpH < 4.5.

Uncertain (UC)

An uncertain classification is used when there is an apparent conflict between the NAPP and NAG results (i.e. when the NAPP is positive and NAGpH > 4.5, or when the NAPP is negative and NAGpH ≤ 4.5). Uncertain samples are generally given a tentative classification that is shown in brackets e.g. UC(NAF).

Figure A-2 shows the format of the classification plot that is typically used for presentation of NAPP and NAG data. Marked on this plot are the quadrats representing the NAF, PAF and UC classifications.

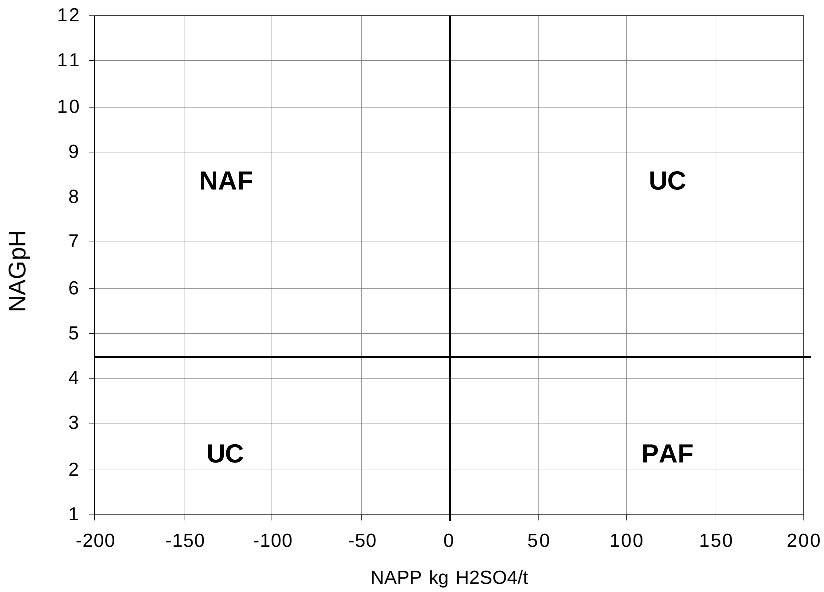


Figure A-2 ARD classification plot

Other Methods

Other test procedures may be used to define the acid forming characteristics of a sample.

pH and Electrical Conductivity

The pH and electrical conductivity (EC) of a sample is determined by equilibrating the sample in deionised water for a minimum of 12 hours (or overnight), typically at a solid to water ratio of 1:2 (w/w). This gives an indication of the inherent acidity and salinity of the waste material when initially exposed in a waste emplacement area.

Acid Buffering Characteristic Curve (ABCC) Test

The ABCC test involves slow titration of a sample with acid while continuously monitoring pH. These data provides an indication of the portion of ANC within a sample that is readily available for acid neutralisation.

APPENDIX E ENVIRONMENTAL GEOCHEMISTRY DATA

All figures extracted from original reports.

					PASTE pH/EC		ACID-BASE ACCOUNTING													SINGLE ADDITION NAG			AMD INTERP.
					$pH_{1:2}$	$EC_{1:2}$	TS	$S\text{-}SO_4$ (HCl)	S-Sulfide	TC	TOC	[1]MPA	[2]MPA_{S2-}	ANC	$ENC_{4.5}$	[3]NAPP	[4]$NAPP_{S2-}$	[5]NPR	[6]NPR_{S2-}	NAGpH	$NAG_{4.5}$	NAG_7	CLASS
			FROM		no units	µS/cm	%S	%S	%S	wt%C	wt%C	kg H_2SO_4/t						no units	no units	no units	kg H_2SO_4/t		no units
SAMPLE ID	STRAT	DEPOSIT	(m)	TO (m)	0.1	10	0.01	0.01	CALC.	0.01	0.01	0.1	0.1	1.0		1.0	1.0	0.1	0.1	0.1			
FNC563	ALL	Dep B	0	2	7.4	559	0.05			0.56	0.14	1.5		44.7	36	-43.1		29.2					NAF
FNH447	ALL	Dep B	2	4	7.3	346	0.05					1.5		1.3		0.3		0.8					NAF
FOG751	ALL	Dep B	4	6	6.7	976	0.03					0.9		6.9		-6.0		7.5					NAF
FOD371	DET	Dep A W	8	10	7.4	251	0.01					0.3		6.1		-5.7		19.8					NAF
FQC173	DET	Dep A W	18	20	7.6	152	0.04					1.2		3.7		-2.5		3.0					NAF
FQH537	DET	Dep A W	22	24	7.4	196	0.03					0.9		7.9		-7.0		8.6					NAF
FQI158	DET	Dep A W	6	8	7.6	127	0.02					0.6		1.7		-1.0		2.7					NAF
FQI876	DET	Dep A W	6	8	6.8	375	0.03					0.9		0.7		0.2		0.7					NAF
FQI965	DET	Dep A W	44	46	6.7	388	0.02					0.6		1.2		-0.6		2.0					NAF
FQL196	DET	Dep A W	30	32	6.8	276	0.02					0.6		7.9		-7.3		13.0					NAF
FQL391	DET	Dep A W	0	2	7.4	128	0.04					1.2		1.8		-0.6		1.5					NAF
FQL434	DET	Dep A W	10	12	6.6	429	0.02					0.6		4.4		-3.8		7.2					NAF
FQQ766	DET	Dep A W	72	74	7.5	144	0.01					0.3		0.8		-0.5		2.5					NAF
FQR817	DET	Dep A W	36	38	7.2	185	0.03					0.9		38.0	40	-37.1		41.4					NAF
FQR914	DET	Dep A W	46	48	7.3	177	0.11					3.4		3.1		0.2		0.9		5.4		6.3	UC-NAF
FQU511	DET	Dep A W	6	8	7.3	289	0.02					0.6		4.8		-4.2		7.9					NAF
FRD062	DET	Dep A W	50	52	6.7	342	0.02			1.17	0.10	0.6		89.4	96	1.1		146.1					NAF
FRD872	DET	Dep A W	54	56	7.5	211	0.46					14.1		3.4		10.7		0.2		6.0		4.4	UC-NAF
FRE655	DET	Dep A W	36	38	8.3	183	0.04					1.2		1.0		0.2		0.8					NAF
FRF768	DET	Dep A W	8	10	7.6	196	0.03					0.9		1.9		-1.0		2.1					NAF
FRG099	DET	Dep A W	38	40	8.1	188	0.02					0.6		3.9		-3.2		6.3					NAF
FRH604	DET	Dep A W	6	8	6.8	521	0.03					0.9		1.3		-0.4		1.4					NAF
ELO107	DET	Dep B	36	38	7.5	1150	0.02			0.22	0.10	0.6		17.6		-17.0		28.8					NAF
EYT775	DET	Dep B	40	42	7.5	142	0.04					1.2		7.8		-6.6		6.4					NAF
EYT782	DET	Dep B	54	56	7.3	385	0.03			0.61	0.50	0.9		9.9	8	-9.0		10.8					NAF
EYT986	DET	Dep B	6	8	6.6	816	0.07					2.1		4.9		-2.8		2.3					NAF
FNH002	DET	Dep B	2	4	7.5	381	0.06					1.8		0.8		1.0		0.4					NAF
FOH078	DET	Dep B	20	22	7.2	725	0.03					0.9		6.1		-5.2		6.6					NAF
FOH267	DET	Dep B	28	30	6.8	612	0.04					1.2		4.1		-2.8		3.3					NAF
FQD434	DET	Dep D	2	4	8.2	166	0.03					0.9		1.0		-0.1		1.1					NAF
FQD642	DET	Dep D	18	20	6.6	289	0.03					0.9		3.0		-2.1		3.3					NAF
FQD687	DET	Dep D	50	52	6.3	177	0.77					23.6		1.9		21.7		0.1		5.7		4.7	UC-NAF
FQD851	DET	Dep D	50	52	6.6	376	0.25					7.7		2.1		5.6		0.3		5.7		5.9	UC-NAF
FQD908	DET	Dep D	52	54	6.7	384	0.55					16.8		3.0		13.8		0.2		5.9		4.2	UC-NAF
FRI027	DET	Dep D	64	66	7.3	181	0.01					0.3		1.5		-1.2		4.8					NAF
FRI612	DET	Dep D	2	4	7.5	252	0.02					0.6		2.6		-2.0		4.2					NAF
FRI928	DET	Dep D	14	16	6.7	295	0.03					0.9		1.1		-0.2		1.2					NAF
FRL097	DET	Dep D	34	36	7.4	338	0.02					0.6		3.4		-2.8		5.6					NAF
FRL157	DET	Dep D	22	24	7.5	167	0.03					0.9		1.6		-0.7		1.7					NAF
FRM221	DET	Dep D	14	16	7.5	167	0.02					0.6		11.9	11	-11.3		19.4					NAF
FWP116	DET	Dep F	36	38	7.4	87	0.01					0.3		6.2		-5.9		20.1					NAF
FWP127	DET	Dep F	58	60	7.4	90	0.01					0.3		2.2		-1.9		7.3					NAF
FWP173	DET	Dep F	0	2	7.4	26	0.04					1.2		1.6		-0.3		1.3					NAF
FWP185	DET	Dep F	24	26	8.1	116	0.06					1.8		3.8		-1.9		2.1					NAF
FWP196	DET	Dep F	44	46	7.3	39	0.02					0.6		0.9		-0.3		1.5					NAF
FWP204	DET	Dep F	60	62	8.0	29	0.06					1.8		1.4		0.4		0.8					NAF

					PASTE pH/EC		ACID-BASE ACCOUNTING														SINGLE ADDITION NAG			AMD INTERP.
					$pH_{1:2}$	$EC_{1:2}$	TS	$S\text{-}SO_4$ (HCl)	S-Sulfide	TC	TOC	[1]MPA	[2]MPA_{S2-}	ANC	$ENC_{4.5}$	[3]NAPP	[4]$NAPP_{S2-}$	[5]NPR	[6]NPR_{S2-}	NAGpH	$NAG_{4.5}$	NAG_7	CLASS
			FROM		no units	µS/cm	%S	%S	%S	wt%C	wt%C	kg H_2SO_4/t						no units	no units	no units	kg H_2SO_4/t		no units
SAMPLE ID	STRAT	DEPOSIT	(m)	TO (m)	0.1	10	0.01	0.01	CALC.	0.01	0.01	0.1	0.1	1.0		1.0	1.0	0.1	0.1	0.1			
FWP287	DET	Dep F	8	10	7.2	25	0.03					0.9		1.9		-1.0		2.1					NAF
FWP311	DET	Dep F	52	54	7.4	41	0.01					0.3		5.5		-5.2		17.9					NAF
FYN779	DET	Dep F	12	14	7.2	32	0.01					0.3		2.5		-2.2		8.1					NAF
FYN787	DET	Dep F	28	30	7.6	24	0.25					7.7		3.0		4.7		0.4		5.6		6.0	UC-NAF
FYN854	DET	Dep F	14	16	7.3	38	<0.01					0.2		0.9		-0.8		5.9					NAF
FYN863	DET	Dep F	32	34	7.5	31	0.01					0.3		3.9		-3.6		12.6					NAF
FYN975	DET	Dep F	10	12	7.2	32	0.02					0.6		1.4		-0.8		2.3					NAF
FYN979	DET	Dep F	18	20	7.3	32	0.05					1.5		1.5		0.1		1.0					NAF
FYN996	DET	Dep F	50	52	7.5	52	0.04					1.2		3.1		-1.8		2.5					NAF
FQR487	DOR	Dep A W	110	112	7.8	161	0.14					4.3		<1		3.8		0.1		3.2	3.3	4.9	PAF
FRL667	DOR	Dep A W	86	88	7.2	176	0.04					1.2		1.3		-0.1		1.1					NAF
FRM103	DOR	Dep D	50	52	7.8	142	0.03					0.9		13.8		-12.9		15.0					NAF
FRM113	DOR	Dep D	66	68	7.9	154	0.14			0.09	0.03	4.3		11.8	5	-7.5		2.8		5.7		0.2	NAF
FRM291	DOR	Dep D	66	68	7.1	139	0.02					0.6		1.8		-1.1		2.9					NAF
WEP/652/902_1	WF	Dep A	428	428	6.8	493	1.25	0.03	1.22		0.03	38.3	37.4	26.1		12.2	11.3	0.7	0.7	4.6		11.0	UC-NAF
WEP/652/902_2	WF	Dep A	429	429	8.2	350	0.49					15.0		51.4		-36.4		3.4					NAF
WEP/652/902_3	WF	Dep A	430	430	6.9	467	0.92					28.2		32.2		-4.0		1.1					UC-NAF
WEP/652/902_4	WF	Dep A	431	431	7.6	354	0.82					25.1		5.7		19.4		0.2					PAF
WEP/652/902_5	WF	Dep A	432	432	7.6	426	1.03	0.02	1.01			31.5	31.0	4.8		26.7	26.2	0.2	0.2	2.2	20.5	21.3	PAF
WEP/652/902_6	WF	Dep A	433	433	7.8	177	0.42					12.9		4.2		8.7		0.3					PAF
WEP/652/902_7	WF	Dep A	434	434	7.7	284	0.57					17.4		6.6		10.8		0.4					PAF
WEP/652/902_8	WF	Dep A	435	435	7.7	414	1.94	0.02	1.92			59.4	58.6	2.4		57.0	56.2	0.0	0.0	2.0	33.3	34.5	PAF
EYA807	WF	Dep A W	92	94	7.2	139	0.02					0.6		<1		0.1		0.8					NAF
FQC572	WF	Dep A W	94	96	7.4	141	0.02					0.6		2.6		-2.0		4.3					NAF
FQI265	WF	Dep A W	108	110	7.7	132	0.02					0.6		0.7		-0.1		1.2					NAF
FQR337	WF	Dep A W	130	132	7.2	132	0.02					0.6		1.0		-0.4		1.6					NAF
FQR860	WF	Dep A W	116	118	7.3	171	1.22					37.3		<1		36.8		0.0		2.5	20.8	34.1	PAF
FRC036	WF	Dep A W	100	102	7.2	167	0.01					0.3		4.9		-4.6		16.0					NAF
FRD106	WF	Dep A W	132	134	7.2	129	0.05					1.5		2.5		-0.9		1.6					NAF
EYT840	WF	Dep B	160	162	7.3	172	0.04			4.39	0.37	1.2		211.6		-210.4		172.9					NAF
EYT925	WF	Dep B	76	78	7.4	421	0.03					0.9		2.3		-1.4		2.6					NAF
EYT978	WF	Dep B	174	176	7.5	174	0.03					0.9		1.6		-0.7		1.7					NAF
FNC936	WF	Dep B	64	66	7.3	329	0.12					3.7		<1		3.2		0.1		3.5	0.8	5.1	PAF
FNC939	WF	Dep B	70	72	5.1	172	0.15					4.6		<1		4.1		0.1		3.8	0.6	3.1	PAF
FNH400	WF	Dep B	70	72	6.2	198	0.05					1.5		0.9		0.6		0.6					NAF
FNH979	WF	Dep B	38	40	6.4	175	0.03					0.9		0.7		0.2		0.8					NAF
FOG166	WF	Dep B	60	62	7.2	188	0.02					0.6		1.2		-0.6		1.9					NAF
FOG458	WF	Dep B	140	142	6.0	155	0.03					0.9		3.2		-2.3		3.5					NAF
FOG706	WF	Dep B	136	138	6.8	981	0.07					2.1		2.4		-0.3		1.1					NAF
FOH147	WF	Dep B	150	152	6.2	169	0.03					0.9		1.7		-0.8		1.8					NAF
FOH244	WF	Dep B	156	158	7.4	128	0.03					0.9		1.6		-0.6		1.7					NAF
FOH880	WF	Dep B	34	36	6.5	191	0.04					1.2		1.4		-0.2		1.2					NAF
FQP208	WF	Dep B	46	48	6.7	168	0.13					4.0		0.6		3.4		0.1		7.2			UC-NAF
FRK244	WF	Dep B	16	18	6.7	196	0.17					5.2		<1		4.7		0.1		3.6	0.8	7.4	PAF
FRK397	WF	Dep B	2	4	7.5	229	0.09					2.8		1.9		0.9		0.7		5.3		1.1	UC-NAF
FRK412	WF	Dep B	30	32	6.8	211	0.13					4.0		<1		3.5		0.1		3.7	0.7	7.4	PAF

					PASTE pH/EC		ACID-BASE ACCOUNTING														SINGLE ADDITION NAG			AMD INTERP. CLASS
					$pH_{1:2}$	$EC_{1:2}$	TS	$S\text{-}SO_4$ (HCl)	S-Sulfide	TC	TOC	[1]MPA	[2]MPA_{S2-}	ANC	$ENC_{4.5}$	[3]NAPP	[4]$NAPP_{S2-}$	[5]NPR	[6]NPR_{S2-}	NAGpH	$NAG_{4.5}$	NAG_7	
			FROM		no units	µS/cm	%S	%S	%S	wt%C	wt%C	kg H_2SO_4/t						no units	no units	no units	kg H_2SO_4/t		no units
SAMPLE ID	STRAT	DEPOSIT	(m)	TO (m)	0.1	10	0.01	0.01	CALC.	0.01	0.01	0.1	0.1	1.0		1.0	1.0	0.1	0.1	0.1			
FRK702	WF	Dep B	10	12	7.2	152	0.11					3.4		0.6		2.7		0.2		3.9	0.2	6.3	PAF
FRK778	WF	Dep B	16	18	7.5	139	0.10					3.1		<1		2.6		0.2		3.7	0.6	6.6	PAF
FTI114	WF	Dep B	12	14	7.2	236	0.11					3.4		0.7		2.7		0.2		3.8	0.3	5.2	PAF
FOM276	WF	Dep D	104	106	6.8	256	0.01					0.3		1.4		-1.1		4.6					NAF
FOM528	WF	Dep D	20	22	6.5	439	1.96					60.0		0.9		59.0		0.0		6.9		<0.5	UC-NAF
FOM740	WF	Dep D	74	76	6.6	225	0.03					0.9		2.0		-1.0		2.1					NAF
FOM940	WF	Dep D	48	50	6.7	203	0.03			3.64	0.10	0.9		297.5	261	-296.6		324.1					NAF
FQP163	WF	Dep D	32	34	7.3	188	0.01					0.3		3.8		-3.5		12.5					NAF
FRI159	WF	Dep D	116	118	7.5	165	0.03					0.9		1.2		-0.2		1.3					NAF
FRI220	WF	Dep D	76	78	7.2	192	0.03			0.52	0.17	0.9		27.3	21	-26.4		29.7					NAF
FRN248	WF	Dep D	40	42	7.4	175	0.04					1.2		1.3		0.0		1.0					NAF
FWP012	WF	Dep F	78	80	7.3	41	<0.01					0.2		1.5		-1.3		9.8					NAF
FWP017	WF	Dep F	88	90	7.3	25	<0.01					0.2		4.4		-4.3		28.8					NAF
FWP214	WF	Dep F	78	80	7.6	34	<0.01					0.2		1.7		-1.5		11.0					NAF
FWP331	WF	Dep F	90	92	7.5	16	0.02					0.6		1.7		-1.1		2.9					NAF
FYN801	WF	Dep F	54	56	7.4	21	0.02					0.6		2.2		-1.6		3.6					NAF
FYN805	WF	Dep F	62	64	7.2	45	<0.01					0.2		2.3		-2.1		14.9					NAF
FYN808	WF	Dep F	68	70	7.5	29	<0.01					0.2		2.3		-2.1		14.8					NAF
FYN886	WF	Dep F	76	78	7.4	26	0.03					0.9		1.2		-0.3		1.3					NAF
FYN891	WF	Dep F	84	86	7.5	71	<0.01					0.2		1.3		-1.1		8.2					NAF
FYN896	WF	Dep F	94	96	8.1	124	<0.01					0.2		1.1		-1.0		7.5					NAF
TomP-200706-1	BIF	N/R			8.4	56	0.06			0.35		1.8		6.5		-4.7		3.5		7.7	<0.1	<0.1	NAF
ECP051	MM	Dep A	92	94	8.4	462	0.42	0.04	0.38	2.35	0.29	12.9	11.8	67.0		-54.1	-55.2	5.2	5.7	7.9			NAF
ECP052	MM	Dep A	94	96	8.3	301	0.43			2.10	0.32	13.2		82.1	94	-68.9		6.2		8.2			NAF
ECP053	MM	Dep A	96	98	8.6	284	0.42			2.32		12.9		63.9		-51.0		5.0		8.0			NAF
ECP054	MM	Dep A	98	100	8.1	302	0.57	0.04	0.53	2.53		17.4	16.1	70.0		-52.6	-53.9	4.0	4.3	8.1			NAF
ECP164	MM	Dep A	92	94	8.6	380	0.66	0.04	0.62	2.39		20.2	18.9	73.5		-53.3	-54.6	3.6	3.9	8.2			NAF
ECP165	MM	Dep A	94	96	8.8	305	0.76	0.04	0.72	2.61	0.40	23.3	22.0	101.0	83	-77.7	-79.0	4.3	4.6	8.2			NAF
ECP281	MM	Dep A	98	100	7.5	358	0.46			3.45		14.1		75.4		-61.3		5.4		8.0			NAF
ECP402	MM	Dep A	86	88	7.2	416	0.46	0.14	0.32	3.41		14.1	9.7	41.7		-27.6	-32.0	3.0	4.3	5.5		2.7	NAF
WAA992_ABA_1	MM	Dep A	125.4	125.5	8.3	120	0.14					4.3		12.0		-7.7		2.8		8.3			NAF
WAA994_ABA_1	MM	Dep A	108.5	108.7	8.5	87	1.80	0.03	1.77			55.1	54.2	10.0		45.1	44.2	0.2	0.2	2.6	36		PAF
WAA994_ABA_2	MM	Dep A	109.0	109.2	8.9	110	0.14					4.3		28.0		-23.7		6.5		9.4			NAF
WAA994_ABA_3	MM	Dep A	117.0	117.2	9.1	150	0.54	0.02	0.52			16.5	15.9	27.0		-10.5	-11.1	1.6	1.7	8.8			NAF
WAA994_ABA_4	MM	Dep A	152.3	152.5	9.0	270	0.33	0.03	0.30			10.1	9.2	180.0		-169.9	-170.8	17.8	19.6	8.6			NAF
EYA261	MM	Dep A W	28	30	7.5	134	0.03					0.9		1.5		-0.5		1.6					NAF
EYA871	MM	Dep A W	46	48	7.4	146	0.03					0.9		2.8		-1.9		3.0					NAF
FOD662	MM	Dep A W	8	10	7.4	139	0.33					10.1		1.4		8.7		0.1		5.5		4.0	UC-NAF
FQC936	MM	Dep A W	120	122	7.5	164	0.01					0.3		<1		-0.2		1.6					NAF
FQI466	MM	Dep A W	74	76	7.3	176	0.01					0.3		<1		-0.2		1.6					NAF
FQI655	MM	Dep A W	84	86	7.6	189	0.01					0.3		0.6		-0.3		2.1					NAF
FQU141	MM	Dep A W	56	58	6.5	267	0.02					0.6		2.0		-1.4		3.3					NAF
FQU326	MM	Dep A W	78	80	7.3	131	0.01					0.3		<1		-0.2		1.6					NAF
FQU497	MM	Dep A W	74	76	7.4	152	0.01					0.3		1.1		-0.8		3.7					NAF
FRE007	MM	Dep A W	52	54	7.2	138	0.02					0.6		1.3		-0.6		2.1					NAF
FRE033	MM	Dep A W	36	38	7.3	151	0.02					0.6		1.1		-0.5		1.8					NAF

Table E1: Acid Base Accounting Data

					PASTE pH/EC		ACID-BASE ACCOUNTING													SINGLE ADDITION NAG			AMD INTERP. CLASS
					$pH_{1:2}$	$EC_{1:2}$	TS	S-SO_4 (HCl)	S-Sulfide	TC	TOC	[1]MPA	[2]MPA_{S2-}	ANC	$ENC_{4.5}$	[3]NAPP	[4]$NAPP_{S2-}$	[5]NPR	[6]NPR_{S2-}	NAGpH	$NAG_{4.5}$	NAG_7	
			FROM (m)	TO (m)	no units	µS/cm	%S	%S	%S	wt%C	wt%C	kg H_2SO_4/t						no units	no units	no units	kg H_2SO_4/t		no units
SAMPLE ID	STRAT	DEPOSIT			0.1	10	0.01	0.01	CALC.	0.01	0.01	0.1	0.1	1.0		1.0	1.0	0.1	0.1	0.1			
FRE144	MM	Dep A W	24	26	7.4	144	0.05					1.5		0.9		0.6		0.6					NAF
FRE775	MM	Dep A W	44	46	7.4	221	0.01					0.3		<1		-0.2		1.6					NAF
FRH214	MM	Dep A W	12	14	8.2	128	0.07					2.1		<1		1.6		0.2		5.3		4.9	UC-NAF
FRH384	MM	Dep A W	100	102	7.6	159	0.02					0.6		1.6		-1.0		2.6					NAF
FRH588	MM	Dep A W	34	36	6.7	176	0.03					0.9		1.2		-0.3		1.3					NAF
EYJ632	MM	Dep B	120	122	7.1	136	0.02					0.6		<1		0.1		0.8					NAF
FNC423	MM	Dep B	152	154	6.5	185	0.02					0.6		0.8		-0.2		1.3					NAF
FNC425	MM	Dep B	156	158	7.3	139	0.01					0.3		<1		-0.2		1.6					NAF
FNC467	MM	Dep B	74	76	7.6	176	0.02			0.64	0.20	0.6		39.8	34	-39.2		65.1					NAF
FNH063	MM	Dep B	62	64	7.7	152	0.09					2.8		<1		2.3		0.2		3.7	0.5	5.5	PAF
FNJ868	MM	Dep B	36	38	7.5	139	0.03					0.9		0.8		0.1		0.9					NAF
FNJ933	MM	Dep B	26	28	6.6	145	0.03					0.9		<1		0.4		0.5					NAF
FOG016	MM	Dep B	106	108	7.7	188	0.02					0.6		0.7		-0.1		1.1					NAF
FOG079	MM	Dep B	92	94	7.8	191	0.03					0.9		<1		0.4		0.5					NAF
FOG111	MM	Dep B	152	154	8.1	435	1.35			3.57	0.09	41.3		144.0	65	-102.7		3.5		7.5			NAF
FOG272	MM	Dep B	74	76	7.2	116	0.02					0.6		0.7		-0.1		1.2					NAF
FOG379	MM	Dep B	86	88	7.7	159	0.02					0.6		1.3		-0.7		2.1					NAF
FOH357	MM	Dep B	28	30	7.8	225	0.03					0.9		2.3		-1.3		2.5					NAF
FOH416	MM	Dep B	92	94	7.4	134	0.73			2.22	0.59	22.3		19.5	13	2.8		0.9		4.3	0.2	3.1	PAF
FOH417	MM	Dep B	94	96	7.2	128	0.18					5.5		9.9		-4.3		1.8		6.9		<0.5	NAF
FOH454	MM	Dep B	62	64	7.6	211	0.02					0.6		0.9		-0.3		1.4					NAF
FOH824	MM	Dep B	92	94	7.8	285	0.02					0.6		25.6	6	-25.0		41.8					NAF
FOH843	MM	Dep B	126	128	7.7	146	0.75			2.59	0.65	23.0		80.0	37	-57.0		3.5		7.8			NAF
FOH848	MM	Dep B	136	138	7.6	245	0.09					2.8		12.4		-9.7		4.5					NAF
FOH851	MM	Dep B	140	142	7.4	299	0.28					8.6		39.0		-30.5		4.6		7.4			NAF
FOH852	MM	Dep B	142	144	6.8	194	0.40			1.61	0.16	12.2		11.1	17	1.1		0.9		7.3			UC-NAF
FOH853	MM	Dep B	144	146	7.3	182	0.23					7.0		44.1	53	-37.0		6.3		7.8			NAF
FOH857	MM	Dep B	150	152	7.2	179	0.16					4.9		7.5		-2.6		1.5		7.3			NAF
FOH858	MM	Dep B	152	154	6.7	164	0.18			1.22	0.12	5.5		34.9	33	-29.4		6.3		7.8			NAF
FOH925	MM	Dep B	30	32	6.8	191	0.02					0.6		1.8		-1.2		3.0					NAF
FQP332	MM	Dep B	128	130	7.5	391	0.03			0.26	0.05	0.9		26.8		-25.9		29.2					NAF
FRF052	MM	Dep B	102	104	7.9	376	0.02					0.6		1.9		-1.3		3.1					NAF
FRF127	MM	Dep B	114	116	7.4	388	0.02					0.6		1.1		-0.5		1.8					NAF
FRK375	MM	Dep B	46	48	6.7	151	0.02					0.6		<1		0.1		0.8					NAF
FRK393	MM	Dep B	28	30	7.5	163	0.10					3.1		<1		2.6		0.2		3.6	0.7	8.5	PAF
FRK446	MM	Dep B	94	96	6.5	155	0.02					0.6		<1		0.1		0.8					NAF
FTI023	MM	Dep B	16	18	7.6	152	0.02					0.6		<1		0.1		0.8					NAF
FTI083	MM	Dep B	100	102	7.6	276	0.02					0.6		2.6		-1.9		4.2					NAF
FTI134	MM	Dep B	48	50	6.1	186	0.02					0.6		0.6		0.0		1.0					NAF
FQD221	MM	Dep D	62	64	7.7	132	0.02					0.6		1.4		-0.8		2.3					NAF
FQD245	MM	Dep D	26	28	7.3	129	0.16					4.9		1.7		3.2		0.3		5.6		5.7	UC-NAF
FQD428	MM	Dep D	56	58	7.1	128	0.01					0.3		1.1		-0.8		3.5					NAF
FRM591	MM	Dep D	82	84	7.5	164	0.01					0.3		<1		-0.2		1.6					NAF
FRN514	MM	Dep D	42	44	6.4	176	0.02					0.6		0.8		-0.2		1.3					NAF
FWP039	MM	Dep F	128	130	7.4	48	0.05					1.5		1.1		0.4		0.7					NAF
FWP040	MM	Dep F	130	132	7.6	69	0.04					1.2		0.8		0.4		0.7					NAF

					PASTE pH/EC		ACID-BASE ACCOUNTING														SINGLE ADDITION NAG			AMD INTERP. CLASS
					$pH_{1:2}$	$EC_{1:2}$	TS	S-SO_4 (HCl)	S-Sulfide	TC	TOC	[1]MPA	[2]MPA_{S2-}	ANC	$ENC_{4.5}$	[3]NAPP	[4]$NAPP_{S2-}$	[5]NPR	[6]NPR_{S2-}	NAGpH	$NAG_{4.5}$	NAG_7	
			FROM		no units	µS/cm	%S	%S	%S	wt%C	wt%C	kg H_2SO_4/t						no units	no units	no units	kg H_2SO_4/t		no units
SAMPLE ID	STRAT	DEPOSIT	(m)	TO (m)	0.1	10	0.01	0.01	CALC.	0.01	0.01	0.1	0.1	1.0		1.0	1.0	0.1	0.1	0.1			
FWP071	MM	Dep F	188	190	7.4	211	0.29					8.9		3.8		5.1		0.4		2.8	8.6	11.2	PAF
FWP075	MM	Dep F	196	198	8.2	112	0.06					1.8		8.6		-6.8		4.7					NAF
FWP080	MM	Dep F	206	208	7.8	568	0.49					15.0		30.0	14	-15.0		2.0		4.8		3.6	NAF
FWP092	MM	Dep F	228	230	8.0	196	0.22					6.7		21.9	4	-15.1		3.2		6.9		<0.5	NAF
FWP142	MM	Dep F	84	86	7.6	52	0.03					0.9		1.2		-0.2		1.3					NAF
FWP153	MM	Dep F	104	106	7.5	104	0.01					0.3		1.0		-0.7		3.2					NAF
FWP156	MM	Dep F	110	112	8.2	159	0.14					4.3		49.8	62	-45.5		11.6		7.2			NAF
FWP163	MM	Dep F	124	126	7.8	62	0.03					0.9		1.8		-0.9		2.0					NAF
FWP167	MM	Dep F	132	134	7.9	107	0.04					1.2		6.9		-5.7		5.6					NAF
FWP172	MM	Dep F	140	142	7.7	111	0.02					0.6		4.5		-3.9		7.3					NAF
FWP231	MM	Dep F	108	110	7.6	42	0.04					1.2		1.0		0.3		0.8					NAF
FWP252	MM	Dep F	148	150	7.6	39	0.01					0.3		2.7		-2.4		8.7					NAF
FWP281	MM	Dep F	204	206	7.6	103	0.03					0.9		0.8		0.1		0.8					NAF
FWP338	MM	Dep F	102	104	7.5	69	0.01					0.3		1.9		-1.5		6.1					NAF
FWP352	MM	Dep F	128	130	7.5	55	0.02					0.6		2.9		-2.3		4.8					NAF
FWP355	MM	Dep F	134	136	7.4	42	0.02					0.6		1.4		-0.8		2.3					NAF
FWP362	MM	Dep F	148	150	7.2	38	0.02					0.6		0.8		-0.1		1.2					NAF
FWP371	MM	Dep F	164	166	7.3	35	0.03					0.9		1.5		-0.6		1.7					NAF
FYN832	MM	Dep F	110	112	7.8	87	0.04					1.2		2.2		-1.0		1.8					NAF
FYN843	MM	Dep F	132	134	8.2	262	0.18					5.5		50.4	53	-44.9		9.2		7.6			NAF
FYN908	MM	Dep F	118	120	7.7	45	0.04					1.2		0.8		0.4		0.7					NAF
FYN911	MM	Dep F	122	124	7.8	39	0.03					0.9		1.1		-0.2		1.2					NAF
FYN931	MM	Dep F	158	160	7.8	176	0.03					0.9		1.5		-0.5		1.6					NAF
ECP332	MM	N/R	92	94	8.3	44	0.16			0.67	0.03	4.9		37.5		-32.6		7.7		9.6			NAF
ECP355	MM	N/R	134	136	7.6	303	0.40			3.46	0.38	12.2		55.3	16	-43.1		4.5		8.0			NAF

KEY

$pH_{1:2}$ = pH of 1:2 extract

$EC_{1:2}$ = Electrical Conductivity of 1:2 extract (µS/m)

TS = Total Sulfur; S-SO_4 = Sulfate Sulfur

ANC = Acid Neutralising Capacity (kg H_2SO_4/t)

MPA = Maximum Potential Acidity (kg H_2SO [1]MPA = TS × 30.6

MPA_{S2-} = Uses Sulfide Sulfur opposed to Tot [2]MPA = S2- × 30.6

NAPP = Net Acid Producing Potential (kg H_2 [3]NAPP = MPA - ANC

$NAPP_{S2-}$ = Uses Sulfide Sulfur opposed to T [4]$NAPP_{S2-}$ = MPA_{S2-} - ANC

NPR = Ratio of ANC over MPA

NPR_{S2-} = Uses Sulfide Sulfur opposed to Total Sulfur

[5]NPR = ANC / MPA

[6]NPR_{S2-} = ANC/MPA_{S2-}

Where TS or S-SO4 is <0.01, 1/2 LOR has been used to calculate MPA, NAPP and Classification

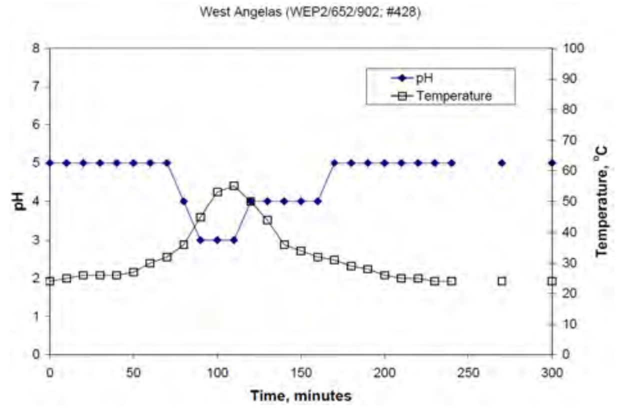
Table E2: Sequential NAG Data

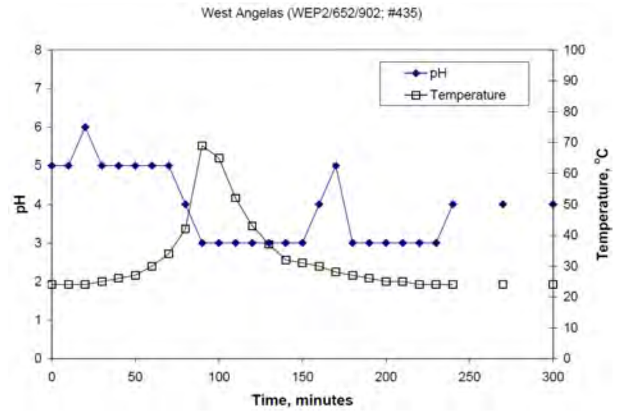
			STAGE 1			STAGE 2			STAGE 3			STAGE 4			TOTAL	
			NAGpH	$NAG_{4.5}$	NAG_7	NAGpH	$NAG_{4.5}$	NAG_7	NAGpH	$NAG_{4.5}$	NAG_7	NAGpH	$NAG_{4.5}$	NAG_7	$NAG_{4.5}$	NAG_7
SAMPLE ID	STRAT	DEPOSIT		kg H_2SO_4/t			kg H_2SO_4/t			kg H_2SO_4/t			kg H_2SO_4/t		kg H_2SO_4/t	
WEP/652/902_1	WF	Dep A	4.6		11.0	4.6		0.5	5.5		0.9					12.4
WEP/652/902_5	WF	Dep A	2.2	20.5	21.3	3.5	1.7	2.3	4.4	0.2	1.0				22.4	24.6
WEP/652/902_8	WF	Dep A	2.0	33.3	34.5	2.8	7.7	9.6	3.8	1.0	2.2				42.0	46.3
FQD687	DET	Dep D	5.7		N/R	5.5		N/R	5.6		N/R	5.5		N/R		N/R
FQD908	DET	Dep D	5.8		N/R	5.6		N/R	5.5		N/R	5.4		N/R		N/R
FOM528	WF	Dep D	6.9		N/R	6.2		N/R	5.8		N/R	5.4		N/R		N/R
FQR860	WF	Dep A W	2.5	22	32	3.0	2.0	4.0	3.7	1.0	4.0	4.2	0.2	7.0	25	47

Table E3: Kinetic NAG Data

Figures taken from SRK, 2008; SRK, 2010; and EGI, 2013

SAMPLE ID	WEP/652/902_1		WEP/652/902_8		ECP052		ECP355	
TIME	pH	TEMP	pH	TEMP	pH	TEMP	pH	TEMP
minutes		°C		°C		°C		°C
0	5	24	5	24	5.88	23.1	6.11	23.2
10	5	25	5	24	6.21	23.4	6.37	23.3
20	5	26	6	24	6.34	23.5	6.57	23.8
30	5	26	5	25	6.35	23.8	6.60	24.0
40	5	26	5	26	6.66	23.4	6.70	24.3
50	5	27	5	27	6.40	23.6	6.70	24.6
60	5	30	5	30	6.39	23.5	6.80	24.8
70	5	32	5	34	6.36	24.3	6.70	24.8
80	4	36	4	42	6.35	24.1	6.70	24.7
90	3	45	3	69	6.34	23.9	6.70	24.4
100	3	53	3	65	6.31	24.0	6.80	24.6
110	3	55	3	52	6.34	24.3	6.80	24.9
120	4	50	3	43	6.35	24.3	6.80	25.0
130	4	44	3	37	6.37	24.7	6.90	25.0
140	4	36	3	32	6.50	24.0	7.00	25.9
150	4	34	3	31	6.44	24.1	6.90	25.0
160	4	32	4	30	6.46	24.3	7.00	25.2
170	5	31	5	28	6.50	24.4	7.00	25.1
180	5	29	3	27	6.53	24.2	7.00	25.6
190	5	28	3	26	6.65	25.0	7.10	25.7
200	5	26	3	25	6.59	25.1	7.00	25.7
210	5	25	3	25	6.60	25.2	7.10	25.6
220	5	25	3	24	6.65	25.8	7.10	26.1
230	5	24	3	24	6.69	25.4	7.10	26.1
240	5	24	4	24	6.69	24.8	7.10	25.5
250					6.72	24.4	7.20	25.1
260					6.74	24.7	7.20	25.4
270	5	24	4	24	6.84	24.9	7.30	25.6
280					6.87	25.0	7.30	25.7
290					6.86	25.1	7.30	25.8
300	5	24	4	24	6.95	25.8	7.30	26.1
310					7.00	25.9	7.40	26.3
320					7.04	25.9	7.40	26.3
330	5	24	4	24	7.03	25.9	7.40	26.2
340					7.02	26.0	7.40	26.1
350					7.00	25.9	7.40	26.1
360	5	24	4	24	7.00	25.9	7.40	26.1





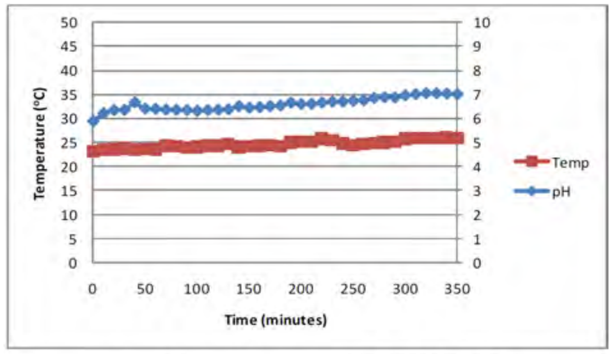


Figure 3-4: Kinetic NAG profile for ECP051 (Total S 0.42 wt %)

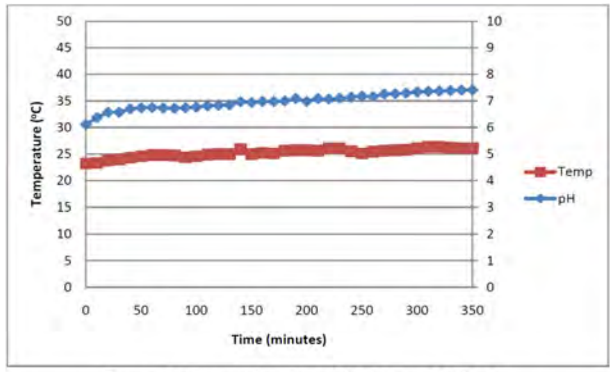


Figure 3-5: Kinetic NAG profile for ECP165 (Total S 0.76 wt %)

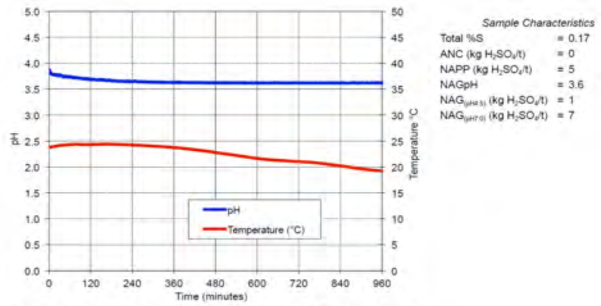


Figure 14: Kinetic NAG plot of West Angela Member sample FRK244.

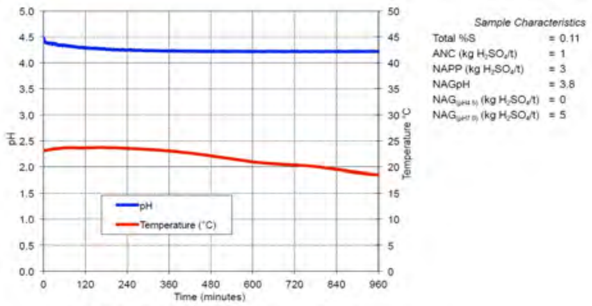


Figure 15: Kinetic NAG plot of Detrital sample FTI114.

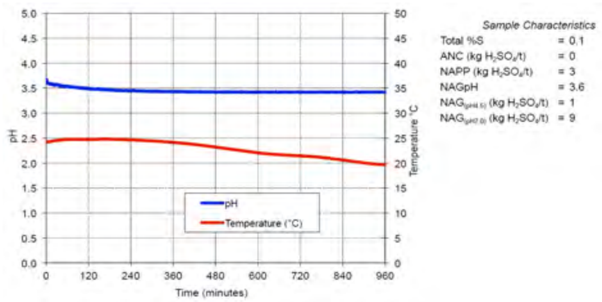


Figure 16: Kinetic NAG plot of Macleod Member sample FRK393.

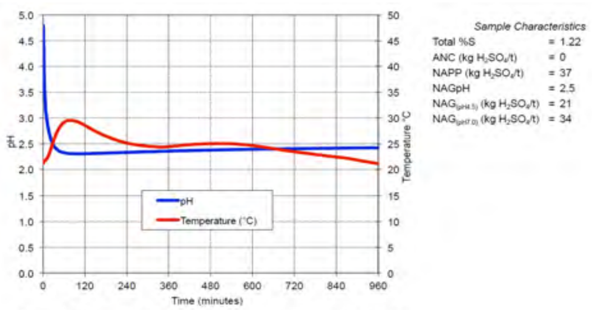


Figure 17: Kinetic NAG plot of Newman Member sample FQR860.

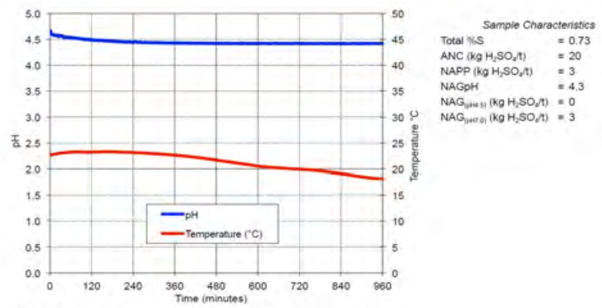
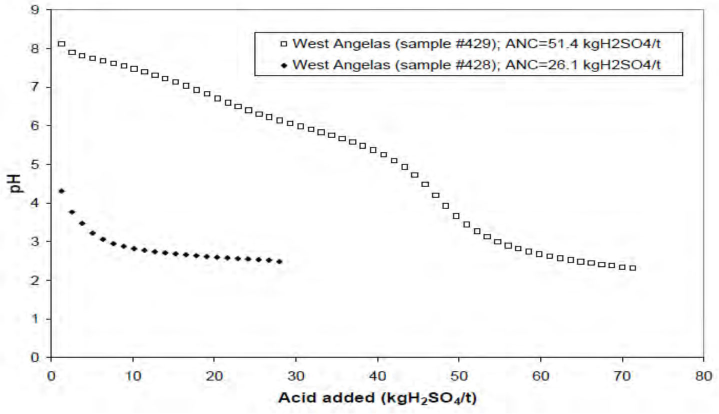


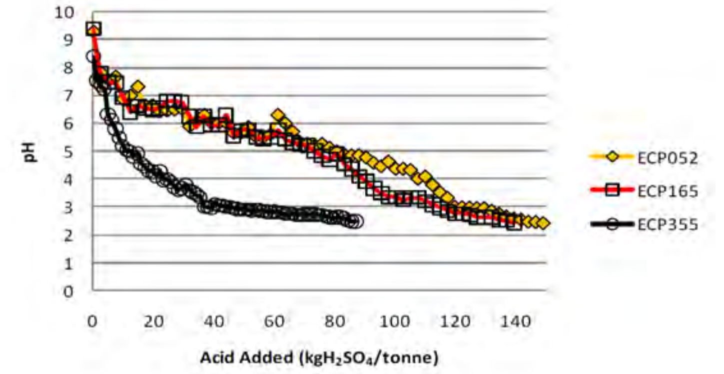
Figure 18: Kinetic NAG plot of Nammuldi Member sample FOH416.

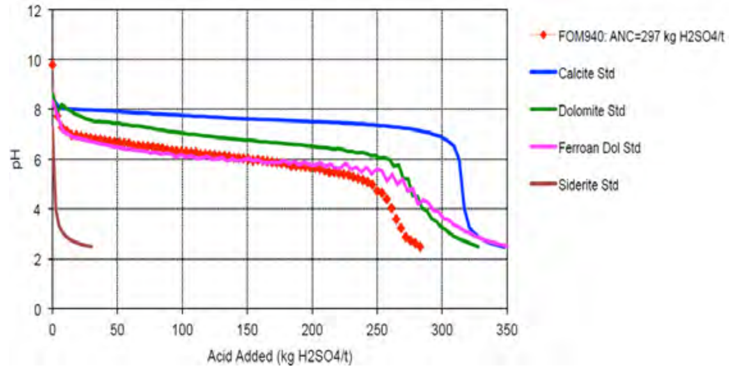
Table E4: ABCC Data

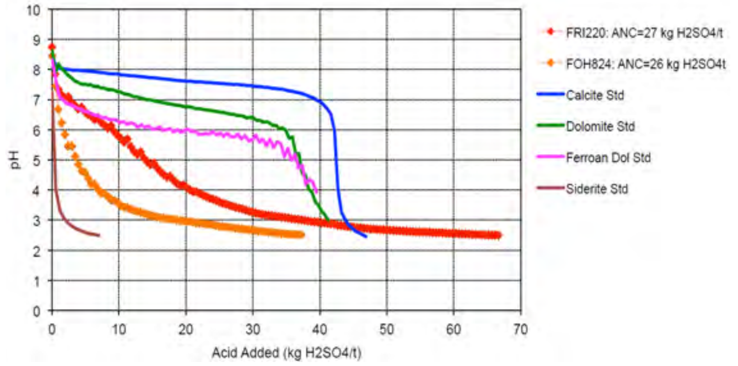
Figures taken from SRK, 2008; SRK, 2010; EGi, 2013; and EGi, 2014

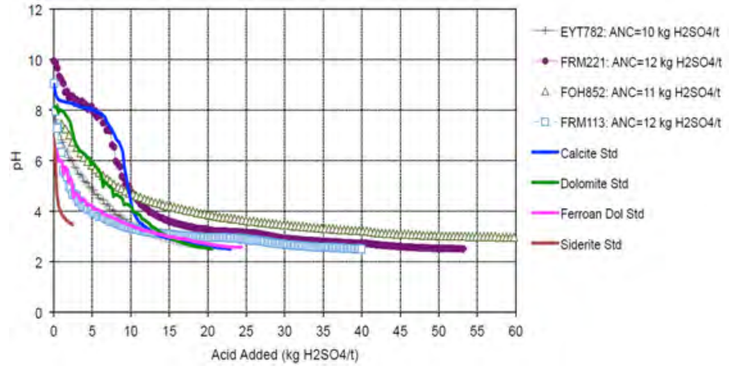
SAMPLE ID	ECP052			ECP165			ECP355		
HCl MOLARITY (M)	0.5			0.5			0.1		
VOLUME HCl (mL)	0.2			0.2			0.5		
WEIGHT (g)	2			2			2.0		
STEP	Vol. Added mL HCl	Acid Added kg H_2SO_4/t	pH	Vol. Added mL HCl	Acid Added kg H_2SO_4/t	pH	Vol. Added mL HCl	Acid Added kg H_2SO_4/t	pH
0	0.0	0.00	9.27	0.0	0.0	9.39	0.0	0.00	8.39
1	0.2	2.45	7.80	0.2	2.5	7.78	0.5	1.23	7.54
2	0.4	4.90	7.53	0.4	4.9	7.49	1.0	2.45	7.35
3	0.6	7.35	7.66	0.6	7.4	7.46	1.5	3.68	7.24
4	0.8	9.80	6.85	0.8	9.8	6.93	2.0	4.90	6.31
5	1.0	12.25	6.98	1.0	12.3	6.39	2.5	6.13	6.11
6	1.2	14.70	7.30	1.2	14.7	6.63	3.0	7.35	5.80
7	1.4	17.15	6.63	1.4	17.2	6.54	3.5	8.58	5.49
8	1.6	19.60	6.63	1.6	19.6	6.47	4.0	9.80	5.19
9	1.8	22.05	6.41	1.8	22.1	6.54	4.5	11.03	5.03
10	2.0	24.50	6.44	2.0	24.5	6.80	5.0	12.25	4.99
11	2.2	26.95	6.48	2.2	27.0	6.80	5.5	13.48	4.79
12	2.4	29.40	6.51	2.4	29.4	6.76	6.0	14.70	4.90
13	2.6	31.85	5.88	2.6	31.9	6.25	6.5	15.93	4.54
14	2.8	34.30	6.05	2.8	34.3	5.86	**7.0**	**17.15**	**4.45**
15	3.0	36.75	6.29	3.0	36.8	6.26	7.5	18.38	4.31
16	3.2	39.20	6.00	3.2	39.2	5.92	8.0	19.60	4.26
17	3.4	41.65	6.00	3.4	41.7	5.95	8.5	20.83	4.11
18	3.6	44.10	6.00	3.6	44.1	6.30	9.0	22.05	4.30
19	3.8	46.55	5.64	3.8	46.6	5.55	9.5	23.28	3.97
20	4.0	49.00	5.65	4.0	49.0	5.73	10.0	24.50	3.98
21	4.2	51.45	5.85	4.2	51.5	5.78	10.5	25.73	3.90
22	4.4	53.90	5.52	4.4	53.9	5.50	11.0	26.95	3.71
23	4.6	56.35	5.48	4.6	56.4	5.45	11.5	28.18	3.60
24	4.8	58.80	5.59	4.8	58.8	5.49	12.0	29.40	3.66
25	5.0	61.25	6.29	5.0	61.3	5.75	12.5	30.63	3.80
26	5.2	63.70	5.99	5.2	63.7	5.42	13.0	31.85	3.60
27	5.4	66.15	5.69	5.4	66.2	5.31	13.5	33.08	3.51
28	5.6	68.60	5.30	5.6	68.6	5.23	14.0	34.30	3.43
29	5.8	71.05	5.25	5.8	71.1	5.20	14.5	35.53	3.36
30	6.0	73.50	5.19	6.0	73.5	5.00	15.0	36.75	3.00
31	6.2	75.95	5.25	6.2	76.0	4.83	15.5	37.98	2.99
32	6.4	78.40	5.11	6.4	78.4	4.70	16.0	39.20	2.97
33	6.6	80.85	4.98	6.6	80.9	4.90	16.5	40.43	3.11
34	6.8	83.30	4.87	6.8	83.3	4.53	17.0	41.65	3.05
35	7.0	85.75	4.84	**7.0**	**85.8**	**4.36**	17.5	42.88	3.04
36	7.2	88.20	4.84	7.2	88.2	4.10	18.0	44.10	3.01
37	7.4	90.65	4.76	7.4	90.7	3.91	18.5	45.33	2.99
38	7.6	93.10	4.57	7.6	93.1	3.67	19.0	46.55	2.96
39	**7.8**	**95.55**	**4.45**	7.8	95.6	3.49	19.5	47.78	2.92
40	8.0	98.00	4.62	8.0	98.0	3.35	20.0	49.00	2.91
41	8.2	100.45	4.36	8.2	100.5	3.35	20.5	50.23	2.91
42	8.4	102.90	4.36	8.4	102.9	3.24	21.0	51.45	2.89

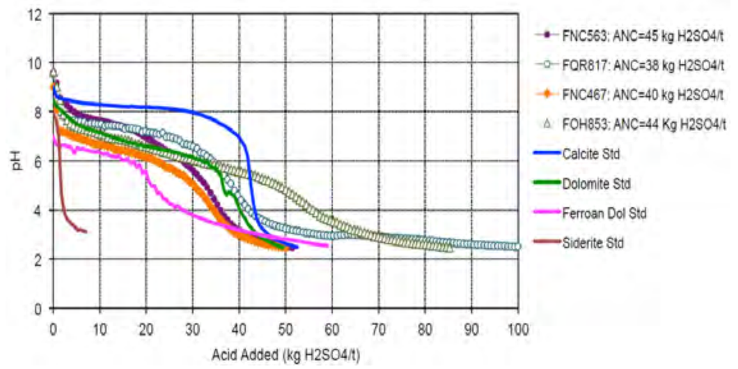


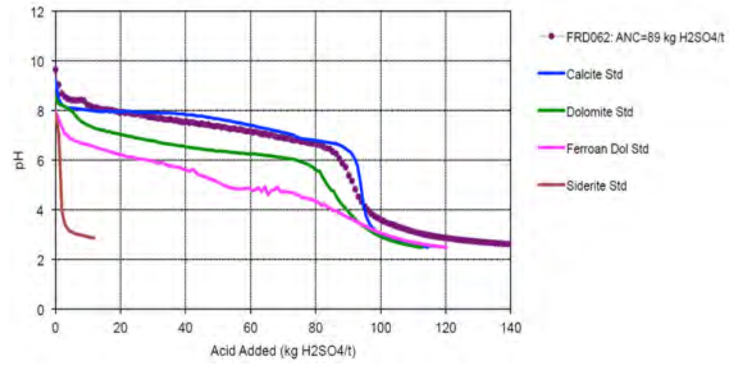












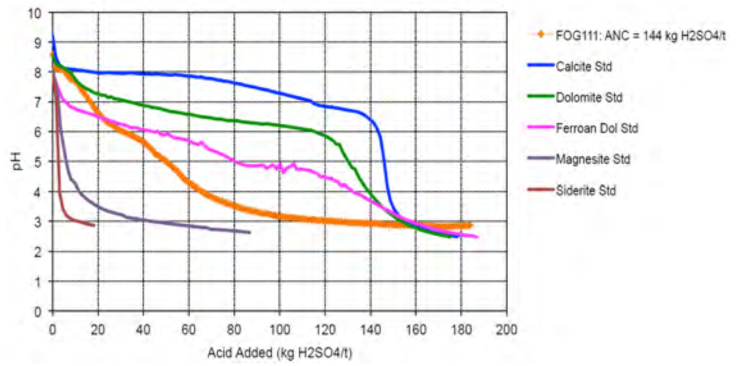
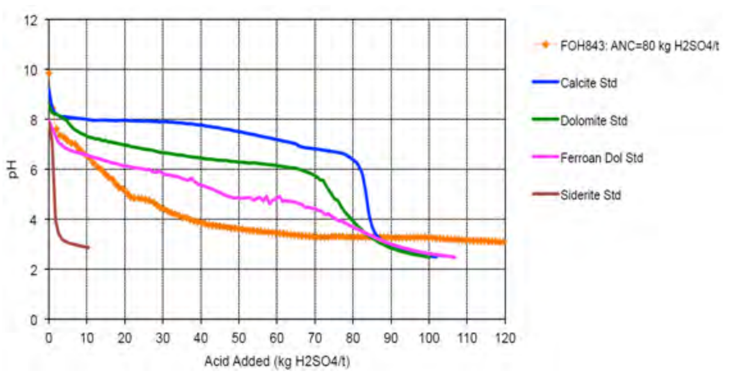
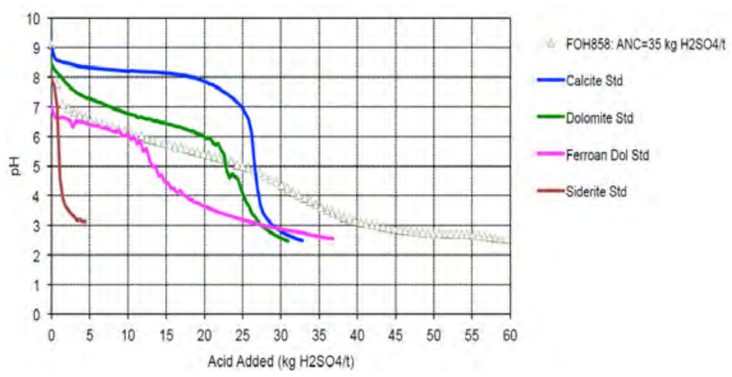


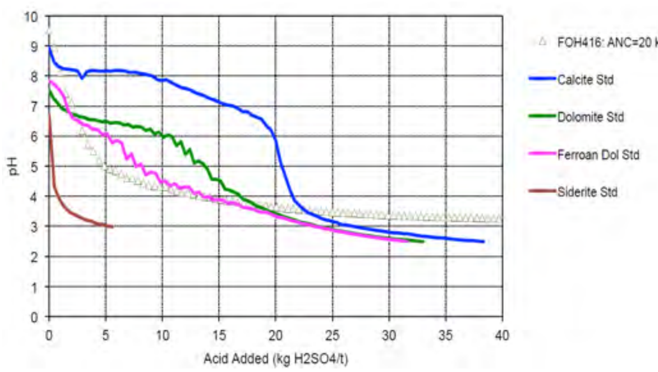
Table E4: ABCC Data

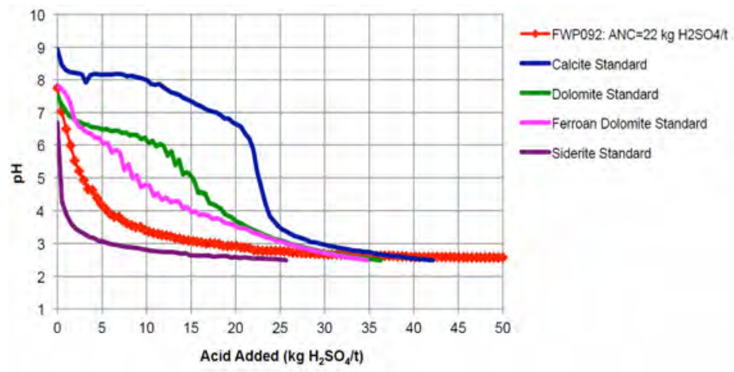
Figures taken from SRK, 2008; SRK, 2010; EGi, 2013; and EGi, 2014

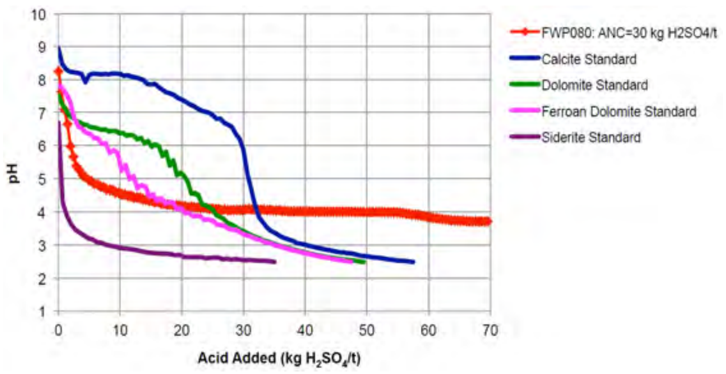
STEP	Vol. Added	Acid Added	pH	Vol. Added	Acid Added	pH	Vol. Added	Acid Added	pH
	mL HCl	kg H_2SO_4/t		mL HCl	kg H_2SO_4/t		mL HCl	kg H_2SO_4/t	
43	8.6	105.35	4.31	8.6	105.4	3.33	21.5	52.68	2.88
44	8.8	107.80	4.00	8.8	107.8	3.33	22.0	53.90	2.89
45	9.0	110.25	4.08	9.0	110.3	3.21	22.5	55.13	2.87
46	9.2	112.70	3.78	9.2	112.7	3.07	23.0	56.35	2.85
47	9.4	115.15	3.51	9.4	115.2	2.95	23.5	57.58	2.82
48	9.6	117.60	3.32	9.6	117.6	2.85	24.0	58.80	2.81
49	9.8	120.05	3.00	9.8	120.1	2.76	24.5	60.03	2.82
50	10.0	122.50	2.98	10.0	122.5	2.76	25.0	61.25	2.81
51	10.2	124.95	2.97	10.2	125.0	2.71	25.5	62.48	2.79
52	10.4	127.40	2.95	10.4	127.4	2.60	26.0	63.70	2.74
53	10.6	129.85	2.95	10.6	129.9	2.63	26.5	64.93	2.74
54	10.8	132.30	2.85	10.8	132.3	2.63	27.0	66.15	2.75
55	11.0	134.75	2.75	11.0	134.8	2.53	27.5	67.38	2.71
56	11.2	137.20	2.65	11.2	137.2	2.49	28.0	68.60	2.71
57	11.4	139.65	2.58	11.4	139.7	2.43	28.5	69.83	2.73
58	11.6	142.10	2.54	11.6	142.1		29.0	71.05	2.73
59	11.8	144.55	2.46	-	-	-	29.5	72.28	2.73
60	12.0	147.00	2.45	-	-	-	30.0	73.50	2.72
61	12.2	149.45	2.41	-	-	-	30.5	74.73	2.70
62	-	-	-	-	-	-	31.0	75.95	2.69
63	-	-	-	-	-	-	31.5	77.18	2.66
64	-	-	-	-	-	-	32.0	78.40	2.63
65	-	-	-	-	-	-	32.5	79.63	2.59
66	-	-	-	-	-	-	33.0	80.85	2.62
67	-	-	-	-	-	-	33.5	82.08	2.62
68	-	-	-	-	-	-	34.0	83.30	2.57
69	-	-	-	-	-	-	34.5	84.53	2.51
70	-	-	-	-	-	-	35.0	85.75	2.48
71	-	-	-	-	-	-	35.5	86.98	2.47











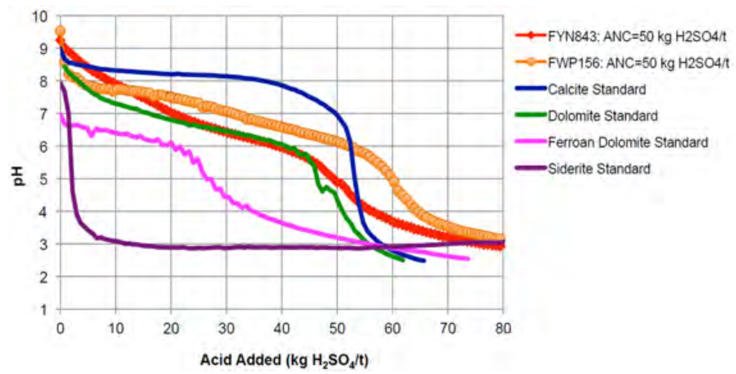


Table E5: Multi-Elemental Analysis

			ELEMENT	Al	Ca	Fe	K	Mg	Mn	Na	P	S	Si	Ti	Ag	As	Au	B	Ba	Be	Bi	Cd	Ce	Co	Cr
			UNITS	%	%	%	%	%	%	%	%	%	%	%	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
SAMPLE ID	STRAT	DEPOSIT	LOR	0.01	0.0001	0.01	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.05	0.05	10	0.01	10	10.0	0.1	0.01	0.02	0.01	0.1	1
FQR817	DET	Dep A W		6.51	1.03	21.8	0.08	0.86	0.0946	0.1	0.028	0.03		0.89	0.21	18			40.0	0.5	0.24	0.8	17.1	43.9	446
FRD872	DET	Dep A W		5.83	0.16	48.7	0.06	0.22	0.0065	0.08	0.028	0.19		0.47	0.11	14			40.0	0.5	0.27	0.0	8.02	5.5	218
FRG099	DET	Dep A W		8.34	0.24	16.1	0.22	0.31	0.0717	0.24	0.027	0.01		0.77	0.11	8			60.0	0.7	0.19	0.2	18.9	41.1	340
FQD908	DET	Dep D		6.89	0.16	37.8	0.07	0.16	0.0125	0.2	0.02	0.57		0.62	0.10	10			30.0	0.2	0.18	0.0	4.19	6.4	417
FWP287	DET	Dep F		7.12	0.06	17.3	0.34	0.1	0.0349	0.04	0.037	0.02		0.50	0.14	17			170.0	1.1	0.39	0.1	29.8	6.9	152
FYN787	DET	Dep F		4.38	0.08	49.50	0.19	0.03	0.0105	0.11	0.036	0.54		0.521	0.15	16.8			60	0.12	0.31	0.03	3.78	1.5	87
FQR487	DOR	Dep A W		10.65	0.03	2	0.01	0.02	0.0378	0.03	0.002	0.13		0.65	0.03	8			10.0	0.9	0.19	0.0	10.05	9.6	441
FRM113	DOR	Dep D		6.26	5.75	11.5	1.1	3.33	0.149	1.53	0.05	0.16		0.71	0.05	1			60.0	0.3	0.03	0.2	12.95	52.6	38
WEP/652/902_1	WF	Dep A		0.238	0.29	14.1286	0.0249	0.5488	0.155	0.4006	0.003	1.33	32.6758	0.01	<0.5	8	0.03	10	20.0		2.00	0.5		3	13
WEP/652/902_2	WF	Dep A		0.260	1.33	41.41	0.05	1.33		0.21		0.49	15.9	0.01											
WEP/652/902_3	WF	Dep A		0.150	0.21	20.07	<0.08	0.47		0.37		0.92	30	0.01											
WEP/652/902_4	WF	Dep A		0.070	0.14	29.31	0.02	1.83		2.8		0.82	23.3	0.01											
WEP/652/902_5	WF	Dep A		0.048	0.24	23.9207	0.0166	2.14092	0.006	3.24931	0.044	1.02	26.3651	0.01	0.50	29	0.01	10	10.0		2.00	0.5		1	2
WEP/652/902_6	WF	Dep A		0.080	0.24	15.11	0.05	1.22		1.88		0.42	33.8	0.01											
WEP/652/902_7	WF	Dep A		0.050	0.21	28.75	0.02	2.02		3.24		0.57	23.1	0.01											
WEP/652/902_8	WF	Dep A		0.042	0.15	27.1381	0.0249	2.1168	0.005	3.15287	0.015	1.82	24.3082	0.01	0.50	49	0.03	20	10.0		2.00	0.5		1	1
FQR860	WF	Dep A W		7.17	0.13	1.7	0.07	0.2	0.003	0.02	0.005	1.33		0.42	0.09	22			10.0	1.1	0.31	0.4	37.4	43.1	149
FNC936	WF	Dep B		4.61	0.01	43.8	0.48	0.15	0.408	0.02	0.085	0.12		0.13	0.08	31			30.0	3.0	0.58	0.1	62.6	18.1	52
FOG458	WF	Dep B		5.05	0.09	25.1	0.79	0.25	0.644	0.02	0.084	0.01		0.16	0.07	28			40.0	2.3	0.56	0.1	97.1	40.7	109
FRK244	WF	Dep B		4.77	0.01	44.7	0.23	0.1	0.15	0.02	0.052	0.17		0.15	0.37	57			30.0	0.9	0.47	0.0	21.7	9.4	41
FTI114	WF	Dep B		3.77	0.02	47.1	0.15	0.1	0.323	0.03	0.054	0.12		0.13	0.26	87			30.0	1.6	0.42	0.0	59.9	21.8	46
FOM528	WF	Dep D		7.69	0.07	31.8	0.22	0.08	0.118	0.6	0.03	1.96		0.48	0.12	24			90.0	0.8	0.63	0.0	20.6	11	111
FOM940	WF	Dep D		2.03	5.57	35.3	0.01	3.27	0.03	0.02	0.031	0.01		0.07	0.08	59			10.0	0.9	0.29	0.0	16.3	3.5	66
FRI220	WF	Dep D		3.86	0.55	45.2	0.03	0.36	0.233	0.02	0.051	0.02		0.14	0.12	25			40.0	0.6	0.52	0.0	36.7	8.1	40
FYN896	WF	Dep F		2.30	0.02	>50	0.01	0.04	0.0045	0.01	0.016	0.01		0.095	0.19	27.6			10	0.99	0.23	0.02	22.1	7.1	49
ECP051	MM	Dep A		1.604	1.11	19.5842	1.46106	2.94904	0.11617	0.09644	0.02618	0.42	23.9342	0.10	0.11	8	<0.01	10	90.0		0.09	0.27		8	68
ECP052	MM	Dep A		1.900	2.43	15.1778	1.64369	2.67766	0.11617	0.08902	0.03055	0.43	26.0378	0.12	0.07	10	0.04	30	80.0		0.12	0.11		8.9	68
ECP053	MM	Dep A		2.641	0.99	20.1438	2.58176	3.00935	0.10842	0.1187	0.02618	0.42	22.0644	0.16	0.08	18	0.01	50	180.0		0.15	0.08		13.2	68
ECP054	MM	Dep A		1.249	1.37	18.7449	1.17051	2.0384	0.08519	0.10386	0.02182	0.57	25.6171	0.08	0.07	6	0.02	70	40.0		0.08	0.08		6.1	68
ECP164	MM	Dep A		1.535	1.62	19.5842	1.37805	3.0395	0.09293	0.19288	0.02618	0.66	23.5603	0.10	0.08	10	0.01	20	50.0		0.12	0.08		9.7	68
ECP165	MM	Dep A		2.244	2.44	19.9339	1.90934	4.02855	0.10068	0.23739	0.02182	0.76	20.475	0.14	0.08	23	0.01	10	90.0		0.21	0.06		15.4	68
ECP281	MM	Dep A		2.170	0.69	22.0322	1.49427	1.26646	0.22459	0.28932	0.01746	0.46	21.6904	0.12	0.11	15	<0.01	60	140.0		0.23	0.28		13.4	68
ECP402	MM	Dep A		2.085	0.70	22.0322	1.49427	1.27852	0.23234	0.41544	0.01309	0.46	21.7371	0.11	0.10	14	0.01	<10	140.0		0.22	0.28		12.9	68
FOD662	MM	Dep A W		2.73	0.10	43.8	0.06	0.09	0.0198	0.11	0.023	0.32		0.06	0.08	20			160.0	1.6	0.07	0.0	10.3	4.7	25
FNJ868	MM	Dep B		0.66	0.01	40.8	0.01	0.01	0.0467	0.01	0.041	0.02		0.03	0.04	2			10.0	0.4	0.10	0.1	8.49	6.8	7
FOG111	MM	Dep B		0.42	2.48	19.1	0.44	1.33	0.0649	0.09	0.013	0.78		0.02	0.04	3			10.0	1.1	0.06	0.1	5.92	1.9	7
FOH416	MM	Dep B		1.19	0.19	21.4	1.1	1.41	0.0786	0.04	0.014	0.89		0.08	0.21	6			50.0	2.2	0.24	0.1	16.4	7	28
FOH824	MM	Dep B		0.24	0.13	18.9	0.06	0.67	0.0274	0.02	0.031	0.01		0.01	0.05	2			10.0	0.9	0.01	0.0	9.65	1.8	5
FOH857	MM	Dep B		0.38	0.20	23.5	0.4	1.67	0.0546	0.02	0.023	0.24		0.03	0.03	2			10.0	1.2	0.09	0.0	8.81	2.2	11
FWP071	MM	Dep F		0.36	0.12	27.1	0.05	0.15	0.0183	0.01	0.046	0.32		0.02	0.07	1			10.0	0.9	0.09	0.0	5.2	1.6	6
FWP080	MM	Dep F		2.23	0.24	22.9	2.08	1.19	0.362	0.06	0.006	0.58		0.14	0.16	19			240.0	1.1	0.14	0.2	24.1	11.8	45
FWP092	MM	Dep F		0.67	0.34	21	0.56	1.64	0.0953	0.02	0.012	0.25		0.03	0.13	3			10.0	1.9	0.06	0.1	14.2	2.1	10
FWP156	MM	Dep F		0.11	1.66	25.1	0.02	1.08	0.024	0.13	0.033	0.11		0.01	0.08	1			10.0	0.4	0.05	0.0	1.74	1.1	2
FWP281	MM	Dep F		0.12	0.01	29.2	0.01	0.02	0.0097	<0.01	0.029	<0.01		0.01	0.10	1			10.0	0.4	0.04	0.0	3.8	1.2	2
FYN843	MM	Dep F		0.13	1.51	28.4	0.05	1.43	0.0191	0.05	0.065	0.11		0.008	0.09	0.5			10	0.45	0.04	0.04	2.12	1.1	3
FYN908	MM	Dep F		0.35	0.01	>50	<0.01	0.02	0.0262	0.01	0.051	<0.01		0.012	0.2	2.6			10	0.37	0.05	0.02	7.44	1.4	1
ECP332	MM	N/R		0.138	1.07	28.1173	0.05811	1.28455	0.03098	0.34125	0.07855	0.16	24.8692	0.01	0.07	<0.2	<0.01	100	20.0		0.02	<0.02		1.5	<68
ECP355	MM	N/R		1.858	0.52	21.1929	1.04599	2.08061	0.24783	0.37834	0.02182	0.4	21.9709	0.11	0.09	7	<0.01	150	130.0		0.10	0.11		7.6	68

	Cs	Cu	F	Ga	Ge	Hf	Hg	In	La	Li	Mo	Nb	Ni	Pb	Rb	Sb	Sc	Se	Sn	Sr	Ta	Th	Tl	U	V	W	Y	Zn	Zr
	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm		ppm	ppm	ppm		ppm	ppm	ppm	ppm		ppm	ppm	ppm
SAMPLE ID	0.05	0.2	20	0.05	0.05	0.1	0.001	0.005	1	0.2	0.05	0.1	0.2	0.5	0.1	0.01	0.1	0.01	0.1	0.05	0.05	0.0001	0.1	0.01	1	0.1	1	1	0.5
FQR817	0.14	186		34	0.47	3.3	0.013	0.329	7.5	9	1.32	6.8	88.3	14.4	2.4	1.55	39.9	3	2.7	25.6	0.46	3.3	0.48	0.6	808	0.5	22.6	189	115
FRD872	0.7	16.6		21.2	2.45	2.7	0.007	0.115	3.5	5	2.24	7.6	30.2	18.4	1.7	1.77	20.4	1	1.9	58.3	0.58	6.5	0.02	1	185	1.3	2.9	15	95.8
FRG099	0.85	165.5		24.2	0.22	2.8	0.006	0.187	7	18.3	1.05	7.1	121	13.3	7.9	0.83	37.8	1	2.2	25.8	0.54	2.6	0.26	0.7	373	0.7	15.9	194	91.6
FQD908	0.18	37.8		26	1.09	2.7	0.008	0.103	2.3	4.9	1.92	6.5	38.5	11.6	1.4	1.12	27.6	1	1.6	57.7	0.47	4.2	0.02	0.8	424	0.7	2	5	94.1
FWP287	2.76	51.6		19.5	0.3	3.7	0.007		17.7	18.8	1.51	10.5	27.6	21.9	34.1	1.51	18.5	2	2.8	29.2	0.91	11.5	0.35	2	163	2.3	11.3	73	135.5
FYN787	0.1	9.3		19.15	2.05	2	0.016		3.000	1.900	3.68	11.6	8.7	16.2	1.8	2.46	6	2	2.6	83.8	0.92	6	0.02	0.7	102	2.9	1.6	9	79
FQR487	0.26	27.3		24.2	0.05	2.7	0.068	0.147	5.7	29.1	0.47	6.2	44.5	9.4	1.1	0.75	20.7	1	1.9	1.4	0.47	3	0.13	1.4	332	1.3	6.5	75	93.7
FRM113	3.66	153		14.95	0.18	2.6	0.026	0.095	4.9	13.1	0.34	3.4	51	1.8	88.8	0.1	49.4	1	0.9	96.3	0.22	0.3	0.23	0.1	352	0.4	31	142	97.2
WEP/652/902_1		21					0.025				1					0.8				5		0.01198999		2			26		
WEP/652/902_2																													
WEP/652/902_3																													
WEP/652/902_4																													
WEP/652/902_5		16					0.029				1					0.4				5		0.01198999		1			17		
WEP/652/902_6																													
WEP/652/902_7																													
WEP/652/902_8		18					0.041				1					0.6				5		0.01198999		1			13		
FQR860	2.09	76.8		15.5	0.1	2.4	0.075	0.106	24.2	38.8	1.53	5.1	141	14.3	7.4	1.74	20.2	2	1.7	5.7	0.41	4.9	4.47	2	118	2.3	31.5	174	89.2
FNC936	0.65	42.6		11.85	3.69	2.2	0.015	0.058	36.7	5.4	1.44	3.2	65.8	18.7	25.7	3.06	10.8	1	1.4	8.5	0.28	8.5	0.13	7.3	60	1.2	23.1	72	84.4
FOG458	1.1	44.7		16.3	1.52	3.2	0.037	0.058	53.9	18.8	0.86	4.1	108	23.9	21.1	3.19	11.5	1	1.8	3.9	0.41	7.1	0.16	3	90	1.4	32.6	243	120
FRK244	0.4	47.5		13.15	2.14	1.9	0.022	0.059	5.9	2.1	1.15	3.5	38.3	23.7	10.4	4.46	15.1	1	1.4	1.8	0.29	9.4	0.1	2.4	74	1.4	11.2	39	74.5
FTI114	0.9	94.5		10.7	1.99	1.8	0.04	0.04	40	4	0.83	3.1	54.4	39.3	8.3	3.04	19.1	2	1.4	3.2	0.26	8.9	0.08	2.4	54	1.5	40.5	29	65.5
FOM528	0.15	29.7		25.9	1.57	4.9	0.036	0.121	5.8	63.6	2.12	8.8	42.2	20.1	1	4.06	24.1	3	2.6	233	0.74	15.8	0.1	1.6	284	3.4	4.7	8	180
FOM940	0.57	14.8		6.27	3.02	0.9	0.049	0.043	7.4	4.5	1.59	2	11.6	15.8	1.2	2.77	9.4	1	0.7	24.7	0.14	4.4	0.02	1.4	54	0.9	9.5	34	37.5
FRI220	0.22	18.1		10.55	7.92	2.3	0.032	0.048	7	12.8	0.78	4.3	23.4	14.8	1.5	2.33	9.6	1	1.3	6.8	0.38	9.1	0.16	1.6	64	1.8	10.2	32	87
FYN896	0.05	7.2		7.43	3.28	0.9	0.027		7.400	3.700	1.46	2.6	21.4	12.7	0.4	1.75	6.4	1	0.8	1.8	0.18	3.4	0.02	1.8	55	1.3	11.5	5	35
ECP051		31.4	430				0.017				0.75		24.4	13.3		1		1	0.6	16.2		2		0.5	27			72	
ECP052		16.2	520				0.025				1.09		29.5	7.3		0.54		1	0.7	19.5		2.4		0.5	38			53	
ECP053		13.5	370				0.025				1.12		35.4	4.3		0.62		1	0.8	12.9		3.4		0.9	46			35	
ECP054		15.6	310				0.018				0.97		17.7	3		0.69		1	0.7	11.1		1.5		0.4	24			42	
ECP164		18.7	420				0.019				0.88		22.5	2.9		0.68		1	0.6	16.4		2		0.5	28			17	
ECP165		20.9	550				0.02				1.17		33.6	2.9		0.8		2	0.8	12.5		2.9		0.7	37			39	
ECP281		32.4	400				0.026				1.76		38.3	9.4		0.84		2	0.9	8.2		2.9		0.8	36			78	
ECP402		33.8	370				0.024				1.64		34.8	8.5		0.77		2	0.9	8.2		3		0.8	34			77	
FOD662	0.13	26.9		2.72	2.36	0.5	0.015	0.06	4.8	1.5	0.52	1.5	22	11.2	2.7	1.55	7.5	1	0.7	54.2	0.09	1.8	0.04	0.8	26	0.5	6.6	52	20.2
FNJ868	0.05	8.3		1.22	0.27	0.3	0.013	0.007	2.5	1.2	0.45	0.7	10.9	4	0.4	0.43	1.2	1	0.2	0.3	0.05	0.7	0.02	0.4	9	1.3	3.5	49	11.9
FOG111	4.84	13.1		1.79	0.19	0.9	0.01	0.007	3.4	1.2	0.43	0.7	5.2	1.9	61.5	0.48	1.4	1	0.3	32.4	0.05	0.5	0.12	0.1	7	0.7	7.8	12	46.3
FOH416	8.14	21.7		3.35	0.2	0.8	0.13	0.017	7.8	2.1	0.77	1.7	19.6	9.3	154	0.81	4.3	1	0.6	7.5	0.15	1.8	0.43	0.5	24	0.5	7	51	33.9
FOH824	2.15	4.3		0.78	0.18	0.2	0.037	0.005	6	1.7	0.36	0.4	8.1	2.1	27.8	0.7	0.9	1	0.2	5.8	0.05	0.4	0.02	0.2	4	0.3	7.3	19	8.9
FOH857	4.16	7.3		1.12	0.23	0.4	0.028	0.009	4.6	2.1	0.66	0.7	7.3	2.2	54.5	0.59	1.5	1	0.3	3.6	0.05	0.6	0.2	0.3	10	1	6.1	27	17
FWP071	0.54	5.4		1.15	0.33	0.6	0.023		2.8	4.7	0.66	0.8	5.3	2.7	7.1	0.4	1	<1	0.3	2.9	0.05	0.7	0.05	0.2	6	3.8	5.3	15	29.4
FWP080	10.95	15.6		5.62	0.31	1.2	0.057		12.4	2.4	1.08	3	30	13.7	165.5	0.79	6.9	1	0.8	2.4	0.26	3.2	0.36	0.9	42	1.1	13.5	68	52.3
FWP092	7.52	6.6		2.19	0.28	0.6	0.021		7.2	2.5	0.98	1.4	9.2	5.8	97.5	1.11	2.2	<1	0.5	3.7	0.11	1.6	0.2	0.4	8	1.5	7	34	25.8
FWP156	0.87	2.1		0.4	0.3	0.4	0.013		1	5.6	0.5	0.4	2.2	2.3	3.3	0.28	0.4	<1	0.2	15.1	0.05	0.2	0.02	0.2	2	2.5	3.5	10	18.1
FWP281	0.06	3.2		0.39	0.47	0.7	0.01		2.1	4.9	0.77	0.4	2.3	2.3	1	0.27	0.6	<1	0.2	0.8	0.05	0.2	0.02	0.1	3	3.7	2.1	10	38.1
FYN843	0.9	3.7		0.47	0.32	0.5	0.010		1.300	4.100	0.31	0.5	2.7	7.8	6.3	0.37	0.5	<1	0.2	40.7	0.05	0.2	0.03	0.2	3	2.7	4.7	17	24.2
FYN908	0.05	3.7		0.89	2.28	0.1	0.016		2.300	1.800	0.27	1.1	5	2.7	0.3	0.46	0.9	<1	0.2	0.9	0.05	0.3	0.02	0.3	8	0.8	4.8	8	5.7
ECP332		2.9	170				0.015				0.97		3.7	1.1		0.17		1	0.2	10.9		0.2		<0.1	3			7	
ECP355		24.4	330				0.025				0.89		23.3	5.9		0.68		1	0.7	9.5		2.2		0.5	32			44	

			ELEMENT	Al	Ca	Fe	K	Mg	Mn	Na	P	S	Si	Ti	Ag	As	Au	B	Ba	Be	Bi	Cd	Ce	Co	Cr	Cs	Cu	F
SAMPLE ID	STRAT	DEPOSIT	ACA	8.13	3.63	5.0	2.59	2.09	0.095	2.30	0.105	0.026	28	4,400	0.07	1.8	0.004	10	425	2.6	0.17	0.2	60	25	100	3	55	585
FQR817	DET	Dep A W		0	0	1	0	0	0	0	0	0		0	1	2			0	0	0	1	0	0	1	0	1	
FRD872	DET	Dep A W		0	0	2	0	0	0	0	0	2		0	0	2			0	0	0	0	0	0	0	0	0	
FRG099	DET	Dep A W		0	0	1	0	0	0	0	0	0		0	0	1			0	0	0	0	0	0	1	0	1	
FQD908	DET	Dep D		0	0	2	0	0	0	0	0	3		0	0	1			0	0	0	0	0	0	1	0	0	
FWP287	DET	Dep F		0	0	1	0	0	0	0	0	0		0	0	2			0	0	0	0	0	0	0	0	0	
FYN787	DET	Dep F		0	0	2	0	0	0	0	0	3		0	0	2			0	0	0	0	0	0	0	0	0	
FQR487	DOR	Dep A W		0	0	0	0	0	0	0	0	1		0	0	1			0	0	0	0	0	0	1	0	0	
FRM113	DOR	Dep D		0	0	0	0	0	0	0	0	2		0	0	0			0	0	0	0	0	0	0	0	0	
WEP/652/902_1	WF	Dep A		0	0	0	0	0	0	0	0	5	0	0	1	1	2	0	0		2	0		0	0		0	
WEP/652/902_2	WF	Dep A		0	0	2	0	0		0		3	0	0														
WEP/652/902_3	WF	Dep A		0	0	1	0	0		0		4	0	0														
WEP/652/902_4	WF	Dep A		0	0	1	0	0		0		4	0	0														
WEP/652/902_5	WF	Dep A		0	0	1	0	0	0	0	0	4	0	0	2	3	0	0	0		2	0		0	0		0	
WEP/652/902_6	WF	Dep A		0	0	1	0	0		0		3	0	0														
WEP/652/902_7	WF	Dep A		0	0	1	0	0		0		3	0	0														
WEP/652/902_8	WF	Dep A		0	0	1	0	0	0	0	0	5	0	0	2	4	2	0	0		2	0		0	0		0	
FQR860	WF	Dep A W		0	0	0	0	0	0	0	0	5		0	0	3			0	0	0	0	0	0	0	0	0	
FNC936	WF	Dep B		0	0	2	0	0	1	0	0	1		0	0	3			0	0	1	0	0	0	0	0	0	
FOG458	WF	Dep B		0	0	1	0	0	2	0	0	0		0	0	3			0	0	1	0	0	0	0	0	0	
FRK244	WF	Dep B		0	0	2	0	0	0	0	0	2		0	1	4			0	0	0	0	0	0	0	0	0	
FTI114	WF	Dep B		0	0	2	0	0	1	0	0	1		0	1	5			0	0	0	0	0	0	0	0	0	
FOM528	WF	Dep D		0	0	2	0	0	0	0	0	5		0	0	3			0	0	1	0	0	0	0	0	0	
FOM940	WF	Dep D		0	0	2	0	0	0	0	0	0		0	0	4			0	0	0	0	0	0	0	0	0	
FRI220	WF	Dep D		0	0	2	0	0	0	0	0	0		0	0	3			0	0	1	0	0	0	0	0	0	
FYN896	WF	Dep F		0	0		0	0	0	0	0	0		0	0	3			0	0	0	0	0	0	0	0	0	
ECP051	MM	Dep A		0	0	1	0	0	0	0	0	3	0	0	0	1	0	0	0		0	0		0	0		0	0
ECP052	MM	Dep A		0	0	1	0	0	0	0	0	3	0	0	0	1	2	1	0		0	0		0	0		0	0
ECP053	MM	Dep A		0	0	1	0	0	0	0	0	3	0	0	0	2	0	1	0		0	0		0	0		0	0
ECP054	MM	Dep A		0	0	1	0	0	0	0	0	3	0	0	0	1	1	2	0		0	0		0	0		0	0
ECP164	MM	Dep A		0	0	1	0	0	0	0	0	4	0	0	0	1	0	0	0		0	0		0	0		0	0
ECP165	MM	Dep A		0	0	1	0	0	0	0	0	4	0	0	0	3	0	0	0		0	0		0	0		0	0
ECP281	MM	Dep A		0	0	1	0	0	0	0	0	3	0	0	0	2	0	2	0		0	0		0	0		0	0
ECP402	MM	Dep A		0	0	1	0	0	0	0	0	3	0	0	0	2	0	0	0		0	0		0	0		0	0
FOD662	MM	Dep A W		0	0	2	0	0	0	0	0	3		0	0	2			0	0	0	0	0	0	0	0	0	
FNJ868	MM	Dep B		0	0	2	0	0	0	0	0	0		0	0	0			0	0	0	0	0	0	0	0	0	
FOG111	MM	Dep B		0	0	1	0	0	0	0	0	4		0	0	0			0	0	0	0	0	0	0	0	0	
FOH416	MM	Dep B		0	0	1	0	0	0	0	0	4		0	1	1			0	0	0	0	0	0	0	0	0	
FOH824	MM	Dep B		0	0	1	0	0	0	0	0	0		0	0	0			0	0	0	0	0	0	0	0	0	
FOH857	MM	Dep B		0	0	1	0	0	0	0	0	2		0	0	0			0	0	0	0	0	0	0	0	0	
FWP071	MM	Dep F		0	0	1	0	0	0	0	0	3		0	0	0			0	0	0	0	0	0	0	0	0	
FWP080	MM	Dep F		0	0	1	0	0	1	0	0	3		0	0	2			0	0	0	0	0	0	0	1	0	
FWP092	MM	Dep F		0	0	1	0	0	0	0	0	2		0	0	0			0	0	0	0	0	0	0	0	0	
FWP156	MM	Dep F		0	0	1	0	0	0	0	0	1		0	0	0			0	0	0	0	0	0	0	0	0	
FWP281	MM	Dep F		0	0	1	0	0	0	0	0	0		0	0	0			0	0	0	0	0	0	0	0	0	
FYN843	MM	Dep F		0	0	1	0	0	0	0	0	1		0	0	0			0	0	0	0	0	0	0	0	0	
FYN908	MM	Dep F		0	0		0	0	0	0	0	0		0	0	0			0	0	0	0	0	0	0	0	0	
ECP332	MM	N/R		0	0	1	0	0	0	0	0	2	0	0	0	0	0	2	0		0	0		0			0	0
ECP355	MM	N/R		0	0	1	0	0	0	0	0	3	0	0	0	1	0	3	0		0	0		0	0		0	0

Table E6: Geochemical Abundance Indices

	Ga	Ge	Hf	Hg	In	La	Li	Mo	Nb	Ni	Pb	Rb	Sb	Sc	Se	Sn	Sr	Ta	Th	Tl	U	V	W	Y	Zn	Zr
SAMPLE ID	19	1.5	3	0.08	0.25	39	20	1.5	20	75	12.5	90	0.2	22	0.05	2	375	2	7.2	0.5	1.8	135	1.25	33	70	165
FQR817	0	0	0	0	0	0	0	0	0	0	0	0	2	0	5	0	0	0	0	0	0	1	0	0	0	0
FRD872	0	0	0	0	0	0	0	0	0	0	0	0	2	0	3	0	0	0	0	0	0	0	0	0	0	0
FRG099	0	0	0	0	0	0	0	0	0	0	0	0	1	0	3	0	0	0	0	0	0	0	0	0	0	0
FQD908	0	0	0	0	0	0	0	0	0	0	0	0	1	0	3	0	0	0	0	0	0	1	0	0	0	0
FWP287	0	0	0	0		0	0	0	0	0	0	0	2	0	4	0	0	0	0	0	0	0	0	0	0	0
FYN787	0	0	0	0		0	0	0	0	0	0	0	3	0	4	0	0	0	0	0	0	0	0	0	0	0
FQR487	0	0	0	0	0	0	0	0	0	0	0	0	1	0	3	0	0	0	0	0	0	0	0	0	0	0
FRM113	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0
WEP/652/902_1				0				0					1				0		0		0			0		
WEP/652/902_2																										
WEP/652/902_3																										
WEP/652/902_4																										
WEP/652/902_5				0				0					0				0		0		0			0		
WEP/652/902_6																										
WEP/652/902_7																										
WEP/652/902_8				0				0					1				0		0		0			0		
FQR860	0	0	0	0	0	0	0	0	0	0	0	0	2	0	4	0	0	0	0	2	0	0	0	0	0	0
FNC936	0	0	0	0	0	0	0	0	0	0	0	0	3	0	3	0	0	0	0	0	1	0	0	0	0	0
FOG458	0	0	0	0	0	0	0	0	0	0	0	0	3	0	3	0	0	0	0	0	0	0	0	0	1	0
FRK244	0	0	0	0	0	0	0	0	0	0	0	0	3	0	3	0	0	0	0	0	0	0	0	0	0	0
FTI114	0	0	0	0	0	0	0	0	0	0	1	0	3	0	4	0	0	0	0	0	0	0	0	0	0	0
FOM528	0	0	0	0	0	0	1	0	0	0	0	0	3	0	5	0	0	0	0	0	0	0	0	0	0	0
FOM940	0	0	0	0	0	0	0	0	0	0	0	0	3	0	3	0	0	0	0	0	0	0	0	0	0	0
FRI220	0	1	0	0	0	0	0	0	0	0	0	0	2	0	3	0	0	0	0	0	0	0	0	0	0	0
FYN896	0	0	0	0		0	0	0	0	0	0	0	2	0	3	0	0	0	0	0	0	0	0	0	0	0
ECP051				0				0		0	0		1		3	0	0		0		0	0			0	
ECP052				0				0		0	0		0		3	0	0		0		0	0			0	
ECP053				0				0		0	0		1		3	0	0		0		0	0			0	
ECP054				0				0		0	0		1		3	0	0		0		0	0			0	
ECP164				0				0		0	0		1		3	0	0		0		0	0			0	
ECP165				0				0		0	0		1		4	0	0		0		0	0			0	
ECP281				0				0		0	0		1		4	0	0		0		0	0			0	
ECP402				0				0		0	0		1		4	0	0		0		0	0			0	
FOD662	0	0	0	0	0	0	0	0	0	0	0	0	2	0	3	0	0	0	0	0	0	0	0	0	0	0
FNJ868	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0
FOG111	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0
FOH416	0	0	0	0	0	0	0	0	0	0	0	0	1	0	3	0	0	0	0	0	0	0	0	0	0	0
FOH824	0	0	0	0	0	0	0	0	0	0	0	0	1	0	3	0	0	0	0	0	0	0	0	0	0	0
FOH857	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0
FWP071	0	0	0	0		0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	1	0	0	0
FWP080	0	0	0	0		0	0	0	0	0	0	0	1	0	3	0	0	0	0	0	0	0	0	0	0	0
FWP092	0	0	0	0		0	0	0	0	0	0	0	1	0	2	0	0	0	0	0	0	0	0	0	0	0
FWP156	0	0	0	0		0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0
FWP281	0	0	0	0		0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0
FYN843	0	0	0	0		0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0
FYN908	0	0	0	0		0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0
ECP332				0				0		0	0		0		3	0	0		0		0	0			0	
ECP355				0				0		0	0		1		3	0	0		0		0	0			0	

Average-crustal-abundances (ACA) of the elements for the GAI calculations are based on the values listed in Field Geologists' Manual (AusIMM, 2011) supplemented with data from Bowen (1979) for mean crustal abundance for the elements Al, Ca, Fe, K, Mg, Na, P, S, and Ti.

For GAI calculation purposes, less than values were treated as equal to half the limit of reporting value.

*Where the limit of reporting exceeds the average crustal abundance value, false enrichments may be presented. Therefore, where GAI's of 3 or greater are due to this false enrichment, cells have been left blank (e.g. Bi, Sb, Te).

GAI Score	Explanation
0	<3 times average crustal abundance
1-2	3 to 12 times average crustal abundance
3	12 to 24 times average crustal abundance
4	24 to 48 times average crustal abundance
5	48 to 96 times average crustal abundance
6≥	>96 times average crustal abundance

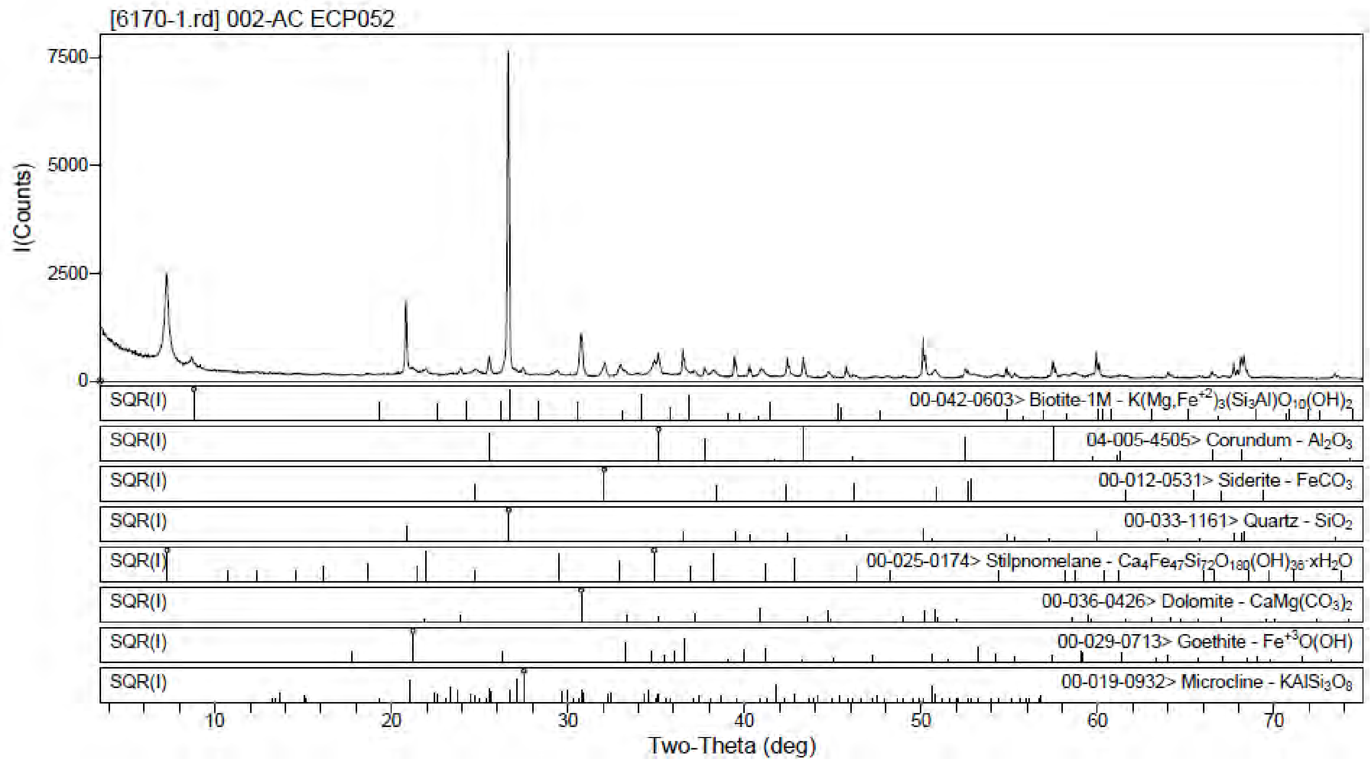
			ELEMENT	pH	EC	Cl	SO4	F	Ca	K	Mg	Na	Ag	Al	As	B	Ba	Be	Bi	Cd	Co	Cr
			UNITS		µS/cm	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
SAMPLE ID	STRAT	DEPOSIT	LOR	0.1	10	2	1	0.1	1	1	1	1	0.001	0.01	0.001	0.05	0.002	0.001	0.001	0.0001	0.001	0.001
FQR817	DET	Dep A W		7.4	233	23	33	0.2	10	3	5	22	<0.001	0.01	<0.001	0.06	0.409	<0.001		<0.0001	<0.001	<0.001
FRD872	DET	Dep A W		7.8	178	12	22	0.5	4	3	2	17	<0.001	0.28	<0.001	0.09	0.403	<0.001		<0.0001	<0.001	<0.001
FRG099	DET	Dep A W		7.8	278	40	64	0.6	11	10	8	37	<0.001	<0.01	<0.001	0.10	0.483	<0.001		<0.0001	<0.001	<0.001
FQD908	DET	Dep D		7.3	296	25	47	0.3	11	3	6	25	<0.001	0.04	<0.001	0.09	0.471	<0.001		<0.0001	<0.001	<0.001
FWP287	DET	Dep F		7.5	21	2	2	<0.1	<1	<1	<1	4	<0.001	0.03	<0.001	0.06	0.077	<0.001		<0.0001	<0.001	<0.001
FYN787	DET	Dep F		7.6	67	21	18	0.2	2	4	1	17	<0.001	0.03	<0.001	0.10	0.407	<0.001		<0.0001	<0.001	<0.001
FQR487	DOR	Dep A W		6.7	379	59	310	0.3	56	5	44	37	<0.001	0.20	0.002	0.26	0.078	0.003		0.0008	0.546	0.003
FRM113	DOR	Dep D		8.4	165	7	17	<0.1	6	8	2	16	<0.001	0.04	<0.001	<0.05	0.339	<0.001		<0.0001	<0.001	<0.001
WEP/652/902_1	WF	Dep A					<0.2	<1	70	<10	110	50	<0.2	<1	<0.2	<1	<2		<0.2	<0.2	<0.2	<0.02
WEP/652/902_5	WF	Dep A					<0.2	1	10	<10	30	90	<0.2	<1	<0.2	<1	<2		<0.2	<0.2	<0.2	<0.02
WEP/652/902_8	WF	Dep A					<0.2	1	10	<10	30	80	<0.2	<1	<0.2	<1	<2		<0.2	<0.2	<0.2	<0.02
FQR860	WF	Dep A W		6.8	496	49	290	<0.1	48	4	51	37	<0.001	0.05	0.019	0.30	0.090	<0.001		0.0002	0.181	0.009
FNC936	WF	Dep B		7.2	476	53	143	<0.1	20	6	26	33	<0.001	0.02	<0.001	0.11	0.140	<0.001		<0.0001	0.005	<0.001
FOG458	WF	Dep B		7.2	291	27	82	0.3	24	2	21	21	<0.001	<0.01	<0.001	0.08	0.400	<0.001		<0.0001	<0.001	<0.001
FRK244	WF	Dep B		5.8	345	52	112	<0.1	13	6	21	35	<0.001	0.04	<0.001	0.21	0.175	<0.001		0.0001	0.004	<0.001
FTI114	WF	Dep B		6.7	488	89	111	<0.1	16	6	24	49	<0.001	<0.01	<0.001	0.24	0.180	<0.001		<0.0001	0.001	<0.001
FOM528	WF	Dep D		7.1	469	69	77	<0.1	23	4	15	40	<0.001	<0.01	<0.001	0.06	0.368	<0.001		<0.0001	<0.001	<0.001
FOM940	WF	Dep D		7.3	229	28	37	0.1	15	2	12	15	<0.001	<0.01	<0.001	<0.05	0.189	<0.001		<0.0001	<0.001	<0.001
FRI220	WF	Dep D		7.5	199	7	15	0.2	14	2	11	11	<0.001	<0.01	<0.001	0.08	0.398	<0.001		<0.0001	<0.001	<0.001
FYN896	WF	Dep F		7.9	112	2	2	0.1	<1	<1	<1	3	<0.001	0.02	<0.001	<0.05	0.130	<0.001		<0.0001	<0.001	<0.001
ECP051	MM	Dep A		8.6		35	555	1.5	35	190	20	340	<0.05	<0.5	<0.05	<0.5	<0.5		<0.005	<0.05	<0.05	
ECP164	MM	Dep A		8.8		30	345	3.5	25	95	30	360	<0.05	<0.5	<0.05	0.5	<0.5		0.010	<0.05	<0.05	
ECP165	MM	Dep A		8.9		35	375	5.0	15	65	20	365	<0.05	<0.5	<0.05	<0.5	<0.5		<0.005	<0.05	<0.05	
ECP281	MM	Dep A		7.1		30	870	1.5	200	165	195	55	<0.05	<0.5	<0.05	<0.5	<0.5		<0.005	<0.05	<0.05	
ECP402	MM	Dep A		6.9		50	1,650	1.0	330	150	320	85	<0.05	<0.5	<0.05	<0.5	<0.5		<0.005	<0.05	<0.05	
FOD662	MM	Dep A W		7.8	133	12	19	0.2	3	3	2	14	<0.001	0.05	<0.001	0.05	0.407	<0.001		<0.0001	<0.001	<0.001
FNJ868	MM	Dep B		7.4	188	31	42	<0.1	10	2	7	11	<0.001	<0.01	<0.001	<0.05	0.404	<0.001		<0.0001	<0.001	<0.001
FOG111	MM	Dep B		8.1	569	6	363	<0.1	90	5	34	23	<0.001	<0.01	<0.001	<0.05	0.075	<0.001		<0.0001	<0.001	<0.001
FOH416	MM	Dep B		7.6	729	28	445	<0.1	38	65	68	56	<0.001	<0.01	0.001	<0.05	0.072	<0.001		<0.0001	<0.001	<0.001
FOH824	MM	Dep B		7.9	345	41	82	0.3	9	3	24	29	<0.001	0.01	<0.001	0.07	0.386	<0.001		<0.0001	<0.001	<0.001
FOH857	MM	Dep B		7.5	267	16	62	<0.1	9	8	11	22	<0.001	<0.01	<0.001	0.05	0.427	<0.001		<0.0001	0.002	<0.001
FWP071	MM	Dep F		7.6	196	9	45	<0.1	8	5	7	6	<0.001	<0.01	<0.001	<0.05	0.418	<0.001		<0.0001	<0.001	<0.001
FWP080	MM	Dep F		7.7	889	10	384	<0.1	24	65	22	79	<0.001	<0.01	<0.001	<0.05	0.074	<0.001		<0.0001	0.002	<0.001
FWP092	MM	Dep F		8.0	259	7	67	<0.1	8	12	8	14	<0.001	<0.01	<0.001	<0.05	0.428	<0.001		<0.0001	<0.001	<0.001
FWP156	MM	Dep F		8.3	155	5	9	<0.1	6	2	7	7	<0.001	<0.01	0.001	<0.05	0.402	<0.001		<0.0001	<0.001	<0.001
FWP281	MM	Dep F		7.9	97	2	2	<0.1	1	<1	<1	3	<0.001	<0.01	<0.001	0.07	0.237	<0.001		<0.0001	<0.001	<0.001
FYN843	MM	Dep F		8.2	259	26	36	<0.1	7	8	8	20	<0.001	<0.01	<0.001	<0.05	0.444	<0.001		<0.0001	<0.001	<0.001
FYN908	MM	Dep F		7.8	42	3	5	<0.1	1	<1	1	3	<0.001	0.04	<0.001	<0.05	0.273	<0.001		<0.0001	<0.001	<0.001

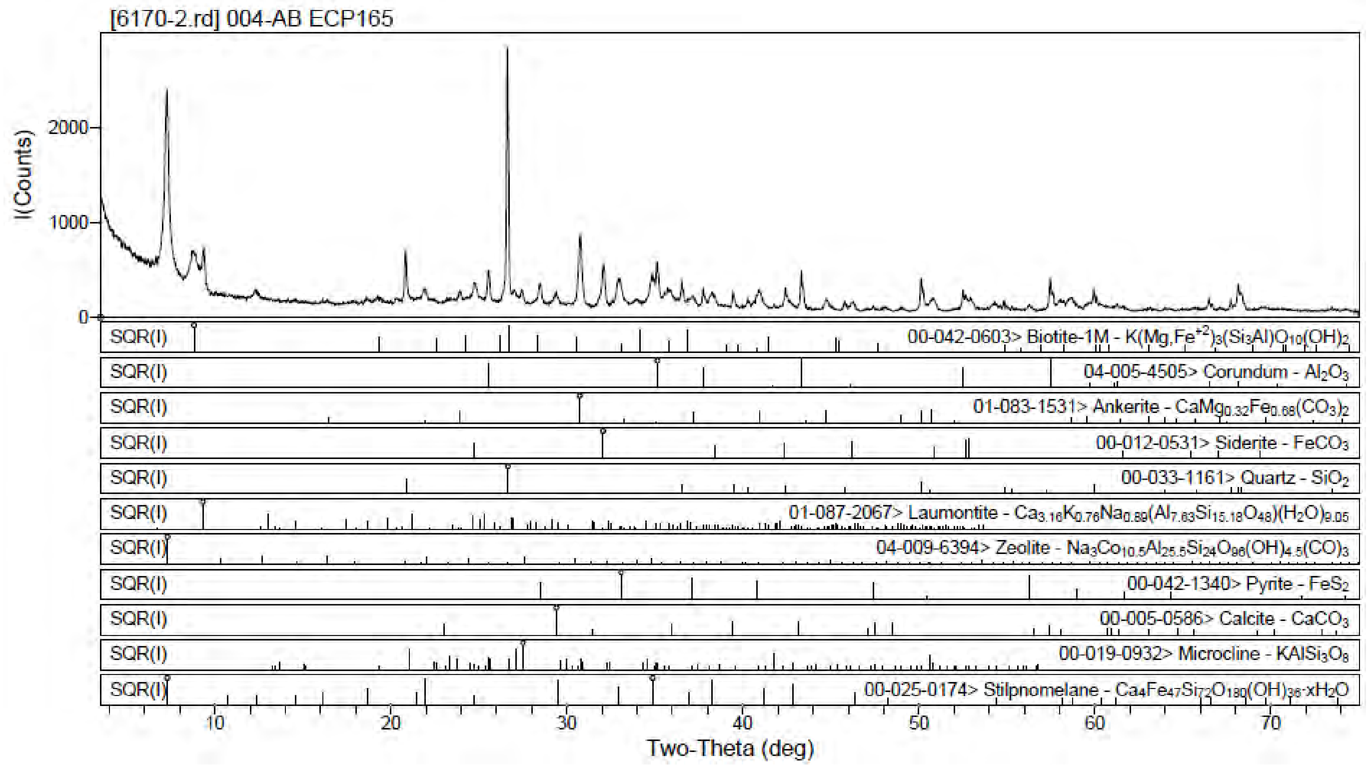
Table E7: Static Leaching Data

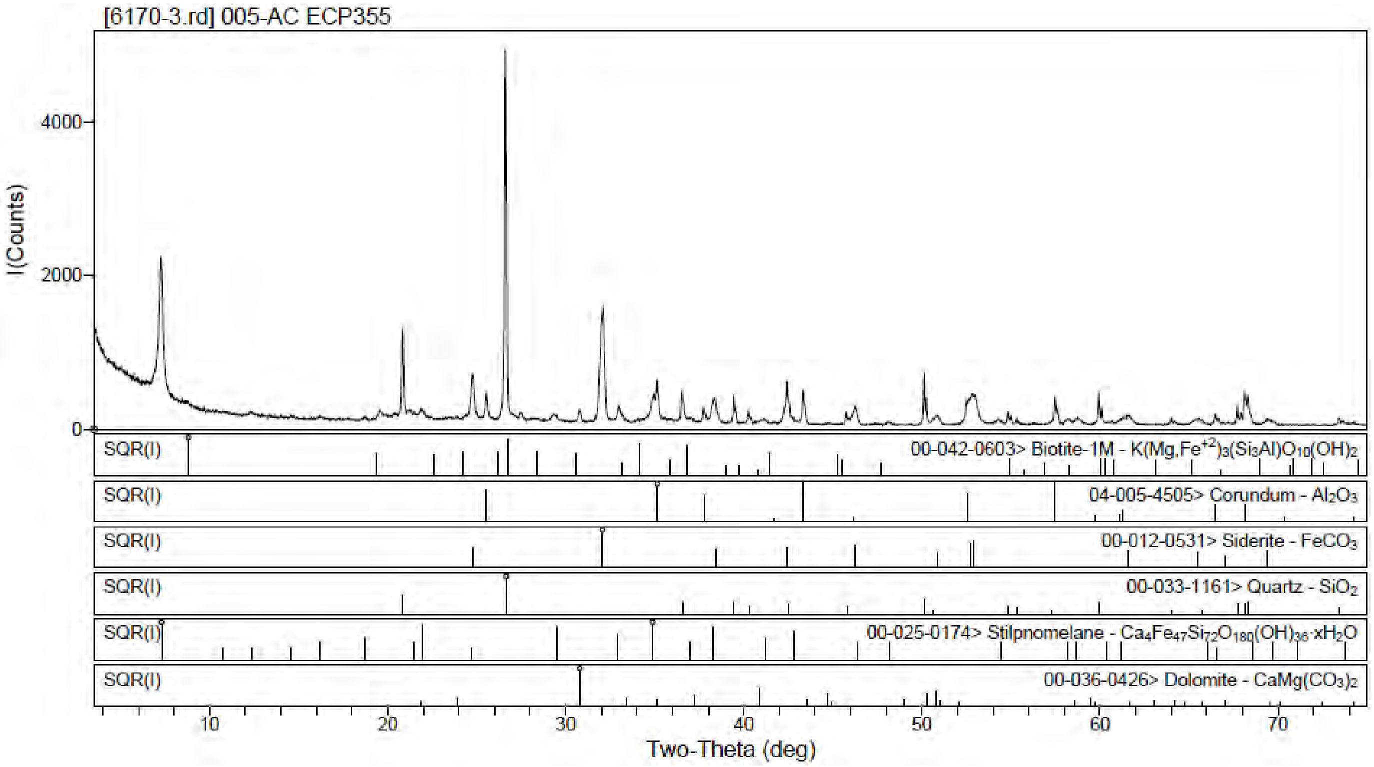
			ELEMENT	Cu	Fe	Hg	Mn	Mo	Ni	P	Pb	S	Sb	Se	Si	Sn	Sr	Th	Ti	U	V	Zn
			UNITS	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
SAMPLE ID	STRAT	DEPOSIT	LOR	0.001	0.05	0.00025	0.001	0.001	0.001	0.05	0.0001	1	0.001	0.01	0.1	0.0010	0.001	0.001	0.5	0.001	0.05	0.001
FQR817	DET	Dep A W		0.001	<0.05	<0.0001	0.003	<0.001	<0.001	<1	<0.001		<0.001	<0.01	7.74	<0.001	0.034	<0.001		<0.001		0.009
FRD872	DET	Dep A W		<0.001	0.32	<0.0001	0.001	<0.001	<0.001	<1	<0.001		<0.001	<0.01	4.11	<0.001	0.011	<0.001		<0.001		0.013
FRG099	DET	Dep A W		0.002	<0.05	<0.0001	0.012	0.001	<0.001	<1	<0.001		<0.001	<0.01	10.80	<0.001	0.044	<0.001		<0.001		0.027
FQD908	DET	Dep D		<0.001	<0.05	<0.0001	0.003	<0.001	<0.001	<1	<0.001		<0.001	<0.01	3.40	<0.001	0.030	<0.001		<0.001		0.010
FWP287	DET	Dep F		<0.001	<0.05	<0.0001	0.002	<0.001	<0.001	<1	<0.001		<0.001	<0.01	5.47	<0.001	0.001	<0.001		<0.001		0.023
FYN787	DET	Dep F		0.002	<0.05	<0.0001	<0.001	<0.001	<0.001	<1	<0.001		<0.001	<0.01	4.21	<0.001	0.012	<0.001		<0.001		0.030
FQR487	DOR	Dep A W		0.125	1.49	<0.0001	1.610	<0.001	0.730	<1	<0.001		<0.001	<0.01	3.64	<0.001	0.170	<0.001		<0.001		1.020
FRM113	DOR	Dep D		0.001	<0.05	<0.0001	0.002	0.005	<0.001	<1	<0.001		<0.001	<0.01	1.70	<0.001	0.014	<0.001		<0.001		<0.005
WEP/652/902_1	WF	Dep A		<0.2	<1	<0.002	2.1	<0.2	<0.2	<0.1	<0.2	190	<0.2	<0.2	37	<0.2	<2				<0.2	<0.2
WEP/652/902_5	WF	Dep A		<0.2	<1	<0.002	<0.2	<0.2	<0.2	<0.1	<0.2	50	<0.2	<0.2	66	<0.2	<2				<0.2	<0.2
WEP/652/902_8	WF	Dep A		<0.2	<1	<0.002	<0.2	<0.2	<0.2	<0.1	<0.2	60	<0.2	<0.2	72	<0.2	<2				<0.2	<0.2
FQR860	WF	Dep A W		0.028	0.08	<0.0001	0.134	0.006	0.113	<1	<0.001		0.006	0.020	2.74	<0.001	0.107	<0.001		<0.001		0.238
FNC936	WF	Dep B		0.007	<0.05	<0.0001	1.410	<0.001	0.006	<1	<0.001		<0.001	<0.01	2.21	<0.001	0.052	<0.001		<0.001		0.128
FOG458	WF	Dep B		0.002	<0.05	<0.0001	0.004	<0.001	<0.001	<1	<0.001		<0.001	<0.01	2.58	<0.001	0.055	<0.001		<0.001		0.018
FRK244	WF	Dep B		0.011	<0.05	<0.0001	0.392	<0.001	0.004	<1	<0.001		<0.001	<0.01	3.57	<0.001	0.070	<0.001		<0.001		0.172
FTI114	WF	Dep B		0.007	<0.05	<0.0001	0.093	<0.001	0.002	<1	<0.001		<0.001	<0.01	2.59	<0.001	0.145	<0.001		<0.001		0.091
FOM528	WF	Dep D		0.002	<0.05	<0.0001	0.049	<0.001	<0.001	<1	<0.001		<0.001	<0.01	5.12	<0.001	0.106	<0.001		<0.001		0.030
FOM940	WF	Dep D		0.002	<0.05	<0.0001	0.008	0.001	<0.001	<1	<0.001		<0.001	<0.01	2.02	<0.001	0.035	<0.001		<0.001		0.007
FRI220	WF	Dep D		0.001	<0.05	<0.0001	0.003	<0.001	<0.001	<1	<0.001		<0.001	<0.01	3.76	<0.001	0.035	<0.001		<0.001		0.015
FYN896	WF	Dep F		0.005	0.05	<0.0001	0.012	<0.001	<0.001	<1	<0.001		<0.001	<0.01	3.00	<0.001	0.004	<0.001		<0.001		0.012
ECP051	MM	Dep A		<0.05	<0.5	<0.00025	<0.05	0.10	<0.05	<5	<0.05	185	<0.05	<0.05	14	<0.05	<0.5	<0.005	<0.5	<0.005	<0.05	<0.05
ECP164	MM	Dep A		<0.05	<0.5	<0.00025	0.05	0.15	<0.05	<5	<0.05	115	<0.05	<0.05	15	<0.05	<0.5	<0.005	<0.5	<0.005	<0.05	<0.05
ECP165	MM	Dep A		<0.05	<0.5	<0.00025	<0.05	0.10	<0.05	<5	<0.05	125	<0.05	<0.05	14	<0.05	<0.5	<0.005	<0.5	<0.005	<0.05	<0.05
ECP281	MM	Dep A		<0.05	<0.5	<0.00025	0.65	<0.05	<0.05	<5	<0.05	290	<0.05	<0.05	18	<0.05	<0.5	<0.005	<0.5	0.005	<0.05	<0.05
ECP402	MM	Dep A		<0.05	<0.5	<0.00025	2.15	<0.05	<0.05	<5	<0.05	550	<0.05	<0.05	19	<0.05	<0.5	<0.005	<0.5	<0.005	<0.05	<0.05
FOD662	MM	Dep A W		<0.001	0.18	<0.0001	0.001	0.002	<0.001	<1	<0.001		<0.001	<0.01	3.63	<0.001	0.020	<0.001		<0.001		0.010
FNJ868	MM	Dep B		<0.001	<0.05	<0.0001	0.007	<0.001	<0.001	<1	<0.001		<0.001	<0.01	2.24	<0.001	0.028	<0.001		<0.001		0.016
FOG111	MM	Dep B		0.003	<0.05	<0.0001	0.012	0.004	<0.001	<1	<0.001		<0.001	<0.01	1.06	<0.001	0.075	<0.001		<0.001		0.009
FOH416	MM	Dep B		0.002	<0.05	<0.0001	0.031	0.001	0.002	<1	<0.001		<0.001	<0.01	1.18	<0.001	0.191	<0.001		<0.001		0.012
FOH824	MM	Dep B		0.002	<0.05	<0.0001	0.002	0.002	<0.001	<1	<0.001		<0.001	<0.01	2.76	<0.001	0.054	<0.001		<0.001		0.008
FOH857	MM	Dep B		0.004	0.05	<0.0001	0.010	0.007	0.005	<1	<0.001		<0.001	<0.01	1.60	<0.001	0.020	<0.001		<0.001		0.016
FWP071	MM	Dep F		0.006	<0.05	<0.0001	0.009	0.003	<0.001	<1	<0.001		<0.001	<0.01	2.96	<0.001	0.018	<0.001		<0.001		0.030
FWP080	MM	Dep F		0.008	<0.05	<0.0001	0.038	0.004	0.001	<1	<0.001		<0.001	<0.01	1.24	<0.001	0.025	<0.001		<0.001		0.053
FWP092	MM	Dep F		0.002	<0.05	<0.0001	0.003	0.013	<0.001	<1	<0.001		<0.001	<0.01	2.03	<0.001	0.018	<0.001		<0.001		0.019
FWP156	MM	Dep F		0.003	<0.05	<0.0001	0.004	0.011	<0.001	<1	<0.001		<0.001	<0.01	5.15	<0.001	0.017	<0.001		<0.001		0.005
FWP281	MM	Dep F		0.003	0.20	<0.0001	0.018	0.002	<0.001	<1	<0.001		<0.001	<0.01	2.85	<0.001	0.005	<0.001		<0.001		0.012
FYN843	MM	Dep F		0.005	<0.05	<0.0001	0.003	0.006	<0.001	<1	<0.001		<0.001	<0.01	2.49	<0.001	0.027	<0.001		<0.001		0.012
FYN908	MM	Dep F		0.002	0.83	<0.0001	0.003	<0.001	<0.001	<1	<0.001		<0.001	<0.01	1.24	<0.001	0.006	<0.001		<0.001		0.011

Table E8: XRD Data

		PARAMETER	TS	SO4-S	ANC	Pyrite	Calcite	Dolomite	Siderite	Goethite	Kaolinite	K-feldspar (Microcline)	Mica (Biotite)	Laumonite	Stilpnomelane	Zeolite	Quartz	Amorphous/ Unknown
		UNIT	%S	%S	kg H_2SO_4/t	%	%	%	%	%	%	%	%	%	%	%		
SAMPLE ID	STRAT	LOR	0.05	0.05	1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	CALC
ECP052	MM		0.43		82.1	0.3	0.2	11.0	4.3	3.5	0.4	5.0	8.4	-	15.5	1.1	35.5	15.0
ECP165	MM		0.76	0.04	101.0	2.0	0.2	10.1	6.8	-	1.0	1.9	12.3	4.4	15.2	3.0	14.2	29.0
ECP355	MM		0.40		55.3	0.3	0.5	1.4	24.9	3.4	0.8	1.7	3.0	-	13.0	4.3	22.5	24.2







APPENDIX F DRILLHOLE ASSAY DATA

DEPOSIT	STRATIGRAPHY	TS < 0.1 wt%S	TS = 0.1-0.3 wt%S	TS ≥0.3 wt%S	TOTAL *n*
DepA	DET-CLA	271			271
	DET	423	2	1	426
	WF	27			27
	ANG	1,083	2		1,085
	NEW	966	4	1	971
	MAC	331	10		341
	DET-ORE	62	1		63
	WF-ORE	245			245
	ANG-ORE	790	3		793
	ANG-HYD	71			71
	NEW-ORE	2,378	5	1	2,384
	MAC-ORE	133	19		152
	MM-HYD	1,095	50	4	1,149
	UNKNOWN	222,459	5,078	366	227,903
	SUB-TOTAL	**230,334**	**5,174**	**373**	**235,881**
DepA West	DET-CAL	16			16
	DET-CLA	9,061	22	1	9,084
	DET	3,956	59	4	4,019
	DOR	44			44
	ANG	745	3		748
	NEW	432	3		435
	MAC	138	3	1	142
	DET-ORE	1,899	48	8	1,955
	ANG-ORE	202			202
	ANG-HYD	80			80
	NEW-ORE	2,288	5		2,293
	MAC-ORE	136	1		137
	MM-HYD	1,278	11	1	1,290
	SUB-TOTAL	**20,275**	**155**	**15**	**20,445**
DepB	ALL	3,376	171	16	3,563
	DET-CLA	1,991	7		1,998
	DET	976	48	2	1,026
	ANG	10,771	1,941	40	12,752
	NEW	3,499	50		3,549
	MAC	626	65	2	693
	OTHER-FILL	11			11
	OTHER-NAM	32			32
	DET-ORE	1,171	227	22	1,420
	ANG-ORE	2,140	179		2,319
	ANG-HYD	1,888	178	1	2,067
	NEW-ORE	12,538	217	1	12,756
	MAC-ORE	942	388	2	1,332
	MM-HYD	5,028	254	1	5,283
	OTHER-NAM-ORE	3			3
	UNKNOWN	5,504	44		5,548
	SUB-TOTAL	**50,496**	**3,769**	**87**	**54,352**

DEPOSIT	STRATIGRAPHY	TS < 0.1 wt%S	TS = 0.1-0.3 wt%S	TS ≥0.3 wt%S	TOTAL *n*
DepC	ALL	3			3
	DET-CAL	35			35
	DET-CLA	233	1		234
	DET	3,902	29	1	3,932
	DOR	15			15
	WF	443			443
	ANG	948	2	6	956
	NEW	1,249	10		1,259
	MAC	284	15	8	307
	OTHER-NAM	5			5
	DET-ORE	3,156	45	7	3,208
	ANG-ORE	461			461
	ANG-HYD	376	5	2	383
	NEW-ORE	4,502	31	9	4,542
	MAC-ORE	111	30	2	143
	MM-HYD	2,076	35	2	2,113
	UNKNOWN	0		2	2
	SUB-TOTAL	**17,799**	**203**	**39**	**18,041**
DepD	DET-CAL	471	1		472
	DET-CLA	3,126	5	2	3,133
	DET	5,049	35	7	5,091
	DOR	505	3		508
	WF	662	5	2	669
	ANG	2,563	11	4	2,578
	NEW	2,126	11		2,137
	MAC	208	11	4	223
	DET-ORE	1,406	83	38	1,527
	ANG-ORE	1,213	6		1,219
	ANG-HYD	129			129
	NEW-ORE	7,637	33	3	7,673
	MAC-ORE	24	1		25
	MM-HYD	992	23	3	1,018
	UNKNOWN	255			255
	SUB-TOTAL	**26,366**	**228**	**63**	**26,657**

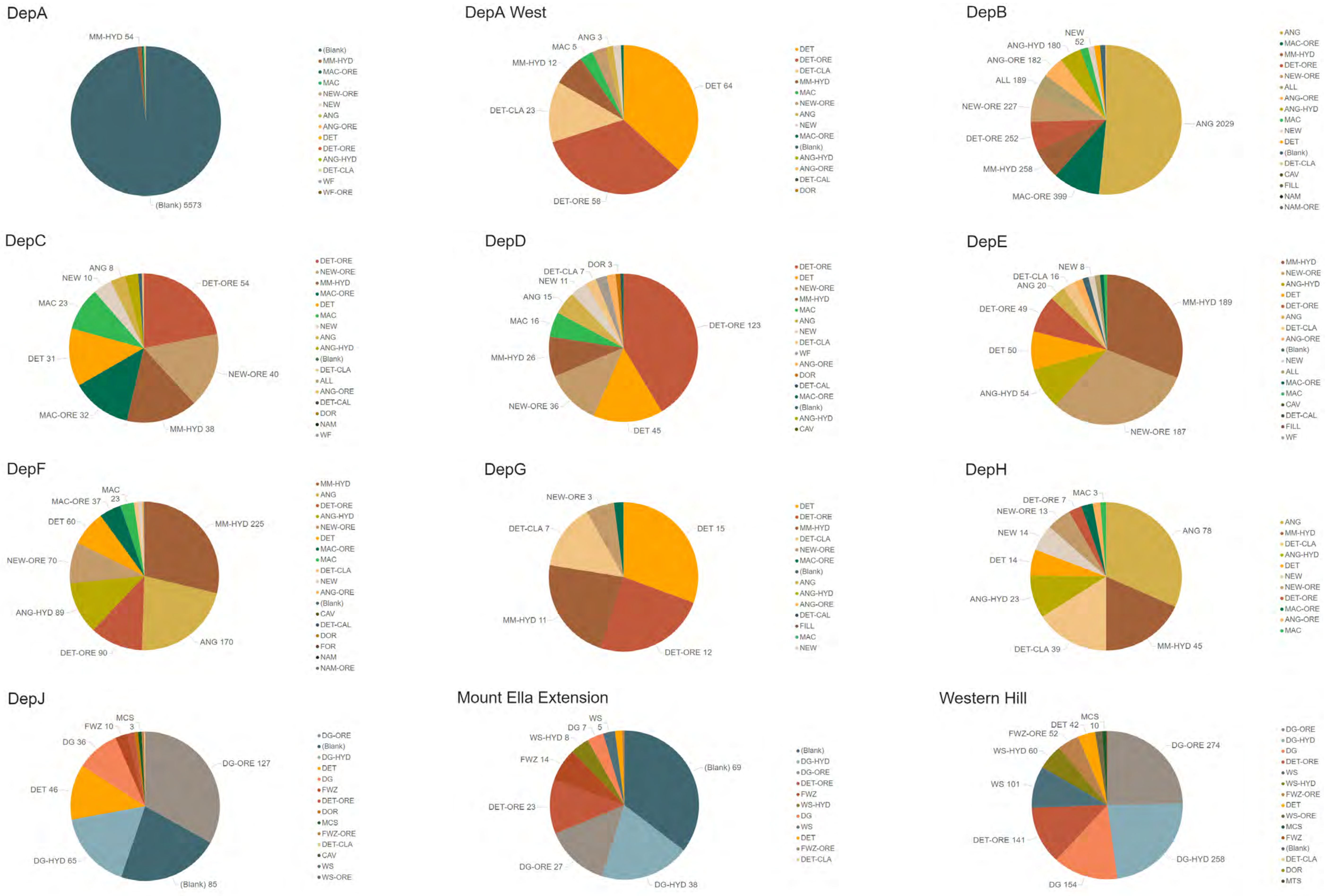
DEPOSIT	STRATIGRAPHY	TS < 0.1 wt%S	TS = 0.1-0.3 wt%S	TS ≥0.3 wt%S	TOTAL *n*
DepE	ALL	1,636	5	1	1,642
	DET-CLA	13,029	11	4	13,044
	DET	1,719	34	15	1,768
	ANG	4,822	18	2	4,842
	NEW	1,353	8		1,361
	MAC	102	4		106
	OTHER-CAV	1			1
	OTHER-FILL	3			3
	DET-ORE	3,268	38	9	3,315
	ANG-ORE	2,781	11		2,792
	ANG-HYD	3,186	47	7	3,240
	NEW-ORE	6,971	165	19	7,155
	MAC-ORE	44	4	1	49
	MM-HYD	2,498	170	18	2,686
	UNKNOWN	640	8		648
	SUB-TOTAL	**42,053**	**523**	**76**	**42,652**
DepF	DET-CAL	1	7		1
	DET-CLA	8,844	7		8,851
	DET	9,770	52	7	9,829
	DOR	178			178
	ANG	1,880	129	41	2,050
	NEW	787	7		794
	MAC	762	17	6	785
	OTHER-CAV	1			1
	OTHER-FOR	1			1
	OTHER-NAM	112			112
	DET-ORE	2,529	72	17	2,618
	ANG-ORE	666	3		669
	ANG-HYD	1,261	82	5	1,348
	NEW-ORE	7,068	64	6	7,138
	MAC-ORE	679	36	1	716
	MM-HYD	4,611	182	32	4,825
	OTHER-NAM-ORE	35			35
	UNKNOWN	163	1		164
	SUB-TOTAL	**39,348**	**652**	**115**	**40,115**

Table F1: In-Pit Total Sulfur Assay Summary Data

DEPOSIT	STRATIGRAPHY	TS < 0.1 wt%S	TS = 0.1-0.3 wt%S	TS ≥0.3 wt%S	TOTAL *n*
DepG	DET-CAL	9			9
	DET-CLA	670	6		676
	DET	1,362	13	2	1,377
	ANG	175			175
	NEW	266			266
	MAC	18			18
	OTHER-FILL	1			1
	DET-ORE	610	11	1	622
	ANG-ORE	42			42
	ANG-HYD	93			93
	NEW-ORE	1,687	3		1,690
	MAC-ORE	66	1		67
	MM-HYD	1,108	11		1,119
	UNKNOWN	10			10
	SUB-TOTAL	**6,117**	**45**	**3**	**6,165**
DepH	DET-CLA	205	39		244
	DET	159	10	3	172
	ANG	588	76	2	666
	NEW	757	13		770
	MAC	32	3		35
	DET-ORE	83	5	2	90
	ANG-ORE	284	4		288
	ANG-HYD	384	22		406
	NEW-ORE	2,355	13		2,368
	MAC-ORE	24	6		30
	MM-HYD	616	45		661
	SUB-TOTAL	**5,487**	**236**	**7**	**5,730**
DepJ	DET-CLA	8	1		9
	DET	594	45	1	640
	DOR	14	1	2	17
	WS	10			10
	DG	308	35	1	344
	FWZ	148	10		158
	OTHER-CAV	2			2
	OTHER-MCS	17	2	1	20
	DET-ORE	37	5		42
	DG-ORE	1,588	111	12	1,711
	DG-HYD	425	55	8	488
	FWZ-ORE	140	2		142
	OTHER-WS-ORE	4			4
	UNKNOWN	684	72	12	768
	SUB-TOTAL	**3,979**	**339**	**37**	**4,355**

DEPOSIT	STRATIGRAPHY	TS < 0.1 wt%S	TS = 0.1-0.3 wt%S	TS ≥0.3 wt%S	TOTAL *n*
Mount Ella Extension	DET	312	3		315
	WS	11	5		16
	DG	36	7		43
	FWZ	4	14		18
	DET-ORE	254	20	1	275
	WS-HYD	8	6	2	16
	DG-ORE	315	22	5	342
	DG-HYD	122	35	1	158
	FWZ-ORE	12	1		13
	UNKNOWN	966	63	5	1,034
	SUB-TOTAL	**2,040**	**176**	**14**	**2,230**
Western Hill	DET-CLA	4			4
	DET	3,026	33	8	3,067
	DOR	58			58
	WS	260	72	27	359
	DG	2,860	130	21	3,011
	FWZ	73	1		74
	OTHER-MCS	121	9		130
	OTHER-MTS	3			3
	DET-ORE	1,572	132	5	1,709
	WS-HYD	169	54	6	229
	DG-ORE	5,804	251	18	6,073
	DG-HYD	2,104	243	12	2,359
	FWZ-ORE	308	48	2	358
	OTHER-WS-ORE	26	17		43
	SUB-TOTAL	**16,388**	**990**	**99**	**17,477**
	TOTAL	**460,682**	**12,490**	**928**	**474,100**

Figure F1: In-Pit Assay Samples with TS > 0.1 wt%S Per Stratigraphy



APPENDIX G MINING MODEL DATA

Table G1: Mining Model Waste Rock Tonnages Per Geozone Per Sulfide Risk Category Per Deposit

DEPOSIT	GEOZONE	STRAT.	SULFIDE RISK = 0 (t)	SULFIDE RISK = 1 (t)	SULFIDE RISK = 2 (t)	SULFIDE RISK = 4 (t)	TOTALS (t)
DepA	1	UNKNOWN	4,143,200	0	0	0	4,143,200
	11	DET	0	9,600	0	0	9,600
	61	DET	366,814,100	0	0	0	366,814,100
	90	DOR	81,300	0	0	0	81,300
	701	ANG	188,397,600	0	158,800	0	188,556,400
	702	ANG-ORE	13,877,700	0	0	0	13,877,700
	705	ANG-HYD	166,944,000	0	0	0	166,944,000
	721	NEW	2,974,800	0	0	0	2,974,800
	722	NEW-ORE	2,925,700	0	0	0	2,925,700
	731	NEW	17,289,000	0	0	0	17,289,000
	732	NEW-ORE	9,185,000	0	0	0	9,185,000
	751	NEW	141,180,400	94,900	0	0	141,275,300
	752	NEW-ORE	15,109,200	0	0	0	15,109,200
	761	MAC	70,891,900	53,000	0	0	70,944,900
	762	MAC-ORE	2,953,100	0	0	0	2,953,100
	785	MM-HYD	143,319,400	0	0	0	143,319,400
	791	MM	15,533,200	0	0	0	15,533,200
	792	MM	6,908,300	0	0	0	6,908,300
		SUB-TOTAL	1,168,528,000	157,500	158,800	0	1,168,844,300
DepA W	7	DET-CLA	96,959,300	0	0	0	96,959,300
	8	DET-CAL	198,800	0	0	0	198,800
	11	DET	33,807,600	0	0	0	33,807,600
	12	DET-ORE	7,643,500	10,700	0	0	7,654,200
	31	DET	6,213,600	0	0	0	6,213,600
	32	DET-ORE	6,425,100	0	0	0	6,425,100
	90	DOR	219,200	0	0	0	219,200
	701	ANG	6,950,300	0	0	0	6,950,300
	702	ANG-ORE	1,193,100	0	0	0	1,193,100
	705	ANG-HYD	621,100	0	0	0	621,100
	721	NEW	438,100	0	0	0	438,100
	722	NEW-ORE	456,900	0	0	0	456,900
	731	NEW	147,300	0	0	0	147,300
	732	NEW-ORE	386,100	0	0	0	386,100
	751	NEW	2,914,300	0	0	0	2,914,300
	752	NEW-ORE	2,195,600	0	0	0	2,195,600
	761	MAC	1,313,500	0	0	0	1,313,500
	762	MAC-ORE	403,200	0	0	0	403,200
	785	MM-HYD	8,063,200	10,200	0	0	8,073,300
		SUB-TOTAL	176,549,700	20,900	0	0	176,570,600

Table G1: Mining Model Waste Rock Tonnages Per Geozone Per Sulfide Risk Category Per Deposit

DEPOSIT	GEOZONE	STRAT.	SULFIDE RISK = 0 (t)	SULFIDE RISK = 1 (t)	SULFIDE RISK = 2 (t)	SULFIDE RISK = 4 (t)	TOTALS (t)
DepB	4	ALL	20,579,700	0	0	0	20,579,700
	11	DET	39,221,000	0	0	0	39,221,000
	12	DET-ORE	9,893,900	0	0	0	9,893,900
	701	ANG	122,151,900	0	0	0	122,151,900
	702	ANG-ORE	8,707,800	0	0	0	8,707,800
	705	ANG-HYD	11,397,300	0	0	0	11,397,300
	721	NEW	10,996,700	0	0	0	10,996,700
	722	NEW-ORE	5,680,000	0	0	0	5,680,000
	731	NEW	8,103,900	0	0	0	8,103,900
	732	NEW-ORE	4,755,400	0	0	0	4,755,400
	751	NEW	31,805,100	0	0	0	31,805,100
	752	NEW-ORE	5,468,100	0	0	0	5,468,100
	761	MAC	17,430,300	0	0	0	17,430,300
	762	MAC-ORE	4,465,500	0	0	0	4,465,500
	771	NAM	5,827,900	0	0	0	5,827,900
	772	NAM-ORE	8,300	0	0	0	8,300
	785	MM-HYD	29,885,800	0	0	0	29,885,800
	801	FOR	28,600	0	0	0	28,600
		SUB-TOTAL	336,407,300	0	0	0	336,407,300
DepC	7	DET-CLA	4,033,500	0	0	0	4,033,500
	8	DET-CAL	249,200	0	0	1,239,400	1,488,700
	11	DET	44,235,800	0	0	0	44,235,800
	12	DET-ORE	19,606,900	0	0	0	19,606,900
	31	DET	11,674,300	0	0	0	11,674,300
	32	DET-ORE	3,289,000	0	0	0	3,289,000
	90	DOR	216,700	0	0	0	216,700
	700	WF	8,974,800	0	0	0	8,974,800
	701	ANG	9,784,000	0	27,200	0	9,811,300
	702	ANG-ORE	1,972,100	0	0	0	1,972,100
	705	ANG-HYD	1,422,400	0	0	0	1,422,400
	721	NEW	1,789,800	0	0	0	1,789,800
	722	NEW-ORE	754,200	0	0	0	754,200
	731	NEW	441,600	0	0	0	441,600
	732	NEW-ORE	793,900	0	0	0	793,900
	751	NEW	8,371,200	0	0	0	8,371,200
	752	NEW-ORE	3,407,700	0	0	0	3,407,700
	761	MAC	2,150,200	0	4,900	0	2,155,200
	762	MAC-ORE	197,900	0	0	0	197,900
	771	NAM	46,700	0	0	0	46,700
	785	MM-HYD	13,227,300	0	0	0	13,227,300
		SUB-TOTAL	136,639,200	0	32,200	1,239,400	137,910,800

Table G1: Mining Model Waste Rock Tonnages Per Geozone Per Sulfide Risk Category Per Deposit

DEPOSIT	GEOZONE	STRAT.	SULFIDE RISK = 0 (t)	SULFIDE RISK = 1 (t)	SULFIDE RISK = 2 (t)	SULFIDE RISK = 4 (t)	TOTALS (t)
DepD	7	DET-CLA	32,787,000	0	0	0	32,787,000
	8	DET-CAL	935,500	0	0	4,681,700	5,617,200
	11	DET	54,427,400	0	0	0	54,427,400
	12	DET-ORE	8,966,600	0	0	0	8,966,600
	31	DET	176,700	0	0	0	176,700
	32	DET-ORE	2,094,100	0	0	0	2,094,100
	41	DET	339,800	0	0	0	339,800
	42	DET-ORE	4,637,100	0	0	0	4,637,100
	90	DOR	205,800	0	0	0	205,800
	700	WF	3,339,700	0	0	0	3,339,700
	701	ANG	21,656,800	0	0	0	21,656,800
	702	ANG-ORE	2,849,100	0	0	0	2,849,100
	705	ANG-HYD	543,300	0	0	0	543,300
	721	NEW	1,879,800	0	0	0	1,879,800
	722	NEW-ORE	1,744,800	0	0	0	1,744,800
	731	NEW	3,589,600	0	0	0	3,589,600
	732	NEW-ORE	2,671,100	0	0	0	2,671,100
	751	NEW	31,734,900	0	0	0	31,734,900
	752	NEW-ORE	5,525,400	0	0	0	5,525,400
	761	MAC	11,921,900	0	1,463,900	0	13,385,900
	762	MAC-ORE	48,900	0	0	0	48,900
	771	NAM	487,500	0	0	0	487,500
	785	MM-HYD	6,590,200	0	0	0	6,590,200
		SUB-TOTAL	199,153,100	0	1,463,900	4,681,700	205,298,700
DepE	4	ALL	8,393,300	0	0	0	8,393,300
	7	DET-CLA	133,318,200	0	0	0	133,318,200
	11	DET	9,078,000	30,900	0	0	9,109,000
	12	DET-ORE	15,033,400	25,700	0	0	15,059,100
	701	ANG	41,712,100	9,200	0	0	41,721,300
	702	ANG-ORE	6,305,900	10,500	0	0	6,316,400
	705	ANG-HYD	26,217,100	32,300	0	0	26,249,400
	721	NEW	730,000	0	0	0	730,000
	722	NEW-ORE	648,800	0	0	0	648,800
	731	NEW	1,064,900	0	0	0	1,064,900
	732	NEW-ORE	1,047,100	0	0	0	1,047,100
	751	NEW	14,853,800	0	0	0	14,853,800
	752	NEW-ORE	2,592,900	0	0	0	2,592,900
	761	MAC	3,247,200	0	14,900	0	3,262,100
	762	MAC-ORE	31,000	0	0	0	31,000
	785	MM-HYD	8,993,800	22,200	0	0	9,016,000
		SUB-TOTAL	273,267,500	130,900	14,900	0	273,413,300

Table G1: Mining Model Waste Rock Tonnages Per Geozone Per Sulfide Risk Category Per Deposit

DEPOSIT	GEOZONE	STRAT.	SULFIDE RISK = 0 (t)	SULFIDE RISK = 1 (t)	SULFIDE RISK = 2 (t)	SULFIDE RISK = 4 (t)	TOTALS (t)
DepF	7	DET-CLA	63,508,400	0	0	0	63,508,400
	11	DET	71,429,700	0	0	0	71,429,700
	12	DET-ORE	14,992,100	0	0	0	14,992,100
	90	DOR	1,676,900	0	0	0	1,676,900
	701	ANG	625,300	11,287,400	0	0	11,912,700
	702	ANG-ORE	1,888,200	0	0	0	1,888,200
	705	ANG-HYD	6,749,800	0	0	0	6,749,800
	721	NEW	194,500	0	0	0	194,500
	722	NEW-ORE	444,600	0	0	0	444,600
	731	NEW	758,800	0	0	0	758,800
	732	NEW-ORE	1,118,700	0	0	0	1,118,700
	751	NEW	5,450,900	0	0	0	5,450,900
	752	NEW-ORE	2,329,300	0	0	0	2,329,300
	761	MAC	5,344,200	0	0	0	5,344,200
	762	MAC-ORE	1,140,900	0	0	0	1,140,900
	771	NAM	119,300	0	0	0	119,300
	785	MM-HYD	17,412,700	0	0	0	17,412,700
		SUB-TOTAL	195,184,400	11,287,400	0	0	206,471,800
DepG	7	DET-CLA	13,846,600	0	0	0	13,846,600
	8	DET-CAL	67,000	0	0	611,400	678,400
	11	DET	10,577,000	0	0	0	10,577,000
	12	DET-ORE	344,000	0	0	0	344,000
	31	DET	97,400	0	0	0	97,400
	32	DET-ORE	243,900	0	0	0	243,900
	41	DET	6,764,800	0	0	0	6,764,800
	42	DET-ORE	3,906,000	0	0	0	3,906,000
	701	ANG	249,400	5,394,000	0	0	5,643,400
	702	ANG-ORE	679,100	0	0	0	679,100
	705	ANG-HYD	2,133,300	0	0	0	2,133,300
	721	NEW	477,200	0	0	0	477,200
	722	NEW-ORE	291,200	0	0	0	291,200
	731	NEW	137,100	0	0	0	137,100
	732	NEW-ORE	173,100	0	0	0	173,100
	751	NEW	1,080,100	0	0	0	1,080,100
	752	NEW-ORE	551,100	0	0	0	551,100
	761	MAC	8,900	100,000	0	0	108,800
	762	MAC-ORE	41,900	0	0	0	41,900
	785	MM-HYD	5,396,200	0	0	0	5,396,200
		SUB-TOTAL	47,065,100	5,494,000	0	611,400	53,170,400

Table G1: Mining Model Waste Rock Tonnages Per Geozone Per Sulfide Risk Category Per Deposit

DEPOSIT	GEOZONE	STRAT.	SULFIDE RISK = 0 (t)	SULFIDE RISK = 1 (t)	SULFIDE RISK = 2 (t)	SULFIDE RISK = 4 (t)	TOTALS (t)
DepH	11	DET	3,607,500	0	0	0	3,607,500
	12	DET-ORE	46,600	0	0	0	46,600
	701	ANG	8,828,400	0	0	0	8,828,400
	702	ANG-ORE	8,000	0	0	0	8,000
	705	ANG-HYD	1,917,500	0	0	0	1,917,500
	721	NEW	1,435,400	0	0	0	1,435,400
	722	NEW-ORE	510,400	0	0	0	510,400
	731	NEW	505,500	0	0	0	505,500
	732	NEW-ORE	333,100	0	0	0	333,100
	751	NEW	1,280,500	0	0	0	1,280,500
	752	NEW-ORE	572,900	0	0	0	572,900
	761	MAC	0	20,600	0	0	20,600
	771	NAM	0	11,100	0	0	11,100
	785	MM-HYD	3,812,800	0	0	0	3,812,800
		SUB-TOTAL	22,858,600	31,700	0	0	22,890,200
DepJ	11	DET	595,700	25,298,800	0	0	25,894,500
	12	DET-ORE	404,400	0	0	0	404,400
	90	DOR	206,500	466,700	0	0	673,200
	301	WS	0	31,300	0	0	31,300
	311	WS	4,100	105,300	0	0	109,400
	401	DG	120,900	1,311,200	0	0	1,432,100
	402	DG-ORE	396,000	0	0	0	396,000
	411	DG	280,500	3,266,400	0	0	3,546,900
	412	DG-ORE	4,125,300	4,300	0	0	4,129,600
	421	DG	695,700	5,062,800	0	0	5,758,500
	422	DG-ORE	989,600	18,600	0	0	1,008,200
	435	DG-HYD	10,643,300	64,100	0	0	10,707,400
	501	FWZ	266,400	4,582,500	0	0	4,848,900
	502	FWZ-ORE	976,400	0	0	0	976,400
	601	MCS	0	3,200	1,437,100	0	1,440,300
		SUB-TOTAL	19,704,900	40,215,100	1,437,100	0	61,357,100
MTEE	11	DET	201,000	8,448,000	0	0	8,649,000
	12	DET-ORE	2,173,800	0	0	0	2,173,800
	321	WS	14,200	75,500	0	0	89,700
	325	WS-HYD	242,500	0	0	0	242,500
	401	DG	10,700	110,200	0	0	121,000
	402	DG-ORE	19,500	0	0	0	19,500
	411	DG	0	103,600	0	0	103,600
	412	DG-ORE	169,600	0	0	0	169,600
	421	DG	5,000	172,800	0	0	177,800
	422	DG-ORE	199,500	0	0	0	199,500
	435	DG-HYD	2,251,300	4,700	0	0	2,256,000
		SUB-TOTAL	5,287,000	8,914,800	0	0	14,201,800

Table G1: Mining Model Waste Rock Tonnages Per Geozone Per Sulfide Risk Category Per Deposit

DEPOSIT	GEOZONE	STRAT.	SULFIDE RISK = 0 (t)	SULFIDE RISK = 1 (t)	SULFIDE RISK = 2 (t)	SULFIDE RISK = 4 (t)	TOTALS (t)
WSTH	11	DET	2,347,300	32,826,100	0	0	35,173,400
	12	DET-ORE	24,689,300	9,500	0	0	24,698,800
	90	DOR	378,200	162,100	0	0	540,300
	321	WS	687,300	4,924,600	0	0	5,612,000
	322	WS	147,100	0	0	0	147,100
	325	WS-HYD	3,885,400	0	0	0	3,885,400
	401	DG	1,408,100	17,910,500	0	0	19,318,600
	402	DG-ORE	1,027,000	5,100	0	0	1,032,200
	411	DG	674,800	9,194,700	0	0	9,869,400
	412	DG-ORE	8,716,200	9,900	0	0	8,726,100
	421	DG	735,500	5,602,200	0	0	6,337,700
	422	DG-ORE	741,000	10,300	0	0	751,300
	435	DG-HYD	20,136,600	4,700	0	0	20,141,300
	501	FWZ	127,300	2,573,200	0	0	2,700,500
	502	FWZ-ORE	749,700	0	0	0	749,700
	601	MCS	0	1,889,700	0	0	1,889,700
	611	MTS	0	171,600	0	0	171,600
		SUB-TOTAL	66,450,800	75,294,300	0	0	141,745,100
TOTAL			**2,647,095,700**	**141,546,500**	**3,106,900**	**6,532,500**	**2,798,281,500**

Table G2: Mining Model Waste Rock Tonnages Per Geozone Per BS Category Per Deposit

DEPOSIT	GEOZONE	STRAT.	BS-HOT (t)	BS-COLD (t)	BS-OXID (t)	TOTALS (t)
DepA	1	UNKNOWN	0	0	0	0
DepA	11	DET	0	0	7,100	7,100
DepA	61	DET	0	15,400	0	15,400
DepA	90	DOR	0	0	0	0
DepA	701	ANG	0	230,100	0	230,100
DepA	702	ANG-ORE	0	500	0	500
DepA	705	ANG-HYD	0	46,300	0	46,300
DepA	721	NEW	0	0	0	0
DepA	722	NEW-ORE	0	0	0	0
DepA	731	NEW	0	0	0	0
DepA	732	NEW-ORE	0	0	0	0
DepA	751	NEW	0	0	80,900	80,900
DepA	752	NEW-ORE	0	0	0	0
DepA	761	MAC	0	0	52,100	52,100
DepA	762	MAC-ORE	0	0	0	0
DepA	785	MM-HYD	0	0	10,800	10,800
DepA	791	MM	0	0	0	0
DepA	792	MM	0	0	0	0
DepA		SUB-TOTAL	0	292,200	151,000	443,200
DepA West	7	DET-CLA	0	0	19,900	19,900
DepA West	8	DET-CAL	0	0	0	0
DepA West	11	DET	0	0	124,600	124,600
DepA West	12	DET-ORE	0	0	123,700	123,700
DepA West	31	DET	0	0	14,300	14,300
DepA West	32	DET-ORE	0	0	17,100	17,100
DepA West	90	DOR	0	0	0	0
DepA West	701	ANG	0	0	0	0
DepA West	702	ANG-ORE	0	0	0	0
DepA West	705	ANG-HYD	0	0	0	0
DepA West	721	NEW	0	0	0	0
DepA West	722	NEW-ORE	0	0	0	0
DepA West	731	NEW	0	0	0	0
DepA West	732	NEW-ORE	0	0	0	0
DepA West	751	NEW	0	0	500	500
DepA West	752	NEW-ORE	0	0	2,100	2,100
DepA West	761	MAC	0	800	0	800
DepA West	762	MAC-ORE	0	0	1,700	1,700
DepA West	785	MM-HYD	0	0	20,500	20,500
DepA West		SUB-TOTAL	0	800	324,500	325,300

Table G2: Mining Model Waste Rock Tonnages Per Geozone Per BS Category Per Deposit

DEPOSIT	GEOZONE	STRAT.	BS-HOT (t)	BS-COLD (t)	BS-OXID (t)	TOTALS (t)
DepB	4	ALL	0	0	0	0
DepB	11	DET	0	0	0	0
DepB	12	DET-ORE	0	0	0	0
DepB	701	ANG	0	0	0	0
DepB	702	ANG-ORE	0	0	0	0
DepB	705	ANG-HYD	0	0	0	0
DepB	721	NEW	0	0	0	0
DepB	722	NEW-ORE	0	0	0	0
DepB	731	NEW	0	0	0	0
DepB	732	NEW-ORE	0	0	0	0
DepB	751	NEW	0	0	0	0
DepB	752	NEW-ORE	0	0	0	0
DepB	761	MAC	0	0	0	0
DepB	762	MAC-ORE	0	0	0	0
DepB	771	NAM	0	0	0	0
DepB	772	NAM-ORE	0	0	0	0
DepB	785	MM-HYD	0	0	0	0
DepB	801	FOR	0	0	0	0
DepB		SUB-TOTAL	0	0	0	0
DepC	7	DET-CLA	0	0	0	0
DepC	8	DET-CAL	0	0	0	0
DepC	11	DET	0	0	0	0
DepC	12	DET-ORE	0	0	0	0
DepC	31	DET	0	0	0	0
DepC	32	DET-ORE	0	0	0	0
DepC	90	DOR	0	0	0	0
DepC	700	WF	0	400	0	400
DepC	701	ANG	0	25,800	0	25,800
DepC	702	ANG-ORE	0	1,800	0	1,800
DepC	705	ANG-HYD	0	1,300	0	1,300
DepC	721	NEW	0	0	0	0
DepC	722	NEW-ORE	0	0	0	0
DepC	731	NEW	0	0	0	0
DepC	732	NEW-ORE	0	0	0	0
DepC	751	NEW	0	0	0	0
DepC	752	NEW-ORE	0	0	0	0
DepC	761	MAC	0	4,900	0	4,900
DepC	762	MAC-ORE	0	0	0	0
DepC	771	NAM	0	0	0	0
DepC	785	MM-HYD	0	0	0	0
DepC		SUB-TOTAL	0	34,300	0	34,300

DEPOSIT	GEOZONE	STRAT.	BS-HOT (t)	BS-COLD (t)	BS-OXID (t)	TOTALS (t)
DepD	7	DET-CLA	0	0	0	0
DepD	8	DET-CAL	0	0	0	0
DepD	11	DET	0	0	0	0
DepD	12	DET-ORE	0	0	0	0
DepD	31	DET	0	0	0	0
DepD	32	DET-ORE	0	0	0	0
DepD	41	DET	0	0	0	0
DepD	42	DET-ORE	0	0	0	0
DepD	90	DOR	0	0	0	0
DepD	700	WF	0	0	0	0
DepD	701	ANG	0	700	0	700
DepD	702	ANG-ORE	0	0	0	0
DepD	705	ANG-HYD	0	0	0	0
DepD	721	NEW	0	5,300	0	5,300
DepD	722	NEW-ORE	0	900	0	900
DepD	731	NEW	0	2,500	0	2,500
DepD	732	NEW-ORE	0	300	0	300
DepD	751	NEW	0	200,900	0	200,900
DepD	752	NEW-ORE	0	1,200	0	1,200
DepD	761	MAC	0	1,283,400	0	1,283,400
DepD	762	MAC-ORE	0	2,100	0	2,100
DepD	771	NAM	0	0	0	0
DepD	785	MM-HYD	0	0	0	0
DepD		SUB-TOTAL	0	1,497,300	0	1,497,300
DepE	4	ALL	0	0	0	0
DepE	7	DET-CLA	0	0	0	0
DepE	11	DET	0	0	29,400	29,400
DepE	12	DET-ORE	0	0	38,600	38,600
DepE	701	ANG	0	0	11,300	11,300
DepE	702	ANG-ORE	0	0	10,500	10,500
DepE	705	ANG-HYD	0	0	34,800	34,800
DepE	721	NEW	0	0	0	0
DepE	722	NEW-ORE	0	0	0	0
DepE	731	NEW	0	0	0	0
DepE	732	NEW-ORE	0	0	0	0
DepE	751	NEW	0	5,500	0	5,500
DepE	752	NEW-ORE	0	0	0	0
DepE	761	MAC	0	9,800	0	9,800
DepE	762	MAC-ORE	0	0	0	0
DepE	785	MM-HYD	0	0	21,200	21,200
DepE		SUB-TOTAL	0	15,300	145,700	161,000

Table G2: Mining Model Waste Rock Tonnages Per Geozone Per BS Category Per Deposit

DEPOSIT	GEOZONE	STRAT.	BS-HOT (t)	BS-COLD (t)	BS-OXID (t)	TOTALS (t)
DepF	7	DET-CLA	0	0	2,100	2,100
DepF	11	DET	0	0	73,900	73,900
DepF	12	DET-ORE	0	0	403,000	403,000
DepF	90	DOR	0	0	77,000	77,000
DepF	701	ANG	0	300	10,140,700	10,141,000
DepF	702	ANG-ORE	0	0	401,400	401,400
DepF	705	ANG-HYD	0	0	411,500	411,500
DepF	721	NEW	0	0	11,900	11,900
DepF	722	NEW-ORE	0	0	23,100	23,100
DepF	731	NEW	0	0	0	0
DepF	732	NEW-ORE	0	0	700	700
DepF	751	NEW	0	0	0	0
DepF	752	NEW-ORE	0	0	600	600
DepF	761	MAC	0	0	200	200
DepF	762	MAC-ORE	0	0	0	0
DepF	771	NAM	0	0	0	0
DepF	785	MM-HYD	0	0	4,900	4,900
DepF		SUB-TOTAL	0	400	11,551,000	11,551,400
DepG	7	DET-CLA	0	0	72,800	72,800
DepG	8	DET-CAL	0	0	0	0
DepG	11	DET	0	0	0	0
DepG	12	DET-ORE	0	0	0	0
DepG	31	DET	0	0	9,100	9,100
DepG	32	DET-ORE	0	0	1,900	1,900
DepG	41	DET	0	0	88,200	88,200
DepG	42	DET-ORE	0	0	36,000	36,000
DepG	701	ANG	0	0	4,769,400	4,769,400
DepG	702	ANG-ORE	0	0	152,700	152,700
DepG	705	ANG-HYD	0	0	190,800	190,800
DepG	721	NEW	0	0	14,700	14,700
DepG	722	NEW-ORE	0	0	7,000	7,000
DepG	731	NEW	0	0	0	0
DepG	732	NEW-ORE	0	0	0	0
DepG	751	NEW	0	0	7,800	7,800
DepG	752	NEW-ORE	0	0	200	200
DepG	761	MAC	0	0	77,000	77,000
DepG	762	MAC-ORE	0	0	4,000	4,000
DepG	785	MM-HYD	0	0	24,800	24,800
DepG		SUB-TOTAL	0	0	5,456,300	5,456,300

Table G2: Mining Model Waste Rock Tonnages Per Geozone Per BS Category Per Deposit

DEPOSIT	GEOZONE	STRAT.	BS-HOT (t)	BS-COLD (t)	BS-OXID (t)	TOTALS (t)
DepH	11	DET	0	0	0	0
DepH	12	DET-ORE	0	0	0	0
DepH	701	ANG	0	0	0	0
DepH	702	ANG-ORE	0	0	0	0
DepH	705	ANG-HYD	0	0	0	0
DepH	721	NEW	0	0	0	0
DepH	722	NEW-ORE	0	0	0	0
DepH	731	NEW	0	0	0	0
DepH	732	NEW-ORE	0	0	0	0
DepH	751	NEW	0	0	500	500
DepH	752	NEW-ORE	0	0	0	0
DepH	761	MAC	0	0	15,100	15,100
DepH	771	NAM	0	0	9,300	9,300
DepH	785	MM-HYD	0	0	14,100	14,100
DepH		SUB-TOTAL	0	0	39,000	39,000
DepJ	11	DET	0	73,500	24,665,400	24,738,900
DepJ	12	DET-ORE	0	0	37,000	37,000
DepJ	90	DOR	0	4,800	511,500	516,300
DepJ	301	WS	0	0	31,300	31,300
DepJ	311	WS	0	0	103,500	103,500
DepJ	401	DG	0	0	1,248,200	1,248,200
DepJ	402	DG-ORE	0	0	79,500	79,500
DepJ	411	DG	0	0	3,092,500	3,092,500
DepJ	412	DG-ORE	0	0	109,900	109,900
DepJ	421	DG	0	0	4,982,900	4,982,900
DepJ	422	DG-ORE	0	0	229,500	229,500
DepJ	435	DG-HYD	0	0	766,800	766,800
DepJ	501	FWZ	0	129,500	4,401,000	4,530,500
DepJ	502	FWZ-ORE	0	12,500	131,700	144,200
DepJ	601	MCS	0	1,306,100	122,000	1,428,100
DepJ		SUB-TOTAL	0	1,526,300	40,512,700	42,039,000
MTEE	11	DET	0	0	8,071,400	8,071,400
MTEE	12	DET-ORE	0	0	259,800	259,800
MTEE	321	WS	0	0	63,600	63,600
MTEE	325	WS-HYD	0	0	27,300	27,300
MTEE	401	DG	0	0	96,900	96,900
MTEE	402	DG-ORE	0	0	4,700	4,700
MTEE	411	DG	0	0	94,100	94,100
MTEE	412	DG-ORE	0	0	8,800	8,800
MTEE	421	DG	0	0	158,100	158,100
MTEE	422	DG-ORE	0	0	33,400	33,400
MTEE	435	DG-HYD	0	0	176,100	176,100
MTEE		SUB-TOTAL	0	0	8,994,200	8,994,200

Table G2: Mining Model Waste Rock Tonnages Per Geozone Per BS Category Per Deposit

DEPOSIT	GEOZONE	STRAT.	BS-HOT (t)	BS-COLD (t)	BS-OXID (t)	TOTALS (t)
WSTH	11	DET	0	0	32,682,200	32,682,200
WSTH	12	DET-ORE	0	0	1,021,600	1,021,600
WSTH	90	DOR	0	0	283,500	283,500
WSTH	321	WS	0	0	4,731,500	4,731,500
WSTH	322	WS	0	0	18,900	18,900
WSTH	325	WS-HYD	0	0	209,700	209,700
WSTH	401	DG	0	0	17,490,300	17,490,300
WSTH	402	DG-ORE	0	0	279,600	279,600
WSTH	411	DG	0	0	9,029,200	9,029,200
WSTH	412	DG-ORE	0	0	296,700	296,700
WSTH	421	DG	0	0	5,485,100	5,485,100
WSTH	422	DG-ORE	0	0	188,100	188,100
WSTH	435	DG-HYD	0	0	1,284,000	1,284,000
WSTH	501	FWZ	0	0	2,485,000	2,485,000
WSTH	502	FWZ-ORE	0	0	70,900	70,900
WSTH	601	MCS	0	0	1,865,400	1,865,400
WSTH	611	MTS	0	0	170,900	170,900
WSTH		SUB-TOTAL	0	0	77,592,700	77,592,700
TOTAL			**0**	**3,366,600**	**144,767,100**	**148,133,700**

APPENDIX H LIMITATIONS

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MINE WASTE
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C.9: Greater West Angelas AMD Risk Assessment

Greater West Angelas

AMD Risk Assessment

March 2014 (Updated September 2016)

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Executive Summary

The acid and metalliferous drainage (AMD) risk assessment for the West Angelas deposits has been updated from an assessment completed in June 2008 and subsequently amended to update the information available for Deposits C, D and G in 2016. This current assessment takes into account total sulfur concentrations within rock types, considering recent drillhole data associated with the greater West Angelas area and individually within the final pit shells. Logging data and the samples location with respect to the water table was used to indicate whether sulfur is in the form of sulfide or sulfate minerals. Geochemical data is also assessed to identify enriched elemental concentrations which may pose an environmental risk. This data, along with site specific baseline information, can be used to generate a conceptual site model to describe mechanisms by which acid and metals/metalloids may mobilise and interact with environmental receptors.

It should be noted that the pit shells will change over time and updates to the geological and mining models will be made; the tonnages reported in this document are subject to change.

West Angelas Deposit A is expected to pose a low AMD risk based on the current pit design. Approximately 2.9% of all in-pit samples have sulfur levels greater than 0.1%, however less than 0.3% of samples have greater than 0.3% sulfur. It is expected that the sulfur associated with elevated-sulfur samples is in the form of sulfate not sulfide minerals.

West Angelas Deposit E is expected to pose a low AMD risk based on the current pit design. Approximately 1.7% of all in-pit samples have sulfur levels greater than 0.1%, with less than 0.2% of samples with sulfur greater than 0.3%. It is expected that the sulfur associated with these material types is in the form of sulfate not sulfide minerals.

West Angelas Deposit B is expected to pose a low AMD risk based on the current pit design. Approximately 7% of all in-pit samples have sulfur levels greater than 0.1%, however less 0.2% of the samples have sulfur levels greater than 0.3%. It is expected that the sulfur associated with these material types is in the form of sulfate not sulfide minerals.

West Angelas Deposit F is expected to pose a low AMD risk based on the current pit design. Approximately 1.3% of all in-pit samples have sulfur levels greater than 0.1%, with less than 0.12% with sulfur greater than 0.3%. It is expected that the sulfur is present as sulfate rather than sulfide minerals.

West Angelas Deposit A West is expected to pose a low AMD risk based on the current pit design. Approximately 1.1% of all in-pit samples have sulfur levels greater than 0.1%, with approximately 0.13% with sulfur greater than 0.3%. It is expected that the sulfur is present as sulfate rather than sulfide minerals.

West Angelas Deposit D is expected to pose a low AMD risk based on the current pit designs. Approximately 1.3% of all in-pit samples have sulfur levels greater than

0.1%, with approximately 0.26% with sulfur levels greater than 0.3%. It is expected that the sulfur is present as sulfate rather than sulfide minerals.

West Angelas Deposit C is expected to pose a low AMD risk based on the current pit designs. Approximately 0.94% of all in-pit samples have sulfur levels greater than 0.1%, with approximately 0.13% with sulfur levels greater than 0.3%. Although the mining model predicts PAF material, a review of in-pit drillholes suggests that the elevated sulfur samples contain sulfate rather than sulfide minerals.

West Angelas Deposit G is expected to pose a low AMD risk based on the current pit designs. Approximately 0.83% of all in-pit samples have sulfur levels greater than 0.1%, with approximately 0.07% with sulfur levels greater than 0.3%. It is expected that the sulfur is present as sulfate rather than sulfide minerals.

Angelo River is expected to pose a low-moderate AMD risk based on the current pit designs. Approximately 0.9% of all in-pit samples have sulfur levels greater than 0.1%, with less than 0.2% with sulfur greater than 0.3%. It is expected that the sulfur is present as sulfate rather than sulfide minerals. The AMD hazard score for Angelo River is influenced by the significant strike length of the deposit, as well as other assumptions, such as no back fill of the pits and should be reviewed as additional information becomes available.

The following elements have been identified as being enriched in the West Angelas deposits and should be monitored in groundwater: **Fe, As and Sn, as well as Co, Cr, Cu, Mn, Ni, Pb and Zn.**

The following work is recommended to improve the understanding of AMD risks in the greater West Angelas area and ensure that the management of mineral waste will effectively mitigate the associated risks.

- These assessments should be updated when new drillhole information and mine planning data becomes available.
- The geological models should be reviewed and updated with regards to the population of the sulfide risk variable.
- Ensure that elements identified as being enriched in rock types as a part of this study or future studies, be captured in on-going groundwater monitoring programmes.

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Data Analysis

1. Introduction

The current risks associated with acid and metalliferous drainage (AMD) in the Greater West Angelas area have been investigated. This assessment includes analysis of:

- Background information and the surrounding environment;
- Total sulfur concentrations within rock types of the general mining area (based on drillhole data);
- Total sulfur concentrations within rock types in the individual pit shells;
- Acid base accounting data including the measured acid neutralising capacity of waste rock types;
- Lithology chemistry including sulfur distribution and chemical enrichment; and
- Estimated tonnes and exposure of elevated-sulfur material (where available).

Static Acid Base Accounting (ABA) has been undertaken on waste rock types from the West Angelas Deposit A, B and D (including Deposit A West). The results from this test work have been used to assess the acid forming and geochemical characteristics of these samples, assisting in determination of the appropriate management strategy.

The total sulfur concentration data taken from the West Angelas drillhole database has been reviewed to determine the presence of sulfate and sulfide minerals. Elemental and oxide concentrations in drillhole samples have been analysed to determine the elemental enrichment in the host rock. The mining model was used to estimate the tonnes of elevated sulfur material, and validated against the geological model and drillhole data.

The purpose of this assessment is to identify and document the AMD risks associated with lithologies that have been, and will be, mined at West Angleas, as well as outlining the monitoring requirements and further work required to better define the risk. By considering the recommendations made in this report, RTIO (WA) will be compliant with Rio Tinto Standards and best practice guidelines.

2. Background Information and Surrounding Environment

The Greater West Angelas area is located approximately 130 km west of the town of Newman in Western Australia (Figure 1). It includes 10 discrete areas of mineralisation (Deposits A – H, Deposit 709 and Angelo River) which make up the Greater West Angelas area (**Error! Reference source not found.**). The deposits are located on the limbs of the east-west trending, west plunging Wonmunna Anticline located in the eastern part of the Ophthalmia Fold Belt. The largest deposits (Deposit A and B) occur in second order synclines on the limbs of the main anticline. The main mineralised units being targeted for mining are the Marra Mamba Iron Formation, which are generally low phosphorus deposits.

The Greater West Angleas area experiences an arid to semi-arid climate characterised by low annual rainfall, high evaporation rates and high daytime temperatures. Under the modified Köppen climate classification scheme the area is classified as grassland: hot, persistently dry.

Rainfall records for West Angleas (2004 – 2007) show an average rainfall of 414 mm per year. The rainfall is episodic and highly variable between years. The majority of the rainfall occurs during the hottest months, normally due to cyclonic lows. Winters are dry and mild in comparison with lighter, winter rainfall expected in June/July.

The majority of the West Angelas deposits are located within the Turee Creek East catchment, with a pit of Deposit F located within the Weeli Wolli catchment and the main Deposit F pit straddling the Turee Creek East and Weeli Wolli catchments. The surface hydrology can be characterised by few well-defined creek channels, and no permanent water bodies. The water table for the West Angelas deposits varies from 700 m RL in the Angelo River deposit to approximately 625 m RL in Deposit D.

Currently mining of the West Angelas deposits is by the conventional drill, blast, load and haul method. Studies are on-going for West Angelas Deposits C, D and G that are investigating alternative options including road train and conveyor options to the Deposit A processing plant.

There are three land systems that are present across the Greater West Angelas area. These are the Boolgeeda, Newman and Wannamunna land systems. Descriptions of these land systems are provided in Table 1.

Table 1 - Land systems of the Greater West Angelas area (Van Vreeswyk et. al. 2004)

Land system	Description
Boolgeeda	Stony lower slopes and plains below hill systems supporting hard and soft spinifex grasslands and mulga shrublands.
Newman	Rugged jaspilite plateaux, ridges and mountains supporting hard spinifex grasslands.
Wannamunna	Hardpan plains and internal drainage tracts supporting mulga shrublands and woodlands (and ocassionally eucalypt woodlands).

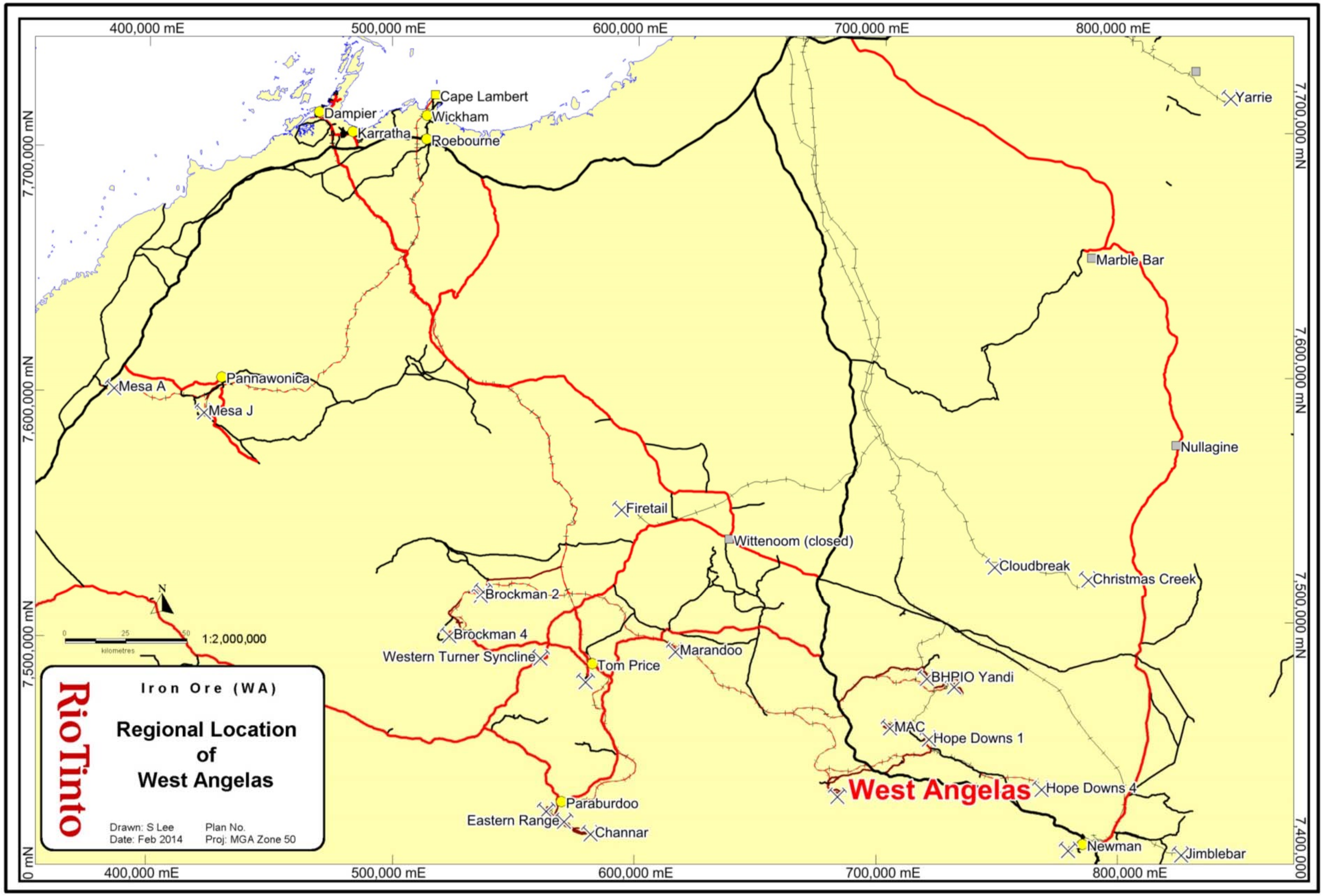

Figure 1 - Location map for the West Angelas project area in relation to other Rio Tinto projects and mine sites.

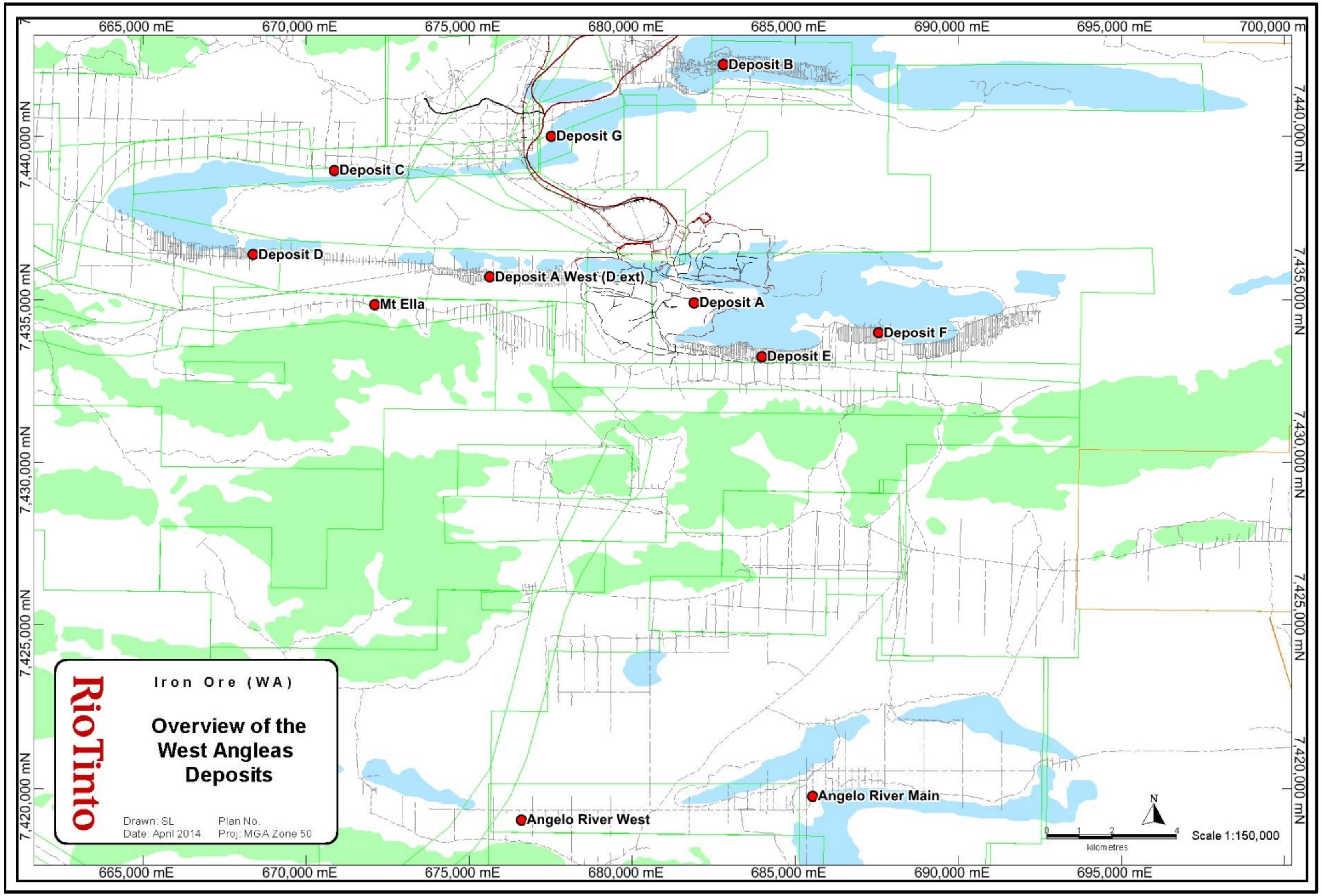

Figure 2 - Plan view of the Greater West Angelas area showing the location of deposits and simplified geology.

3. Sulfur Analysis

A summary of the assessment process followed here is detailed in Geochemical Risk Assessment Process for Rio Tinto's Pilbara Iron Ore Mines (Green and Borden, 2011) and in Mineral Waste Management in the Pilbara: A Position Statement (Brown, 2012). A risk based approach is used to identify rock types that require specific management to mitigate the impacts associated with AMD.

Rio Tinto Iron Ore (WA) (RTIO) has undertaken static acid base accounting (ABA) and kinetic characterisation on different lithologies to identify the potential for these rock types to generate acidity. These tests are completed using nationally and internationally recognised methods (e.g. Sobek (1978) and Miller (1997), as referenced in Maest et al. (2005); AMIRA, (2002); INAP (2010)).

Analysis of the existing ABA data for sulfidic black shale confirms a value of 0.1% total sulfur could be adopted as the boundary value to delineate potentially acid forming (PAF) material from inert/non-acid forming (NAF) material. For other lithologies such as banded iron formation (BIF) and detrital rock types, a value of 0.3% total sulfur concentration is the most appropriate boundary. In oxidised material, it has been shown (RTIO, 2011) that sulfur may be in the form of the hydroxysulfate mineral alunite ($KAl_3(SO_4)_2(OH)_6$). There is the potential for relatively low levels of acid generation from elevated-sulfate samples that contain alunite (when compared against acid generation from sulfide minerals), since the low solubility of alunite may result in a low flux of acid release (and contaminant release). Weathered Brockman 2 samples associated with elevated-sulfate (where sulfur values may range from 0.1% to greater than 1%) have been classified as potentially acid forming in a low-capacity (PAF-LC). A sulfur cut-off of both 0.1% and 0.3% are considered for the purpose of this assessment.

It is recognised that sulfur-related AMD includes acid drainage and neutral drainage, with both potentially containing elevated concentrations of contaminants (INAP, 2010; DITR, 2007). For those rock types associated with sulfides and some sulfate minerals, it is understood that metalliferous drainage requires, at a minimum, low-pH conditions on a microscopic scale as a mechanism to initially solubilise contaminants. Brown (2012) has summarised geochemical data from the RTIO drillhole database showing that contaminants predominately become soluble when associated with material containing elevated sulfur (i.e. pyrite and alunite). If there is sufficient neutralising capacity in the acid-generating rock then any acid generated at the microscopic scale is subsequently neutralised; however, as a result, concentrations of some contaminants (e.g. Zn, As, Ni and Cd) which do not precipitate at circumneutral pH, may remain in solution and result in poor-quality drainage (DITR, 2007). For this reason, the analysis of total sulfur in rock types will identify those with the propensity to generate acidity and lead to poor quality drainage characterised at both low-pH and circumneutral pH conditions.

Poor quality drainage may also result from contaminants soluble at neutral pH (and not related to sulfur). Many minerals are unstable when exposed to the atmosphere after disturbance; elevated concentrations of dissolved minor and trace elements in surface water runoff may result from the dissolution of readily soluble salts (being a source of such elements). The potential for this risk is assessed by considering the oxidation state of minerals characterising the rock types likely to be exposed, and by also considering the average concentration of elements relative to the average crustal abundance for that element, as well as ecological toxicity trigger values. Section 4 addresses this risk.

3.1 Acid Base Accounting and Geochemical Characterisation

A total of 158 samples from the Greater West Angelas deposits have been submitted for Acid Base Accounting (ABA) and geochemical characterisation (Figure 3). The classification of samples and the corresponding stratigraphy is given in Table 2. Samples taken in 1998 (Golder Associates, 1998), 2007 (ANSTO 2007, SRK 2008) and 2009 (SRK, 2010) were Newman and MacLeod banded iron formation (BIF) from Deposit A. The 2013 samples (EGi, 2014) were taken from Deposits B, D and A West and included the bulk of the material characterised. In total approximately 82% of the samples submitted for ABA were classified as non-acid forming (NAF). Approximately seven percent of the samples submitted for ABA were classified as Uncertain and were expected to be NAF. The remaining 11% of samples were classified as potentially acid forming (PAF) or PAF in a low capacity (PAF-LC). It should be noted that samples with higher sulfur are selected as they are deemed to pose the greatest AMD risk.

Table 2 - AMD Classification of Greater West Angelas ABA samples broken down by stratigraphy

Stratigraphy	NAF	NAF-Barren	Uncertain	PAF	PAF-LC	Total
Pisolite	0	2	1	0	0	**3**
Clay	2	1	0	0	1	**4**
Detritals	10	21	5	0	1	**37**
West Angelas	3	19	2	0	5	**29**
Newman	12	26	2	8	2	**50**
MacLeod	16	17	1	0	1	**35**
Total	**43**	**86**	**11**	**8**	**10**	**158**

The PAF samples are predominately from the Newman Member of the Marra Mamba Iron Formation. These samples are banded iron formation waste samples and the majority had visible pyrite logged. The PAF-LC samples are expected to have few sulfides present with the majority of the acid to be produced from the precipitation of metallic ions as hydroxides between pH 4.5 and 7.

For the greater West Angelas area the mean ANC values for various stratigraphic units are compared to mean ANC determined from two other Marra Mamba hosted iron deposits; Hope Downs 1 and Nammuldi (Table 3). In general, the ANC of samples from the West Angelas area were similar albeit slightly lower to the corresponding stratigraphic units from Hope Downs 1 and Nammuldi.

In terms of chemical enrichment, Fe is the dominant element either enriched or elevated in the majority of samples tested. Other elements enriched include As, Be, S, V and Tl. For the short term leach tests the pH of the resulting liquors were between 5.8 and 8.4 with Ca, Cl, K, Mg, Na, Si and SO_4 being the dominant anions and cations mobilised.

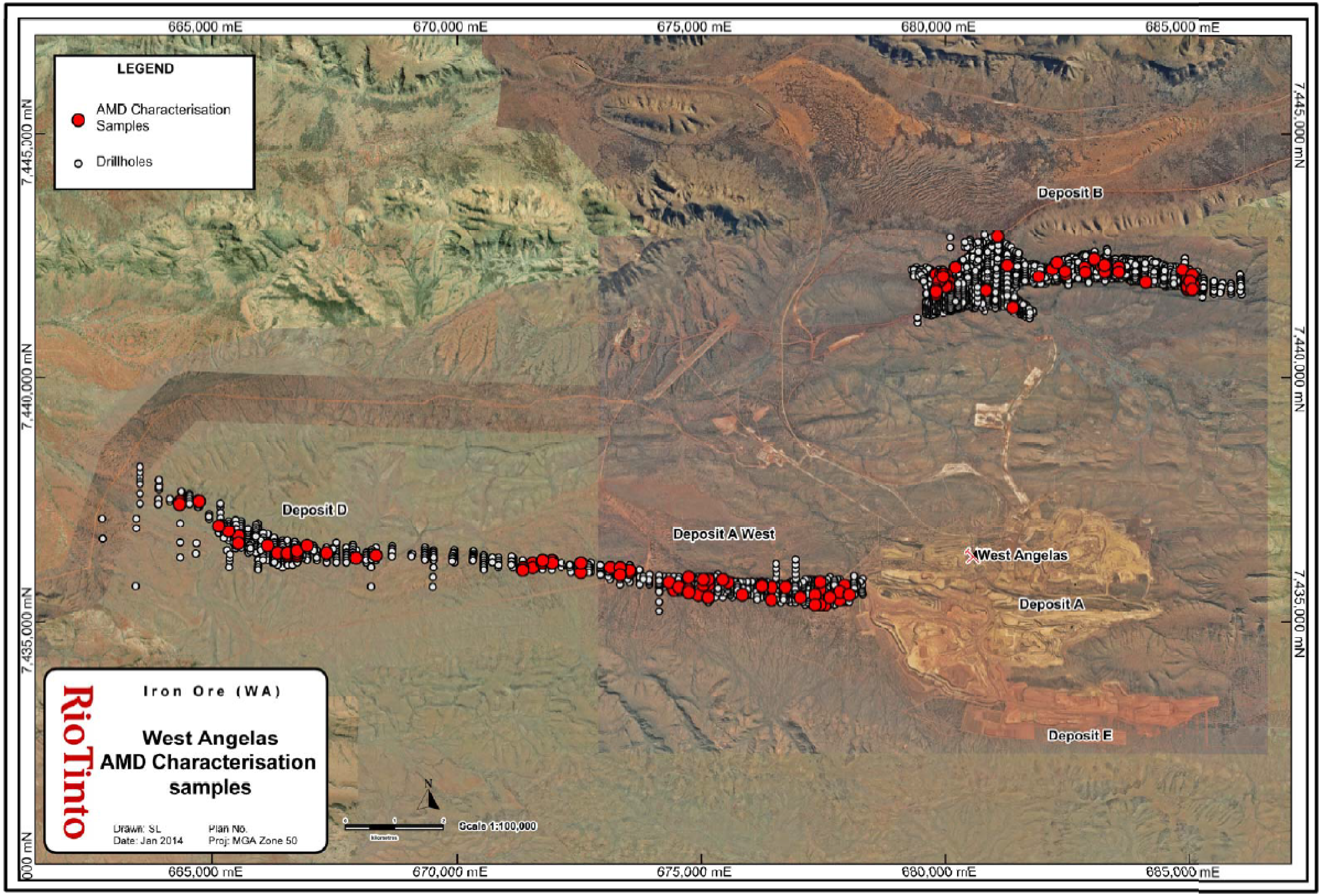

Figure 3 - Location of acid base accounting and geochemical characterisation samples submitted for the West Angelas Deposit B, D and A West.

Table 3 - ANC statistics for the Greater West Angelas deposits grouped by stratigraphic unit from the ABA characterisation compared to other RTIO sites

Stratigraphy	HD1/Nammuldi		West Angelas	
	# samples	Average ANC (kg(H_2SO_4)/t)	# samples	Average ANC (kg(H_2SO_4)/t)
CLA	21	15	4	6
CAL	14	458		
DET	40	32	40*	7
LIG	72	18		
SID	3	15		
WD	32	390		
ANG	41	53	29	23
NEW	33	2	42	9
MAC	21	22	35	38
NAM	8	10	8	22

*Pisolite has been grouped with Detritals for simplicity.

3.2 Total Drillhole Sulfur Analysis

An analysis of sulfur values in drillhole data (to the end of December 2013 for all deposits other than Deposits C, D and G, and August 2016 for Deposits C, D and G) was undertaken to identify those rock types that require further investigation related to acid-forming potential (and any related metalliferous drainage). An outcome of this analysis includes determining the likelihood that a particular rock type will pose an acid drainage risk. For the purpose of this assessment, the rock types, or "strand-tag groups" comprise like-material separated into their sub-divided stratigraphy (strands) and further differentiated based on dominant material type (tag). It should be noted that the following factors may also influence the interpretations within this report:

- Negative assay results represent concentrations below the detection limit. The assay value for the element or oxide was taken to be the absolute value (i.e. the detection limit). This approach is conservative, as the true values for these assays may be below the detection limit value. Where the negative assay is below the current detection limit, the sample was treated as not assayed (e.g. -1, -2 or -3) and were deleted;
- Assay values of "-99" or "zero" indicate that the element was not assayed and were deleted and not considered in this assessment;
- The logging code for pyrite (PYT) can be used where it is readily identifiable. Pyrrhotite (PYR) has been logged historically, but this code is now used for pyrolusite. However, logging codes either do not exist or are not readily used for the sulfate minerals gypsum and alunite as these minerals are less identifiable. In lieu of direct logging information for these two minerals, concentrations of potassium and calcium within elevated-sulfur samples can be used to infer the presence of sulfate minerals (e.g. gypsum or alunite), though it is also possible that the two elements may be present in various other minerals in the sample.

- Total sulfur was measured using the XRF method rather than the LECO method. The XRF method may underestimate the total sulfur concentration when sulfur values are high;
- The drillhole data for the ore body is extensive with less data collected for waste rock types. Information on all waste material that has or will be mined in the future may be missing due to the focus on characterising the ore body rather than the waste material;
- Some intervals had incomplete stratigraphy, strand or tag information. These samples were grouped into an UNKNOWN strand-tag category;
- Limited information exists relating to the neutralising potential of the rock type; the presumed risk of acid drainage may be over-stated if the available neutralising capacity of that rock type is unaccounted for; and
- The drillhole spacing varies across the different deposits.

The following sulfur analysis has been conducted on the dataset divided spatially using a filter in the acQuire database on the "HOLEID" field and split into the corresponding deposits. Drillhole samples represent rock types associated with the Greater West Angelas area, and that not all rock types drilled and listed in the tables are expected to be mined.

A total of 64 samples from the West Angleas area had pyrite visually identified in the logging by a geologist (Table 4). Most of the pyrite samples were from the MacLeod and Newman members. Only 42 out of the 64 samples had sulfur levels greater than 0.1%. It is possible that the samples assayed were not homogeneous and therefore do not reflect what was logged. A total of 24 samples from Deposit A and 24 from Deposit E had pyrite identified. The remaining 16 samples were from Deposit B (9), Deposit D (3), Angelo River (2), Deposit G (1) and from the WA7 deposit (1).

Table 4 – Summary of pyrite observations in West Angelas drillhole samples

		Deposit							
		Angelo River	**West Ang 797**	**Deposit A**	**Deposit B**	**Deposit E**	**Deposit D**	**Deposit G**	**Total**
Stratigraphic unit	**DOR**	2							**2**
	WD		1						**1**
	NEW			5		11		1	**17**
	MAC			19	5	6	2		**32**
	NAM				4	7	1		**12**
	Total	**2**	**1**	**24**	**9**	**24**	**3**	**1**	**64**

3.2.1 Total Drillhole Sulfur Analysis for Deposit A

For Deposit A approximately 2.5% of more than 266,000 samples have sulfur values greater than 0.1%. Nearly 3.4% of all the Deposit A waste samples have sulfur grades greater than 0.1%, though only 0.34% have sulfur values greater than 0.3%. The elevated sulfur samples come from the West Angela, Newman, MacLeod and Nammuldi waste and the MacLeod ore. The maximum sulfur content measured from Deposit A is from a West Angela Member sample with sulfur measured at 3.37%. This analysis is considered preliminary to the subsequent in-pit analysis and serves to identify those rock types which may pose an acid drainage risk if exposed during mining.

Almost 5.4% of West Angela Member waste (ANG WASTE) samples have sulfur levels greater than 0.1%, which drops to 0.6% of samples with sulfur levels greater than 0.3%. These samples are located in several drillholes scattered throughout the deposit. Based on the low sulfur values associated with the elevated-sulfur samples (i.e. average of 0.2%) and the observation that these relatively low numbers of samples are distributed across numerous drillholes and depths both above and below the water table, **ANG Waste is expected to pose a low acid drainage risk.**

Approximately 3.4% of Newman Waste (NEW WASTE) samples have sulfur levels measured above 0.1%. Less than 0.25% of samples have sulfur values greater than 0.3%. The highest measured sulfur value associated with the Newman Member at Deposit A is 3.01%. Of the Newman Member samples from Deposit A with visibly logged pyrite, only five had sulfur levels greater than 0.1% and only one sample had greater than 0.3% sulfur. Almost 72% of the elevated sulfur samples are located within 30 m of the surface. Based on the low sulfur values associated with the elevated-sulfur samples (i.e. average is less than 0.2%), **NEW WASTE is expected to pose a low acid drainage risk.**

MacLeod Member ore (MAC ORE) and waste (MAC WASTE) have 7.4% and 7.8% of samples with sulfur levels greater than 0.1%. Less than 1% of MacLeod samples have sulfur levels greater than 0.3%. Pyrite has been logged in MAC waste 19 times (Table 4) from 10 drill holes from the 2010 geotechnical drilling programme. Only 15 of the samples logged with pyrite had sulfur levels greater than 0.1%. Based on the presence of pyrite **MAC WASTE is expected to pose a low to moderate acid drainage risk** and requires further analysis to determine whether this material will be present within the final pit shells. Based on the low sulfur values associated with elevated sulfur samples (i.e. average is less than 0.15%), **MAC ORE is expected to pose a low acid drainage risk.**

Over 47% of Nammuldi Waste (NAM WASTE) samples have sulfur levels greater than 0.1%. Nearly 29% of Nammuldi Waste samples have sulfur levels greater than 0.3%. The samples were collected during the 2011 and 2012 geotechnical drilling programmes with the majority of the samples located below the water table. Although not visibly seen within the RC chips, it is expected that pyrite and pyrrhotite would be present within the samples as indicated by Blockley et al. (1993). Given the high sulfur values associated with the elevated sulfur samples (i.e. average is 0.45%), **NAM WASTE is expected to pose a low to moderate acid drainage risk,** and further investigation is required to determine whether significant quantities will be encountered during mining.

Table 5 – Total sulfur analysis for the Deposit A drillhole samples

Strand-tag Group	Total Samples Assayed for S	Number of Samples with S>0.1%	Percentage of total samples with S>0.1%	Number of samples with S>0.3%	Percentage of total samples with S>0.3%	Average S for samples with S>0.1%
DET WAS	52822	711	1.35%	72	0.14%	0.19
DET ORE	1027	30	2.92%	0	0.00%	0.14
CLA	6	0	0.00%	0	0.00%	-
DOR	135	0	0.00%	0	0.00%	-
ANG ORE	13079	314	2.40%	2	0.02%	0.14
ANG WASTE	**41760**	**2252**	**5.39%**	250	0.60%	0.2
NEW ORE	107451	1399	1.30%	31	0.03%	0.15
NEW WASTE	**41760**	**1401**	**3.35%**	98	0.23%	0.18
MAC ORE	**2423**	**179**	**7.39%**	1	0.04%	0.14
MAC WASTE	**5312**	**413**	**7.77%**	47	0.88%	0.19
NAM WASTE	**63**	**30**	**47.62%**	**18**	**28.57%**	0.45
UNKNOWN	671	3	0.45%	0	0.00%	0.11

Total number of samples assayed for S	**266509**	**266509**
Total number of samples with S>0.1%/0.3%	**6732**	**519**
Percentage of total with S>0.1%/0.3%	**2.53%**	**0.19%**
Total number of waste samples assayed for S**	**141858**	**141858**
Total number of waste samples with S>0.1%/0.3%	**4807**	**485**
Percentage of total waste samples with S>0.1%/0.3%	**3.39%**	**0.34%**

*those groups with greater than 3% of samples having sulfur values exceeding 0.1%/0.3% have been highlighted

**waste samples do not include HYD or UNKNOWN

3.2.2 Total Drillhole Sulfur Analysis for Deposit E

Based on the analysis of total sulfur assays for samples collected from Deposit E (Table 6), only 1.7% of drillhole samples have sulfur levels greater than 0.1%, with the number dropping to 0.3% when a greater than 0.3% filter is applied. Five strand-tag groups have a significant (greater than 3% of samples with sulfur greater than 0.1%) proportion of samples with greater than 0.1% sulfur. These strand-tag groups that warrant further investigation include: ANG HYD, MAC WASTE, MAC ORE, NAM WASTE and MM HYD. This analysis is considered preliminary to the subsequent in-pit analysis and serves to identify those rock types which may pose an acid drainage risk if exposed during mining.

A total of 11 NEW WASTE samples were logged as having pyrite and were from three drill holes. The samples were collected from below 120 m and were therefore located below the water table. Only three of the samples were measured with sulfur levels greater than 0.1%. It is possible that the samples were not homogeneous and therefore had little sulfur present. Although pyrite has been logged within the NEW WASTE, less than 1% of samples had sulfur greater than 0.1%. Therefore **NEW WASTE is expected to pose a low acid drainage risk.**

A total of 143 samples or 3% of ANG HYD samples have sulfur levels greater than 0.1%, but only 30 samples have sulfur levels greater than 0.3%. These samples are located in several drill holes scattered throughout the deposit. It is likely that the sulfur is present as a sulfate for example gypsum or alunite. Based on the low sulfur values associated with the elevated-sulfur samples (i.e. average of 0.24%) and the observation that these relatively low numbers of samples are distributed across numerous drill holes and located close to the surface (within 40 m of the surface), **ANG HYD is likely to pose a low acid drainage risk.**

A total of 102 or a little over 10% of MAC WASTE samples have sulfur values greater than 0.1%, with approximately 3% having sulfur values greater than 0.3%. Pyrite was visibly identified in three MAC WASTE samples and carbonaceous shale was identified in 23 samples. These samples were from 31 drill holes, of which 21 were drilled as part of the 2010 and 2011 geotechnical drilling programmes. Given the presence of pyrite and carbonaceous shale, and the relatively high sulfur values associated with the elevated-sulfur samples (i.e. average of 0.24%), **MAC WASTE is expected to pose a low to moderate acid drainage risk.** Further investigation is required to determine whether significant quantities will be encountered during mining.

A total of 10 or just over 4.1% of MAC ORE samples have sulfur levels greater than 0.1%, however only one (1) has sulfur values greater than 0.3%. The majority of the samples are located within 40 m of the surface and were from three (3) drill holes. Given the low sulfur values associated with the elevated-sulfur samples (i.e. average of 0.16) and the fact that the elevated sulfur samples were taken from three drill holes, **MAC ORE is likely to pose a low acid drainage risk.**

Almost 70% of NAM WASTE samples have sulfur greater than 0.1%, and close to 18% have sulfur levels greater than 0.3%. Pyrite has been visually identified in seven samples, six of which have sulfur levels greater than 0.1%. These samples were from two geotechnical drill holes from the 2010 programme. Based on the presence of pyrite, **NAM WASTE is expected to pose a low to moderate acid drainage risk.** Further investigation is required to determine whether significant quantities will be encountered during mining.

Over 7% of Marra Mamba hydrated (MM HYD) samples have sulfur levels greater than 0.1%, however less than 1% have sulfur levels greater than 0.3%. Over 70% of the samples are located within 30 m of the surface including the highest measured sulfur level of 0.611% for MM HYD material. Given the relatively low sulfur values associated with elevated-sulfur samples (i.e. average of 0.18%) and that the samples are located close to the surface, **MM HYD is expected to pose a low acid drainage risk.**

Table 6 – Total sulfur analysis for Deposit E drillhole samples

Strand-tag group	Number of Samples assayed for S	Number of samples with S>0.1%	Percentage of samples with S>0.1%	Number of samples with S>0.3%	Percentage of total with S>0.3%	Average S for samples with S>0.1%
ALLUVIUM	1956	7	0.36	1	0.05	0.17
CLAY	15792	24	0.15	6	0.04	0.23
DET WASTE	2456	72	2.93	22	0.90	0.27
DET ORE	4536	84	1.85	10	0.22	0.18
ANG WASTE	10368	162	1.56	40	0.39	0.28
ANG ORE	4812	17	0.35	0	0.00	0.15
ANG HYD	**4766**	**143**	**3.00**	30	0.63	0.24
NEW WASTE	7025	59	0.84	5	0.07	0.15
NEW ORE	11831	217	1.83	20	0.17	0.18
MAC WASTE	**1008**	**102**	**10.12**	30	2.98	0.24
MAC ORE	**242**	**10**	**4.13**	1	0.41	0.16
NAM WASTE	**56**	**39**	**69.64**	**10**	**17.86**	0.26
MM HYD	**3073**	**221**	**7.19**	19	0.62	0.18
UNKNOWN	662	17	2.57	0	0.00	0.14

Total number of samples assayed for S	**68583**	**68583**
Total number of samples with S>0.1/0.03%	**1174**	**194**
Percentage of total with S>0.1/0.3%	**1.71%**	**0.28%**
Total number of waste samples assayed for S**	**38661**	**38661**
Total number of waste samples with S>0.1/0.3%	**465**	**114**
Percentage of total waste samples with S>0.1/0.3%	**1.20%**	**0.29%**

*those groups with greater than 3% of samples having sulfur values exceeding 0.1%/0.3% have been highlighted

**waste samples do not include HYD or UNKNOWN

3.2.3 Total Drillhole Sulfur Analysis for Deposit B

For Deposit B pyrite has been visibly identified in a total of 9 samples. The samples with pyrite were associated with MAC WASTE and NAM WASTE, with all located at least 90 m below the surface. The highest sulfur grade in Deposit B is 2.07% and is a sample interpreted as DET WASTE, and is located at the surface (0 – 2 m interval). This sample is interpreted as containing gypsum as the sample also contains high levels of calcium. Some elevated-sulfur samples are associated with manganiferous shale, although the Mn assay results do not confirm this to be so. It is possible that the material is carbonaceous shale which has a similar appearance and therefore the elevated sulfur may be a result of sulfide minerals.

Based on the analysis of total sulfur within drill holes (Table 7) just over 5.4% of drillhole samples have sulfur values greater than 0.1%, although less than 0.2% of all the samples have sulfur greater than 0.3%. When looking specifically at waste samples almost 5.6% of samples have sulfur greater than 0.1%, however only 0.2% of waste samples have sulfur greater than 0.3%. Strand-tag groups requiring further investigation include DET ORE, DET WASTE, ANG WASTE, ANG ORE, ANG HYD, MAC WASTE, MAC ORE, NAM WASTE, NAM ORE and MM HYD.

Over 5.7% of DET WASTE had sulfur levels greater than 0.1% however only 0.36% had sulfur levels greater than 0.3%. The elevated-sulfur samples are generally located close to the surface (average depth is under 20 m). Based on the low average sulfur content for elevated sulfur samples (0.18%), **DET WASTE is likely to pose a low acid drainage risk.**

Close to 15% of DET ORE samples had sulfur levels greater than 0.1%, and less than 1.5% of samples have sulfur levels greater than 0.3%. Generally the samples are located within close proximity of the surface. Based on the low average sulfur content for the elevated sulfur samples (0.19%), **DET ORE is likely to pose a low acid drainage risk.**

Almost 11% of ANG WASTE samples have sulfur levels greater than 0.1%, however less than 0.3% of samples have sulfur levels greater than 0.3%. There is the potential for samples logged from sufficient depth being mis-logged as manganiferous shale, and are potentially black shale and contain finely disseminated pyrite. This would explain the samples with elevated levels of sulfur, low levels of manganese and high loss on ignition values. Based on the potential for black shale to be encountered and the relatively low sulfur values for elevated-sulfur material (i.e. average of 0.15%), **ANG WASTE is likely to pose a low to moderate acid drainage risk.** Further investigation should be undertaken to determine whether significant quantities of this material is likely to be encountered during mining.

Approximately 6.6% of ANG ORE samples and approximately 7.7% of ANG HYD samples have sulfur levels greater than 0.1%, however no ANG ORE samples and only one ANG HYD sample had sulfur greater than 0.3%. Based on the logging information the elevated-sulfur samples are dominated by hematite and goethite with minor amounts of shale. It is likely that the sulfur is present as sulfate minerals like alunite or gypsum. Based on the low sulfur values for elevated-sulfur material (i.e. average is 0.13% and 0.16%), **ANG ORE and ANG HYD are likely to pose a low acid drainage risk.**

A total of five (5) MAC WASTE samples had pyrite visually identified. These samples were from two drill holes from the 2012 geotechnical and hydrogeological drilling programmes and therefore would have extended past the expected base of the pit shell. Almost 7.5% of MAC WASTE samples had sulfur levels greater than 0.1%; however this declined to 0.74% when using a 0.3% sulfur filter. Elevated sulfur MAC WASTE was logged in 51 drill holes in Deposit B, which is 2.9% of all the samples analysed. Given the presence of pyrite and black shale in some drill holes and a relatively low sulfur value for the elevated-sulfur samples (i.e. average of 0.18%), **MAC WASTE is likely to pose a low to moderate acid drainage risk.** Further investigation should be undertaken to determine whether significant quantities of this material is likely to be encountered during mining.

Over 27% of MAC ORE samples had sulfur levels greater than 0.1% though less than 0.5% had sulfur levels greater than 0.3%. The average Fe assay value for the elevated-sulfur samples is 55.5%, indicating that most of this material may be considered as crusher feed. With a low average sulfur value for elevated sulfur samples (average of 0.14%), **MAC ORE is likely to pose a low acid drainage risk.**

A total of 7.1% of NAM WASTE samples from Deposit B have sulfur levels greater than 0.1%, of which four (4) or 1.3% have sulfur levels greater than 0.3%. A total of four (4) samples had pyrite identified, all having sulfur greater than 0.1%. In the same hole, carbonaceous shale was also identified. Given the relatively high average sulfur level for the elevated sulfur samples (average of 0.25%); **NAM WASTE is likely to pose a low to moderate acid drainage risk.** Further investigation should be undertaken to determine whether significant quantities of this material is likely to be encountered during mining.

Nearly 15% of NAM ORE samples have sulfur levels greater than 0.1%, but all were less than 0.3%. The four samples with sulfur greater than 0.1% were located in two drill holes and were associated with elevated levels of Fe (between 45% to 58%). It is likely that the sulfur is present as sulfate minerals. Based on the low number of samples and the relatively low average sulfur content for the elevated-sulfur samples (0.13%); **NAM ORE is likely to pose a low acid drainage risk.**

Approximately 4.3% of MM HYD samples have sulfur levels greater than 0.1%, though only less than 0.1% have sulfur levels greater than 0.3%. The average depth below the surface for the samples is 23 m, and indicates that the sulfur is likely to be present in sulfate minerals. The average Fe content for the samples is high (56.7%) indicating that the material is potential crusher feed. Based on this information and the relatively low average sulfur content for the elevated-sulfur samples (0.14%); **MM HYD is likely to pose a low acid drainage risk.**

Table 7 – Total sulfur analysis is for Deposit B

Strand-tag group	Number of Samples assayed for S	Number of samples with S>0.1%	Percentage of samples with S>0.1%	Number of samples with S>0.3%	Percentage of total with S>0.3%	Average S for samples with S>0.1%
ALLUVIUM	3235	35	1.08	4	0.12	0.17
CLAY	5911	23	0.39	1	0.02	0.16
CALCRETE	7	0	0.00	0	0.00	-
DET WASTE	**3301**	**189**	**5.73**	12	0.36	0.18
DET ORE	**1934**	**285**	**14.74**	28	1.45	0.19
ANG WASTE	**19334**	**2034**	**10.52**	56	0.29	0.15
ANG ORE	**2956**	**195**	**6.60**	0	0.00	0.13
ANG HYD	**2141**	**165**	**7.71**	1	0.05	0.16
NEW WASTE	11411	73	0.64	1	0.01	0.14
NEW ORE	14753	207	1.40	2	0.01	0.13
MAC WASTE	**2831**	**211**	**7.45**	21	0.74	0.18
MAC ORE	**1870**	**511**	**27.33**	6	0.32	0.14
NAM WASTE	**308**	**22**	**7.14**	4	1.30	0.25
NAM ORE	**27**	**4**	**14.81**	0	0.00	0.13
MM HYD	**7407**	**317**	**4.28**	3	0.04	0.14
UNKNOWN	1848	41	2.22	9	0.49	0.23
Total number of samples assayed for S		**79274**		**79274**		
Total number of samples with S>0.1/0.03%		**4312**		**148**		
Percentage of total with S>0.1/0.3%		**5.44%**		**0.19%**		
Total number of waste samples assayed for S**		**46338**		**46338**		
Total number of waste samples with S>0.1/0.3%		**2587**		**99**		
Percentage of total waste samples with S>0.1/0.3%		**5.58%**		**0.21%**		

*those groups with greater than 3% of samples having sulfur values exceeding 0.1%/0.3% have been highlighted

**waste samples do not include HYD or UNKNOWN

3.2.4 Total Drillhole Sulfur Analysis for Deposit F

For Deposit F (Table 8), only a small proportion, 1.1%, of the samples assayed for sulfur had sulfur values greater than 0.1%. Approximately 0.65% of samples were considered to be waste were classified in this category. Less than 0.2% of all samples had sulfur levels greater than 0.3%. Significant (i.e. greater than 3%) quantities of elevated-sulfur samples were from the ANG HYD and MAC ORE strand-tag groups. Further analysis of these strand-tag groups is warranted to determine whether they pose an acid drainage risk.

Approximately 3.8% of ANG HYD samples have sulfur levels greater than 0.1%, with less than 0.5% having sulfur levels greater than 0.3%. Most of the samples are located within close proximity to the natural surface, with the average depth below the surface being 32 m. It is therefore likely that the sulfur is present as sulfate minerals. **ANG HYD is likely to pose a low AMD risk.**

Over 8% of MAC ORE samples have sulfur levels greater than 0.1%, though only 0.23% have sulfur levels greater than 0.3%. The elevated sulfur samples have relatively high Fe content and it is likely that this material will be used as either direct or blending crusher feed. Given the relatively low average sulfur values for the elevated-sulfur samples (average is 0.16%); **MAC ORE is expected to pose a low acid drainage risk.**

Table 8 – Total sulfur analysis for Deposit F drillhole samples

Strand-tag group	Number of Samples assayed for S	Number of samples with S>0.1%	Percentage of samples with S>0.1%	Number of samples with S>0.3%	Percentage of total with S>0.3%	Average S for samples with S>0.1%
ALLUVIUM	9	0	0.00	0	0.00	-
CLAY	13606	8	0.06	0	0.00	0.17
CALCRETE	5	0	0.00	0	0.00	-
DET WASTE	12817	57	0.44	5	0.04	0.19
DET ORE	3751	72	1.92	12	0.32	0.23
DOLERITE	147	0	0.00	0	0.00	-
ANG WASTE	4235	104	2.46	28	0.66	0.26
ANG ORE	1198	4	0.33	0	0.00	0.12
ANG HYD	**2524**	**96**	**3.80**	12	0.48	0.20
NEW WASTE	5818	32	0.55	8	0.14	0.40
NEW ORE	7449	32	0.43	3	0.04	0.16
MAC WASTE	2087	51	2.44	2	0.10	0.16
MAC ORE	**886**	**71**	**8.01**	2	0.23	0.16
NAM WASTE	108	0	0.00	0	0.00	-
MM HYD	6074	156	2.57	5	0.08	0.15
UNKNOWN	175	1	0.57	0	0.00	0.29

Total number of samples assayed for S	**60889**	**60889**
Total number of samples with S>0.1/0.03%	**684**	**77**
Percentage of total with S>0.1/0.3%	**1.12%**	**0.13%**
Total number of waste samples assayed for S**	**38832**	**38832**
Total number of waste samples with S>0.1/0.3%	**252**	**43**
Percentage of total waste samples with S>0.1/0.3%	**0.65%**	**0.11%**

*those groups with greater than 3% of samples having sulfur values exceeding 0.1%/0.3% have been highlighted

**waste samples do not include HYD or UNKNOWN

3.2.5 Total Drillhole Sulfur Analysis for Deposit A West

Less than 1% of Deposit A West samples have sulfur levels greater than 0.1%. No strand-tag groups have greater than 3% of samples with elevated-sulfur. The strand-tag group with the highest proportion of samples with elevated-sulfur levels is dolerite, though there are only four (4) samples with sulfur levels greater than 0.1%. No pyrite has been visually identified in samples from the A West deposit. **It is therefore unlikely that material from the A West deposit will pose an acid drainage risk**.

Table 9 - Total sulfur analysis for Deposit A West drill hole samples

Strand-tag group	Number of Samples assayed for S	Number of samples with S>0.1%	Percentage of samples with S>0.1%	Number of samples with S>0.3%	Percentage of total with S>0.3%	Average S for samples with S>0.1%
ALLUVIUM	8	0	0.00	0	0.00	-
CLAY	8076	40	0.50	1	0.01	0.15
CALCRETE	45	0	0.00	0	0.00	-
DET WASTE	4081	111	2.72	18	0.44	0.24
DET ORE	1730	35	2.02	6	0.35	0.20
DOLERITE	136	4	2.94	1	0.74	0.18
ANG WASTE	2878	13	0.45	2	0.07	0.20
ANG ORE	599	0	0.00	0	0.00	-
ANG HYD	163	0	0.00	0	0.00	-
NEW WASTE	2231	8	0.36	0	0.00	0.14
NEW ORE	2260	4	0.18	0	0.00	0.15
MAC WASTE	1276	18	1.41	4	0.31	0.20
MAC ORE	415	8	1.93	0	0.00	0.14
NAM WASTE	24	0	0.00	0	0.00	-
MM HYD	1510	18	1.19	1	0.07	0.18
UNKNOWN	1676	6	0.36	2	0.12	0.26

Total number of samples assayed for S	27108	27108
Total number of samples with S>0.1/0.03%	265	35
Percentage of total with S>0.1/0.3%	0.98%	0.13%
Total number of waste samples** assayed for S	18619	18619
Total number of waste samples with S>0.1/0.3%	194	26
Percentage of total waste samples with S>0.1/0.3%	1.04%	0.14%

*those groups with greater than 3% of samples having sulfur values exceeding 0.1%/0.3% have been highlighted

**waste samples do not include HYD or UNKNOWN

3.2.6 Total Drillhole Sulfur Analysis for Deposit D

Slightly below 1.5% of samples from Deposit D have sulfur levels greater than 0.1%, with less than 0.4% having sulfur levels greater than 0.3% (Table 10). Strand-tag groups with greater than 3% of elevated-sulfur samples, and require further investigation to determine whether they will pose an acid drainage risk include DET ORE, PI WASTE, PI ORE, DOR and NAM WASTE.

Over 5.1% of DET ORE samples have sulfur levels greater than 0.1%, with approximately 1.3% having sulfur levels greater than 0.3%. These samples are generally located close to the surface (majority within 30 m) and have high levels of Fe and are potentially upgradable. It is likely that the sulfur is present as sulfate minerals including gypsum or halotrichite. **DET ORE is likely to pose a low acid drainage risk.**

Approximately 7.7% of PI WASTE samples have sulfur greater than 0.1%, and greater than 3% with sulfur levels greater than 0.3%. Elevated-sulfur samples only represent five of the PI WASTE samples of Deposit D and are located in two drillholes and do not appear to be related to the presence of sulfides. Given the small number of samples and the limited distribution; **PI WASTE is likely to pose a low acid drainage risk.**

Approximately 17.1% of PI ORE samples have sulfur greater than 0.1%, with approximately 7.9% with sulfur greater than 0.3%. These samples are generally located close to the surface (average 40 m), and generally have iron grades greater than 50%. It is likely that sulfur is present in the form of sulfates not sulfides. **PI ORE is likely to pose a low acid drainage risk.**

Approximately 3.2% of dolerite (DOR) samples from Deposit D have sulfur levels greater than 0.1% and only one (1) sample has a sulfur level greater than 0.3%. Elevated-sulfur is only logged in three (3) drill holes suggesting that the sulfur is limited in distribution. The elevated sulfur samples appear to be coincident with elevated levels of manganese, potassium and calcium. Given the low number of elevated sulfur samples that are limited to three drillholes; **DOR is likely to pose a low acid drainage risk.**

A total of 4.4% of NAM WASTE samples have sulfur greater than 0.1%; however none have sulfur greater than 0.3%. This represents a total of three samples, one identified as having pyrite present. Given that pyrite has been identified in NAM WASTE material in other West Angelas deposits, **NAM WASTE is likely to pose a low-moderate acid drainage risk** and will require further investigation to determine whether it will be encountered within the pit shell.

Table 10 - Total sulfur analysis for Deposit D drill hole samples

Strand-tag group	Number of Samples assayed for S	Number of samples with S>0.1%	Percentage of samples with S>0.1%	Number of samples with S>0.3%	Percentage of total with S>0.3%	Average S for samples with S>0.1%
CLAY	4815	62	1.29	24	0.50	0.28
CALCRETE	1479	6	0.41	0	0.00	0.14
DET WASTE	7919	126	1.59	32	0.40	0.30
DET ORE	3290	168	5.11	43	1.31	0.25
LI WASTE	137	0	0.00	0	0.00	-
LI ORE	901	11	1.22	1	0.11	0.15
PI WASTE	65	5	7.69	2	3.08	0.27
PI ORE	152	26	17.11	12	7.89	0.34
DOR	589	19	3.23	1	0.17	0.18
ANG WASTE	5745	46	0.80	20	0.35	0.39
ANG ORE	1704	2	0.12	0	0.00	0.11
ANG HYD	240	2	0.83	0	0.00	0.13
NEW WASTE	6080	41	0.67	3	0.05	0.16
NEW ORE	7821	10	0.13	0	0.00	0.15
MAC WASTE	974	13	1.33	3	0.31	0.23
MAC ORE	170	1	0.59	0	0.00	0.17
NAM WASTE	69	3	4.35	0	0.00	0.16
NAM ORE	3	0	0.00	0	0.00	-
MM HYD	1444	32	2.22	1	0.07	0.18
UNKNOWN	5220	155	2.97	44	0.84	0.30

Total number of samples assayed for S	48817	48817
Total number of samples with S>0.1/0.03%	728	186
Percentage of total with S>0.1/0.3%	1.49%	0.38%
Total number of waste samples** assayed for S	27872	27872
Total number of waste samples with S>0.1/0.3%	321	85
Percentage of total waste samples with S>0.1/0.3%	1.15%	0.30%

*those groups with greater than 3% of samples having sulfur values exceeding 0.1%/0.3% have been highlighted

**waste samples do not include HYD or UNKNOWN

3.2.7 Total Drillhole Sulfur Analysis for Deposit C

Overall less than 1.5% of samples from West Angelas Deposit C have sulfur levels greater than 0.1%, with less than 0.3% with sulfur greater than 0.3% (Table 11). Strand-tag groups with a significant number of elevated sulfur samples (greater than 3% of samples with sulfur greater than 0.1%) include MAC WASTE, MAC ORE and NAM WASTE. These strand-tag groups will be assessed to determine the level of risk of generating acid drainage.

Approximately 4.2% of MAC WASTE samples have sulfur greater than 0.1%, with approximately 0.6% with sulfur greater than 0.3%. Carbonaceous shale has been identified in two MAC WASTE samples. The remaining samples are associated with BIF, CHT and SHL; none were associated with pyrite. The elevated sulfur samples were distributed across 39 drillholes, located both above and below the water table. **MAC WASTE is likely to pose a moderate acid drainage risk**. Further investigation should be undertaken to determine whether this material will be encountered with in the pit.

Approximately 7.4% of MAC ORE samples have sulfur greater than 0.1%; however none exceed 0.3% sulfur. All elevated sulfur samples are located above the water table, but are not associated with elevated levels of Ca, Mg or K. The average sulfur grades of the elevated sulfur samples is relatively low (average is 0.13%). Given the high iron grades and the relatively low sulfur grades, **MAC ORE is likely to pose a low acid drainage risk.**

Elevated sulfur samples represent 17.9% of the NAM WASTE samples encountered in Deposit C. A total of 3.7% of samples have sulfur levels exceeding 0.3%. The elevated NAM WASTE samples are distributed across seven drillholes, both above and below the water table. Given that pyrite has been identified in NAM WASTE in other West Angelas deposits, **NAM WASTE is likely to pose a low-moderate acid drainage risk**. Further investigation is required to determine whether this material will be encountered in pit.

Table 11 - Total sulfur analysis for Deposit C drill hole samples

Strand-tag group	Number of Samples assayed for S	Number of samples with S>0.1%	Percentage of samples with S>0.1%	Number of samples with S>0.3%	Percentage of total with S>0.3%	Average S for samples with S>0.1%
ALLUVIUM	3	0	0.00	0	0.00	-
CLAY	1633	18	1.10	10	0.61	0.74
CALCRETE	122	0	0.00	0	0.00	-
DET WASTE	3747	40	1.07	3	0.08	0.17
DET ORE	3300	67	2.03	9	0.27	0.18
LI WASTE	1127	4	0.35	1	0.09	0.16
LI ORE	668	4	0.60	1	0.15	0.27
PI WASTE	3	0	0.00	0	0.00	-
DOR	198	0	0.00	0	0.00	-
ANG WASTE	5001	85	1.70	35	0.70	0.46
ANG ORE	1302	0	0.00	0	0.00	-
ANG HYD	436	7	1.61	2	0.46	0.26
NEW WASTE	6105	37	0.61	1	0.02	0.15
NEW ORE	5952	27	0.45	4	0.07	0.17
MAC WASTE	**2620**	**110**	**4.20**	16	0.61	0.18
MAC ORE	**417**	**31**	**7.43**	0	0.00	0.13
NAM WASTE	**162**	**29**	**17.90**	**6**	**3.70**	0.26
MM HYD	2691	40	1.49	1	0.04	0.15
UNKNOWN	**907**	**34**	**3.75**	6	0.66	0.24
Total number of samples assayed for S	**36394**			**36394**		
Total number of samples with S>0.1/0.03%	**533**			**95**		
Percentage of total with S>0.1/0.3%	**1.46%**			**0.26%**		
Total number of waste samples assayed for S**	**20721**			**20721**		
Total number of waste samples with S>0.1/0.3%	**327**			**73**		
Percentage of total waste samples with S>0.1/0.3%	**1.58%**			**0.35%**		

*those groups with greater than 3% of samples having sulfur values exceeding 0.1%/0.3% have been highlighted

**waste samples do not include HYD or UNKNOWN

3.2.8 Total Drillhole Sulfur Analysis for Deposit G

For Deposit G, no strand-tag groups were found to have a significant amount of elevated sulfur samples (Table 12). In total 86 samples were found to have sulfur greater than 0.1%, with the most number of elevated-sulfur samples associated with DET WASTE (other than UNKNOWN). Only four samples had sulfur levels in excess of 0.3%. In terms of waste, 34 waste samples had sulfur levels greater than 0.1%, with three with sulfur greater than 0.3%. **It is unlikely that material from Deposit G will pose an acid drainage risk.**

Table 12 – Total sulfur analysis for Deposit G drill hole samples

Strand-tag group	Number of Samples assayed for S	Number of samples with S>0.1%	Percentage of samples with S>0.1%	Number of samples with S>0.3%	Percentage of total with S>0.3%	Average S for samples with S>0.1%
CLAY	969	2	0.21	0	0.00	0.13
CALCRETE	47	0	0.00	0	0.00	-
DET WASTE	1222	11	0.90	3	0.25	0.13
DET ORE	150	4	2.67	0	0.00	0.12
LI WASTE	20	0	0.00	0	0.00	-
LI ORE	3	0	0.00	0	0.00	-
PI WASTE	810	10	1.23	0	0.00	0.15
PI ORE	378	9	2.38	1	0.26	0.16
ANG WASTE	441	0	0.00	0	0.00	-
ANG ORE	73	0	0.00	0	0.00	-
ANG HYD	110	0	0.00	0	0.00	-
NEW WASTE	2342	4	0.17	0	0.00	0.11
NEW ORE	1863	0	0.00	0	0.00	-
MAC WASTE	384	7	1.82	0	0.00	0.15
MAC ORE	64	1	1.56	0	0.00	0.10
MM HYD	1385	7	0.51	0	0.00	0.12
UNKNOWN	2408	31	1.29	0	0.00	0.13

Total number of samples assayed for S	**12669**	**12669**
Total number of samples with S>0.1/0.03%	**86**	**4**
Percentage of total with S>0.1/0.3%	**0.68%**	**0.03%**
Total number of waste samples assayed for S**	**6235**	**6235**
Total number of waste samples with S>0.1/0.3%	**34**	**3**
Percentage of total waste samples with S>0.1/0.3%	**0.55%**	**0.05%**

*those groups with greater than 3% of samples having sulfur values exceeding 0.1%/0.3% have been highlighted

**waste samples do not include HYD or UNKNOWN

3.2.9 Total Drillhole Sulfur Analysis for Angelo River

Angelo River is a unique deposit for the West Angelas area as both Marra Mamba and Brockman Iron Formation units are encountered. The current mine plan focuses on Marra Mamba iron formation. Approximately 1.5% of the Angelo River samples have sulfur levels greater than 0.1%, with approximately 0.35% of samples with sulfur levels greater than 0.3%. Strand-tag units with greater than 3% of samples with sulfur greater than 0.1% include WS WASTE, DG HYD, FWZ WASTE, MCS, MAC WASTE, MM WASTE, MM HYD and UNKNOWN. The majority of the unknown samples were from the 2013 drilling programme and have yet to be validated and interpreted.

Almost 10.2% of Whaleback Shale waste (WS WASTE) samples have sulfur levels greater than 0.1%, with 3.8% of samples with sulfur greater than 0.3%. The majority of the elevated-sulfur samples are located within 30 m of the natural surface. Elevated levels of aluminium, iron and potassium coincident with the elevated-sulfur samples indicate that it is likely that the sulfur is present as either alunite or jarosite. The average sulfur level is 0.47% for the elevated-sulfur samples; **WS WASTE is likely to pose a low to moderate acid drainage risk.** Further investigation should be undertaken to determine whether significant quantities of this material is likely to be encountered during mining.

More than 9.1% of Dales Gorge hydrated (DG HYD) samples have sulfur levels greater than 0.1%, none have sulfur levels greater than 0.3%. The maximum sulfur sample for DG HYD samples is 0.19%, with all of the elevated sulfur samples located above the water table. It is therefore likely that all the elevated-sulfur is associated as sulfate minerals. Based on the relatively low average sulfur level for elevated sulfur samples (average of 0.14%); **DG HYD is likely to pose a low acid drainage risk.**

A total of three (3) FWZ WASTE samples have sulfur levels greater than 0.1%, with two (2) with sulfur levels greater than 0.3%. The three samples were from one drill hole at a depth of 64 to 76 m. The elevated-sulfur is coincident with elevated levels of aluminium and potassium which could potentially indicate the presence of the mineral alunite. Given the low number of samples, **FWZ WASTE is expected to pose a low acid drainage risk.**

A total of four MCS samples have sulfur levels greater than 0.1%, with only one sample with sulfur greater than 0.3%. The elevated-sulfur does not appear to be associated with black carbonaceous shale but does appear to be coincident with elevated levels of potassium and aluminium. It is therefore likely that the sulfur is present as the sulfate mineral alunite. Given the low number of samples, **MCS is likely to pose a low acid drainage risk.**

Almost 3.5% of MAC WASTE samples have sulfur levels greater than 0.1%, but less than 0.4% have sulfur levels greater than 0.3%. The majority of samples are located within 20 m of the natural surface, with all samples located within 34 m of the natural surface. Given the low number of elevated-sulfur samples and the low average sulfur values for the elevated-sulfur samples (average of 0.17); **MAC WASTE is likely to pose a low acid drainage risk.**

Only four (4) MM WASTE samples have sulfur levels greater than 0.1%, and one of these has a sulfur level greater than 0.3%. These four samples are located close to the surface and it is unlikely that the sulfur is present in sulfide minerals. Given the low number of samples, **MM WASTE is likely to pose a low acid drainage risk.**

Almost 5.8% of MM HYD samples have sulfur levels greater than 0.1%, with less than 1% with sulfur greater than 0.3%. All elevated-sulfur samples are located within 30 m of the surface and do not appear to be coincident with any other elements. The average sulfur value for the elevated sulfur samples is 0.2%. Given the close proximity of the samples to the surface and the relatively low average sulfur values; **MM HYD is likely to pose a low acid drainage risk.**

Table 13 - Total sulfur analysis for Angelo River drill hole samples

Strand-tag group	Number of Samples assayed for S	Number of samples with S>0.1%	Percentage of samples with S>0.1%	Number of samples with S>0.3%	Percentage of total with S>0.3%	Average S for samples with S>0.1%
ALLUVIUM	258	0	0.00	0	0.00	-
CLAY	1868	10	0.54	2	0.11	0.25
CALCRETE	432	0	0.00	0	0.00	-
DET WASTE	4691	17	0.36	3	0.06	0.18
DET ORE	821	9	1.10	2	0.24	0.22
DOLERITE	297	5	1.68	2	0.67	0.58
JOF WASTE	65	0	0.00	0	0.00	-
JOF HYD	11	0	0.00	0	0.00	-
WS WASTE	471	48	10.19	18	3.82	0.47
DG WASTE	993	12	1.21	0	0.00	0.14
DG ORE	239	3	1.26	0	0.00	0.11
DG HYD	273	25	9.16	0	0.00	0.14
FWZ WASTE	79	3	3.80	2	2.53	0.30
FWZ ORE	7	0	0.00	0	0.00	-
MCS	110	4	3.64	1	0.91	0.19
MTS	103	0	0.00	0	0.00	-
WD	845	1	0.12	0	0.00	0.16
ANG WASTE	2278	18	0.79	5	0.22	0.24
ANG ORE	213	0	0.00	0	0.00	-
ANG HYD	984	13	1.32	2	0.20	0.23
NEW WASTE	1607	3	0.19	0	0.00	0.15
NEW ORE	1953	4	0.20	2	0.10	0.27
MAC WASTE	260	9	3.46	1	0.38	0.17
MAC ORE	31	0	0.00	0	0.00	-
NAM WASTE	169	5	2.96	2	1.18	0.18
NAM ORE	5	0	0.00	0	0.00	-
MM WASTE	45	4	8.89	1	2.22	0.18
MM HYD	747	43	5.76	7	0.94	0.20
UNKNOWN	4132	124	3.00	33	0.80	0.36

Total number of samples assayed for S	23987	23987
Total number of samples with S>0.1/0.03%	360	83
Percentage of total with S>0.1/0.3%	1.50%	0.35%
Total number of waste samples** assayed for S	14571	14571
Total number of waste samples with S>0.1/0.3%	139	37
Percentage of total waste samples with S>0.1/0.3%	0.95%	0.25%

*those groups with greater than 3% of samples having sulfur values exceeding 0.1%/0.3% have been highlighted

**waste samples do not include HYD or UNKNOWN

3.2.10 Total Drillhole Sulfur Analysis for the other Greater West Angelas deposits

West Angelas exploration leases 709, 797, 798 and 986 do not have mine planning information. The results of the total sulfur drill hole analysis will not be discussed as part of this assessment, and if further information is required then the West Angelas Mineral Waste Risk Assessment by Terrusi (2008) should be consulted. The tables are provided in Appendix 1 for reference.

3.3 Total Sulfur Analysis Considering the Proposed Final Pit Shells

The proposed final pit designs that were provided by the mine planning group were used to further filter the West Angelas drillhole sample dataset according to which intervals were located within the pit shells. This filtering (done using the Vulcan software) is summarised in the following sections. The water table levels used for filtering are listed in Table 14.

Table 14 - Water table levels used for in pit analysis

Deposit	Water Table level
Deposit A	640 m RL
Deposit E	666 m RL
Deposit B	627 m RL
Deposit A West	630 m RL
Deposit F	670 m RL
Deposit D	625 m RL
Deposit C	635 – 636 m RL (East) / 624 m RL (West)
Deposit G	635 m RL
Angelo River	700 m RL

3.3.1 In-pit Total Sulfur Drillhole Analysis for Deposit A

The Deposit A final pit shell (depa_uf17.00t) was used to filter the drillhole data according to which samples are located within the final pit shells. The breakdown by stratigraphic units was not possible as the acQuire drillhole database is incomplete. Approximately 2.9% of all in-pit samples (including all waste samples) have sulfur values greater than 0.1% with less than 0.2% with sulfur levels greater than 0.3% (Table 15). None of the samples identified as having pyrite or pyrrhotite are located within the pit shell. Only four elevated-sulfur samples are located below the water table. It is therefore likely that the sulfur associated with elevated-sulfur samples is present in sulfate minerals.

Table 15 - Deposit A in-pit sulfur analysis

	Total	S>0.1	S>0.3
Total	168,712	4827	295
AWT	153,399	4823	294
BWT	15,313	4	1

The estimated quantities of material quoted in Terrusi (2008) indicated that the MacLeod Member only made up a small proportion of the material to be mined from Deposit A and that the sulfur levels were generally low with only low grade and waste MacLeod with levels as high as 0.2%. No Nammuldi Member material was expected to be mined from Deposit A. **It is therefore likely that the risk of acid drainage from Deposit A is low,** but if elevated sulfur is mined in bulk then it may require management.

3.3.2 In-pit Total Sulfur Drillhole Analysis for Deposit E

The Deposit E pit shell (depe_pit_v14_notsigned_clip.00t) was used to filter the drillhole data according to which samples are located within the final pit shells. A summary is provided in Table 16. Approximately 1.7% of all in-pit samples (including all waste samples) have sulfur values greater than 0.1%. The majority of the elevated-sulfur samples are located above the water table, with only six elevated-sulfur samples located below the water table.

Approximately 3.2% of DET WASTE samples have sulfur grades greater than 0.1%, with less than 1% with sulfur greater than 0.3%. This is in contrast to the initial analysis which showed less than 3% (2.93%) of DET WASTE samples had sulfur levels greater than 0.1%. All elevated-sulfur samples are located above the water table and are located within 40 m of the surface. It is likely that the sulfur is present within sulfate minerals including gypsum or alunite. **DET WASTE is likely to pose a low acid drainage risk.**

Nearly 3.5% of MAC WASTE samples have sulfur levels greater than 0.1%; however none have sulfur levels greater than 0.3%. All elevated-sulfur samples are located above the water table. It is therefore likely that the sulfur is in the form of a sulfate mineral. Given that only four samples have sulfur levels between 0.1% and 0.3%, **MAC WASTE is likely to pose a low acid drainage risk.**

Over 10.4% of MAC ORE samples have sulfur levels greater than 0.1%, though this is only five samples. Only one sample has sulfur greater than 0.3%. All elevated sulfur samples are located above the water table. Given the small number of samples with sulfur greater than 0.1%; **MAC ORE is likely to pose a low acid drainage risk.**

Approximately 7.3% of MM HYD samples have sulfur levels greater than 0.1%, with less than 0.7% with sulfur levels greater than 0.3%. All elevated sulfur samples are located above the water table. It is therefore likely that the sulfur is present as sulfate minerals. The elevated-sulfur samples are located in numerous drill holes scattered throughout the deposit. **MM HYD is likely to pose a low acid drainage risk.**

Table 16 – Total sulfur analysis for drill holes located within the final Deposit E pit shell

Strand-tag group	Number of Samples assayed for S	Number of samples with S>0.1%	Percentage of samples with S>0.1%	Number of samples with S>0.3%	Percentage of total with S>0.3%	Average S for samples with S>0.1%
ALLUVIUM	1774	7	0.39	1	0.06	0.17
CLAY	14008	22	0.16	4	0.03	0.21
DET WASTE	1845	59	3.20	17	0.92	0.27
DET ORE	3349	55	1.64	9	0.27	0.20
ANG WASTE	5237	112	2.14	25	0.48	0.27
ANG ORE	3145	12	0.38	0	0.00	0.16
ANG HYD	3958	103	2.60	27	0.68	0.27
NEW WASTE	1562	7	0.45	0	0.00	0.15
NEW ORE	7801	189	2.42	19	0.24	0.18
MAC WASTE	115	4	3.48	0	0.00	0.13
MAC ORE	48	5	10.42	1	2.08	0.19
MM HYD	2751	202	7.34	19	0.69	0.19
UNKNOWN	409	8	1.96	0	0.00	0.13

Total number of samples assayed for S	46002	46002
Total number of samples with S>0.1/0.03%	785	122
Percentage of total with S>0.1/0.3%	1.71%	0.27%
Total number of waste samples** assayed for S	24541	24541
Total number of waste samples with S>0.1/0.3%	211	47
Percentage of total waste samples with S>0.1/0.3%	0.86%	0.19%
Total number of samples inpit, AWT and S>0.1/0.3%	779	121
Total number of samples inpit, BWT and S>0.1/0.3%	6	1

*those groups with greater than 3% of samples having sulfur values exceeding 0.1%/0.3% have been highlighted

**waste samples do not include HYD or UNKNOWN

3.3.3 In-pit Total Sulfur Drillhole Analysis for Deposit B

The proposed final pit shell (wadb_uf02.00t) for the deposit B was used to filter the drillhole database according to which samples are located within the final pit shell. A summary is provided in Table 17. Approximately 7% of all in-pit samples (including all waste samples) have sulfur values greater than 0.1%. When a 0.3% sulfur filter is applied only 0.16% of samples exceed the higher cut-off. Only one elevated sulfur sample is located below the water table with all others located above water table. It is likely that the sulfur is present in the form of sulfate minerals such as alunite or gypsum.

Almost 7.2% of DET WASTE samples located within the pit shell have sulfur levels greater than 0.1%, with the average sulfur grade for the elevated-sulfur samples being 0.18%. Less than 0.5% of samples have sulfur levels greater than 0.3%. Approximately 98% of samples are located within 50 m of the surface and all are located above water table. It is likely that the sulfur material is in the form of the sulfate mineral alunite or gypsum. **DET WASTE is likely to pose a low acid drainage risk.**

Almost 18% of DET ORE samples have sulfur levels greater than 0.1%, with approximately 1.6% with sulfur levels greater than 0.3%. All samples are located within 60 m of the surface and are located above the water table. It is likely that the sulfur material is in the form of the sulfate mineral alunite or gypsum. **DET ORE is likely to pose a low acid drainage risk.**

Approximately 13.6% of ANG WASTE samples are located within the pit and have sulfur values greater than 0.1%, though less than 0.25% have sulfur greater than 0.3%. The average sulfur grade for these elevated-sulfur samples is 0.15%. All samples are located above the water table with the deepest ANG WASTE in-pit samples taken from a depth of 102 m, having a sulfur level of 0.11% and was logged as red shale. The samples with black shale logged for ANG WASTE have high manganese assay values and which is more consistent with manganiferous shale. It is likely that the sulfur in these samples is present in a sulfate mineral like alunite or gypsum. **ANG WASTE is likely to pose a low acid drainage risk.**

Elevated-sulfur samples (i.e. S>0.1%) comprise 7.9% of all ANG ORE samples located within the Deposit B proposed pit design. None of these samples have sulfur levels greater than 0.3%. All samples are located above water table and generally have elevated levels of Fe and, as such, most material is likely to be sent to the crusher. **ANG ORE is likely to pose a low acid drainage risk.**

Almost 8.4% of ANG HYD samples are located within the proposed Deposit B pit and have sulfur levels greater than 0.1%. All samples are located AWT and are predominately located within 50 m of the surface. It is likely that the sulfur is present as the sulfate minerals alunite or gypsum. **ANG HYD is likely to pose a low acid drainage risk.**

Almost 9.2% of MAC WASTE samples that are located within the Deposit B pit have sulfur levels greater than 0.1%. All samples are located AWT, and the samples are not associated with either pyrite or black carbonaceous shale. Sulfur in the samples is therefore likely to be associated with sulfate minerals. **MAC WASTE is likely to pose a low acid drainage risk.**

Almost 31% of in-pit MAC ORE samples have sulfur levels greater than 0.1%, though only 0.24% have sulfur levels greater than 0.3%. All elevated sulfur samples are located above water table. As MAC ORE samples are associated with higher levels of Fe, it is likely that this material will be sent to the crusher. **MAC ORE is likely to pose a low acid drainage risk.**

There are only five NAM ORE samples located within the Deposit B final pit design. Only three have sulfur levels between 0.1% and 0.3%. The three elevated sulfur samples were from the same drill hole and were located above the water table. **NAM ORE is likely to pose a low acid drainage risk.**

Over 4.6% of MM HYD samples have sulfur levels greater than 0.1%, with only one sample with sulfur levels greater than 0.3%. All samples are located above the water table and are located within 50 m of the surface. It is likely that the sulfur within these samples is present as sulfate minerals like alunite or gypsum. **MM HYD is likely to pose a low acid drainage risk.**

No NAM WASTE samples located within the final pit shell have sulfur levels greater than 0.1%, therefore it is unlikely to pose an acid drainage risk.

Table 17 – Total sulfur analysis for drill holes located within the final Deposit B pit shell

Strand-tag group	Number of Samples assayed for S	Number of samples with S>0.1%	Percentage of samples with S>0.1%	Number of samples with S>0.3%	Percentage of total with S>0.3%	Average S for samples with S>0.1%
ALLUVIUM	2795	34	1.22%	4	0.14%	0.18
CLAY	3722	13	0.35%	0	-	0.17
CALCRETE	2	0	-	0	-	-
DET WASTE	2533	182	7.19%	12	0.47%	0.18
DET ORE	1496	261	17.45%	24	1.60%	0.19
DOLERITE	1	0	-	0	-	-
ANG WASTE	13820	1885	13.64%	33	0.24%	0.15
ANG ORE	2341	185	7.90%	0	-	0.13
ANG HYD	1975	165	8.35%	1	0.05%	0.16
NEW WASTE	3928	53	1.35%	0	-	0.13
NEW ORE	12733	206	1.62%	2	0.02%	0.13
MAC WASTE	958	88	9.19%	5	0.52%	0.18
MAC ORE	1275	395	30.98%	3	0.24%	0.14
NAM WASTE	68	0	-	0	-	-
NAM ORE	5	3	60.00%	0	-	0.13
MM HYD	6149	285	4.63%	1	0.02%	0.14
UNKNOWN	220	12	5.45%	0	-	0.12
Total number of samples assayed for S		54021		54021		
Total number of samples with S>0.1/0.03%		3767		85		
Percentage of total with S>0.1/0.3%		6.97%		0.16%		
Total number of waste samples** assayed for S		27827		27827		
Total number of waste samples with S>0.1/0.3%		2255		54		
Percentage of total waste samples with S>0.1/0.3%		8.10%		0.19%		
Total number of samples inpit, AWT and S>0.1/0.3%		3766		85		
Total number of samples inpit,BWT and S>0.1/0.3%		1		0		

*those groups with greater than 3% of samples having sulfur values exceeding 0.1%/0.3% have been highlighted

**waste samples do not include HYD or UNKNOWN

3.3.4 In-pit Total Sulfur Drillhole Analysis for Deposit F

The Deposit F pit shells (wadepf_cf01_f1.00t, wadepf_cf01_f2_2.00t, wadepf_cf01_f3.00t) were used to filter the drillhole data according to which samples are located within the final pit designs. A summary is provided in Table 18. Approximately 1.3% of all in-pit samples (including all waste samples) have sulfur values greater than 0.1%. All of the elevated sulfur samples were located above the water table.

Approximately 5.8% of ANG WASTE samples have sulfur grades greater than 0.1%, with approximately 1.2% with sulfur greater than 0.3%. This is in contrast to the initial analysis which showed less than 2.5% (2.46%) of ANG WASTE samples having sulfur levels greater than 0.1%. All elevated-sulfur samples are located above the water table and are located between 24 m to 56 m from the surface. It is likely that the sulfur is present as sulfate minerals including gypsum or alunite. **ANG WASTE is likely to pose a low acid drainage risk.**

Nearly 4.9% of ANG HYD samples have sulfur levels greater than 0.1%; with less than 0.7% having sulfur levels greater than 0.3%. All elevated-sulfur samples are located above the water table. It is therefore likely that the sulfur is in the form of a sulfate mineral. **MAC WASTE is likely to pose a low acid drainage risk.**

Over 6.4% of MAC ORE samples have sulfur levels greater than 0.1%; no samples have sulfur greater than 0.3%. All elevated sulfur samples are located above the water table. Given the small number of samples with sulfur greater than 0.1%; **MAC ORE is likely to pose a low acid drainage risk.**

Less than 3.25% of MM HYD samples have sulfur levels greater than 0.1%, with only five samples with sulfur levels greater than 0.3%. All elevated-sulfur samples are located above the water table with the majority of samples located within 50 m of the surface. It is likely that the sulfur in these samples is present as sulfate minerals such as gypsum or alunite. **MM HYD is likely to pose a low acid drainage risk.**

Table 18 - Total sulfur analysis for drill holes located within the final Deposit F pit shell

Strand-tag group	Number of Samples assayed for S	Number of samples with S>0.1%	Percentage of samples with S>0.1%	Number of samples with S>0.3%	Percentage of total with S>0.3%	Average S for samples with S>0.1%
CLAY	6790	4	0.06	0	0.00	0.12
CALCRETE	1	0	0.00	0	0.00	-
DET WASTE	8835	42	0.48	4	0.05	0.19
DET ORE	2054	37	1.80	2	0.10	0.18
DOLERITE	62	0	0.00	0	0.00	-
ANG WASTE	1064	62	5.83	13	1.22	0.23
ANG ORE	353	1	0.28	0	0.00	0.12
ANG HYD	1069	52	4.86	7	0.65	0.21
NEW WASTE	574	2	0.35	0	0.00	0.13
NEW ORE	4453	26	0.58	3	0.07	0.17
MAC WASTE	353	9	2.55	0	0.00	0.16
MAC ORE	389	25	6.43	0	0.00	0.17
NAM WASTE	4	0	0.00	0	0.00	-
MM HYD	3392	110	3.24	5	0.15	0.15
UNKNOWN	118	1	0.85	0	0.00	0.29
Total number of samples assayed for S		**29511**		**29511**		
Total number of samples with S>0.1/0.03%		**371**		**34**		
Percentage of total with S>0.1/0.3%		**1.26%**		**0.12%**		
Total number of waste samples assayed for S**		**17683**		**17683**		
Total number of waste samples with S>0.1/0.3%		**119**		**17**		
Percentage of total waste samples with S>0.1/0.3%		**0.67%**		**0.10%**		
Total number of samples inpit, AWT and S>0.1/0.3%		**371**		**34**		
Total numer of samples inpit, BWT and S>0.1/0.3%		**0**		**0**		

*those groups with greater than 3% of samples having sulfur values exceeding 0.1%/0.3% have been highlighted

**waste samples do not include HYD or UNKNOWN

3.3.5 In-pit Total Sulfur Drillhole Analysis for Deposit A West

The Deposit A West pit shells (wadepawest_pit1E.00t, wadepawest_pit1W.00t, wadepawest_pit2.00t) were used to filter the drillhole data according to which samples are located within the final pit designs. A summary is provided in Table 19. Approximately 1.1% of all in-pit samples (including all waste samples) have sulfur values greater than 0.1%, with only 0.13% with sulfur levels greater than 0.3%. Only one elevated sulfur sample was located below the water table.

In contrast to the total drill hole sulfur analysis undertaken in Section 3.2.5, MAC ORE was identified as having greater than 3% of samples with sulfur levels greater than 0.1%. A total of seven elevated-sulfur samples from two drill holes are located within the proposed pit shells. All samples are located above the water table and have sulfur levels less than 0.2%. It is likely that the sulfur is present as sulfate minerals. **MAC ORE is likely to pose a low acid drainage risk.**

Table 19 - Total sulfur analysis for drill holes located within the final Deposit A West pit shells

Strand-tag group	Number of Samples assayed for S	Number of samples with S>0.1%	Percentage of samples with S>0.1%	Number of samples with S>0.3%	Percentage of total with S>0.3%	Average S for samples with S>0.1
CLAY	6149	24	0.39	0	0.00	0.15
DET WASTE	3086	73	2.37	10	0.32	0.20
DET ORE	1120	29	2.59	7	0.63	0.21
DOLERITE	50	0	0.00	0	0.00	-
ANG WASTE	419	2	0.48	0	0.00	0.19
ANG ORE	207	0	0.00	0	0.00	-
ANG HYD	65	0	0.00	0	0.00	-
NEW WASTE	638	3	0.47	0	0.00	0.13
NEW ORE	1726	4	0.23	0	0.00	0.15
MAC WASTE	334	8	2.40	2	0.60	0.19
MAC ORE	203	7	3.45	0	0.00	0.15
MM HYD	1011	11	1.09	1	0.10	0.20
UNKNOWN	199	0	0.00	0	0.00	-

Total number of samples assayed for S	15207	15207
Total number of samples with S>0.1/0.03%	161	20
Percentage of total with S>0.1/0.3%	1.06%	0.13%
Total number of waste samples** assayed for S	10676	10676
Total number of waste samples with S>0.1/0.3%	110	12
Percentage of total waste samples with S>0.1/0.3%	1.03%	0.11%
Total number of samples inpit, AWT and S>0.1/0.3%	160	20
Total number of samples inpit, BWT and S>0.1/0.3%	1	0

*those groups with greater than 3% of samples having sulfur values exceeding 0.1%/0.3% have been highlighted

**waste samples do not include HYD or UNKNOWN

3.3.6 In-pit Total Sulfur Drillhole Analysis for Deposit D

The Deposit D pit shells (wad_pfs_pit_design_23062016) was used to filter the drillhole data according to which samples are located within the final pit designs. A summary is provided in Table 20. Approximately 1.2% of all in-pit samples (including all waste samples) have sulfur values greater than 0.1%. A total of five elevated-sulfur samples were located below the water table.

Strand-tag groups with a significant number of elevated-sulfur samples include DET ORE, PI ORE and in contrast to the initial analysis MAC WASTE.

Approximately 5.9% of DET ORE samples have sulfur grades greater than 0.1%, with approximately 1.4% with sulfur greater than 0.3%. All elevated-sulfur samples are located above the water table and are located within 40 m of the surface. It is likely that the sulfur is present as sulfate minerals including gypsum or halotrichite. **DET ORE is likely to pose a low acid drainage risk.**

Approximately 13.2% of PI ORE samples have sulfur greater than 0.1%, with 9.4% with sulfur greater than 0.3%. These seven samples are distributed across four drillholes, are located within 38 m of the surface and located above the pre-mining water table. It is likely that the sulfur is present as sulfates not sulfides. **PI ORE is likely to pose a low acid drainage risk.**

Approximately 4.4% of MAC WASTE samples have sulfur greater than 0.1%; however none of the samples have sulfur greater than 0.3%. The two samples are located above the water table, within 10 m of the surface. Given the close proximity to the surface and the low sulfur values, **MAC WASTE is likely to pose a low acid drainage risk.**

Although NAM WASTE was assessed as posing a low-moderate AMD risk in Section 3.2.7, when the final pit shell is considered no NAM WASTE is expected to be encountered. **NAM WASTE will pose a low acid drainage risk** based on the current pit shell.

Table 20 - Total sulfur analysis for drill holes located within the final Deposit D pit shells

Strand-tag group	Number of Samples assayed for S	Number of samples with S>0.1%	Percentage of samples with S>0.1%	Number of samples with S>0.3%	Percentage of total with S>0.3%	Average S for samples with S>0.1%
CLAY	2929	22	0.75	10	0.34	0.30
CALCRETE	654	0	0.00	0	0.00	-
DET WASTE	5091	55	1.08	12	0.24	0.27
DET ORE	2241	131	5.85	31	1.38	0.23
LI WASTE	21	0	0.00	0	0.00	-
LI ORE	563	9	1.60	1	0.18	0.15
PI WASTE	3	0	0.00	0	0.00	-
PI ORE	53	7	13.21	5	9.43	0.47
DOR	263	0	0.00	0	0.00	-
ANG WASTE	2724	4	0.15	0	0.00	0.17
ANG ORE	896	1	0.11	0	0.00	0.10
ANG HYD	176	2	1.14	0	0.00	0.13
NEW WASTE	1802	7	0.39	0	0.00	0.12
NEW ORE	5489	6	0.11	0	0.00	0.12
MAC WASTE	45	2	4.44	0	0.00	0.13
MAC ORE	60	0	0.00	0	0.00	-
MM HYD	875	18	2.06	0	0.00	0.15
UNKNOWN	800	23	2.88	5	0.63	0.21

Total number of samples assayed for S	24685	24685
Total number of samples with S>0.1/0.03%	287	64
Percentage of total with S>0.1/0.3%	1.16%	0.26%
Total number of waste samples** assayed for S	13532	13532
Total number of waste samples with S>0.1/0.3%	90	22
Percentage of total waste samples with S>0.1/0.3%	0.67%	0.16%

*those groups with greater than 3% of samples having sulfur values exceeding 0.1%/0.3% have been highlighted

**waste samples do not include HYD or UNKNOWN

3.3.7 In-pit Total Sulfur Drillhole Analysis for Deposit C

The Deposit C pit shells (wac_pfs_pit_design_23062016) was used to filter the drillhole data according to which samples are located within the pit. A summary is provided in

Table 21. Approximately 0.94% of Deposit C in-pit samples have sulfur greater than 0.1%, with approximately 0.13% with sulfur greater than 0.3%. Strand-tag groups with a significant number of elevated-sulfur samples located in-pit include MAC WASTE and MAC ORE. No elevated sulfur NAM WASTE samples are located within the proposed pit design.

Approximately 6.4% of MAC WASTE samples have sulfur greater than 0.1% and 1.6% have sulfur greater than 0.3%. These elevated sulfur samples are located above the pre-mining water table, and located within 25m of the pre-mining topography. It is therefore likely that the sulfur is present as sulfates not sulfides. Given the limited number of samples with sulfur greater than 0.3%, **MAC WASTE is likely to pose a low acid drainage risk.**

Approximately 3.9% of MAC ORE samples located within the proposed pit have sulfur greater than 0.1%; however no samples have sulfur greater than 0.3%. These elevated-sulfur samples have high iron grades (greater than 50% Fe), are located above the pre-mining water table and are limited in distribution (located in three drillholes). It is therefore likely that **MAC ORE will pose a low acid drainage risk.**

Although NAM WASTE was assessed as posing a low-moderate AMD risk in Section 3.2.7, when the final pit shell is considered no elevated sulfur samples are expected to be encountered. It is therefore likely that **NAM WASTE will pose a low acid drainage risk** based on the current pit shell.

Table 21 - Total sulfur analysis for drill holes located within the final Deposit C pit shells

Strand-tag group	Number of Samples assayed for S	Number of samples with S>0.1%	Percentage of samples with S>0.1%	Number of samples with S>0.3%	Percentage of total with S>0.3%	Average S for samples with S>0.1%
ALLUVIUM	3	0	0.00	0	0.00	-
CLAY	538	1	0.19	0	0.00	0.12
CALCRETE	31	0	0.00	0	0.00	-
DET WASTE	2963	28	0.94	1	0.03	0.16
DET ORE	2743	52	1.90	8	0.29	0.19
LI WASTE	728	3	0.41	0	0.00	0.11
LI ORE	473	1	0.21	0	0.00	0.12
PI WASTE	3	0	0.00	0	0.00	-
DOR	17	0	0.00	0	0.00	-
ANG WASTE	1814	8	0.44	6	0.33	0.93
ANG ORE	541	0	0.00	0	0.00	-
ANG HYD	316	7	2.22	2	0.63	0.26
NEW WASTE	1165	7	0.60	0	0.00	0.15
NEW ORE	4007	18	0.45	3	0.07	0.18
MAC WASTE	125	8	6.40	2	1.60	0.18
MAC ORE	102	4	3.92	0	0.00	0.12
NAM WASTE	11	0	0.00	0	0.00	-
MM HYD	1885	28	1.49	1	0.05	0.17
UNKNOWN	20	0	0.00	0	0.00	-
Total number of samples assayed for S		17485		17485		
Total number of samples with S>0.1/0.03%		165		23		
Percentage of total with S>0.1/0.3%		0.94%		0.13%		
Total number of waste samples** assayed for S		7398		7398		
Total number of waste samples with S>0.1/0.3%		56		9		
Percentage of total waste samples with S>0.1/0.3%		0.76%		0.12%		

*those groups with greater than 3% of samples having sulfur values exceeding 0.1%/0.3% have been highlighted

**waste samples do not include HYD or UNKNOWN

3.3.8 In-pit Total Sulfur Drillhole Analysis for Deposit G.

The Deposit G pit shells (wag_pitshell) was used to filter the drillhole data according to which samples are located within the final pit designs. A summary is provided in Table 20. Approximately 0.83% of all in-pit samples (including all waste samples) have sulfur values greater than 0.1%, with less than 0.1% with sulfur greater than 0.3%. In the analysis for the total Deposit G drillhole dataset, no strand-tag groups had a significant number of elevated sulfur samples; however within the pit-shell PI ORE is the only strand-tag group with a significant number of elevated-sulfur samples (i.e. greater than 3% of samples with sulfur greater than 0.1%).

Approximately 3.5% of in-pit PI ORE samples have sulfur greater than 0.1%, with only one sample with sulfur greater than 0.3%. These eight samples are distributed across six drillholes, are located within 26 m of the surface and located above the pre-mining water table. It is likely that the sulfur is present as sulfates not sulfides. **PI ORE is likely to pose a low acid drainage risk.**

Table 22 – Total sulfur analysis for drill holes located within the final Deposit G pit shells

Strand-tag group	Number of Samples assayed for S	Number of samples with S>0.1%	Percentage of samples with S>0.1%	Number of samples with S>0.3%	Percentage of total with S>0.3%	Average S for samples with S>0.1%
CLAY	302	2	0.66	0	0.00	0.13
DET WASTE	743	7	0.94	2	0.27	0.20
DET ORE	90	0	0.00	0	0.00	-
PI WASTE	490	7	1.43	0	0.00	0.15
PI ORE	229	8	3.49	1	0.44	0.17
ANG WASTE	89	0	0.00	0	0.00	-
ANG ORE	21	0	0.00	0	0.00	-
ANG HYD	15	0	0.00	0	0.00	-
NEW WASTE	46	0	0.00	0	0.00	-
NEW ORE	1192	0	0.00	0	0.00	-
MAC WASTE	3	0	0.00	0	0.00	-
MAC ORE	41	0	0.00	0	0.00	-
MM HYD	693	6	0.87	0	0.00	0.12
UNKNOWN	652	8	1.23	0	0.00	0.14

	S>0.1%	S>0.3%
Total number of samples assayed for S	4606	4606
Total number of samples with S>0.1/0.03%	38	3
Percentage of total with S>0.1/0.3%	0.83%	0.07%
Total number of waste samples** assayed for S	1673	1673
Total number of waste samples with S>0.1/0.3%	16	2
Percentage of total waste samples with S>0.1/0.3%	0.96%	0.12%

*those groups with greater than 3% of samples having sulfur values exceeding 0.1%/0.3% have been highlighted

**waste samples do not include HYD or UNKNOWN

3.3.9 In-pit Total Sulfur Drillhole Analysis for Angelo River

The Angelo River/Indabiddy pit shells (angr_main_uf101_clip.00t, angr_west_uf101_clip.00t) were used to filter the drillhole data according to which samples are located within the final pit designs. A summary is provided in Table 20. Approximately 0.9% of all in-pit samples (including all waste samples) have sulfur values greater than 0.1%. Only four elevated sulfur samples were located below the water table.

Approximately 4.6% of MM HYD samples have sulfur grades greater than 0.1%, with less than 1% with sulfur greater than 0.3%. All elevated-sulfur samples are located above the water table and are located within 28 m of the surface. It is likely that the sulfur is present as sulfate minerals including gypsum or alunite. **MM HYD is likely to pose a low acid drainage risk.**

Table 23 - Total sulfur analysis for drill holes located within the final Angelo River pit shells

Strand-tag group	Number of Samples assayed for S	Number of samples with S>0.1%	Percentage of samples with S>0.1%	Number of samples with S>0.3%	Percentage of total with S>0.3%	Average S for samples with S>0.1%
ALLUVIUM	13	0	0.00	0	0.00	-
CLAY	800	5	0.63	1	0.13	0.34
CALCRETE	66	0	0.00	0	0.00	-
DET WASTE	721	2	0.28	0	0.00	0.11
DET ORE	393	7	1.78	2	0.51	0.24
DOLERITE	36	0	0.00	0	0.00	-
WD	5	0	0.00	0	0.00	-
ANG WASTE	492	2	0.41	1	0.20	0.22
ANG ORE	40	0	0.00	0	0.00	-
ANG HYD	454	6	1.32	1	0.22	0.25
NEW WASTE	136	0	0.00	0	0.00	-
NEW ORE	1194	4	0.34	2	0.17	0.27
MAC WASTE	8	0	0.00	0	0.00	-
MAC ORE	4	0	0.00	0	0.00	-
MM HYD	329	15	4.56	2	0.61	0.20
UNKNOWN	44	0	0.00	0	0.00	-

Total number of samples assayed for S	**4735**	**4735**
Total number of samples with S>0.1/0.03%	**41**	**9**
Percentage of total with S>0.1/0.3%	**0.87%**	**0.19%**
Total number of waste samples assayed for S**	**2277**	**2277**
Total number of waste samples with S>0.1/0.3%	**9**	**2**
Percentage of total waste samples with S>0.1/0.3%	**0.40%**	**0.09%**
Total number of samples in pit, AWT and S>0.1/0.3%	**37**	**8**
Total number of samples in pit, BWT and S>0.1/0.3%	**4**	**1**

*those groups with greater than 3% of samples having sulfur values exceeding 0.1%/0.3% have been highlighted

**waste samples do not include HYD or UNKNOWN

3.4 Population of the Sulfide_risk Variable in the Geological Model

In the West Angelas deposit geological models, the sulfide_risk variable has been scripted according to the RTIO (WA) Mineral Waste Management Plan. This generally results in a blanket application of variables to a particular stratigraphy.

3.5 Quantity of sulfide_risk 2/3 material in the Mining Model

As most of the pit designs are awaiting review and sign-off, they have not been flagged into the corresponding mining models. The quantities of sulfide risk 2 and 3 material have been provided from the various mining engineers. For Deposit A West and Deposit F the quantity of material in each sulfur bin was obtained.

From the 2013 Life of Mine (LOM) report (in draft), 12,837 t of black shale material is expected to be encountered during the life of Deposit E. This has been incorrectly interpreted, as only material assigned with sulfide_risk 1 is located in pit. This material is located above the water table, and is therefore unlikely to be black shale. This should be reviewed for the LOM report.

Approximately 4.7 Mt of material flagged as sulfide_risk 2 is expected to encountered in the Deposit F pits (B Yaqub 2014, pers. comm., 6 Mar). The sulfide_risk 2 material flagged in the pit is from the MacLeod member and is not associated with pyrite, is located above the water table and associated with low sulfur levels. Approximately 99%

of material to be mined from Deposit F is expected to have sulfur levels less than 0.1% (Table 24), including the material flagged as sulfide_risk 2.

Table 24 - Breakdown of material by sulfide_risk variable and sulfur bin to be mined from Deposit F

		Sulfide_risk				Grand Total (t)
		-99	0	1	2	
Sulfur Bin	**0.05**	3,758,071	156,956,468	92,838,358	4,217,586	**257,770,482**
	0.10	42,771	13,192,524	1,261,141	470,295	**14,966,731**
	0.15		1,295,312	164,726	9,809	**1,469,847**
	0.20		336,978	71,336		**408,313**
	0.25		111,303	12,098		**123,400**
	0.30		33,301	12,333		**45,634**
	0.35		21,960	11,823		**33,784**
	0.40		31,000			**31,000**
	0.45		11,233			**11,233**
	100		18,234			**18,234**
Grand total (t)		**3,800,842**	**172,008,312**	**94,371,815**	**4,697,689**	**274,878,659**

For the A West Deposit all material has been flagged with a sulfide risk variable of 0. This is consistent with the in-pit sulfur analysis undertaken in Section 3.3.5. The bulk of the material is expected to have low sulfur levels (Table 25). All material has sulfur levels less than 0.2%, with the majority of the material with sulfur levels less than 0.05%.

Table 25 - Breakdown of the A West Deposit via sulfur bin

Sulfur Bin	**0.05**	209,269,844
	0.10	3,818,851
	0.15	77,428
	0.20	4,587
Grand Total (t)		**213,170,710.31**

For Deposits D and G, no sulfide risk 2 or 3 material will be encountered as indicated in the mining models (waipr_depd_20160530_043, waipr_depg_20160726_004). For the Deposit C mining model (waipr_depc_20160530_025), slightly over 49 kt of sulfide risk 2 material flagged as NEW, MAC and NAM WASTE is expected to be encountered (Table 26). It should be noted that NEW WASTE was not flagged in the geological model with a sulfide_risk 2, however with the regularisation process it has been assigned. No elevated-sulfur NAM WASTE samples were identified as occurring in pit, and had likely occurred as a result of elevated-sulfur blocks being captured as part of the regularisation process. A limited number of MAC WASTE elevated-sulfur samples were found to be located in-pit; however these samples were also deemed to pose a low acid drainage risk as the elevated-sulfur samples are determined to have sulfates present.

Table 26 – Breakdown of strand-tag groups assigned to particular acid drainage risk variables for Deposit C. Note: no material has been flagged as bsoxid_t, bshot_t or bsneut_t.

		Acid Drainage Risk		Grand Total (kt)
		bsnon_t (kt)	bscold_t (kt)	
Strand-tag group	CLAY	3,451.13	0.00	3,451.13
	CALCRETE	131.37	0.00	131.37
	DET WASTE	53,563.03	0.00	53,563.03
	DET ORE	36,154.91	0.00	36,154.91
	LI WASTE	14,224.64	0.00	14,224.64
	LI ORE	3,732.91	0.00	3,732.91
	DOR	215.33	0.00	215.33
	ANG WASTE	22,854.76	0.00	22,854.76
	ANG ORE	5,091.61	0.00	5,091.61
	ANG HYD	3,739.58	0.00	3,739.58
	NEW WASTE	11,628.31	0.09	11,628.40
	NEW ORE	47,326.71	0.00	47,326.71
	MAC WASTE	2,515.57	21.77	2,537.34
	MAC ORE	852.70	0.00	852.70
	NAM WASTE	44.76	27.49	72.25
	MM HYD	31,060.60	0.00	31,060.60
	AIR	6,723.58	0.00	6,723.58
Grand Total (kt)		243,310.48	49.34	243,359.82

The other West Angelas deposits are not expected to have sulfide_risk 2 or 3 material encountered as part of mining.

4. Chemical Enrichment

Understanding the geochemistry of rock types can assist with more environmentally sound management of waste rock and low-grade stock piles. Drillholes are regularly analysed for the main chemical element suite of Fe, Si, Al, P, Ti, Ca, Mg, S, and Mn. Occasionally there have been full chemical suite analyses of As, Ba, Bi, Cl, Co, Cr, Cu, K, Na, Ni, Pb, Sn, Sr, V, Zn and Zr. The assay results are determined using XRF and it is now common practice to analyse for the full chemical suite as part of the ore body evaluation.

The extent of enrichment of a drillhole sample can be reported as the Geochemical Abundance Index (GAI), which relates the actual concentration with average crustal abundance on an adjusted log 2 scale (Bowen, 1979). The GAI is expressed in integer increments where a GAI of zero indicates the element is present at a concentration similar to, or less than, median crustal abundance, and a GAI of 6 indicates approximately a 100 fold enrichment above the median crustal abundance. The main purpose of the GAI is to provide an indication of any elemental enrichment. As a general rule, a GAI of 3 or greater (more than 12-times the average crustal abundance) signifies enrichment that warrants further examination, while a GAI or 1 or 2 indicates the element may be elevated.

The GAI values from the drillhole samples were contrasted with Ecological Investigation levels (EILs) and Health Investigation Levels (HILs) provided in the Contaminated Sites Management Series Assessment Levels for Soil, Sediment and Water (DEC, 2010), as well as US EPA Ecological Soil Screening Levels (Eco-SSLs) (US EPA 2005, 2010). These various screening levels identify contaminants of potential concern in soils and sediments, which can then be evaluated through site specific assessments. The comparison of the crustal abundance (GAI) trigger concentrations which are used in this assessment against the EILs, HILs and Eco-SSLs is summarised in Green (2011). This shows that the GAI trigger is lower than the EILs, HILs and Eco-SSL values with the exception of Ba, Cd, Co, Cr, Cu, Mn, Ni, P, Pb, S, Sb, V and Zn. The GAI trigger is generally higher than the Eco-SSLs in the US EPA report with the exception of As and Se, for which the crustal abundance values are lower than the most conservative Eco-SSL values.

The most conservative Eco-SSLs were considered for the purpose of this comparison, however these values may not be the most appropriate for Pilbara-specific receptors. Some potential issues:

- Material mined on RTIO mine sites is mostly rock and not soil, and therefore whilst the EILs, HILs and Eco-SSLs are useful for screening, they may not be the most appropriate to use as management triggers.
- Concentrations of some trace elements of environmental concern (e.g. As) may be enriched in some of the sampled materials, but these elements may not necessarily mobilise into groundwater.

4.1 Analysis of Drillhole Samples from the West Angelas area

The multi-element analysis of all drillhole assay data (derived from the full chemical suite) for the West Angelas deposits with mine planning information and the corresponding GAI values are summarised in Table 27. The full details for these deposits as well as the other West Angelas deposits are given in Appendix 3. The same factors outlined in Section 3.2 may also influence the interpretations within this section. Most rock types are either enriched or elevated in Fe, as correlated with the iron mineralisation associated with the ore body. Arsenic (As) is enriched in most rock types while tin (Sn) is either enriched or elevated. Strand-tag groups that have additional elements enriched include Calcrete (Ca, Cr, Mg, Mn, Pb), Dolerite from Deposit F with Pb elevated, Wittenoom Formation from Deposit D with elevated levels of Mn, Ang Waste from Deposit B, D, E and A West with elevated levels of Mn and Nammuldi Waste from Deposit B with elevated Mn and Deposit E with elevated levels of S. It should be noted that the detection limits for these analyses vary widely and most are greater than the actual GAI triggers considered.

For the standard element suite including Ba, Co, Cr, Cu, Mn, Ni, P, Pb S, V and Zn, the GAI triggers are higher than the DEC/US EPA EILs, HILs and Eco-SSL triggers (see Green, 2011). An analysis comparing the lower triggers against the median concentration of those elements in each rock type (Appendix 4) indicates that:

- All rock types have average elemental values lower than DEC/EPA triggers for Ba and P.
- The majority of rock types have relatively high mean concentrations of Mn and V.
- NAM WASTE samples from Deposit A and Deposit E have relatively higher concentrations of S.
- Pb levels are relatively high in Deposit E, F, Angelo River and West Angelas 6, 7, 8 and 9.
- Zn levels in the majority of strand-tag groups from Deposit B are high.
- ALLUVIUM, CLAY, DET WASTE and DET ORE have relatively higher concentrations of Co, Cr, Cu, Mn and Ni.

In general, whilst concentrations of some trace elements of potential environmental concern (e.g. As, Pb) were enriched or elevated in some of the sampled ore and waste materials, these elements will not necessarily mobilise into groundwater. Arsenic in particular is commonly enriched in ore and waste for many Hamersley Group deposits. Iron oxy-hydroxides such as hematite and magnetite have high sorption capacities for As (e.g. Zhang et al. 2004), and consequently these materials have been used around the world for treating water enriched in arsenic. Further work on adsorption capacity of Pilbara lithologies including iron oxides/oxy-hydroxides and clays, is summarised in *Solute Sorption onto Nammuldi and Hope Downs 1 Samples* (SRK, 2011).

In summary, the following elements have been identified as being enriched in greater West Angelas rock types and should be considered in any source-path-receptor modelling related to potential AMD impacts: **Fe, As and Sn (based on GAI triggers) and Co, Cr, Cu, Mn, Ni, Pb and Zn (based on DEC/EPA triggers).**

Table 27 - Summary of median GAI values for enriched and elevated elements within deposits of the West Angelas project area where mine planning information is available

Strand-tag group	Deposit A			Deposit B			Deposit C		Deposit D			Deposit E			Deposit F			A WEST			Angelo River			
	Enriched (GAI >3)		Elevated (GAI = 1 or 2)	Enriched (GAI >3)		Elevated (GAI = 1 or 2)	Enriched (GAI >3)	Elevated (GAI = 1 or 2)	Enriched (GAI >3)		Elevated (GAI = 1 or 2)	Enriched (GAI >3)		Elevated (GAI = 1 or 2)	Enriched (GAI >3)		Elevated (GAI = 1 or 2)	Enriched (GAI >3)		Elevated (GAI = 1 or 2)	Enriched (GAI >3)			Elevated (GAI = 1 or 2)
	As	Fe		As	Fe		Fe		As	Fe		As	Fe		As	Fe		As	Fe		As	Fe	Sn	
ALLUVIUM	-	-	-	3		Fe, Sn		Fe	-	-	-	3		Fe, Sn	3		Fe, Sn	4		Fe, Sn	3			Fe, Sn
CLAY	3		Fe, Sn	3		Fe, Sn		Fe	3		Fe, Sn	3		Fe, Sn	3		Cr, Fe, Sn			As, Fe, Sn	4			Fe, Sn
CAL	-	-	-			As, Ca, Cr, Mg, Sn		Fe			As, Sn	-	-	-	3		Ca, Mg, Mn, Pb			As, Fe, Sn	3			Fe, Sn
DET WASTE	3		Cr, Fe, Sn	3		Fe, Sn		Fe	3		Fe, Sn	3		Fe, Sn	3		Fe, Sn	3		Fe, Sn	3			Fe, Sn
DET ORE	3	3	Sn	3	3	Sn	3		3	3	Sn	3	3	Sn	3	3	Sn	3	3	Sn	3	3		Sn
DOR	3		Fe	-	-	-					As, Fe, Sn	-	-	-	3		Fe, Pb, Sn	3		Fe, Sn	4			Fe, Sn
JOF WASTE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3			Fe, Sn
JOF HYD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	3		Sn
WS WASTE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4			Fe, Sn
DG WASTE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3			Fe, Sn
DG ORE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	3		Sn
DG HYD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	3		Sn
FWZ WASTE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3			Fe, Sn
FWZ ORE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	3	3	
MCS	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4			Fe, Sn
MTS	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4			Fe, Sn
WD	-	-	-	-	-	-	-	-	3		Fe, Mn, Sn	-	-	-	-	-	-	-	-	-	3			Fe, Sn
ANG WASTE	4		Fe, Sn	4		Fe, Mn, Sn		Fe	4		Fe, Mn, Sn	4		Fe, Mn, Sn	4		Fe, Sn	4		Fe, Mn, Sn	4			Fe, Sn
ANG ORE	3	3	Sn	3	3	Sn	3		3	3	Sn	4	3	Sn	3	3	Fe, Sn	3	3	Sn	3	3		Sn
ANG HYD	-	-	-	3	3	Sn	-	-	3	3	Sn	4	3	Sn	3	3	Sn	3	3	Sn	4	3		Sn
NEW WASTE			As, Fe, Sn			As, Fe, Sn		Fe			As, Fe, Sn	3		Fe, Sn	3		Fe, Sn			Sn	3			Fe, Sn
NEW ORE		3	As, Sn		3	As, Sn	3			3	As, Sn	3	3	Sn	3	3	Sn		3	Sn	3	3		Sn
MAC WASTE			As, Fe, Sn	3		Fe, Sn		Fe	-	-	-	3		Fe, Sn	3		Fe, Sn			Sn	3			Fe, Sn
MAC ORE		3	As, Sn	3	3	Sn	3		-	-	-	3	3	Sn	3	3	Sn	3	3	Sn		3		As, Sn
NAM WASTE			As, Fe, Sn			As, Fe, Sn, Mn	-	-			As, Fe, Sn			As, Fe, Sn, S			As, Fe, Sn			Sn	-	-	-	-
NAM ORE	-	-	-	3	3	Sn	-	-	3	3	Sn	-	-	-	-	-	-	-	-	-	-	-	-	-
MM WASTE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3			Fe, Sn
MM HYD	-	-	-	3	3	Sn	3			3	As, Sn	3	3	Sn	3	3	Sn	3	3	Sn	3	3		Sn

5. AMD Risk Assessment and Conclusions

The risk associated with AMD for the West Angelas deposits has been investigated and takes into account the total sulfur concentrations within drillhole samples, logging data to indicate the presence of sulfide or sulfate minerals and estimated tonnes expected during mining. Geochemical data was also assessed to identify enriched concentrations of elements which may pose an environmental risk. The results of this assessment, taking into account background information related to mining the deposits, as well as environmental factors which may be impacted, are summarised in Table 28 and presented in the AMD Hazard Scorecards for each deposit (Appendix 2).

West Angelas Deposit A is expected to pose a low AMD risk based on the current pit design. Approximately 2.9% of all in-pit samples have sulfur levels greater than 0.1%, however less than 0.3% of samples have greater than 0.3% sulfur. It is expected that the sulfur associated with elevated-sulfur samples is in the form of sulfate not sulfide minerals.

West Angelas Deposit E is expected to pose a low AMD risk based on the current pit design. Approximately 1.7% of all in-pit samples have sulfur levels greater than 0.1%, with less than 0.2% of samples with sulfur greater than 0.3%. It is expected that the sulfur associated with these material types are in the form of sulfate not sulfide minerals.

West Angelas Deposit B is expected to pose a low AMD risk based on the current pit designs. Approximately 7% of all in-pit samples have sulfur levels greater than 0.1%, however less 0.2% of the samples have sulfur levels greater than 0.3%. It is expected that the sulfur associated with these material types are in the form of sulfate not sulfide minerals.

West Angelas Deposit F is expected to pose a low AMD risk based on the current pit designs. Approximately 1.3% of all in-pit samples have sulfur levels greater than 0.1%, with less than 0.12% with sulfur greater than 0.3%. It is expected that the sulfur is present as sulfate rather than sulfide minerals.

West Angelas Deposit A West is expected to pose a low AMD risk based on the current pit designs. Approximately 1.1% of all in-pit samples have sulfur levels greater than 0.1%, with approximately 0.13% with sulfur greater than 0.3%. It is expected that the sulfur is present as sulfate rather than sulfide minerals.

West Angelas Deposit D is expected to pose a low AMD risk based on the current pit designs. Approximately 1.3% of all in-pit samples have sulfur levels greater than 0.1%, with approximately 0.26% with sulfur levels greater than 0.3%. It is expected that the sulfur is present as sulfate rather than sulfide minerals.

West Angelas Deposit C is expected to pose a low AMD risk based on the current pit designs. Approximately 0.94% of all in-pit samples have sulfur levels greater than 0.1%, with approximately 0.13% with sulfur levels greater than 0.3%. Although the mining model predicts PAF material, a review of in-pit drillholes suggests that the elevated sulfur samples contain sulfate rather than sulfide minerals.

West Angelas Deposit G is expected to pose a low AMD risk based on the current pit designs. Approximately 0.83% of all in-pit samples have sulfur levels greater than

0.1%, with approximately 0.07% with sulfur levels greater than 0.3%. It is expected that the sulfur is present as sulfate rather than sulfide minerals.

Angelo River is expected to pose a low-moderate AMD risk based on the current pit designs. Approximately 0.9% of all in-pit samples have sulfur levels greater than 0.1%, with less than 0.2% with sulfur greater than 0.3%. It is expected that the sulfur is present as sulfate minerals rather than sulfides. The AMD hazard score for Angelo River is influenced by the significant strike length of the deposit, as well as other assumptions, such as no back fill of the pits and should be reviewed as additional information becomes available.

Although pyrite has been visually identified in drillhole samples from different stratigraphic units and different deposits, no pyrite samples are located within the current proposed pit shells. As mentioned above the sulfur associated with elevated-sulfur samples are likely to be associated with sulfate minerals including gypsum which will not generate acid, or alunite which has the potential for relatively low levels of acid release from elevated-sulfate samples. The low solubility of alunite means that only a low flux of acid (and contaminant) release.

The following elements have been identified as being enriched in the West Angelas deposits and should be monitored in groundwater: **Fe, As and Sn, as well as Co, Cr, Cu, Mn, Ni, Pb and Zn.**

Table 28 - Summary of AMD risk assessment criteria for West Angelas Deposits

Deposit	% in-pit waste samples with S>0.1%	% in-pit waste samples with S>0.3%	AMD Hazard Score	AMD Hazard Risk Ranking
Deposit A*	2.86%	0.18%	29	Low
Deposit E	0.86%	0.19%	28	Low
Deposit B	8.10%	0.19%	29	Low
Deposit F	0.67%	0.10%	27	Low
Deposit A West	1.03%	0.11%	27	Low
Deposit D	0.67%	0.16%	29	Low
Deposit C	0.76%	0.12%	29	Low
Deposit G	0.96%	0.12%	22	Low
Angelo River	0.40%	0.09%	30	Low-moderate

*Breakdown into ore and waste not possible and therefore total in-pit samples are provided.

6. Recommendations

The following work is recommended to improve the understanding of AMD risks in the West Angelas areas and ensure that the management of mineral waste will effectively mitigate the associated risks.

- These assessments should be updated when new drillhole information and mine planning data becomes available.
- The geological models should be reviewed and updated with regards to the population of the sulfide risk variable.
- Ensure that elements identifies as being enriched in rock types as a part of this study or future studies, be captured in on-going groundwater monitoring programmes.

7. Acknowledgements

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SRK (2008), Geochemical characterisation of Paraburdoo Lens 2, Tom Price North Deposit Dales Gorge and West Angelas Samples (RTIO-PDE-0034616)

SRK (2010), Geochemical Characterisation of Banded Iron Formation Samples from the West Angelas Mine - RTS032 (RTIO-PDE-0073566)

SRK (2011), Solute Sorption onto Nammuldi and Hope Downs 1 Samples

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Appendix 1 – Total Sulfur Analysis for Exploration Leases 709, 797, 798 and 986

Table 29 - Total sulfur analysis for West Angelas EL 709

Strand-tag group	Number of Samples assayed for S	Number of samples with S>0.1%	Percentage of samples with S>0.1%	Number of samples with S>0.3%	Percentage of total with S>0.3%	Average S for samples with S>0.1%
ALLUVIUM	687	48	6.99	0	0.00	0.13
CLAY	65	6	9.23	2	3.08	0.22
CALCRETE	25	0	0.00	0	0.00	-
DET WASTE	5991	65	1.08	0	0.00	0.11
DET ORE	6001	78	1.30	2	0.03	0.15
DOLERITE	4	3	75.00	1	25.00	0.26
WS WASTE	16	0	0.00	0	0.00	-
WS HYD	23	0	0.00	0	0.00	-
DG WASTE	81	1	1.23	0	0.00	0.10
DG ORE	22	0	0.00	0	0.00	-
DG HYD	229	3	1.31	0	0.00	0.19
MCS	658	40	6.08	7	1.06	0.24
MTS	164	12	7.32	4	2.44	0.29
WD	42	0	0.00	0	0.00	-
UNKNOWN	653	10	1.53	2	0.31	0.18

Total number of samples assayed for S	**14661**	**14661**
Total number of samples with S>0.1/0.03%	**266**	**18**
Percentage of total with S>0.1/0.3%	**1.81%**	**0.12%**
Total number of waste samples assayed for S**	**7733**	**7733**
Total number of waste samples with S>0.1/0.3%	**175**	**14**
Percentage of total waste samples with S>0.1/0.3%	**2.26%**	**0.18%**

Table 30 - Total sulfur analysis for West Angelas EL 797

Strand-tag group	Number of Samples assayed for S	Number of samples with S>0.1%	Percentage of samples with S>0.1%	Number of samples with S>0.3%	Percentage of total with S>0.3%	Average S for samples with S>0.1%
CALCRETE	7	0	0.00	0	0.00	-
DET WASTE	1681	37	2.20	10	0.59	0.29
DET ORE	721	16	2.22	1	0.14	0.14
WS HYD	13	0	0.00	0	0.00	-
DG WASTE	91	5	5.49	0	0.00	0.13
DG ORE	188	6	3.19	0	0.00	0.13
DG HYD	37	14	37.84	0	0.00	0.14
FWZ WASTE	72	6	8.33	0	0.00	0.12
FWZ ORE	69	5	7.25	0	0.00	0.14
MCS ORE	3	0	0.00	0	0.00	-
MCS WASTE	292	19	6.51	5	1.71	0.58
MTS	19	0	0.00	0	0.00	-
WD	223	15	6.73	6	2.69	0.33
ANG WASTE	154	14	9.09	4	2.60	0.44
ANG ORE	6	1	16.67	0	0.00	0.12
UNKNOWN	3	0	0.00	0	0.00	-

Total number of samples assayed for S	**3579**	**3579**
Total number of samples with S>0.1/0.03%	**138**	**26**
Percentage of total with S>0.1/0.3%	**3.86%**	**0.73%**
Total number of waste samples assayed for S**	**2539**	**2539**
Total number of waste samples with S>0.1/0.3%	**96**	**25**
Percentage of total waste samples with S>0.1/0.3%	**3.78%**	**0.98%**

Table 31 - Total sulfur analysis for West Angelas EL 798

Strand-tag group	Number of Samples assayed for S	Number of samples with S>0.1%	Percentage of samples with S>0.1%	Number of samples with S>0.3%	Percentage of total with S>0.3%	Average S for samples with S>0.1%
ALLUVIUM	1003	12	1.20	2	0.20	0.27
CLAY	307	6	1.95	2	0.65	0.29
CALCRETE	31	0	0.00	0	0.00	-
DET WASTE	259	1	0.39	0	0.00	0.18
DET ORE	**150**	**6**	**4.00**	2	1.33	0.59
PISOLITE	243	0	0.00	0	0.00	-
WEELI WOLLI	313	1	0.32	0	0.00	0.21
YANDICOOGINA SHAL	**18**	**1**	**5.56**	0	0.00	0.11
BROCKMAN IF	16	0	0.00	0	0.00	-
MCS	**115**	**7**	**6.09**	2	1.74	0.27
MTS	**32**	**6**	**18.75**	0	0.00	0.15
WD	**149**	**17**	**11.41**	4	2.68	0.36
UNKNOWN	1	0	0.00	0	0.00	-

Total number of samples assayed for S	**2637**	**2637**
Total number of samples with S>0.1/0.03%	**57**	**12**
Percentage of total with S>0.1/0.3%	**2.16%**	**0.46%**
Total number of waste samples assayed for S**	**2486**	**2486**
Total number of waste samples with S>0.1/0.3%	**51**	**10**
Percentage of total waste samples with S>0.1/0.3%	**2.05%**	**0.40%**

Table 32 - Total sulfur analysis for West Angleas EL 986

Strand-tag group	Number of Samples assayed for S	Number of samples with S>0.1%	Percentage of samples with S>0.1%	Number of samples with S>0.3%	Percentage of total with S>0.3%	Average S for samples with S>0.1%
ALLUVIUM	**107**	**61**	**57.01**	10	9.35	0.17
DET WASTE	**2844**	**330**	**11.60**	33	1.16	0.18
DET ORE	521	1	0.19	0	0.00	0.19
DG WASTE	**37**	**4**	**10.81**	1	2.70	0.15
DG HYD	195	0	0.00	0	0.00	0.13
MCS	537	11	2.05	0	0.00	0.16
MTS	38	0	0.00	0	0.00	0.14
WD	94	2	2.13	0	0.00	0.13
UNKNOWN	**1611**	**57**	**3.54**	1	0.06	0.23

Total number of samples assayed for S	**5984**	**5984**
Total number of samples with S>0.1/0.03%	**466**	**45**
Percentage of total with S>0.1/0.3%	**7.79%**	**0.75%**
Total number of waste samples assayed for S**	**3657**	**3657**
Total number of waste samples with S>0.1/0.3%	**408**	**44**
Percentage of total waste samples with S>0.1/0.3%	**11.16%**	**1.20%**

Appendix 2 – AMD Hazard Scorecards

Project Name	West Angelas Deposit A	
Assessment Date	18/03/2014	
Compiled by	Steven Lee	
Final ARD Hazard Assessment	LOW	

Version Date: 13/02/12
Version Number: 2

RTIO ARD Hazard Score

1. Preliminary Assessment (Order of Magnitude/Exploration)

A. Preliminary Geology Hazard

	Select Relevant Option Below	Score	Option Details
Ore Deposit Type	C) Enriched Marra Mamba Formation and Joffre Member, and/or channel and detrital ore bodies mined below the water table (un-oxidised lignite and black shales other than Mt McRae may be present). Enriched Dales Gorge Member mined above the water table only	14	Moderate / moderate
Host & Country Rock Neutralising Potential	None (<5%)	10	
Brownfield's / Greenfields	Brownfield		
Known ARD Issues on Site	No	0	
		Geology Hazard Score	**24**

Complete following sections

B. Incipient ARD Risk

	Select Relevant Option Below	Score
Operation Age	10 -20 years	2

**By default, all new projects should receive a <5 years value*

C. Scale of Disturbance

	Select Relevant Option Below	Score	
Total Waste Stored	250 - 1 billions tonnes	10	
Footprint	250 - 1000 hectares	6	From Referral document

D. Transport Pathways

	Select Relevant Option Below	Score
Project / Exploration?	No	
Precipitation / Areal Potential Evapo-transpiration Ratio	1/10 to 1/3 ratio_mining below the water table in an aquitard or an isolated local aquifer	2

**All new projects should respond Yes to Project / Exploration*

E. Sensitivity of Receiving Environment

	Select Relevant Option Below	Score	
Distance to Perennial/Ephemeral Water Bodies	>2000 metres	0	Approx. 6km
Alkalinity	10 - 35 mg/L	3	estimated
Distance to closest protected / permanently inhabited area	>10000 metres	0	

Preliminary Hazard Assessment

Preliminary Hazard Score	47
Preliminary Risk Assessment	MODERATE

2. Detailed Assessment (Pre Feasibility/ Feasibility/Mining)

This assessment should be completed by an ARD expert

Pit	**West Angelas Deposit A**

F. Geochemical Hazard (Interrogate the drill hole database)

	Select Relevant Option Below	Score	Option Details
Waste sulfur risk	Total number of waste samples with S>0.1% is between 3% and 10%, less than 0.5% of samples have S>0.3%	2	3.4% of waste samples with sulfur greater than 0.1%, 0.34% with sulfur greater than 0.3%
Ore grade sulfur risk	Total number of ore grade samples with S>0.1% is less than 3%	0	
Spatial distribution of sulfur	Sulfur scattered throughout the pit and through numerous lithologies	3	Elevated-sulfur in other rock types likely to be in the form of sulfate.
Chemical enrichment	Enrichments of contaminants that are unlikely to mobilise into groundwater	1	Unlikely that sulfidic material will be exposed

G. Mine Planning Hazard

	Select Relevant Option Below	Score	Option Details
PAF material management	No special waste management needed	0	No sulfides expected to be mined
Bulk NPR (Mass of neutralising material x mean ANC) / (Percent of lithology greater than 0.1% x tonnes of lithology x mean sulfur concentration for all data greater than 0.1 x 30.6 + repeat for each PAF lithologies)	>3	0	No sulfides expected to be mined
PAF rock mass disturbed or exposed (waste tonnes with S>0.1%)/(total tonnes of waste)*100	< 3% of the total disturbed mass	0	No sulfides expected to be mined
Pit backfilling	Pit will not be backfilled	5	No commitment to backfill pits

H. Water Management Hazard

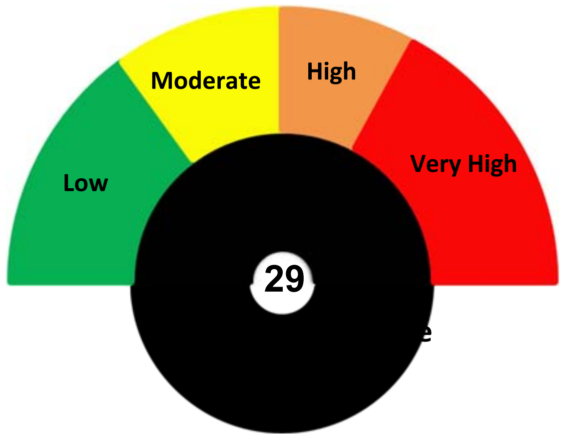
	Select Relevant Option Below	Score	Option Details
Dewatering volume	0 to 80 ML/day	1	
Surface water	Catchment area above the pit	5	Lower risk due to sump before Dep E, limiting flow through to Dep A.
Water treatment during Operation	No water treatment or special management for ARD needed	0	No Black shale expected to be encountered
Final void management	No PAF rock exposures likely on final pit shell	0	No Black shale expected to be encountered

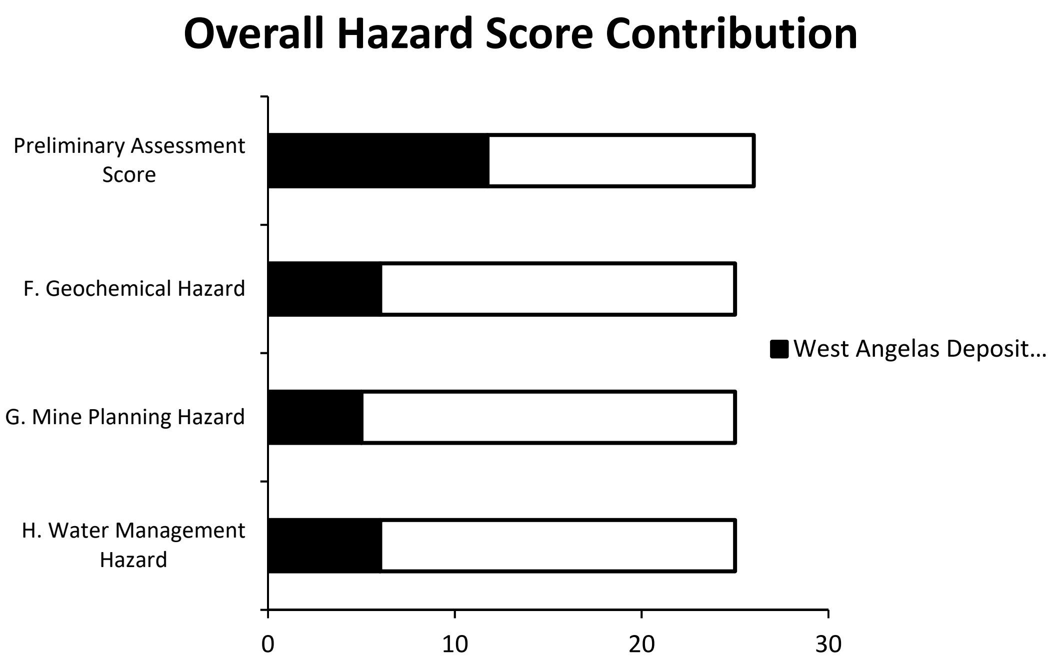
Combined Hazard Assessment

Preliminary Assessment Score	47
Detailed Assessment Score	17
Combined Hazard Score	29
Risk Ranking	**LOW**

This risk ranking score card is relevant for Pilbara based iron ore operations and the ranking system can be used to assess the relative risk of each operation. The ranking system is likely to overestimate the risk if compared to porphry copper or some coal deposits.

For RTIO internal distribution only. The manager of Technical Projects and Development will need to review and approve this prior to external release. This risk assessment should be read in conjunction with the detailed ARD Risk Assessment


Moderate
High
Low
Very High
29


Overall Hazard Score Contribution
Preliminary Assessment Score
F. Geochemical Hazard
G. Mine Planning Hazard
H. Water Management Hazard
West Angelas Deposit...
0
10
20
30

Project Name	West Angelas Deposit E
Assessment Date	18/03/2014
Compiled by	Steven Lee
Final ARD Hazard Assessment	**LOW**

Version Date: 13/02/12
Version Number: 2

RTIO ARD Hazard Score

1. Preliminary Assessment (Order of Magnitude/Exploration)

A. Preliminary Geology Hazard

	Select Relevant Option Below	Score	Option Details
Ore Deposit Type	C) Enriched Marra Mamba Formation and Joffre Member, and/or channel and detrital ore bodies mined below the water table (un-oxidised lignite and black shales other than Mt McRae may be present). Enriched Dales Gorge Member mined above the water table only	14	Moderate / moderate
Host & Country Rock Neutralising Potential	None (<5%)	10	
Brownfield's / Greenfields	Brownfield		
Known ARD Issues on Site	No	0	
		Geology Hazard Score	**24**

Complete following sections

B. Incipient ARD Risk

	Select Relevant Option Below	Score
Operation Age	< 5 years	5

**By default, all new projects should receive a <5 years value*

C. Scale of Disturbance

	Select Relevant Option Below	Score
Total Waste Stored	50 - 250 million tonnes	5
Footprint	250 - 1000 hectares	6

D. Transport Pathways

	Select Relevant Option Below	Score
Project / Exploration?	No	
Precipitation / Areal Potential Evapo-transpiration Ratio	1/10 to 1/3 ratio_mining below the water table in an aquitard or an isolated local aquifer	2

**All new projects should respond Yes to Project / Exploration*

E. Sensitivity of Receiving Environment

	Select Relevant Option Below	Score	
Distance to Perennial/Ephemeral Water Bodies	>2000 metres	0	
Alkalinity	10 - 35 mg/L	3	estimated
Distance to closest protected / permanently inhabited area	>10000 metres	0	

Preliminary Hazard Assessment

Preliminary Hazard Score	45
Preliminary Risk Assessment	**MODERATE**

2. Detailed Assessment (Pre Feasibility/ Feasibility/Mining)

This assessment should be completed by an ARD expert

Pit	West Angelas Deposit E

F. Geochemical Hazard (Interrogate the drill hole database)

	Select Relevant Option Below	Score	Option Details
Waste sulfur risk	Total number of waste samples with S>0.1% is less than 3%	0	1.7% of waste samples with sulfur greater than 0.1%
Ore grade sulfur risk	Total number of ore grade samples with S>0.1% is less than 3%	0	
Spatial distribution of sulfur	Sulfur scattered throughout the pit and through numerous lithologies	3	Elevated-sulfur in other rock types likely to be in the form of sulfate.
Chemical enrichment	Enrichments of contaminants that are unlikely to mobilise into groundwater	1	Unlikely that sulfidic material will be exposed

G. Mine Planning Hazard

	Select Relevant Option Below	Score	Option Details
PAF material management	No special waste management needed	0	No sulfides expected to be mined
Bulk NPR (Mass of neutralising material x mean ANC) / (Percent of lithology greater than 0.1% x tonnes of lithology x mean sulfur concentration for all data greater than 0.1 x 30.6 + repeat for each PAF lithologies)	>3	0	No sulfides expected to be mined
PAF rock mass disturbed or exposed (waste tonnes with S>0.1%)/(total tonnes of waste)*100	< 3% of the total disturbed mass	0	No sulfides expected to be mined
Pit backfilling	Pit will not be backfilled	5	No commitment to backfill pits

H. Water Management Hazard

	Select Relevant Option Below	Score	Option Details
Dewatering volume	0 to 80 ML/day	1	
Surface water	Creek flow	7	Waste dump and sump will limit runoff from events up to 20% AEP.
Water treatment during Operation	No water treatment or special management for ARD needed	0	No Black shale expected to be encountered
Final void management	No PAF rock exposures likely on final pit shell	0	No Black shale expected to be encountered

Combined Hazard Assessment

Preliminary Assessment Score	45
Detailed Assessment Score	17
Combined Hazard Score	28
Risk Ranking	LOW

This risk ranking score card is relevant for Pilbara based iron ore operations and the ranking system can be used to assess the relative risk of each operation. The ranking system is likely to overestimate the risk if compared to porphry copper or some coal deposits.

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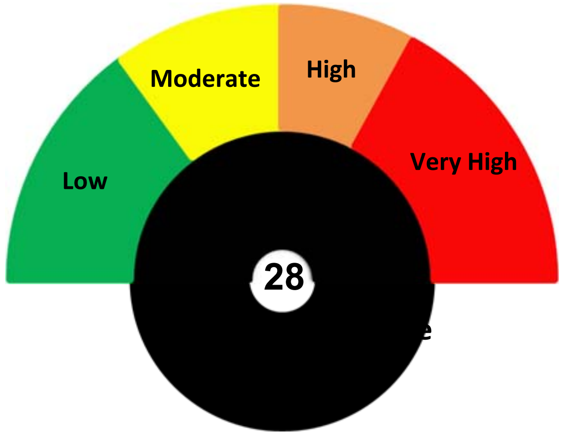
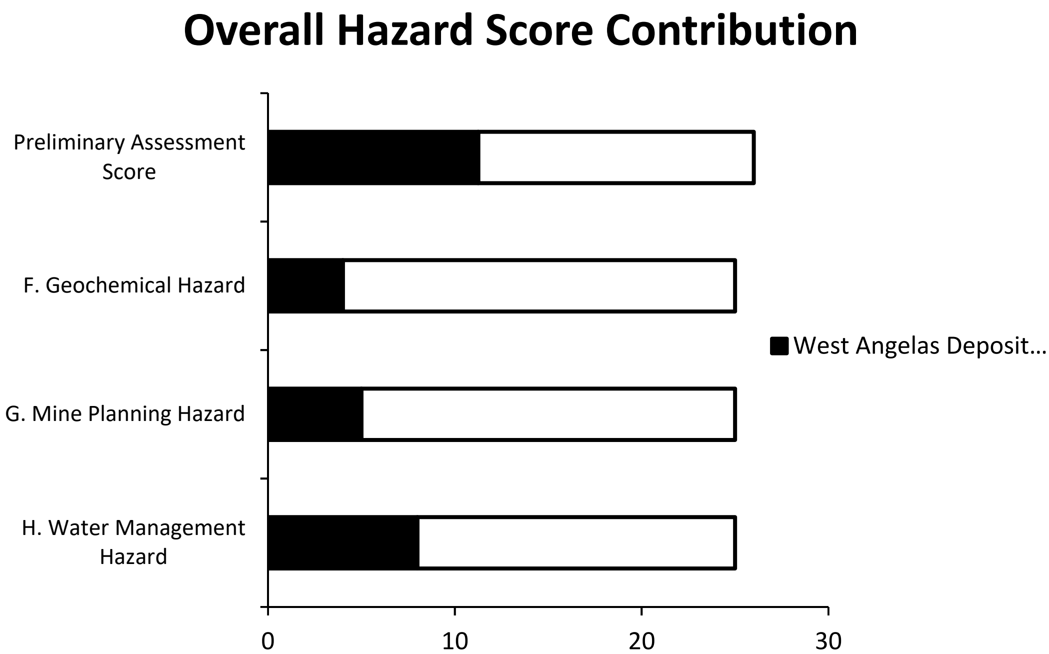

Moderate
High
Low
Very High
28


Overall Hazard Score Contribution
Preliminary Assessment Score
F. Geochemical Hazard
G. Mine Planning Hazard
H. Water Management Hazard
West Angelas Deposit...
0
10
20
30

Project Name	West Angelas Deposit B	
Assessment Date	18/03/2014	
Compiled by	Steven Lee	
Final ARD Hazard Assessment	**LOW**	

Version Date: 13/02/12
Version Number: 2

RTIO ARD Hazard Score

1. Preliminary Assessment (Order of Magnitude/Exploration)

A. Preliminary Geology Hazard

	Select Relevant Option Below	Score	Option Details
Ore Deposit Type	C) Enriched Marra Mamba Formation and Joffre Member, and/or channel and detrital ore bodies mined below the water table (un-oxidised lignite and black shales other than Mt McRae may be present). Enriched Dales Gorge Member mined above the water table only	14	Moderate / moderate
Host & Country Rock Neutralising Potential	None (<5%)	10	
Brownfield's / Greenfields	Brownfield		
Known ARD Issues on Site	No	0	
		Geology Hazard Score	**24**

Complete following sections

B. Incipient ARD Risk

	Select Relevant Option Below	Score
Operation Age	< 5 years	5

**By default, all new projects should receive a <5 years value*

C. Scale of Disturbance

	Select Relevant Option Below	Score
Total Waste Stored	250 - 1 billions tonnes	10
Footprint	1000 - 3000 hectares	8

D. Transport Pathways

	Select Relevant Option Below	Score
Project / Exploration?	No	
Precipitation / Areal Potential Evapo-transpiration Ratio	1/10 to 1/3 ratio_mining below the water table in an aquitard or an isolated local aquifer	2

**All new projects should respond Yes to Project / Exploration*

E. Sensitivity of Receiving Environment

	Select Relevant Option Below	Score	
Distance to Perennial/Ephemeral Water Bodies	>2000 metres	0	
Alkalinity	10 - 35 mg/L	3	estimated
Distance to closest protected / permanently inhabited area	>10000 metres	0	

Preliminary Hazard Assessment

Preliminary Hazard Score	52
Preliminary Risk Assessment	**MODERATE**

2. Detailed Assessment (Pre Feasibility/ Feasibility/Mining)

This assessment should be completed by an ARD expert

Pit	West Angelas Deposit B

F. Geochemical Hazard (Interrogate the drill hole database)

	Select Relevant Option Below	Score	Option Details
Waste sulfur risk	Total number of waste samples with S>0.1% is between 3% and 10%, less than 0.5% of samples have S>0.3%	2	5.6% with S>0.1, 0.2% with S>0.3%
Ore grade sulfur risk	Total number of ore grade samples with S>0.1% is between 3% and 10% but less than 0.5% of the samples have S>0.3%	2	Approximately 5.4% with S>0.1, 0.1 % with S>0.3%
Spatial distribution of sulfur	Sulfur scattered throughout the pit and through numerous lithologies	3	Elevated-sulfur in other rock types likely to be in the form of sulfate.
Chemical enrichment	Enrichments of contaminants that are unlikely to mobilise into groundwater	1	Unlikely that sulfidic material will be exposed

G. Mine Planning Hazard

	Select Relevant Option Below	Score	Option Details
PAF material management	No special waste management needed	0	No sulfides expected to be mined
Bulk NPR (Mass of neutralising material x mean ANC) / (Percent of lithology greater than 0.1% x tonnes of lithology x mean sulfur concentration for all data greater than 0.1 x 30.6 + repeat for each PAF lithologies)	>3	0	No sulfides expected to be mined
PAF rock mass disturbed or exposed (waste tonnes with S>0.1%)/(total tonnes of waste)*100	< 3% of the total disturbed mass	0	No sulfides expected to be mined
Pit backfilling	Pit will be backfilled to above the post mining water table but below ground surface	2	Planned

H. Water Management Hazard

	Select Relevant Option Below	Score	Option Details
Dewatering volume	0 to 80 ML/day	1	
Surface water	Catchment area above the pit	5	Reduced due to diversion berm and channel desinged to contain 2000 year ARI event.
Water treatment during Operation	No water treatment or special management for ARD needed	0	No Black shale expected to be encountered
Final void management	No PAF rock exposures likely on final pit shell	0	No Black shale expected to be encountered

Combined Hazard Assessment

Preliminary Assessment Score	52
Detailed Assessment Score	16
Combined Hazard Score	29
Risk Ranking	LOW

This risk ranking score card is relevant for Pilbara based iron ore operations and the ranking system can be used to assess the relative risk of each operation. The ranking system is likely to overestimate the risk if compared to porphry copper or some coal deposits.

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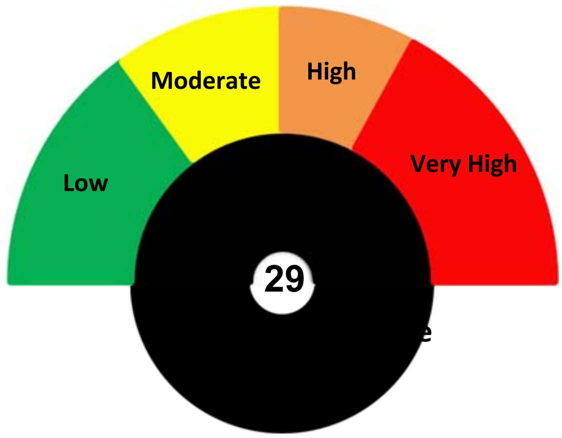
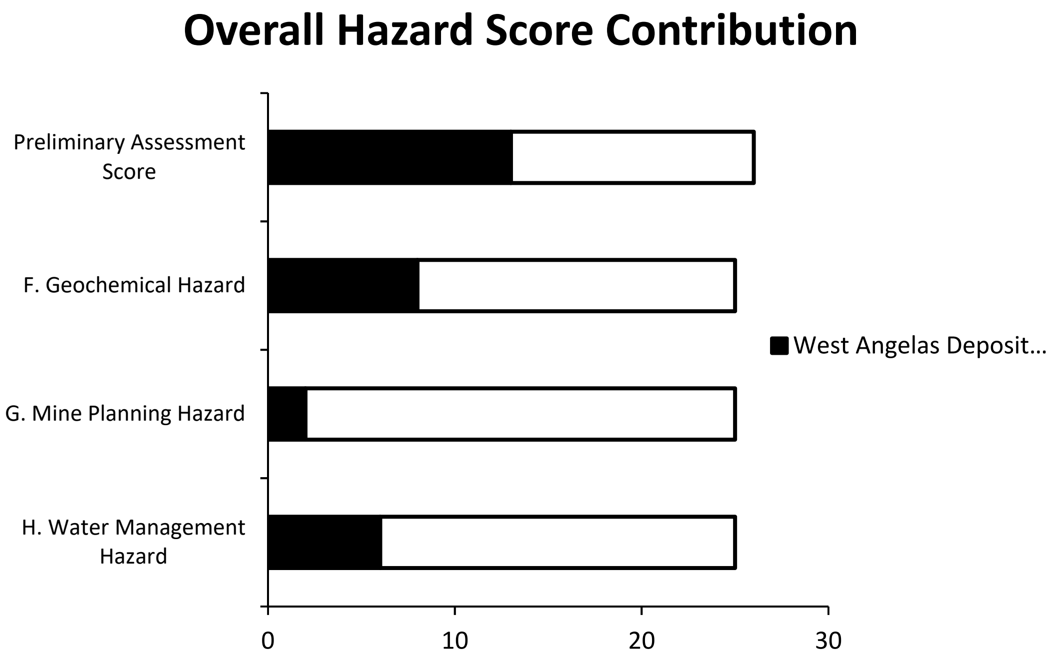

Moderate
High
Low
Very High
29


Overall Hazard Score Contribution
Preliminary Assessment Score
F. Geochemical Hazard
G. Mine Planning Hazard
H. Water Management Hazard
West Angelas Deposit...
0
10
20
30

Project Name	West Angelas Deposit F
Assessment Date	24/03/2014
Compiled by	Steven Lee
Final ARD Hazard Assessment	**LOW**

Version Date: 13/02/12
Version Number: 2

RTIO ARD Hazard Score

1. Preliminary Assessment (Order of Magnitude/Exploration)

A. Preliminary Geology Hazard

	Select Relevant Option Below	Score	Option Details
Ore Deposit Type	C) Enriched Marra Mamba Formation and Joffre Member, and/or channel and detrital ore bodies mined below the water table (un-oxidised lignite and black shales other than Mt McRae may be present). Enriched Dales Gorge Member mined above the water table only	14	Moderate / moderate
Host & Country Rock Neutralising Potential	None (<5%)	10	
Brownfield's / Greenfields	Greenfield		
Known ARD Issues on Site	No	0	
		Geology Hazard Score	**26**

Complete following sections

B. Incipient ARD Risk

	Select Relevant Option Below	Score
Operation Age	< 5 years	5

By default, all new projects should receive a <5 years value

C. Scale of Disturbance

	Select Relevant Option Below	Score
Total Waste Stored	50 - 250 million tonnes	5
Footprint	250 - 1000 hectares	6

D. Transport Pathways

	Select Relevant Option Below	Score
Project / Exploration?	No	
Precipitation / Areal Potential Evapo-transpiration Ratio	1/10 to 1/3 ratio_mining below the water table in an aquitard or an isolated local aquifer	2

All new projects should respond Yes to Project / Exploration

E. Sensitivity of Receiving Environment

	Select Relevant Option Below	Score	
Distance to Perennial/Ephemeral Water Bodies	>2000 metres	0	
Alkalinity	10 - 35 mg/L	3	estimated
Distance to closest protected / permanently inhabited area	>10000 metres	0	

Preliminary Hazard Assessment

Preliminary Hazard Score	47
Preliminary Risk Assessment	**MODERATE**

2. Detailed Assessment (Pre Feasibility/ Feasibility/Mining)

This assessment should be completed by an ARD expert

Pit	West Angelas Deposit F

F. Geochemical Hazard (Interrogate the drill hole database)

	Select Relevant Option Below	Score	Option Details
Waste sulfur risk	Total number of waste samples with S>0.1% is less than 3%	0	0.7% of waste samples with sulfur greater than 0.1%
Ore grade sulfur risk	Total number of ore grade samples with S>0.1% is less than 3%	0	
Spatial distribution of sulfur	Sulfur scattered throughout the pit and through numerous lithologies	3	Elevated-sulfur in other rock types likely to be in the form of sulfate.
Chemical enrichment	Enrichments of contaminants that are unlikely to mobilise into groundwater	1	Unlikely that sulfidic material will be exposed

G. Mine Planning Hazard

	Select Relevant Option Below	Score	Option Details
PAF material management	No special waste management needed	0	No sulfides expected to be mined
Bulk NPR (Mass of neutralising material x mean ANC) / (Percent of lithology greater than 0.1% x tonnes of lithology x mean sulfur concentration for all data greater than 0.1 x 30.6 + repeat for each PAF lithologies)	>3	0	No sulfides expected to be mined
PAF rock mass disturbed or exposed (waste tonnes with S>0.1%)/(total tonnes of waste)*100	< 3% of the total disturbed mass	0	No sulfides expected to be mined
Pit backfilling	Pit will not be backfilled	5	No commitment to backfill pits

H. Water Management Hazard

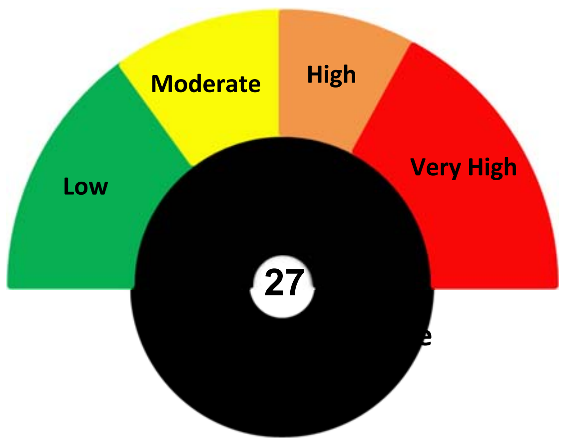
	Select Relevant Option Below	Score	Option Details
Dewatering volume	0 to 80 ML/day	1	
Surface water	Catchment area above the pit	5	
Water treatment during Operation	No water treatment or special management for ARD needed	0	No Black shale expected to be encountered
Final void management	No PAF rock exposures likely on final pit shell	0	No Black shale expected to be encountered

Combined Hazard Assessment

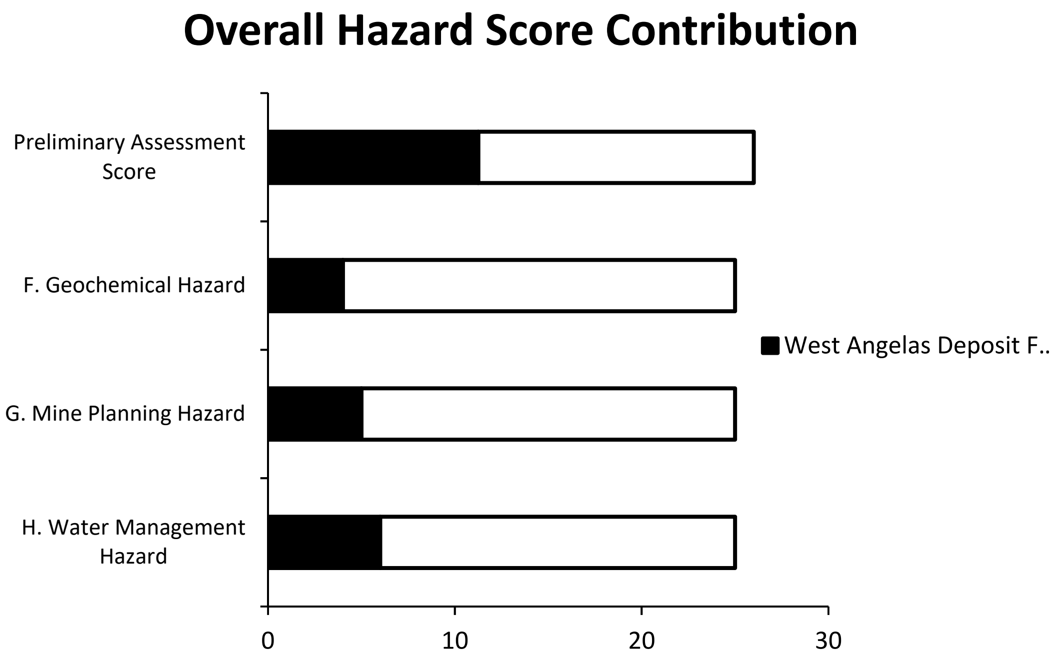
Preliminary Assessment Score	47
Detailed Assessment Score	15
Combined Hazard Score	27
Risk Ranking	LOW

This risk ranking score card is relevant for Pilbara based iron ore operations and the ranking system can be used to assess the relative risk of each operation. The ranking system is likely to overestimate the risk if compared to porphry copper or some coal deposits.

For RTIO internal distribution only. The manager of Technical Projects and Development will need to review and approve this prior to external release. This risk assessment should be read in conjunction with the detailed ARD Risk Assessment



Moderate
High
Low
Very High
27



Overall Hazard Score Contribution
Preliminary Assessment Score
F. Geochemical Hazard
G. Mine Planning Hazard
H. Water Management Hazard
West Angelas Deposit F..
0
10
20
30

Project Name	West Angelas Deposit A West
Assessment Date	24/03/2014
Compiled by	Steven Lee
Final ARD Hazard Assessment	**LOW**

Version Date: 13/02/12
Version Number: 2

RTIO ARD Hazard Score

1. Preliminary Assessment (Order of Magnitude/Exploration)

A. Preliminary Geology Hazard

	Select Relevant Option Below	Score	Option Details
Ore Deposit Type	C) Enriched Marra Mamba Formation and Joffre Member, and/or channel and detrital ore bodies mined below the water table (un-oxidised lignite and black shales other than Mt McRae may be present). Enriched Dales Gorge Member mined above the water table only	14	Moderate / moderate
Host & Country Rock Neutralising Potential	None (<5%)	10	
Brownfield's / Greenfields	Greenfield		
Known ARD Issues on Site	No	0	
		Geology Hazard Score	**26**

Complete following sections

B. Incipient ARD Risk

	Select Relevant Option Below	Score
Operation Age	< 5 years	5

**By default, all new projects should receive a <5 years value*

C. Scale of Disturbance

	Select Relevant Option Below	Score
Total Waste Stored	50 - 250 million tonnes	5
Footprint	250 - 1000 hectares	6

D. Transport Pathways

	Select Relevant Option Below	Score
Project / Exploration?	No	
Precipitation / Areal Potential Evapo-transpiration Ratio	1/10 to 1/3 ratio_mining below the water table in an aquitard or an isolated local aquifer	2

**All new projects should respond Yes to Project / Exploration*

E. Sensitivity of Receiving Environment

	Select Relevant Option Below	Score	
Distance to Perennial/Ephemeral Water Bodies	>2000 metres	0	
Alkalinity	10 - 35 mg/L	3	estimated
Distance to closest protected / permanently inhabited area	>10000 metres	0	

Preliminary Hazard Assessment

Preliminary Hazard Score	47
Preliminary Risk Assessment	**MODERATE**

2. Detailed Assessment (Pre Feasibility/ Feasibility/Mining)

This assessment should be completed by an ARD expert

Pit	West Angelas Deposit A West

F. Geochemical Hazard (Interrogate the drill hole database)

	Select Relevant Option Below	Score	Option Details
Waste sulfur risk	Total number of waste samples with S>0.1% is less than 3%	0	1.0% of waste samples with sulfur greater than 0.1%
Ore grade sulfur risk	Total number of ore grade samples with S>0.1% is less than 3%	0	
Spatial distribution of sulfur	Sulfur scattered throughout the pit and through numerous lithologies	3	Elevated-sulfur in other rock types likely to be in the form of sulfate.
Chemical enrichment	Enrichments of contaminants that are unlikely to mobilise into groundwater	1	Unlikely that sulfidic material will be exposed

G. Mine Planning Hazard

	Select Relevant Option Below	Score	Option Details
PAF material management	No special waste management needed	0	No sulfides expected to be mined
Bulk NPR (Mass of neutralising material x mean ANC) / (Percent of lithology greater than 0.1% x tonnes of lithology x mean sulfur concentration for all data greater than 0.1 x 30.6 + repeat for each PAF lithologies)	>3	0	No sulfides expected to be mined
PAF rock mass disturbed or exposed (waste tonnes with S>0.1%)/(total tonnes of waste)*100	< 3% of the total disturbed mass	0	No sulfides expected to be mined
Pit backfilling	Pit will not be backfilled	5	worst case scenario

H. Water Management Hazard

	Select Relevant Option Below	Score	Option Details
Dewatering volume	0 to 80 ML/day	1	
Surface water	Catchment area above the pit	5	
Water treatment during Operation	No water treatment or special management for ARD needed	0	No Black shale expected to be encountered
Final void management	No PAF rock exposures likely on final pit shell	0	No Black shale expected to be encountered

Combined Hazard Assessment

Preliminary Assessment Score	47
Detailed Assessment Score	15
Combined Hazard Score	27
Risk Ranking	LOW

This risk ranking score card is relevant for Pilbara based iron ore operations and the ranking system can be used to assess the relative risk of each operation. The ranking system is likely to overestimate the risk if compared to porphry copper or some coal deposits.

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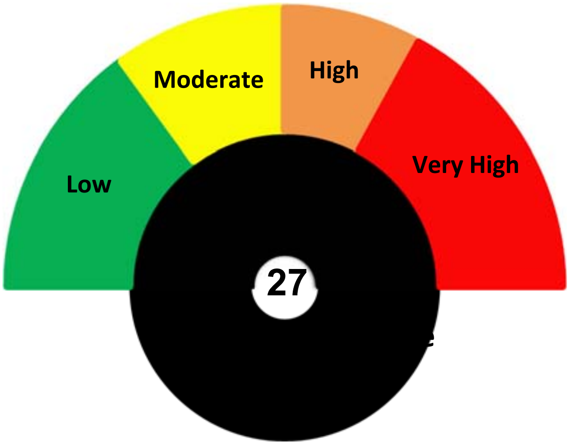
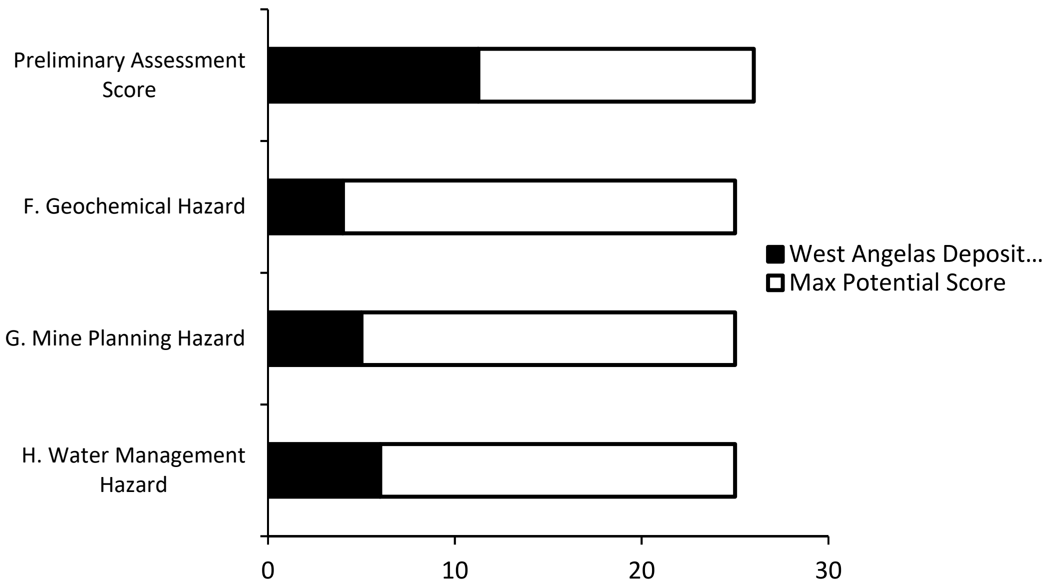


Overall Hazard Score Contribution



Project Name	West Angelas Deposit D
Assessment Date	29/09/2016
Compiled by	Steven Lee
Final ARD Hazard Assessment	**LOW**

Version Date: 13/02/12
Version Number: 2

RTIO ARD Hazard Score

1. Preliminary Assessment (Order of Magnitude/Exploration)

A. Preliminary Geology Hazard

	Select Relevant Option Below	Score	Option Details
Ore Deposit Type	C) Enriched Marra Mamba Formation and Joffre Member, and/or channel and detrital ore bodies mined below the water table (un-oxidised lignite and black shales other than Mt McRae may be present). Enriched Dales Gorge Member mined above the water table only	14	Moderate / moderate
Host & Country Rock Neutralising Potential	None (<5%)	10	
Brownfield's / Greenfields	Greenfield		
Known ARD Issues on Site	No	0	
		Geology Hazard Score	**26**

Complete following sections

B. Incipient ARD Risk

	Select Relevant Option Below	Score
Operation Age	< 5 years	5

By default, all new projects should receive a <5 years value

C. Scale of Disturbance

	Select Relevant Option Below	Score
Total Waste Stored	50 - 250 million tonnes	5
Footprint	250 - 1000 hectares	6

D. Transport Pathways

	Select Relevant Option Below	Score
Project / Exploration?	No	
Precipitation / Areal Potential Evapo-transpiration Ratio	1/10 to 1/3 ratio_mining below the water table in a rock mass that is connected to a regionally significant aquifer	3

All new projects should respond Yes to Project / Exploration

E. Sensitivity of Receiving Environment

	Select Relevant Option Below	Score	
Distance to Perennial/Ephemeral Water Bodies	>2000 metres	0	
Alkalinity	10 - 35 mg/L	3	estimated
Distance to closest protected / permanently inhabited area	>10000 metres	0	

Preliminary Hazard Assessment

Preliminary Hazard Score	48
Preliminary Risk Assessment	**MODERATE**

2. Detailed Assessment (Pre Feasibility/ Feasibility/Mining)

This assessment should be completed by an ARD expert

Pit	West Angelas Deposit D

F. Geochemical Hazard (Interrogate the drill hole database)

	Select Relevant Option Below	Score	Option Details
Waste sulfur risk	Total number of waste samples with S>0.1% is less than 3%	0	1.3% of waste samples with sulfur greater than 0.1%
Ore grade sulfur risk	Total number of ore grade samples with S>0.1% is less than 3%	0	
Spatial distribution of sulfur	Sulfur scattered throughout the pit and through numerous lithologies	3	Elevated-sulfur in other rock types likely to be in the form of sulfate.
Chemical enrichment	Enrichments of contaminants that are unlikely to mobilise into groundwater	1	No PAF material to be encountered

G. Mine Planning Hazard

	Select Relevant Option Below	Score	Option Details
PAF material management	No special waste management needed	0	No PAF material to be encountered
Bulk NPR (Mass of neutralising material x mean ANC) / (Percent of lithology greater than 0.1% x tonnes of lithology x mean sulfur concentration for all data greater than 0.1 x 30.6 + repeat for each PAF lithologies)	>3	0	No PAF material to be encountered
PAF rock mass disturbed or exposed (waste tonnes with S>0.1%)/(total tonnes of waste)*100	< 3% of the total disturbed mass	0	No PAF material to be encountered
Pit backfilling	Pit will not be backfilled	5	No commitment to backfill pits

H. Water Management Hazard

	Select Relevant Option Below	Score	Option Details
Dewatering volume	0 to 80 ML/day	1	
Surface water	Creek flow	7	
Water treatment during Operation	No water treatment or special management for ARD needed	0	No PAF material to be encountered
Final void management	No PAF rock exposures likely on final pit shell	0	No PAF material to be encountered

Combined Hazard Assessment

Preliminary Assessment Score	48
Detailed Assessment Score	17
Combined Hazard Score	29
Risk Ranking	LOW

This risk ranking score card is relevant for Pilbara based iron ore operations and the ranking system can be used to assess the relative risk of each operation. The ranking system is likely to overestimate the risk if compared to porphry copper or some coal deposits.

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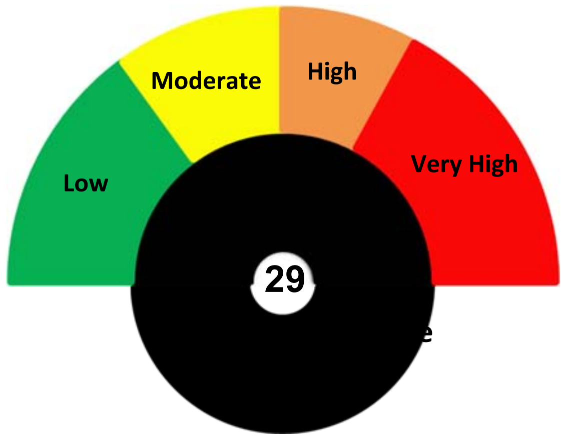
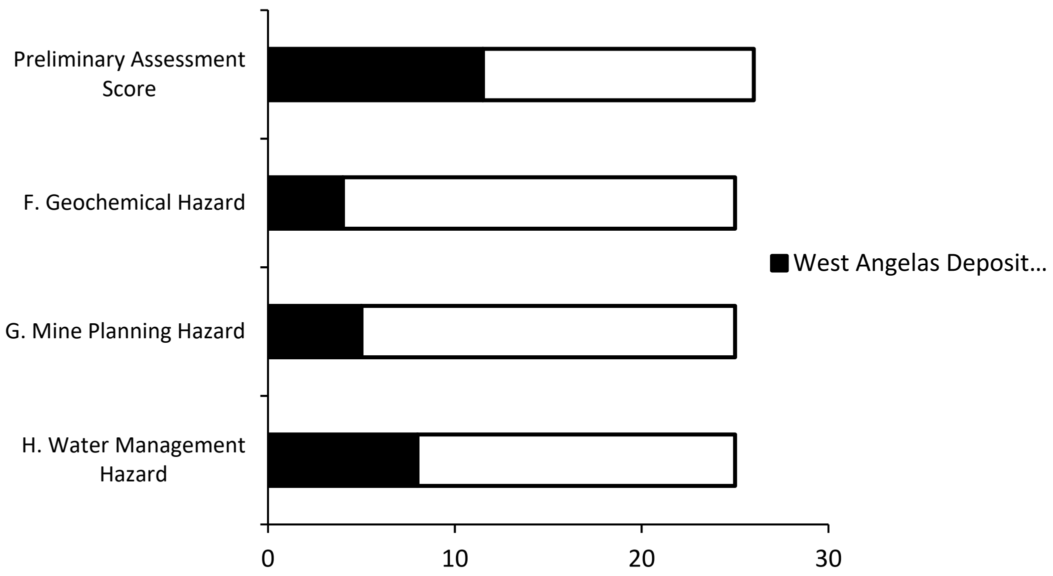


Overall Hazard Score Contribution



Project Name	West Angelas Deposit C	
Assessment Date	29/09/2016	
Compiled by	Steven Lee	
Final ARD Hazard Assessment	**LOW**	

Version Date: 13/02/12
Version Number: 2

RTIO ARD Hazard Score

1. Preliminary Assessment (Order of Magnitude/Exploration)

A. Preliminary Geology Hazard

	Select Relevant Option Below	Score	Option Details
Ore Deposit Type	C) Enriched Marra Mamba Formation and Joffre Member, and/or channel and detrital ore bodies mined below the water table (un-oxidised lignite and black shales other than Mt McRae may be present). Enriched Dales Gorge Member mined above the water table only	14	Moderate / moderate
Host & Country Rock Neutralising Potential	None (<5%)	10	
Brownfield's / Greenfields	Greenfield		
Known ARD Issues on Site	No	0	
		Geology Hazard Score	**26**

Complete following sections

B. Incipient ARD Risk

	Select Relevant Option Below	Score
Operation Age	< 5 years	5

**By default, all new projects should receive a <5 years value*

C. Scale of Disturbance

	Select Relevant Option Below	Score	
Total Waste Stored	50 - 250 million tonnes	5	Estimated 159 Mt
Footprint	250 - 1000 hectares	6	

D. Transport Pathways

	Select Relevant Option Below	Score
Project / Exploration?	No	
Precipitation / Areal Potential Evapo-transpiration Ratio	1/10 to 1/3 ratio_mining below the water table in a rock mass that is connected to a regionally significant aquifer	3

**All new projects should respond Yes to Project / Exploration*

E. Sensitivity of Receiving Environment

	Select Relevant Option Below	Score	
Distance to Perennial/Ephemeral Water Bodies	>2000 metres	0	Approx. 13km
Alkalinity	>35 mg/L	1	estimated
Distance to closest protected / permanently inhabited area	>10000 metres	0	Newman

Preliminary Hazard Assessment

Preliminary Hazard Score	46
Preliminary Risk Assessment	**MODERATE**

2. Detailed Assessment (Pre Feasibility/ Feasibility/Mining)

This assessment should be completed by an ARD expert

Pit	West Angelas Deposit C

F. Geochemical Hazard (Interrogate the drill hole database)

	Select Relevant Option Below	Score	Option Details
Waste sulfur risk	Total number of waste samples with S>0.1% is less than 3%	0	0.55% of Waste samples have sulfur greater than 0.1%
Ore grade sulfur risk	Total number of ore grade samples with S>0.1% is less than 3%	0	0.5% of Ore samples have sulfur greater than 0.1%
Spatial distribution of sulfur	Sulfur scattered throughout the pit and through numerous lithologies	3	Elevated-sulfur in other rock types likely to be in the form of sulfate.
Chemical enrichment	Enrichments of contaminants that are unlikely to mobilise into groundwater	1	Release of metals controlled by weathering and dissolution

G. Mine Planning Hazard

	Select Relevant Option Below	Score	Option Details
PAF material management	No special waste management needed	0	No PAF material expected to be encountered
Bulk NPR (Mass of neutralising material x mean ANC) / (Percent of lithology greater than 0.1% x tonnes of lithology x mean sulfur concentration for all data greater than 0.1 x 30.6 + repeat for each PAF lithologies)	>3	0	No PAF material expected to be encountered
PAF rock mass disturbed or exposed (waste tonnes with S>0.1%)/(total tonnes of waste)*100	< 3% of the total disturbed mass	0	No PAF material expected to be encountered
Pit backfilling	Pit will not be backfilled	5	No commitment to backfill pits

H. Water Management Hazard

	Select Relevant Option Below	Score	Option Details
Dewatering volume	0 to 80 ML/day	1	Above Water Table mining only
Surface water	Creek flow	7	Diversion of Turee Creek East required
Water treatment during Operation	No water treatment or special management for ARD needed	0	No PAF material to be encountered
Final void management	No PAF rock exposures likely on final pit shell	0	No PAF material to be encountered

Combined Hazard Assessment

Preliminary Assessment Score	46
Detailed Assessment Score	17
Combined Hazard Score	29
Risk Ranking	LOW

This risk ranking score card is relevant for Pilbara based iron ore operations and the ranking system can be used to assess the relative risk of each operation. The ranking system is likely to overestimate the risk if compared to porphry copper or some coal deposits.

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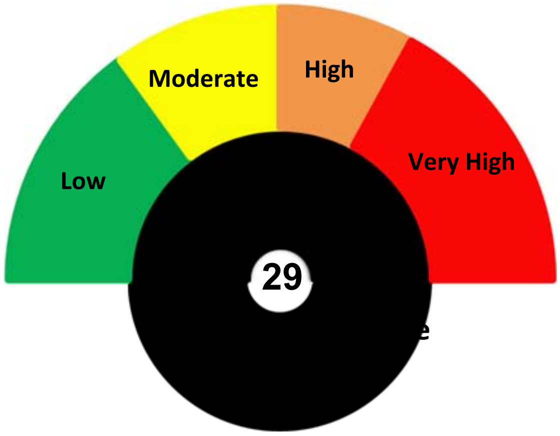
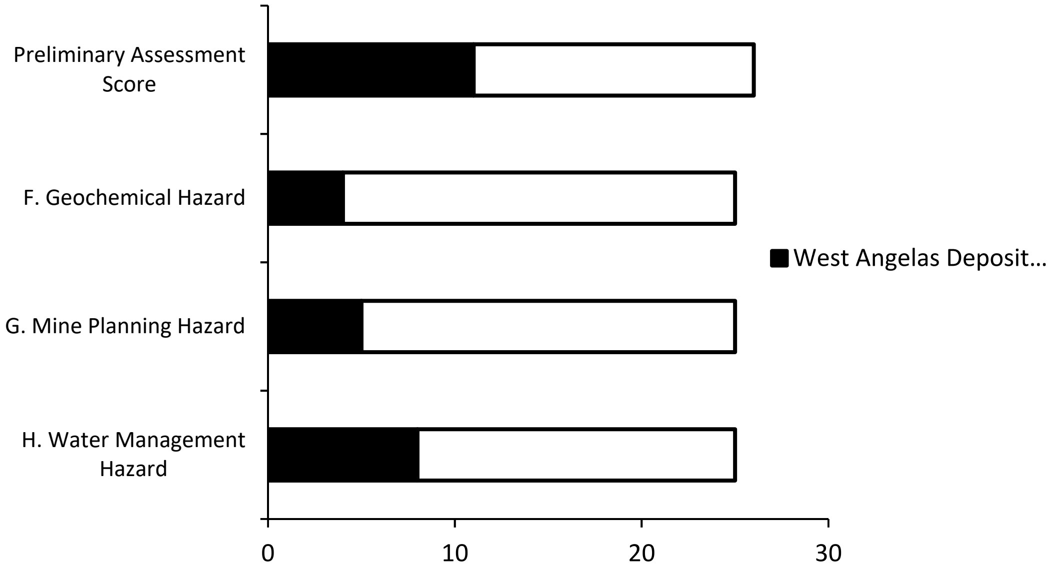
This risk assessment should be read in conjunction with the detailed AMD Risk Assessment



Overall Hazard Score Contribution



Project Name	West Angelas Deposit G	
Assessment Date	29/09/2016	
Compiled by	Steven Lee	
Final ARD Hazard Assessment	**LOW**	

Version Date: 13/02/12
Version Number: 2

RTIO ARD Hazard Score

1. Preliminary Assessment (Order of Magnitude/Exploration)

A. Preliminary Geology Hazard

	Select Relevant Option Below	Score	Option Details
Ore Deposit Type	B) Enriched Marra Mamba Formation and Joffre Member, and/or channel and detrital ore bodies mined above water table only (no Mt McRae Shale present and all rock types likely oxidised).	7	Low / moderate
Host & Country Rock Neutralising Potential	None (<5%)	10	
Brownfield's / Greenfields	Greenfield		
Known ARD Issues on Site	No	0	
		Geology Hazard Score	19

Complete following sections

B. Incipient ARD Risk

	Select Relevant Option Below	Score
Operation Age	< 5 years	5

By default, all new projects should receive a <5 years value

C. Scale of Disturbance

	Select Relevant Option Below	Score	
Total Waste Stored	<50 million tonnes	0	Estimated 58 Mt
Footprint	250 - 1000 hectares	6	Based on pit footprint Approx. 270 ha

D. Transport Pathways

	Select Relevant Option Below	Score	
Project / Exploration?	No		
Precipitation / Areal Potential Evapo-transpiration Ratio	1/10 to 1/3 ratio_mining above the water table exclusively	1	AWT Mining only

All new projects should respond Yes to Project / Exploration

E. Sensitivity of Receiving Environment

	Select Relevant Option Below	Score	
Distance to Perennial/Ephemeral Water Bodies	>2000 metres	0	Approx. 6km
Alkalinity	>35 mg/L	1	estimated
Distance to closest protected / permanently inhabited area	>10000 metres	0	Newman

Preliminary Hazard Assessment

Preliminary Hazard Score	32
Preliminary Risk Assessment	**LOW**

2. Detailed Assessment (Pre Feasibility/ Feasibility/Mining)

This assessment should be completed by an ARD expert

Pit	West Angelas Deposit G

F. Geochemical Hazard (Interrogate the drill hole database)

	Select Relevant Option Below	Score	Option Details
Waste sulfur risk	Total number of waste samples with S>0.1% is less than 3%	0	0.55% of Waste samples have sulfur greater than 0.1%
Ore grade sulfur risk	Total number of ore grade samples with S>0.1% is less than 3%	0	0.5% of Ore samples have sulfur greater than 0.1%
Spatial distribution of sulfur	Sulfur scattered throughout the pit and through numerous lithologies	3	Elevated-sulfur in other rock types likely to be in the form of sulfate.
Chemical enrichment	Enrichments of contaminants that are unlikely to mobilise into groundwater	1	Release of metals controlled by weathering and dissolution

G. Mine Planning Hazard

	Select Relevant Option Below	Score	Option Details
PAF material management	No special waste management needed	0	No PAF material expected to be encountered
Bulk NPR (Mass of neutralising material x mean ANC) / (Percent of lithology greater than 0.1% x tonnes of lithology x mean sulfur concentration for all data greater than 0.1 x 30.6 + repeat for each PAF lithologies)	>3	0	No PAF material expected to be encountered
PAF rock mass disturbed or exposed (waste tonnes with S>0.1%)/(total tonnes of waste)*100	< 3% of the total disturbed mass	0	No PAF material expected to be encountered
Pit backfilling	Pit will not be backfilled	5	No commitment to backfill pits

H. Water Management Hazard

	Select Relevant Option Below	Score	Option Details
Dewatering volume	No releases of water	0	Above Water Table mining only
Surface water	Catchment area above the pit	5	
Water treatment during Operation	No water treatment or special management for ARD needed	0	No PAF material to be encountered
Final void management	No PAF rock exposures likely on final pit shell	0	No PAF material to be encountered

Combined Hazard Assessment

Preliminary Assessment Score	32
Detailed Assessment Score	14
Combined Hazard Score	22
Risk Ranking	LOW

This risk ranking score card is relevant for Pilbara based iron ore operations and the ranking system can be used to assess the relative risk of each operation. The ranking system is likely to overestimate the risk if compared to porphry copper or some coal deposits.

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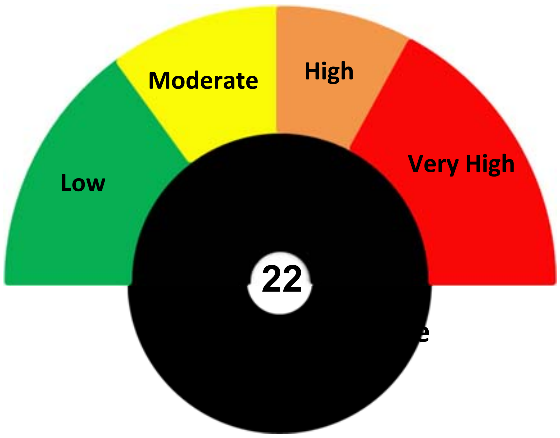
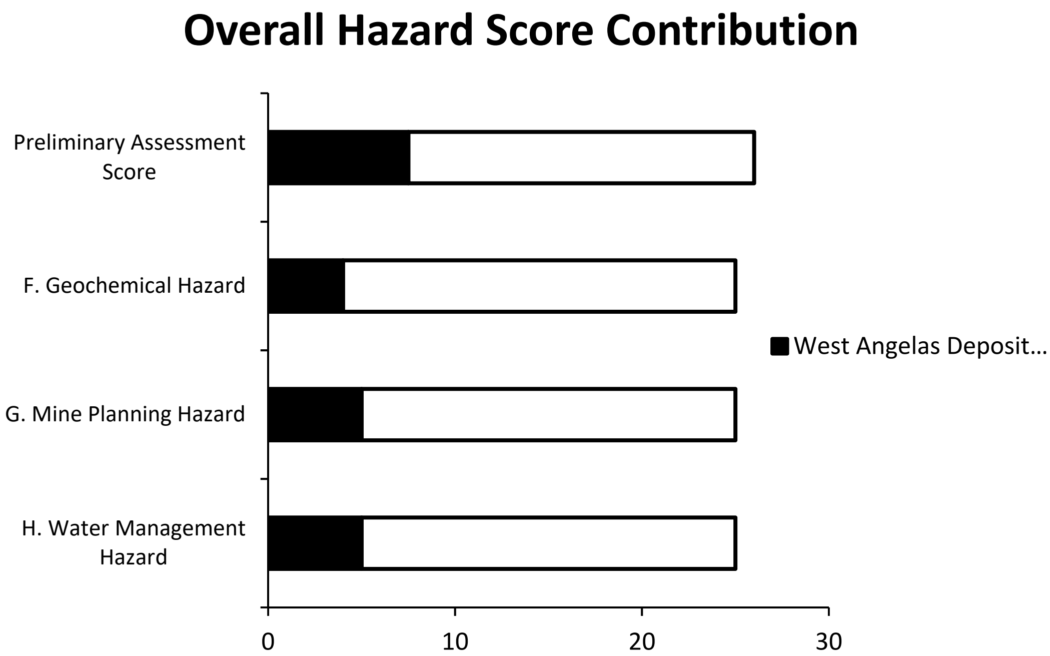

Moderate
High
Low
Very High
22


Overall Hazard Score Contribution
Preliminary Assessment Score
F. Geochemical Hazard
G. Mine Planning Hazard
H. Water Management Hazard
West Angelas Deposit...
0
10
20
30

Project Name	West Angelas Angelo River
Assessment Date	24/03/2014
Compiled by	Steven Lee
Final ARD Hazard Assessment	MODERATE

Version Date: 13/02/12
Version Number: 2

RTIO ARD Hazard Score

1. Preliminary Assessment (Order of Magnitude/Exploration)

A. Preliminary Geology Hazard

	Select Relevant Option Below	Score	Option Details
Ore Deposit Type	C) Enriched Marra Mamba Formation and Joffre Member, and/or channel and detrital ore bodies mined below the water table (un-oxidised lignite and black shales other than Mt McRae may be present). Enriched Dales Gorge Member mined above the water table only	14	Moderate / moderate
Host & Country Rock Neutralising Potential	None (<5%)	10	
Brownfield's / Greenfields	Greenfield		
Known ARD Issues on Site	No	0	
		Geology Hazard Score	26

Complete following sections

B. Incipient ARD Risk

	Select Relevant Option Below	Score
Operation Age	< 5 years	5

By default, all new projects should receive a <5 years value

C. Scale of Disturbance

	Select Relevant Option Below	Score
Total Waste Stored	250 - 1 billions tonnes	10
Footprint	250 - 1000 hectares	6

D. Transport Pathways

	Select Relevant Option Below	Score
Project / Exploration?	No	
Precipitation / Areal Potential Evapo-transpiration Ratio	1/10 to 1/3 ratio_mining below the water table in an aquitard or an isolated local aquifer	2

All new projects should respond Yes to Project / Exploration

E. Sensitivity of Receiving Environment

	Select Relevant Option Below	Score	
Distance to Perennial/Ephemeral Water Bodies	>2000 metres	0	
Alkalinity	10 - 35 mg/L	3	estimated
Distance to closest protected / permanently inhabited area	>10000 metres	0	

Preliminary Hazard Assessment

Preliminary Hazard Score	52
Preliminary Risk Assessment	MODERATE

2. Detailed Assessment (Pre Feasibility/ Feasibility/Mining)

This assessment should be completed by an ARD expert

Pit	West Angelas Angelo River

F. Geochemical Hazard (Interrogate the drill hole database)

	Select Relevant Option Below	Score	Option Details
Waste sulfur risk	Total number of waste samples with S>0.1% is less than 3%	0	1% of waste samples with sulfur greater than 0.1%
Ore grade sulfur risk	Total number of ore grade samples with S>0.1% is less than 3%	0	
Spatial distribution of sulfur	Sulfur scattered throughout the pit and through numerous lithologies	3	Elevated-sulfur in other rock types likely to be in the form of sulfate.
Chemical enrichment	Enrichments of contaminants that are unlikely to mobilise into groundwater	1	Unlikely that sulfidic material will be exposed

G. Mine Planning Hazard

	Select Relevant Option Below	Score	Option Details
PAF material management	No special waste management needed	0	No sulfides expected to be mined
Bulk NPR (Mass of neutralising material x mean ANC) / (Percent of lithology greater than 0.1% x tonnes of lithology x mean sulfur concentration for all data greater than 0.1 x 30.6 + repeat for each PAF lithologies)	>3	0	No sulfides expected to be mined
PAF rock mass disturbed or exposed (waste tonnes with S>0.1%)/(total tonnes of waste)*100	< 3% of the total disturbed mass	0	No sulfides expected to be mined
Pit backfilling	Pit will not be backfilled	5	Closure objective unknown

H. Water Management Hazard

	Select Relevant Option Below	Score	Option Details
Dewatering volume	0 to 80 ML/day	1	
Surface water	Creek flow	7	
Water treatment during Operation	No water treatment or special management for ARD needed	0	No Black shale expected to be encountered
Final void management	No PAF rock exposures likely on final pit shell	0	No Black shale expected to be encountered

Combined Hazard Assessment

Preliminary Assessment Score	52
Detailed Assessment Score	17
Combined Hazard Score	30
Risk Ranking	**MODERATE**

This risk ranking score card is relevant for Pilbara based iron ore operations and the ranking system can be used to assess the relative risk of each operation. The ranking system is likely to overestimate the risk if compared to porphry copper or some coal deposits.

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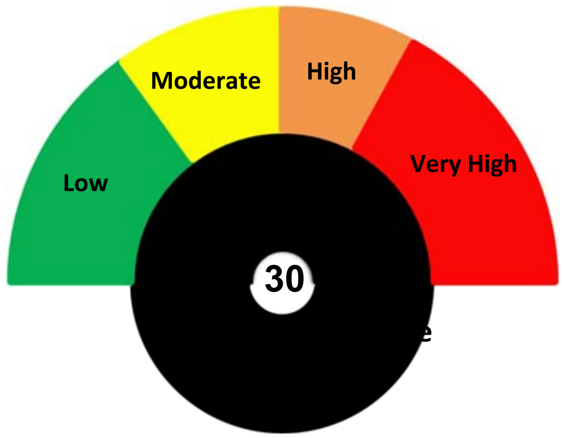
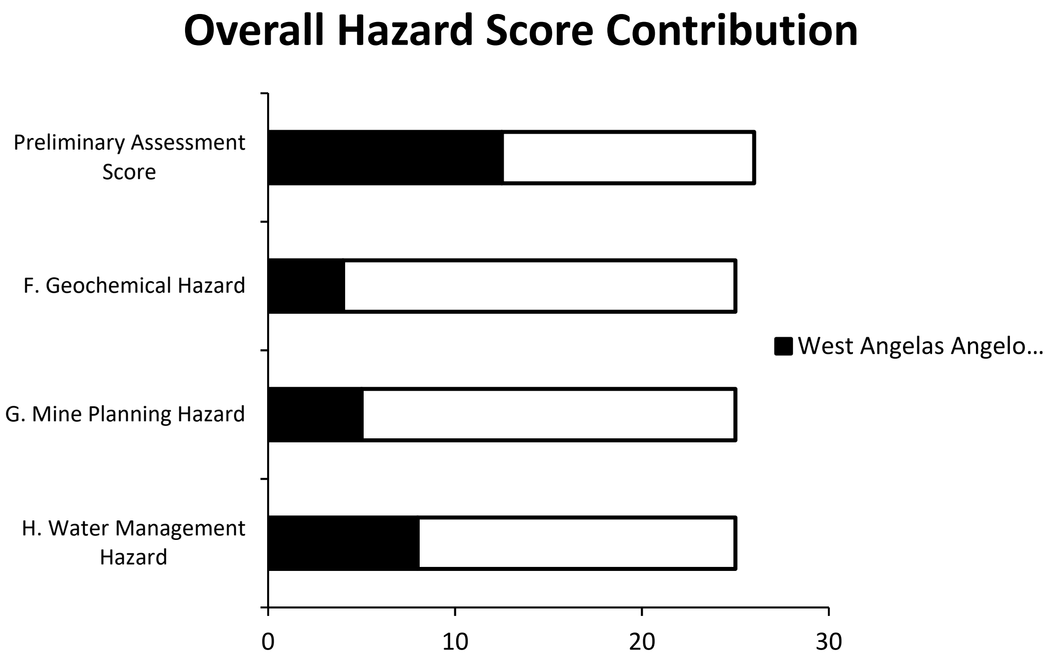

Moderate
High
Low
Very High
30


Overall Hazard Score Contribution
Preliminary Assessment Score
F. Geochemical Hazard
G. Mine Planning Hazard
H. Water Management Hazard
West Angelas Angelo...
0
10
20
30

Appendix 3 - Geochemical Enrichment

West Angelas Deposit A Global Abundance Index

Element/Oxide _Analysis_Units	DET Was Count	DET Was Mean	DET Was Median	DET Was Maximum	DET Was Minimum	Det Ore Count	Det Ore Mean	Det Ore Median	Det Ore Maximum	Det Ore Minimum	Clay Count	Clay Mean	Clay Median	Clay Maximum	Clay Minimum	DOR Count	DOR Mean	DOR Median	DOR Maximum	DOR Minimum	ANG ORE Count	ANG ORE Mean	ANG ORE Median	ANG ORE Maximum	ANG ORE Minimum	ANG Waste Count	ANG Waste Mean	ANG Waste Median	ANG Waste Maximum	ANG Waste Minimum
AL2O3_XRF_pct	52822	15.43	14.38	34.47	0.20	1027	4.89	4.95	9.97	0.61	6	21.91	26.91	31.22	5.41	135	17.25	18.86	23.38	3.24	13066	3.32	3.17	20.86	0.48	41725	12.06	11.00	51.18	0.15
AS_XRF_pct	43059	0.004	0.002	0.038	0.001	777	0.002	0.002	0.021	0.001	6	0.003	0.002	0.006	0.001	123	0.003	0.002	0.015	0.001	9558	0.002	0.002	0.027	0.001	31603	0.005	0.004	0.056	0.001
BA_XRF_pct	43059	0.008	0.006	0.395	0.001	777	0.004	0.004	0.037	0.001	6	0.001	0.001	0.001	0.001	123	0.005	0.001	0.141	0.001	9558	0.002	0.001	0.523	0.001	31603	0.006	0.001	0.828	0.001
CAO_XRF_pct	52822	0.22	0.18	15.38	0.01	1027	0.057	0.050	1.010	0.005	6	0.09	0.09	0.16	0.01	135	0.36	0.08	9.07	0.02	13070	0.02	0.02	1.17	0.01	41748	0.073	0.040	34.590	0.005
CL_XRF_pct	43059	0.007	0.005	1.290	0.001	777	0.009	0.006	0.057	0.001	6	0.003	0.002	0.007	0.001	123	0.004	0.003	0.025	0.001	9558	0.007	0.006	0.137	0.001	31603	0.009	0.006	0.179	0.001
CO_XRF_pct	43059	0.003	0.002	0.025	0.001	777	0.001	0.001	0.010	0.001	6	0.002	0.002	0.002	0.001	123	0.002	0.001	0.039	0.001	9558	0.001	0.001	0.033	0.001	31602	0.002	0.002	0.092	0.001
CR_XRF_pct	43059	0.031	0.030	0.103	0.001	777	0.010	0.009	0.049	0.001	6	0.024	0.027	0.036	0.006	123	0.004	0.002	0.030	0.001	9558	0.005	0.004	0.042	0.001	31603	0.010	0.008	0.096	0.001
CU_XRF_pct	52796	0.008	0.006	0.035	0.001	1026	0.001	0.001	0.011	0.001	6	0.003	0.002	0.005	0.001	135	0.011	0.012	0.034	0.001	13021	0.002	0.001	0.035	0.001	41623	0.004	0.003	4.878	0.001
FE_CALC_pct	52822	29.83	28.93	55.00	5.40	1027	58.01	57.24	65.45	55.01	6	27.93	19.60	55.33	12.54	135	29.81	27.24	57.63	12.77	13079	58.52	58.29	66.52	55.01	41759	40.34	43.64	55.00	0.55
K2O_XRF_pct	52816	0.17	0.13	1.87	0.00	1026	0.02	0.01	0.11	0.001	6	0.03	0.03	0.05	0.00	135	0.25	0.07	2.95	0.003	12991	0.01	0.01	0.53	0.001	41644	0.35	0.04	4.43	0.001
MGO_XRF_pct	52822	0.28	0.23	15.26	0.01	1026	0.06	0.06	0.25	0.01	6	0.18	0.20	0.26	0.08	135	0.49	0.15	6.10	0.07	13069	0.08	0.07	0.90	0.01	41702	0.30	0.16	17.60	0.01
MN_XRF_pct	52817	0.06	0.05	12.30	0.01	1027	0.06	0.03	2.31	0.01	6	0.04	0.01	0.11	0.01	135	0.17	0.06	5.10	0.01	13070	0.12	0.08	8.44	0.01	41698	0.49	0.12	46.90	0.01
MNO_XRF_pct	52569	0.08	0.07	15.88	0.01	966	0.08	0.05	2.98	0.01	0					135	0.22	0.08	6.59	0.01	12448	0.16	0.10	10.90	0.01	40289	0.63	0.14	60.56	0.01
NA_XRF_pct	43059	0.06	0.04	0.66	0.01	777	0.014	0.010	0.150	0.005	6	0.050	0.055	0.080	0.010	123	0.011	0.005	0.070	0.005	9558	0.009	0.005	0.180	0.005	31603	0.019	0.020	0.870	0.005
NI_XRF_pct	43059	0.008	0.008	0.133	0.001	777	0.002	0.002	0.012	0.001	6	0.008	0.009	0.014	0.001	123	0.005	0.004	0.031	0.001	9558	0.003	0.002	0.031	0.001	31603	0.006	0.004	0.097	0.001
PB_XRF_pct	52715	0.003	0.001	0.112	0.001	1026	0.002	0.001	0.043	0.001	6	0.001	0.001	0.002	0.001	135	0.001	0.001	0.009	0.001	12995	0.001	0.001	0.083	0.001	41482	0.002	0.001	1.298	0.001
SN_XRF_pct	43059	0.002	0.001	0.013	0.001	777	0.002	0.002	0.007	0.001	6	0.001	0.001	0.001	0.001	123	0.001	0.001	0.002	0.001	9558	0.002	0.001	0.011	0.001	31603	0.002	0.001	0.017	0.001
SR_XRF_pct	43059	0.004	0.004	0.023	0.001	777	0.002	0.002	0.007	0.001	6	0.005	0.006	0.010	0.001	123	0.002	0.001	0.012	0.001	9558	0.001	0.001	0.025	0.001	31603	0.002	0.002	0.172	0.001
SULP_XRF_pct	52822	0.02	0.02	1.21	0.001	1027	0.032	0.024	0.233	0.004	6	0.03	0.03	0.04	0.01	135	0.008	0.007	0.039	0.001	13079	0.024	0.016	0.456	0.001	41758	0.034	0.021	3.370	0.001
TIO2_XRF_pct	52822	1.22	1.24	11.20	0.01	1027	0.84	0.89	2.77	0.01	6	1.75	2.20	2.64	0.36	135	1.57	1.71	2.19	0.17	13076	0.16	0.11	2.83	0.01	41579	0.611	0.540	12.800	0.005
V_XRF_pct	43059	0.033	0.030	0.136	0.001	777	0.010	0.011	0.041	0.001	6	0.019	0.020	0.027	0.007	123	0.036	0.036	0.071	0.003	9558	0.003	0.002	0.030	0.001	31603	0.010	0.009	0.114	0.001
ZR_XRF_pct	43059	0.016	0.016	0.112	0.001	777	0.010	0.010	0.023	0.001	6	0.018	0.023	0.026	0.004	123	0.006	0.005	0.013	0.001	9558	0.003	0.002	0.021	0.001	31603	0.010	0.008	0.115	0.001
PHOS_XRF_pct	52822	0.031	0.031	0.128	0.002	1027	0.047	0.046	0.100	0.020	6	0.031	0.029	0.057	0.012	135	0.065	0.068	0.154	0.004	13079	0.056	0.052	0.214	0.009	41760	0.058	0.051	0.273	0.001
SIO2_XRF_pct	52822	32.64	34.87	74.43	2.08	1027	5.83	5.69	15.35	1.10	6	23.87	29.90	36.47	2.62	135	26.40	26.93	53.65	4.55	13074	3.57	3.34	22.23	0.59	41732	17.09	12.29	95.96	0.66
ZN_XRF_pct	52811	0.009	0.006	0.051	0.001	1027	0.002	0.001	0.048	0.001	6	0.002	0.002	0.002	0.001	135	0.006	0.005	0.025	0.001	13056	0.004	0.003	0.151	0.001	41730	0.006	0.004	4.878	0.001
MN_D	52569	0.063	0.050	12.300	0.004	966	0.061	0.039	2.310	0.004	0					135	0.174	0.060	5.100	0.004	12456	0.128	0.080	8.440	0.004	40339	0.489	0.110	46.90	0.004

Element/Oxide _Analysis_Units	Crustal Abundance mg/kg	DET Was Mean	DET Was Median	DET Was Maximum	DET Was Minimum	Det Ore Mean	Det Ore Median	Det Ore Maximum	Det Ore Minimum	Clay Mean	Clay Median	Clay Maximum	Clay Minimum	DOR Mean	DOR Median	DOR Maximum	DOR Minimum	ANG ORE Mean	ANG ORE Median	ANG ORE Maximum	ANG ORE Minimum	ANG Waste Mean	ANG Waste Median	ANG Waste Maximum	ANG Waste Minimum
AL2O3_XRF_pct	309886																								
AS_XRF_pct	1.5	4	3	7	1	3	3	6	1	3	3	4	2	3	3	6	1	3	3	6	1	4	4	7	1
BA_XRF_pct	500			2																2				3	
CAO_XRF_pct	57367																							2	
CL_XRF_pct	130			6				1												2				3	
CO_XRF_pct	20			3				1								3				3				4	
CR_XRF_pct	100	1	1	2				1				1				1				1				2	
CU_XRF_pct	50			2												2				2				9	
FE_CALC_pct	41000	2	2	3		3	3	3	3	2	1	3	1	2	2	3	1	3	3	3	3	2	2	3	
K2O_XRF_pct	50593																								
MGO_XRF_pct	37540			1																				1	
MN_XRF_pct	950			6				4								5				5		1		8	
MNO_XRF_pct	1226.665			6				4								5				5		1		8	
NA_XRF_pct	23000																								
NI_XRF_pct	80			3												1				1				3	
PB_XRF_pct	14			5				4								2				5				9	
SN_XRF_pct	2	2	1	5		2	2	4		1	1	1	1			2		2	1	5		2	1	5	
SR_XRF_pct	370																							1	
SULP_XRF_pct	260			4				2												3				6	
TIO2_XRF_pct	9343			2																1				3	
V_XRF_pct	160			2												1								2	
ZR_XRF_pct	190			1																				2	
PHOS_XRF_pct	1000																								
SIO2_XRF_pct	592557.138																								
ZN_XRF_pct	75			2				2								1				3				8	
MN_D	950			6				4								5				5		1		8	

Element/Oxide _Analysis_Units	NEW Ore Count	NEW Ore Mean	NEW Ore Median	NEW Ore Maximum	NEW Ore Minimum	NEW waste Count	NEW waste Mean	NEW waste Median	NEW waste Maximum	NEW waste Minimum	MAC Ore Count	MAC Ore Mean	MAC Ore Median	MAC Ore Maximum	MAC Ore Minimum	MAC Waste Count	MAC Waste Mean	MAC Waste Median	MAC Waste Maximum	MAC Waste Minimum	NAM WASTE Count	NAM WASTE Mean	NAM WASTE Median	NAM WASTE Maximum	NAM WASTE Minimum
AL2O3_XRF_pct	106638	1.71	1.30	13.10	0.08	41760	4.47	3.54	46.63	0.04	2423	2.36	2.21	6.32	0.34	5292	4.02	3.07	34.26	0.14	63	2.42	1.95	7.56	0.41
AS_XRF_pct	70561	0.001	0.001	0.019	0.001	30631	0.003	0.001	0.041	0.001	1221	0.001	0.001	0.011	0.001	3266	0.003	0.001	0.027	0.001	63	0.002	0.001	0.004	0.001
BA_XRF_pct	70561	0.003	0.001	0.680	0.001	30631	0.004	0.001	1.770	0.001	1221	0.003	0.001	0.108	0.001	3266	0.004	0.001	0.513	0.001	63	0.003	0.001	0.035	0.001
CAO_XRF_pct	107389	0.017	0.010	1.770	0.005	41754	0.043	0.020	9.590	0.005	2420	0.027	0.020	1.840	0.005	5308	0.076	0.030	8.080	0.005	63	0.868	0.310	3.860	0.020
CL_XRF_pct	70561	0.007	0.005	0.510	0.001	30631	0.007	0.005	0.214	0.001	1221	0.012	0.007	0.118	0.001	3266	0.009	0.005	0.123	0.001	63	0.006	0.006	0.013	0.002
CO_XRF_pct	70560	0.001	0.001	0.044	0.001	30631	0.001	0.001	0.118	0.001	1221	0.001	0.001	0.018	0.001	3266	0.002	0.001	0.044	0.001	63	0.002	0.002	0.003	0.001
CR_XRF_pct	70561	0.002	0.002	0.199	0.001	30631	0.004	0.003	0.371	0.001	1221	0.002	0.001	0.013	0.001	3266	0.004	0.003	0.040	0.001	63	0.002	0.001	0.009	0.001
CU_XRF_pct	107194	0.001	0.001	4.386	0.001	41676	0.002	0.001	4.854	0.001	2419	0.002	0.001	0.019	0.001	5308	0.002	0.001	0.021	0.001	63	0.001	0.001	0.006	0.001
FE_CALC_pct	107451	61.90	62.68	67.60	55.01	41760	44.15	46.68	55.00	1.37	2423	58.19	58.11	67.79	55.01	5312	39.98	41.36	54.99	2.08	63	23.99	23.08	42.61	12.83
K2O_XRF_pct	107159	0.01	0.01	0.57	0.0001	41672	0.02	0.01	3.55	0.001	2419	0.01	0.01	0.29	0.001	5308	0.05	0.01	4.50	0.001	63	0.92	0.38	5.22	0.01
MGO_XRF_pct	107390	0.05	0.05	0.73	0.01	41749	0.07	0.05	5.76	0.01	2420	0.06	0.05	0.42	0.01	5310	0.14	0.05	6.69	0.01	63	2.00	1.13	5.58	0.02
MN_XRF_pct	107402	0.07	0.04	9.41	0.01	41741	0.10	0.02	38.05	0.01	2420	0.03	0.02	2.29	0.01	5310	0.04	0.02	12.55	0.01	63	0.07	0.06	0.22	0.01
MNO_XRF_pct	104829	0.09	0.05	12.15	0.01	39047	0.13	0.03	49.13	0.01	2305	0.04	0.03	2.96	0.01	4464	0.05	0.02	16.20	0.01	0				
NA_XRF_pct	70561	0.009	0.005	0.520	0.001	30631	0.012	0.005	1.020	0.005	1221	0.012	0.010	0.190	0.005	3266	0.013	0.010	0.230	0.005	63	0.048	0.020	0.240	0.010
NI_XRF_pct	70561	0.002	0.001	0.132	0.001	30631	0.002	0.001	0.086	0.001	1221	0.002	0.001	0.009	0.001	3266	0.002	0.002	0.017	0.001	63	0.003	0.002	0.011	0.001
PB_XRF_pct	107215	0.002	0.001	0.179	0.001	41675	0.002	0.001	1.000	0.001	2420	0.002	0.001	0.123	0.001	5309	0.002	0.001	0.047	0.001	63	0.001	0.001	0.002	0.001
SN_XRF_pct	70561	0.002	0.001	0.011	0.001	30631	0.002	0.001	0.011	0.001	1221	0.001	0.001	0.007	0.001	3266	0.001	0.001	0.007	0.001	63	0.001	0.001	0.003	0.001
SR_XRF_pct	70561	0.001	0.001	0.039	0.001	30631	0.003	0.002	0.043	0.001	1221	0.001	0.001	0.005	0.001	3266	0.003	0.002	0.019	0.001	63	0.012	0.015	0.022	0.003
SULP_XRF_pct	107451	0.018	0.010	0.868	0.001	41760	0.025	0.013	3.010	0.001	2423	0.033	0.016	0.567	0.001	5312	0.034	0.013	0.923	0.001	63	0.225	0.077	3.120	0.003
TIO2_XRF_pct	107439	0.062	0.030	2.430	0.005	41749	0.216	0.110	11.090	0.005	2423	0.084	0.070	0.900	0.005	5312	0.180	0.120	3.170	0.005	63	0.127	0.100	0.400	0.020
V_XRF_pct	70561	0.001	0.001	0.025	0.001	30631	0.003	0.001	0.128	0.001	1221	0.002	0.001	0.060	0.001	3266	0.003	0.002	0.049	0.001	63	0.002	0.001	0.008	0.001
ZR_XRF_pct	70560	0.001	0.001	0.042	0.000	30631	0.004	0.003	0.090	0.001	1221	0.001	0.001	0.014	0.001	3266	0.003	0.003	0.025	0.001	63	0.003	0.003	0.010	0.001
PHOS_XRF_pct	107451	0.064	0.060	1.344	0.004	41760	0.055	0.049	6.534	0.003	2423	0.083	0.077	0.379	0.009	5312	0.055	0.050	0.279	0.004	63	0.026	0.023	0.068	0.009
SIO2_XRF_pct	106879	2.88	2.07	43.87	0.48	41760	24.50	18.09	96.01	0.71	2423	4.27	3.92	15.78	0.88	5309	30.25	27.96	92.15	1.90	63	51.87	51.28	63.38	30.78
ZN_XRF_pct	107337	0.002	0.002	0.119	0.001	41721	0.002	0.001	0.153	0.001	2420	0.004	0.003	0.054	0.001	5310	0.004	0.003	0.063	0.001	63	0.004	0.003	0.013	0.001
MN_D	104869	0.068	0.040	9.41	0.004	39056	0.098	0.020	38.05	0.004	2308	0.034	0.020	5.42	0.004	4466	0.041	0.015	12.55	0.004	0				

Element/Oxide _Analysis_Units	Crustal Abundance mg/kg	NEW Ore Mean	NEW Ore Median	NEW Ore Maximum	NEW Ore Minimum	NEW waste Mean	NEW waste Median	NEW waste Maximum	NEW waste Minimum	MAC Ore Mean	MAC Ore Median	MAC Ore Maximum	MAC Ore Minimum	MAC Waste Mean	MAC Waste Median	MAC Waste Maximum	MAC Waste Minimum	NAM WASTE Mean	NAM WASTE Median	NAM WASTE Maximum	NAM WASTE Minimum
AL2O3_XRF_pct	309886																				
AS_XRF_pct	1.5	2	1	6	1	3	2	7	1	2	1	5	1	3	2	6	1	2	2	4	2
BA_XRF_pct	500			3				4								2					
CAO_XRF_pct	57367																				
CL_XRF_pct	130			4				3				2				2					
CO_XRF_pct	20			3				5				2				3					
CR_XRF_pct	100			3				4								1					
CU_XRF_pct	50			9				9				1				1					
FE_CALC_pct	41000	3	3	3	3	2	2	3		3	3	3	3	2	2	3		1	1	2	1
K2O_XRF_pct	50593																				
MGO_XRF_pct	37540																				
MN_XRF_pct	950			6				8				4				6					
MNO_XRF_pct	1226.665			6				8				4				6					
NA_XRF_pct	23000																				
NI_XRF_pct	80			3				2													
PB_XRF_pct	14			6				8				5				4					
SN_XRF_pct	2	2	1	5		2	1	5		1	1	4		2	1	4		2	1	3	1
SR_XRF_pct	370																				
SULP_XRF_pct	260			4				6				3				4		2		6	
TIO2_XRF_pct	9343							2								1					
V_XRF_pct	160							2				1				1					
ZR_XRF_pct	190							1													
PHOS_XRF_pct	1000			3				5				1									
SIO2_XRF_pct	592557.138																				
ZN_XRF_pct	75			3				3				2				2					
MN_D	950			6				8				5				6					

West Angelas Deposit E Global Abundance Index

Element/Oxide	ALLUVIUM					CLAY					DET WASTE				
_Analysis_Units	Count	Mean	Median	Maximum	Minimum	Count	Mean	Median	Maximum	Minimum	Count	Mean	Median	Maximum	Minimum
AL2O3_XRF_pct	1956	7.10	5.76	20.87	0.26	15792	12.92	12.89	26.45	0.55	2456	6.44	6.08	27.84	0.62
AS_XRF_pct	1442	0.003	0.003	0.02	0.001	11732	0.003	0.003	0.024	0.001	2056	0.004	0.003	0.021	0.001
BA_XRF_pct	1574	0.012	0.011	0.065	0.001	12704	0.011	0.01	0.431	0.001	1935	0.010	0.006	0.219	0.001
CAO_XRF_pct	1949	0.37	0.16	7.01	0.01	15745	0.16	0.12	19.26	0.01	2454	0.14	0.1	3.02	0.01
CL_XRF_pct	1640	0.020	0.0115	0.407	0.001	13408	0.017	0.012	1.34	0.001	2192	0.024	0.021	0.257	0.001
CO_XRF_pct	990	0.002	0.002	0.009	0.001	9785	0.002	0.002	0.011	0.001	1390	0.002	0.001	0.011	0.001
CR_XRF_pct	1714	0.010	0.01	0.049	0.001	14271	0.013	0.013	0.194	0.001	2228	0.009	0.009	0.023	0.001
CU_XRF_pct	1780	0.003	0.003	0.012	0.001	15014	0.005	0.004	0.047	0.001	2115	0.002	0.002	0.012	0.001
FE_CALC_pct	1956	32.34	31.635	57	12.03	15792	27.23	25	63.34	2.01	2456	42.63	43.31	61.93	3.07
K2O_XRF_pct	1955	0.342	0.277	1.984	0.009	15787	0.336	0.319	1.704	0.004	2456	0.177	0.165	0.87	0.004
MGO_XRF_pct	1956	0.19	0.17	4.98	0.01	15783	0.21	0.18	12.6	0.01	2453	0.14	0.13	0.85	0.02
MN_XRF_pct	1721	0.05	0.04	1.19	0.01	14304	0.07	0.05	12.1	0.01	2206	0.11	0.04	19.5	0.01
MNO_XRF_pct	232	0.06	0.04	0.39	0.01	1365	0.08	0.06	1.19	0.01	216	0.18	0.045	15.2	0.01
NA_XRF_pct	1571	0.04	0.04	0.17	0.01	13354	0.05	0.05	0.33	0.01	2076	0.05	0.04	5.19	0.01
NI_XRF_pct	1666	0.003	0.003	0.022	0.001	13895	0.005	0.004	0.111	0.001	2080	0.003	0.002	0.016	0.001
PB_XRF_pct	1533	0.004	0.002	0.02	0.001	12523	0.003	0.002	0.025	0.001	1583	0.003	0.002	0.018	0.001
SN_XRF_pct	1155	0.002	0.002	0.018	0.001	10756	0.002	0.002	0.012	0.001	1377	0.002	0.001	0.007	0.001
SR_XRF_pct	1654	0.006	0.006	0.017	0.001	13990	0.006	0.006	0.03	0.001	2053	0.004	0.004	0.025	0.001
SULP_XRF_pct	1956	0.02	0.016	0.39	0.001	15792	0.017	0.015	0.722	0.001	2456	0.035	0.025	0.999	0.005
TIO2_XRF_pct	1956	0.43	0.37	1.09	0.01	15792	0.87	0.9	1.52	0.02	2456	0.45	0.44	3.29	0.03
V_XRF_pct	1715	0.010	0.01	0.018	0.001	14272	0.014	0.015	0.029	0.001	2225	0.009	0.008	0.025	0.001
ZR_XRF_pct	1718	0.014	0.014	0.03	0.001	14277	0.018	0.019	0.109	0.002	2228	0.012	0.011	0.032	0.001
PHOS_XRF_pct	1956	0.041	0.041	0.091	0.007	15792	0.040	0.041	0.098	0.005	2456	0.045	0.043	0.12	0.004
SIO2_XRF_pct	1956	39.75	42.005	77.39	8.99	15792	40.22	42.52	64.38	1.53	2456	25.80	25.27	85.71	1.73
ZN_XRF_pct	1879	0.004	0.004	0.083	0.001	15438	0.009	0.006	0.802	0.001	2257	0.004	0.003	0.074	0.001
MN_D	233	0.046	0.031	0.775	0.008	1373	0.066	0.046	0.922	0.008	217	0.145	0.039	11.8	0.008

Element/Oxide	DET ORE					ANG WASTE					ANG ORE					ANG HYD				
_Analysis_Units	Count	Mean	Median	Maximum	Minimum	Count	Mean	Median	Maximum	Minimum	Count	Mean	Median	Maximum	Minimum	Count	Mean	Median	Maximum	Minimum
AL2O3_XRF_pct	4536	5.89	5.94	22.63	0.64	10368	11.46	11.32	48.05	0.12	4812	3.65	2.88	35.91	0.4	4766	7.49	6.945	36.08	0.68
AS_XRF_pct	2674	0.003	0.003	0.033	0.001	9660	0.005	0.005	0.057	0.001	4332	0.004	0.004	0.063	0.001	4142	0.005	0.004	0.091	0.001
BA_XRF_pct	2304	0.005	0.004	0.219	0.001	8210	0.023	0.007	0.651	0.001	2596	0.006	0.003	0.661	0.001	2383	0.007	0.003	0.399	0.001
CAO_XRF_pct	4470	0.06	0.05	0.65	0.01	10351	0.96	0.08	45.37	0.01	4774	0.040	0.04	0.36	0.01	4661	0.05	0.04	4.07	0.01
CL_XRF_pct	3124	0.012	0.009	0.093	0.001	9568	0.010	0.008	0.15	0.001	4501	0.007	0.006	0.36	0.001	4001	0.010	0.007	0.136	0.001
CO_XRF_pct	1916	0.002	0.002	0.011	0.001	8635	0.003	0.003	0.036	0.001	2979	0.002	0.002	0.013	0.001	2891	0.002	0.002	0.024	0.001
CR_XRF_pct	3148	0.008	0.008	0.202	0.001	9851	0.010	0.008	0.263	0.001	4362	0.005	0.004	0.033	0.001	4282	0.008	0.007	0.167	0.001
CU_XRF_pct	2800	0.002	0.002	0.008	0.001	9581	0.004	0.003	0.056	0.001	3147	0.002	0.001	0.049	0.001	3186	0.002	0.002	0.014	0.001
FE_CALC_pct	4536	55.98	55.7	67.47	19.29	10368	33.07	33.93	63.02	0.69	4812	57.26	58.355	66.19	3.83	4766	51.11	51.81	65.47	6.35
K2O_XRF_pct	4222	0.030	0.02	0.33	0.001	10368	0.835	0.4715	6.805	0.002	4650	0.037	0.012	1.424	0.001	4648	0.074	0.02	3.278	0.001
MGO_XRF_pct	4488	0.07	0.06	1.19	0.01	10366	1.09	0.48	19.4	0.01	4811	0.16	0.14	0.84	0.01	4757	0.13	0.1	3.76	0.01
MN_XRF_pct	3619	0.05	0.03	5.28	0.01	9986	1.31	0.43	28.7	0.01	4604	0.23	0.13	14.9	0.01	4162	0.18	0.05	16.6	0.01
MNO_XRF_pct	754	0.06	0.04	0.7	0.01	285	1.62	0.6	12.04	0.01	206	0.27	0.17	8.23	0.01	361	0.24	0.06	14.2	0.01
NA_XRF_pct	2370	0.02	0.02	0.21	0.01	8891	0.03	0.02	0.3	0.01	2298	0.02	0.01	0.09	0.01	2745	0.02	0.02	0.41	0.01
NI_XRF_pct	2672	0.002	0.002	0.112	0.001	9916	0.008	0.007	0.072	0.001	4071	0.003	0.002	0.034	0.001	3836	0.003	0.003	0.093	0.001
PB_XRF_pct	2385	0.003	0.002	0.017	0.001	6564	0.002	0.001	0.02	0.001	1654	0.002	0.001	0.029	0.001	1921	0.002	0.001	0.018	0.001
SN_XRF_pct	2294	0.002	0.002	0.009	0.001	7434	0.002	0.002	0.01	0.001	3094	0.002	0.002	0.007	0.001	2672	0.002	0.002	0.007	0.001
SR_XRF_pct	2568	0.003	0.002	0.013	0.001	9386	0.005	0.004	0.111	0.001	2697	0.002	0.002	0.009	0.001	2897	0.002	0.002	0.029	0.001
SULP_XRF_pct	4536	0.028	0.022	0.86	0.003	10368	0.016	0.009	2.14	0.001	4812	0.012	0.009	0.245	0.001	4766	0.031	0.02	1.53	0.001
TIO2_XRF_pct	4536	0.57	0.55	2.72	0.02	10342	0.54	0.53	5.77	0.01	4805	0.15	0.1	1.09	0.01	4766	0.44	0.41	3.19	0.02
V_XRF_pct	3147	0.008	0.008	0.024	0.001	9793	0.008	0.008	0.054	0.001	3616	0.003	0.002	0.02	0.001	4223	0.007	0.007	0.054	0.001
ZR_XRF_pct	3157	0.011	0.011	0.025	0.001	9805	0.011	0.01	0.062	0.001	3697	0.004	0.003	0.04	0.001	4255	0.008	0.007	0.04	0.001
PHOS_XRF_pct	4536	0.039	0.036	0.193	0.018	10368	0.061	0.06	0.331	0.002	4812	0.058	0.056	0.241	0.008	4766	0.043	0.04	0.184	0.006
SIO2_XRF_pct	4536	9.02	8.455	54.1	0.66	10368	25.47	21.76	94.89	0.46	4812	5.04	3.77	43.74	0.87	4766	8.30	7.19	60.41	0.94
ZN_XRF_pct	3425	0.003	0.002	0.02	0.001	9885	0.008	0.007	1.82	0.001	4384	0.004	0.003	0.475	0.001	3710	0.003	0.002	0.219	0.001
MN_D	767	0.061	0.031	0.775	0.008	289	1.25	0.47	9.32	0.008	206	0.21	0.13	6.37	0.01	373	0.20	0.05	11.00	0.01

Element/Oxide _Analysis_Units	Crustal Abundance mg/kg	ALLUVIUM Mean	Median	Maximum	Minimum	CLAY Mean	Median	Maximum	Minimum	DET WASTE Mean	Median	Maximum	Minimum
AL2O3_XRF_pct	309886												
AS_XRF_pct	1.5	3	3	6	2	3	3	6	2	4	3	6	2
BA_XRF_pct	500							2				1	
CAO_XRF_pct	57367							1					
CL_XRF_pct	130			4				6				3	
CO_XRF_pct	20			1				1				1	
CR_XRF_pct	100			1				3					
CU_XRF_pct	50							2					
FE_CALC_pct	41000	2	2	3		2	2	3		2	2	3	
K2O_XRF_pct	50593												
MGO_XRF_pct	37540							1					
MN_XRF_pct	950			3				6				7	
MNO_XRF_pct	1226.665			1				2				6	
NA_XRF_pct	23000												
NI_XRF_pct	80							3					
PB_XRF_pct	14			3				3				3	
SN_XRF_pct	2	2	2	5	1	2	2	5	1	2	1	4	1
SR_XRF_pct	370												
SULP_XRF_pct	260			3				4				4	
TIO2_XRF_pct	9343											1	
V_XRF_pct	160												
ZR_XRF_pct	190							1					
PHOS_XRF_pct	1000												
SIO2_XRF_pct	592557.138												
ZN_XRF_pct	75			2				6				2	
MN_D	950			2				2				6	

Element/Oxide _Analysis_Units	DET ORE Mean	Median	Maximum	Minimum	ANG WASTE Mean	Median	Maximum	Minimum	ANG ORE Mean	Median	Maximum	Minimum	ANG HYD Mean	Median	Maximum	Minimum
AL2O3_XRF_pct																
AS_XRF_pct	3	3	7	2	4	4	7	2	4	4	8	2	4	4	8	2
BA_XRF_pct			1				3				3				2	
CAO_XRF_pct							2									
CL_XRF_pct			2				2				4				2	
CO_XRF_pct			1				3				2				3	
CR_XRF_pct			3				4				1				3	
CU_XRF_pct							2				2					
FE_CALC_pct	3	3	3	1	2	2	3		3	3	3		3	3	3	
K2O_XRF_pct																
MGO_XRF_pct							1									
MN_XRF_pct			5		3	1	7				6				6	
MNO_XRF_pct			1		3	1	6				5				6	
NA_XRF_pct																
NI_XRF_pct			3				2				1				2	
PB_XRF_pct			3				3				3				3	
SN_XRF_pct	2	2	4	1	2	2	5	1	2	2	4	1	2	2	4	1
SR_XRF_pct							1									
SULP_XRF_pct			4				5				2				5	
TIO2_XRF_pct							2								1	
V_XRF_pct							1								1	
ZR_XRF_pct							1									
PHOS_XRF_pct							1									
SIO2_XRF_pct																
ZN_XRF_pct							7				5				4	
MN_D			2		3	1	6				5				6	

Element/Oxide	NEW ORE					NEW WASTE					MAC WASTE				
_Analysis_Units	Count	Mean	Median	Maximum	Minimum	Count	Mean	Median	Maximum	Minimum	Count	Mean	Median	Maximum	Minimum
AL2O3_XRF_pct	11831	1.71	1.25	34.15	0.28	7025	1.08	0.6	30.75	0.08	1008	2.29	1.59	16.17	0.13
AS_XRF_pct	8001	0.002	0.002	0.014	0.001	4371	0.002	0.002	0.031	0.001	872	0.002	0.002	0.007	0.001
BA_XRF_pct	6726	0.007	0.004	0.567	0.001	3574	0.006	0.003	0.935	0.001	842	0.004	0.002	0.047	0.001
CAO_XRF_pct	9826	0.02	0.02	1.03	0.01	5948	0.16	0.02	29.39	0.01	968	0.28	0.04	7.59	0.01
CL_XRF_pct	10684	0.010	0.006	0.201	0.001	6520	0.007	0.006	0.141	0.001	977	0.012	0.01	0.107	0.001
CO_XRF_pct	6023	0.002	0.002	0.017	0.001	3864	0.002	0.002	0.018	0.001	847	0.002	0.001	0.009	0.001
CR_XRF_pct	7203	0.003	0.002	0.043	0.001	3595	0.002	0.001	0.029	0.001	854	0.003	0.002	0.049	0.001
CU_XRF_pct	5295	0.001	0.001	0.018	0.001	5312	0.001	0.001	0.025	0.001	971	0.002	0.001	0.009	0.001
FE_CALC_pct	11831	61.87	62.96	67.68	7.16	7025	37.50	36.52	60.79	1.1	1008	27.53	26.685	57.94	0.65
K2O_XRF_pct	10570	0.012	0.006	0.635	0.001	6859	0.016	0.008	1.854	0.001	1004	0.297	0.031	5.138	0.002
MGO_XRF_pct	11712	0.07	0.06	1.22	0.01	6931	0.16	0.05	18.9	0.01	990	0.55	0.07	7.16	0.01
MN_XRF_pct	10674	0.16	0.06	17	0.01	6107	0.10	0.03	29.2	0.01	904	0.08	0.05	0.93	0.01
MNO_XRF_pct	964	0.21	0.08	16.69	0.01	328	0.07	0.03	3.06	0.01	24	0.03	0.025	0.06	0.01
NA_XRF_pct	4374	0.02	0.01	0.24	0.01	3005	0.02	0.01	0.5	0.01	837	0.02	0.02	0.24	0.01
NI_XRF_pct	7848	0.002	0.002	0.069	0.001	4959	0.002	0.002	0.033	0.001	929	0.002	0.002	0.054	0.001
PB_XRF_pct	3361	0.002	0.002	0.048	0.001	5515	0.004	0.002	0.024	0.001	918	0.002	0.001	0.019	0.001
SN_XRF_pct	7144	0.002	0.002	0.008	0.001	4872	0.002	0.002	0.009	0.001	860	0.002	0.001	0.007	0.001
SR_XRF_pct	5234	0.002	0.002	0.086	0.001	6398	0.005	0.004	0.019	0.001	977	0.006	0.007	0.016	0.001
SULP_XRF_pct	11831	0.018	0.009	0.76	0.001	7025	0.011	0.005	0.549	0.001	1008	0.043	0.015	0.819	0.001
TIO2_XRF_pct	11607	0.05	0.03	5.37	0.01	6102	0.05	0.02	1.7	0.01	997	0.104	0.07	0.69	0.01
V_XRF_pct	4336	0.002	0.001	0.016	0.001	2858	0.002	0.001	0.012	0.001	831	0.002	0.001	0.019	0.001
ZR_XRF_pct	5013	0.002	0.001	0.051	0.001	5764	0.002	0.002	0.036	0.001	974	0.003	0.003	0.015	0.001
PHOS_XRF_pct	11831	0.063	0.057	0.261	0.008	7025	0.048	0.043	0.712	0.003	1008	0.035	0.029	0.221	0.003
SIO2_XRF_pct	11831	2.88	1.72	41.16	0.68	7025	41.08	43.07	96.71	1.46	1008	51.18	52.08	96.55	5.61
ZN_XRF_pct	9366	0.002	0.002	0.802	0.001	4594	0.002	0.002	0.201	0.001	969	0.005	0.004	0.428	0.001
MN_D	971	0.17	0.06	12.93	0.01	366	0.13	0.02	2.37	0.01	25	0.05	0.02	0.77	0.01

Element/Oxide	MAC ORE					NAM WASTE					MM HYD				
_Analysis_Units	Count	Mean	Median	Maximum	Minimum	Count	Mean	Median	Maximum	Minimum	Count	Mean	Median	Maximum	Minimum
AL2O3_XRF_pct	242	3.17	2.69	15.98	0.42	56	0.82	0.645	2.94	0.38	3073	2.98	2.39	29.45	0.36
AS_XRF_pct	158	0.002	0.002	0.007	0.001	56	0.002	0.001	0.005	0.001	2100	0.002	0.002	0.013	0.001
BA_XRF_pct	102	0.004	0.003	0.063	0.001	56	0.002	0.001	0.023	0.001	2035	0.009	0.005	0.295	0.001
CAO_XRF_pct	222	0.03	0.03	0.06	0.01	56	1.52	1.435	3.56	0.12	2764	0.07	0.04	3.35	0.01
CL_XRF_pct	213	0.016	0.009	0.167	0.002	56	0.010	0.01	0.016	0.004	2671	0.019	0.013	0.356	0.001
CO_XRF_pct	96	0.002	0.002	0.005	0.001	56	0.001	0.001	0.001	0.001	1643	0.002	0.002	0.023	0.001
CR_XRF_pct	136	0.004	0.003	0.026	0.001	56	0.001	0.001	0.004	0.001	2261	0.004	0.003	0.048	0.001
CU_XRF_pct	165	0.002	0.002	0.005	0.001	56	0.001	0.001	0.003	0.001	1646	0.001	0.001	0.009	0.001
FE_CALC_pct	242	56.53	57.225	63.38	37.34	56	24.22	24.425	29.46	16.64	3073	57.00	57.82	65.6	11.25
K2O_XRF_pct	217	0.011	0.009	0.28	0.001	56	0.636	0.541	1.804	0.179	2930	0.033	0.018	0.54	0.001
MGO_XRF_pct	241	0.06	0.05	0.14	0.01	56	2.66	2.75	3.85	0.35	3002	0.06	0.05	0.89	0.01
MN_XRF_pct	144	0.03	0.02	1.22	0.01	56	0.03	0.03	0.09	0.02	2488	0.10	0.04	11	0.01
MNO_XRF_pct	20	0.02	0.02	0.05	0.01	0					326	0.12	0.04	12.5	0.01
NA_XRF_pct	84	0.02	0.02	0.09	0.01	56	0.08	0.04	1.29	0.01	1977	0.03	0.02	0.21	0.01
NI_XRF_pct	138	0.002	0.002	0.006	0.001	56	0.001	0.001	0.002	0.001	1894	0.002	0.002	0.019	0.001
PB_XRF_pct	71	0.002	0.002	0.011	0.001	56	0.002	0.001	0.005	0.001	1196	0.003	0.002	0.016	0.001
SN_XRF_pct	121	0.002	0.002	0.006	0.001	56	0.001	0.001	0.002	0.001	1693	0.002	0.002	0.008	0.001
SR_XRF_pct	169	0.002	0.002	0.008	0.001	56	0.009	0.008	0.016	0.002	1774	0.003	0.002	0.027	0.001
SULP_XRF_pct	242	0.029	0.018	0.339	0.005	56	0.194	0.1645	0.955	0.009	3073	0.049	0.037	0.611	0.001
TIO2_XRF_pct	239	0.10	0.08	0.51	0.01	56	0.04	0.03	0.15	0.01	3065	0.14	0.09	3.94	0.01
V_XRF_pct	128	0.003	0.002	0.015	0.001	56	0.001	0.001	0.002	0.001	1847	0.003	0.002	0.017	0.001
ZR_XRF_pct	164	0.003	0.0025	0.012	0.001	56	0.003	0.003	0.005	0.001	2307	0.003	0.003	0.033	0.001
PHOS_XRF_pct	242	0.07	0.069	0.189	0.02	56	0.038	0.0295	0.174	0.008	3073	0.05	0.048	0.134	0.01
SIO2_XRF_pct	242	5.57	4.475	21.74	1.55	56	54.21	54.415	66.91	39.39	3073	6.76	5.27	56.55	0.87
ZN_XRF_pct	230	0.003	0.003	0.008	0.001	56	0.002	0.002	0.013	0.001	2418	0.002	0.002	0.025	0.001
MN_D	26	0.19	0.02	0.77	0.01						357	0.15	0.04	9.68	0.008

Element/Oxide _Analysis_Units	Crustal Abundance mg/kg	NEW ORE Mean	Median	Maximum	Minimum	NEW WASTE Mean	Median	Maximum	Minimum	MAC WASTE Mean	Median	Maximum	Minimum
AL2O3_XRF_pct	309886												
AS_XRF_pct	1.5	3	3	5	2	3	3	7	2	3	3	4	2
BA_XRF_pct	500			2				3					
CAO_XRF_pct	57367							1					
CL_XRF_pct	130			3				2				2	
CO_XRF_pct	20			2				2				1	
CR_XRF_pct	100			1								1	
CU_XRF_pct	50			1				1					
FE_CALC_pct	41000	3	3	3		2	2	3		2	2	3	
K2O_XRF_pct	50593												
MGO_XRF_pct	37540							1					
MN_XRF_pct	950			6				7				2	
MNO_XRF_pct	1226.665			6				4					
NA_XRF_pct	23000												
NI_XRF_pct	80			2				1				2	
PB_XRF_pct	14			4				3				3	
SN_XRF_pct	2	2	2	4	1	2	2	4	1	2	1	4	1
SR_XRF_pct	370												
SULP_XRF_pct	260			4				3				4	
TIO2_XRF_pct	9343			1									
V_XRF_pct	160												
ZR_XRF_pct	190												
PHOS_XRF_pct	1000							2					
SIO2_XRF_pct	592557.138												
ZN_XRF_pct	75			6				4				5	
MN_D	950			6				4				2	

Element/Oxide _Analysis_Units	MAC ORE Mean	Median	Maximum	Minimum	NAM WASTE Mean	Median	Maximum	Minimum	MM HYD Mean	Median	Maximum	Minimum
AL2O3_XRF_pct												
AS_XRF_pct	3	3	4	2	2	2	4	2	3	3	5	2
BA_XRF_pct											1	
CAO_XRF_pct												
CL_XRF_pct			3								4	
CO_XRF_pct											2	
CR_XRF_pct											1	
CU_XRF_pct												
FE_CALC_pct	3	3	3	2	1	1	2	1	3	3	3	
K2O_XRF_pct												
MGO_XRF_pct												
MN_XRF_pct			3								6	
MNO_XRF_pct											6	
NA_XRF_pct												
NI_XRF_pct												
PB_XRF_pct			2				1				2	
SN_XRF_pct	2	2	4	1	1	1	2	1	2	2	4	1
SR_XRF_pct												
SULP_XRF_pct			3		2	2	4				3	
TIO2_XRF_pct											1	
V_XRF_pct												
ZR_XRF_pct												
PHOS_XRF_pct												
SIO2_XRF_pct												
ZN_XRF_pct											1	
MN_D			2								6	

West Angelas Deposit B Global Abundance Index

Element/Oxide	Alluvium					Clay					CAL					DET WASTE				
_Analysis_Units	Count	Mean	Median	Maximum	Minimum	Count	Mean	Median	Maximum	Minimum	Count	Mean	Median	Maximum	Minimum	Count	Mean	Median	Maximum	Minimum
AL2O3_XRF_pct	3235	10.87	10.1	32.78	0.28	5911	19.21	18.76	37.57	2.18	7	7.36	6.27	11.73	2.67	3301	12.14	11.6	34	0.88
AS_XRF_pct	2831	0.003	0.003	0.014	0.001	5306	0.003	0.002	0.046	0.001	7	0.001	0.001	0.002	0.001	2892	0.003	0.003	0.018	0.001
BA_XRF_pct	2770	0.009	0.006	0.196	0.001	4999	0.005	0.004	0.121	0.001	7	0.019	0.013	0.058	0.001	2800	0.006	0.003	0.333	0.001
CAO_XRF_pct	3235	0.93	0.74	6.57	0.01	5911	0.635	0.42	27.06	0.03	7	18.65	22.32	26.01	2.87	3289	0.338	0.19	22.78	0.01
CL_XRF_pct	2839	0.013	0.008	0.894	0.001	5344	0.013	0.01	0.535	0.001	7	0.006	0.007	0.013	0.001	2916	0.018	0.012	0.316	0.001
CO_XRF_pct	2716	0.003	0.0025	0.022	0.001	5152	0.003	0.003	0.084	0.001	7	0.005	0.004	0.01	0.003	2744	0.003	0.002	0.043	0.001
CR_XRF_pct	2839	0.028	0.023	0.075	0.001	5374	0.036	0.033	0.22	0.001	7	0.007	0.006	0.011	0.002	2920	0.024	0.019	0.103	0.001
CU_XRF_pct	3156	0.010	0.009	0.028	0.001	5837	0.010	0.008	0.057	0.001	7	0.004	0.004	0.01	0.001	3146	0.007	0.005	0.036	0.001
FE_CALC_pct	3235	32.54	32.2	58.5	4.43	5911	25.124	24.86	60.07	0.96	7	8.51	4.73	28.47	1.85	3301	40.47	42.57	60.19	3.96
K2O_XRF_pct	3230	0.238	0.22	2.15	0.001	5852	0.095	0.077	1.4	0.002	7	0.01	0.01	0.03	0.003	3241	0.094	0.056	1.48	0.001
MGO_XRF_pct	3234	0.799	0.81	2.84	0.02	5911	0.820	0.68	19.3	0.01	7	12.1	11.4	18.7	2.9	3300	0.357	0.24	17.4	0.01
MN_XRF_pct	2840	0.109	0.08	34.8	0.01	5300	0.048	0.04	0.67	0.01	7	0.13	0.08	0.32	0.07	2906	0.103	0.05	19.5	0.01
MNO_XRF_pct	392	0.110	0.1	0.74	0.02	491	0.054	0.04	0.47	0.01						374	0.223	0.06	18	0.01
NA_XRF_pct	2838	0.130	0.13	0.52	0.01	5372	0.070	0.06	0.42	0.01	7	0.03	0.03	0.04	0.01	2912	0.051	0.04	0.34	0.01
NI_XRF_pct	2836	0.007	0.007	0.082	0.001	5374	0.010	0.009	0.33	0.001	7	0.008	0.007	0.015	0.004	2918	0.006	0.005	0.116	0.001
PB_XRF_pct	2868	0.003	0.003	0.021	0.001	5255	0.003	0.002	0.023	0.001	7	0.001	0.001	0.001	0.001	2915	0.002	0.001	0.02	0.001
SN_XRF_pct	2771	0.001	0.001	0.017	0.001	5185	0.002	0.001	0.008	0.001	7	0.002	0.001	0.003	0.001	2840	0.001	0.001	0.022	0.001
SR_XRF_pct	2837	0.006	0.005	0.026	0.001	5372	0.006	0.005	0.032	0.001	7	0.009	0.009	0.013	0.004	2916	0.006	0.005	0.035	0.001
SULP_XRF_pct	3235	0.032	0.028	0.442	0.004	5911	0.021	0.018	0.333	0.001	7	0.013	0.013	0.018	0.005	3301	0.040	0.028	2.07	0.004
TIO2_XRF_pct	3235	0.96	0.84	5.34	0.02	5911	1.546	1.58	3.12	0.17	7	0.66	0.53	1.19	0.22	3301	0.928	0.84	5.22	0.03
V_XRF_pct	2839	0.036	0.026	0.11	0.001	5374	0.041	0.031	0.125	0.001	7	0.006	0.003	0.02	0.001	2920	0.026	0.019	0.133	0.001
ZR_XRF_pct	2840	0.013	0.013	0.038	0.001	5374	0.017	0.017	0.031	0.001	7	0.004	0.002	0.011	0.001	2920	0.013	0.013	0.075	0.001
PHOS_XRF_pct	3235	0.036	0.036	0.079	0.005	5911	0.021	0.02	0.056	0.003	7	0.007	0.006	0.014	0.004	3301	0.033	0.032	0.126	0.006
SIO2_XRF_pct	3235	32.52	33.1	65.99	4.45	5911	33.009	33.77	68.63	6.05	7	17.99	17.6	28.28	5.81	3301	20.17	18.01	71.31	4.4
ZN_XRF_pct	3194	0.019	0.019	0.215	0.001	5747	0.013	0.007	0.378	0.001	7	0.02	0.01	0.08	0.001	3181	0.01	0.005	0.139	0.001
MN_D	395	0.09	0.08	0.77	0.02	513	0.073	0.038725	0.7745	0.007745						381	0.184	0.046	13.94	0.008

Element/Oxide	DET ORE					ANG WASTE					ANG ORE					ANG HYD				
_Analysis_Units	Count	Mean	Median	Maximum	Minimum	Count	Mean	Median	Maximum	Minimum	Count	Mean	Median	Maximum	Minimum	Count	Mean	Median	Maximum	Minimum
AL2O3_XRF_pct	1934	6.87	6.99	15.3	1.4	19334	13.14	12.08	47.02	0.13	2956	4.163	3.56	29.56	0.4	2141	5.04	4.81	23.6	0.2
AS_XRF_pct	1650	0.003	0.003	0.016	0.001	16736	0.004	0.004	0.088	0.001	2442	0.003	0.002	0.098	0.001	1648	0.003	0.002	0.027	0.001
BA_XRF_pct	1531	0.004	0.002	0.153	0.001	16105	0.012	0.003	0.781	0.001	2410	0.002	0.001	0.225	0.001	1615	0.004	0.001	0.301	0.001
CAO_XRF_pct	1923	0.120	0.1	2.75	0.01	19034	0.14	0.04	28.82	0.01	2841	0.029	0.02	0.35	0.01	2105	0.062	0.04	2.93	0.01
CL_XRF_pct	1721	0.017	0.012	0.137	0.001	16871	0.021	0.014	0.355	0.001	2445	0.012	0.01	0.107	0.001	1661	0.013	0.008	0.116	0.001
CO_XRF_pct	1479	0.002	0.001	0.131	0.001	16567	0.003	0.003	0.369	0.001	2438	0.002	0.002	0.11	0.001	1655	0.002	0.001	0.056	0.001
CR_XRF_pct	1721	0.011	0.011	0.05	0.001	16763	0.014	0.009	0.11	0.001	2442	0.004	0.003	0.027	0.001	1662	0.006	0.005	0.046	0.001
CU_XRF_pct	1640	0.002	0.002	0.02	0.001	18257	0.005	0.004	0.075	0.001	2663	0.002	0.001	0.168	0.001	1934	0.003	0.002	0.039	0.001
FE_CALC_pct	1934	54.12	53.7	65.71	38.58	19334	31.97	32.58	62.7	0.35	2956	55.742	56.825	65.59	13.61	2141	54.36	54.4	65.23	25.7
K2O_XRF_pct	1889	0.034	0.022	0.607	0.001	19079	0.41	0.20	3.96	0.001	2686	0.043	0.02	1.416	0.001	1903	0.033	0.012	0.62	0.001
MGO_XRF_pct	1934	0.142	0.12	0.81	0.01	19318	0.40	0.29	19.1	0.01	2944	0.115	0.1	3.01	0.01	2136	0.124	0.1	2.54	0.01
MN_XRF_pct	1688	0.074	0.03	3.74	0.01	16708	1.35	0.3	40.2	0.01	2440	0.215	0.14	9.06	0.01	1657	0.162	0.05	14.3	0.01
MNO_XRF_pct	210	0.123	0.05	4.06	0.01	2342	1.89	0.52	56.89	0.01	511	0.242	0.17	5.78	0.01	463	0.162	0.07	2.53	0.01
NA_XRF_pct	1696	0.028	0.02	0.34	0.01	16652	0.033	0.03	3.71	0.01	2410	0.014	0.01	0.14	0.01	1621	0.017	0.01	0.11	0.01
NI_XRF_pct	1655	0.003	0.002	0.066	0.001	16833	0.008	0.007	0.086	0.001	2445	0.005	0.004	0.038	0.001	1654	0.004	0.003	0.075	0.001
PB_XRF_pct	1507	0.002	0.001	0.038	0.001	17051	0.002	0.001	0.03	0.001	2551	0.002	0.001	0.014	0.001	1726	0.002	0.001	0.013	0.001
SN_XRF_pct	1665	0.002	0.001	0.007	0.001	16581	0.001	0.001	0.056	0.001	2439	0.001	0.001	0.012	0.001	1659	0.001	0.001	0.005	0.001
SR_XRF_pct	1677	0.003	0.003	0.026	0.001	16797	0.005	0.005	0.068	0.001	2418	0.002	0.001	0.02	0.001	1625	0.002	0.002	0.034	0.001
SULP_XRF_pct	1934	0.057	0.031	1.42	0.008	19334	0.05	0.03	1.45	0.001	2956	0.035	0.022	0.264	0.001	2141	0.041	0.026	0.353	0.002
TIO2_XRF_pct	1934	0.578	0.56	1.9	0.04	19286	0.72	0.59	8.8	0.01	2956	0.17	0.13	1.55	0.01	2140	0.25	0.22	2.02	0.01
V_XRF_pct	1720	0.010	0.01	0.061	0.001	16801	0.013	0.01	0.317	0.001	2439	0.003	0.002	0.023	0.001	1658	0.005	0.004	0.028	0.001
ZR_XRF_pct	1720	0.009	0.009	0.027	0.001	16809	0.011	0.011	0.055	0.001	2436	0.003	0.003	0.027	0.001	1647	0.004	0.004	0.021	0.001
PHOS_XRF_pct	1934	0.038	0.036	0.114	0.015	19334	0.052	0.047	0.199	0.001	2956	0.060	0.058	0.167	0.007	2141	0.049	0.043	3.45	0.008
SIO2_XRF_pct	1934	8.80	8.33	25.15	1.61	19334	27.00	22.75	96.09	1.75	2956	6.19	5.07	64.73	0.99	2141	6.23	5.71	26.12	1.06
ZN_XRF_pct	1547	0.004	0.003	0.086	0.001	19175	0.011	0.009	0.379	0.001	2882	0.009	0.007	0.437	0.001	2047	0.008	0.005	0.087	0.001
MN_D	210	0.09	0.04	3.14	0.01	2414	1.44	0.42	44.06	0.01	511	0.19	0.13	4.48	0.01	477	0.14	0.06	1.96	0.01

Element/Oxide	Crustal Abundance	Alluvium				Clay				CAL				DET WASTE			
_Analysis_Units	mg/kg	Mean	Median	Maximum	Minimum	Mean	Median	Maximum	Minimum	Mean	Median	Maximum	Minimum	Mean	Median	Maximum	Minimum
AL2O3_XRF_pct	309886																
AS_XRF_pct	1.5	3	3	5	2	3	3	7	2	2	2	3	2	3	3	6	2
BA_XRF_pct	500			1												2	
CAO_XRF_pct	57367							1		1	1	1				1	
CL_XRF_pct	130			5				4								4	
CO_XRF_pct	20			2				4				1				3	
CR_XRF_pct	100			2		1	1	3								2	
CU_XRF_pct	50			1				2								2	
FE_CALC_pct	41000	2	2	3		2	2	3				2		2	2	3	
K2O_XRF_pct	50593																
MGO_XRF_pct	37540							1		1	1	1				1	
MN_XRF_pct	950			7				2				1				7	
MNO_XRF_pct	1226.665			2				1								6	
NA_XRF_pct	23000																
NI_XRF_pct	80			2				4								3	
PB_XRF_pct	14			3				3								3	
SN_XRF_pct	2	2	1	5	1	2	1	4	1	2	1	3	1	2	1	6	1
SR_XRF_pct	370																
SULP_XRF_pct	260			3				3								5	
TIO2_XRF_pct	9343			1				1								1	
V_XRF_pct	160			2				2								2	
ZR_XRF_pct	190															1	
PHOS_XRF_pct	1000																
SIO2_XRF_pct	592557.138																
ZN_XRF_pct	75			4				5		1		2				3	
MN_D	950			2				2								6	

Element/Oxide	DET ORE				ANG WASTE				ANG ORE				ANG HYD			
_Analysis_Units	Mean	Median	Maximum	Minimum	Mean	Median	Maximum	Minimum	Mean	Median	Maximum	Minimum	Mean	Median	Maximum	Minimum
AL2O3_XRF_pct																
AS_XRF_pct	3	3	6	2	4	4	8	2	3	3	8	2	3	3	6	2
BA_XRF_pct			1				3				1				2	
CAO_XRF_pct							1									
CL_XRF_pct			2				4				2				2	
CO_XRF_pct			5				6				5				4	
CR_XRF_pct			1				2								1	
CU_XRF_pct			1				3				4				2	
FE_CALC_pct	3	3	3	2	2	2	3		3	3	3	1	3	3	3	2
K2O_XRF_pct																
MGO_XRF_pct							1									
MN_XRF_pct			4		3	1	8				5				6	
MNO_XRF_pct			4		3	1	8				4				3	
NA_XRF_pct																
NI_XRF_pct			2				2				1				2	
PB_XRF_pct			4				3				2				2	
SN_XRF_pct	2	1	4	1	2	1	7	1	2	1	5	1	2	1	4	1
SR_XRF_pct																
SULP_XRF_pct			5				5				2				3	
TIO2_XRF_pct							2									
V_XRF_pct			1				3									
ZR_XRF_pct																
PHOS_XRF_pct															4	
SIO2_XRF_pct																
ZN_XRF_pct			2				5				5				2	
MN_D			4		3	1	8				4				3	

Element/Oxide	NEW WASTE					NEW ORE					MAC WASTE					MAC ORE				
_Analysis_Units	Count	Mean	Median	Maximum	Minimum	Count	Mean	Median	Maximum	Minimum	Count	Mean	Median	Maximum	Minimum	Count	Mean	Median	Maximum	Minimum
AL2O3_XRF_pct	11411	1.37	0.56	36.29	0.01	14753	1.55	1.05	30.26	0.23	2831	3.61	2.45	24.77	0.22	1870	3.75	2.97	23.27	0.49
AS_XRF_pct	9533	0.002	0.001	0.025	0.001	11482	0.002	0.001	0.024	0.001	2444	0.002	0.002	0.013	0.001	1472	0.002	0.002	0.01	0.001
BA_XRF_pct	9099	0.003	0.001	0.734	0.001	11278	0.003	0.001	0.772	0.001	2296	0.010	0.001	1.28	0.001	1469	0.003	0.001	0.068	0.001
CAO_XRF_pct	10876	0.032	0.02	8.89	0.01	13852	0.023	0.02	0.71	0.01	2718	0.107	0.03	16.9	0.01	1729	0.030	0.02	0.5	0.01
CL_XRF_pct	10177	0.007	0.006	0.289	0.001	11616	0.009	0.007	0.124	0.001	2606	0.012	0.008	0.148	0.001	1500	0.017	0.014	0.107	0.001
CO_XRF_pct	9206	0.001	0.001	0.048	0.001	11459	0.002	0.001	0.248	0.001	2344	0.003	0.001	0.128	0.001	1485	0.002	0.001	0.06	0.001
CR_XRF_pct	9348	0.002	0.001	0.048	0.001	11381	0.002	0.001	0.104	0.001	2434	0.004	0.002	0.067	0.001	1488	0.003	0.003	0.019	0.001
CU_XRF_pct	10029	0.001	0.001	0.038	0.001	12416	0.002	0.001	0.176	0.001	2581	0.002	0.001	0.072	0.001	1730	0.002	0.002	0.011	0.001
FE_CALC_pct	11411	36.57	35.13	64.2	0.58	14753	61.80	62.87	66.45	13.77	2831	34.73	33.7	60.01	1.62	1870	56.21	57.3	65.08	23.06
K2O_XRF_pct	10501	0.013	0.006	2.763	0.001	11933	0.007	0.003	0.82	0.001	2738	0.087	0.014	4.673	0.001	1581	0.008	0.004	0.696	0.001
MGO_XRF_pct	11248	0.060	0.04	2.9	0.01	14560	0.062	0.05	1.35	0.01	2794	0.178	0.05	10.9	0.01	1797	0.065	0.05	0.41	0.01
MN_XRF_pct	9840	0.053	0.03	18.7	0.01	11585	0.082	0.05	15	0.01	2494	0.130	0.03	18.4	0.01	1493	0.043	0.02	2	0.01
MNO_XRF_pct	1065	0.081	0.04	7.27	0.01	3121	0.114	0.06	24.56	0.01	193	0.086	0.03	7.34	0.01	345	0.074	0.04	1.82	0.01
NA_XRF_pct	9588	0.013	0.01	0.22	0.01	11232	0.012	0.01	0.16	0.01	2440	0.020	0.01	0.23	0.01	1467	0.015	0.01	0.14	0.01
NI_XRF_pct	9911	0.002	0.001	0.111	0.001	11432	0.002	0.002	0.169	0.001	2570	0.003	0.002	0.074	0.001	1484	0.002	0.002	0.027	0.001
PB_XRF_pct	9907	0.002	0.001	0.022	0.001	11865	0.002	0.001	0.019	0.001	2496	0.002	0.002	0.015	0.001	1650	0.002	0.001	0.017	0.001
SN_XRF_pct	10007	0.001	0.001	0.008	0.001	11543	0.002	0.002	0.008	0.001	2521	0.001	0.001	0.008	0.001	1498	0.001	0.001	0.006	0.001
SR_XRF_pct	10160	0.005	0.005	0.025	0.001	11287	0.002	0.001	0.051	0.001	2595	0.005	0.004	0.023	0.001	1472	0.002	0.001	0.014	0.001
SULP_XRF_pct	11411	0.013	0.008	0.323	0.001	14753	0.020	0.012	0.311	0.001	2831	0.038	0.018	1.1	0.001	1870	0.063	0.035	0.741	0.002
TIO2_XRF_pct	10739	0.070	0.02	4.69	0.01	14675	0.053	0.03	1.87	0.01	2816	0.168	0.1	3.39	0.01	1869	0.146	0.11	0.96	0.01
V_XRF_pct	9398	0.002	0.001	0.043	0.001	11419	0.002	0.001	0.049	0.001	2417	0.004	0.002	0.035	0.001	1481	0.003	0.002	0.018	0.001
ZR_XRF_pct	9795	0.003	0.002	0.044	0.001	11248	0.001	0.001	0.027	0.001	2525	0.004	0.004	0.032	0.001	1485	0.003	0.002	0.016	0.001
PHOS_XRF_pct	11410	0.045	0.041	0.608	0.001	14753	0.070	0.062	5.3	0.008	2831	0.036	0.03	0.151	0.002	1870	0.059	0.053	0.181	0.013
SIO2_XRF_pct	11411	41.70	44.9	98.16	1.93	14753	2.82	1.74	51.67	0.63	2831	38.86	41.6	94.6	2.81	1870	5.03	3.87	43.1	0.96
ZN_XRF_pct	10469	0.004	0.003	0.209	0.001	13807	0.006	0.004	0.218	0.001	2694	0.008	0.006	0.115	0.001	1851	0.010	0.007	0.06	0.001
MN_D	1198	0.14	0.04	5.63	0.01	3137	0.09	0.05	19.02	0.01	223	0.16	0.03	5.68	0.01	370	0.11	0.03	1.41	0.01

Element/Oxide	NAM WASTE					NAM ORE					MM HYD				
_Analysis_Units	Count	Mean	Median	Maximum	Minimum	Count	Mean	Median	Maximum	Minimum	Count	Mean	Median	Maximum	Minimum
AL2O3_XRF_pct	308	1.54	1.11	10.25	0.17	27	3.24	2.54	10.66	1.06	7407	3.31	2.82	39.93	0.19
AS_XRF_pct	287	0.001	0.001	0.005	0.001	25	0.002	0.002	0.005	0.001	5581	0.002	0.002	0.018	0.001
BA_XRF_pct	289	0.005	0.001	0.259	0.001	25	0.002	0.001	0.008	0.001	5460	0.005	0.002	0.816	0.001
CAO_XRF_pct	298	0.399	0.02	21.91	0.01	25	0.028	0.03	0.07	0.01	7277	0.075	0.04	11.3	0.01
CL_XRF_pct	296	0.009	0.007	0.075	0.001	25	0.014	0.008	0.033	0.002	5975	0.014	0.009	0.419	0.001
CO_XRF_pct	286	0.002	0.001	0.011	0.001	25	0.002	0.002	0.013	0.001	5480	0.002	0.001	0.157	0.001
CR_XRF_pct	293	0.002	0.001	0.01	0.001	25	0.002	0.002	0.007	0.001	5717	0.003	0.003	0.028	0.001
CU_XRF_pct	302	0.002	0.001	0.006	0.001	27	0.002	0.001	0.004	0.001	6092	0.002	0.001	0.356	0.001
FE_CALC_pct	308	28.73	28.145	56.43	2.42	27	55.82	57.32	59.85	45.74	7407	56.70	57.09	66.8	14.85
K2O_XRF_pct	303	0.085	0.016	3.121	0.003	25	0.004	0.003	0.007	0.002	6577	0.016	0.01	0.706	0.001
MGO_XRF_pct	308	0.373	0.04	11.8	0.01	27	0.058	0.05	0.25	0.01	7280	0.084	0.06	7.15	0.01
MN_XRF_pct	289	0.069	0.02	2.69	0.01	25	0.040	0.03	0.13	0.01	5834	0.062	0.03	16.3	0.01
MNO_XRF_pct	6	0.047	0.03	0.11	0.02	2	0.015	0.015	0.02	0.01	1385	0.071	0.04	3.72	0.01
NA_XRF_pct	295	0.016	0.01	0.3	0.01	25	0.014	0.01	0.02	0.01	5609	0.019	0.01	0.17	0.01
NI_XRF_pct	296	0.003	0.002	0.016	0.001	25	0.002	0.002	0.007	0.001	5587	0.002	0.001	0.114	0.001
PB_XRF_pct	297	0.002	0.002	0.009	0.001	25	0.001	0.001	0.003	0.001	5448	0.002	0.001	0.019	0.001
SN_XRF_pct	295	0.001	0.001	0.004	0.001	25	0.001	0.001	0.002	0.001	5778	0.002	0.001	0.008	0.001
SR_XRF_pct	296	0.006	0.005	0.018	0.001	25	0.002	0.002	0.007	0.001	5524	0.002	0.002	0.019	0.001
SULP_XRF_pct	308	0.042	0.02	0.914	0.004	27	0.050	0.047	0.145	0.008	7407	0.037	0.028	0.36	0.002
TIO2_XRF_pct	308	0.069	0.04	0.43	0.01	27	0.103	0.09	0.47	0.02	7380	0.163	0.11	2.59	0.01
V_XRF_pct	296	0.002	0.001	0.025	0.001	25	0.003	0.002	0.01	0.001	5580	0.003	0.002	0.036	0.001
ZR_XRF_pct	288	0.003	0.003	0.009	0.001	25	0.002	0.001	0.009	0.001	5445	0.003	0.002	0.159	0.001
PHOS_XRF_pct	308	0.036	0.0315	0.18	0.006	27	0.053	0.051	0.09	0.029	7407	0.056	0.052	1.96	0.005
SIO2_XRF_pct	308	50.77	52.35	93.49	7.36	27	6.37	6.12	17.8	2.09	7407	5.98	4.89	44.22	0.86
ZN_XRF_pct	307	0.006	0.003	0.032	0.001	27	0.010	0.008	0.03	0.001	6439	0.006	0.003	0.309	0.001
MN_D	12	0.41	0.43	0.77	0.02	2	0.01	0.01	0.02	0.01	1429	0.08	0.03	2.88	0.01

Element/Oxide	Crustal	NEW WASTE				NEW ORE				MAC WASTE				MAC ORE			
_Analysis_Units	mg/kg	Mean	Median	Maximum	Minimum	Mean	Median	Maximum	Minimum	Mean	Median	Maximum	Minimum	Mean	Median	Maximum	Minimum
AL2O3_XRF_pct	309886																
AS_XRF_pct	1.5	2	2	6	2	2	2	6	2	3	3	5	2	3	3	5	2
BA_XRF_pct	500			3				3				4					
CAO_XRF_pct	57367																
CL_XRF_pct	130			3				2				2				2	
CO_XRF_pct	20			4				6				5				4	
CR_XRF_pct	100			1				2				2					
CU_XRF_pct	50			2				4				3					
FE_CALC_pct	41000	2	2	3		3	3	3	1	2	2	3		3	3	3	1
K2O_XRF_pct	50593																
MGO_XRF_pct	37540																
MN_XRF_pct	950			7				6				7				3	
MNO_XRF_pct	1226.665			5				7				5				3	
NA_XRF_pct	23000																
NI_XRF_pct	80			3				3				2				1	
PB_XRF_pct	14			3				3				2				3	
SN_XRF_pct	2	2	1	4	1	2	2	4	1	2	1	4	1	2	1	4	1
SR_XRF_pct	370																
SULP_XRF_pct	260			3				2				4				4	
TIO2_XRF_pct	9343			1								1					
V_XRF_pct	160							1									
ZR_XRF_pct	190																
PHOS_XRF_pct	1000			2				5									
SIO2_XRF_pct	592557.138																
ZN_XRF_pct	75			4				4				3				2	
MN_D	950			5				7				5				3	

Element/Oxide	NAM WASTE				NAM ORE				MM HYD			
_Analysis_Units	Mean	Median	Maximum	Minimum	Mean	Median	Maximum	Minimum	Mean	Median	Maximum	Minimum
AL2O3_XRF_pct												
AS_XRF_pct	2	2	4	2	3	3	4	2	3	3	6	2
BA_XRF_pct			1								3	
CAO_XRF_pct			1									
CL_XRF_pct			1								4	
CO_XRF_pct			1				2				5	
CR_XRF_pct												
CU_XRF_pct											5	
FE_CALC_pct	2	2	3		3	3	3	2	3	3	3	1
K2O_XRF_pct												
MGO_XRF_pct			1									
MN_XRF_pct			4								6	
MNO_XRF_pct											4	
NA_XRF_pct												
NI_XRF_pct											3	
PB_XRF_pct			2								3	
SN_XRF_pct	1	1	3	1	1	1	2	1	2	1	4	1
SR_XRF_pct												
SULP_XRF_pct			4				1				3	
TIO2_XRF_pct												
V_XRF_pct												
ZR_XRF_pct											2	
PHOS_XRF_pct											3	
SIO2_XRF_pct												
ZN_XRF_pct			1				1				4	
MN_D	1	1	2								4	

West Angelas Deposit F Global Abundance Index

Element/Oxide_Analysis_Units	ALLUVIUM Count	Mean	Median	Maximum	Minimum	CLAY Count	Mean	Median	Maximum	Minimum	CALCRETE Count	Mean	Median	Maximum	Minimum	DET WASTE Count	Mean	Median	Maximum	Minimum
AL2O3_XRF_pct	9	10.21	10.17	13.01	8.41	13606	17.17	17.225	27.23	1.99	5	2.88	3.34	4.22	0.89	12817	9.74	8.65	23.43	0.49
AS_XRF_pct	9	0.002	0.002	0.004	0.002	9826	0.003	0.002	0.008	0.001	4	0.002	0.002	0.003	0.002	7378	0.002	0.002	0.007	0.001
BA_XRF_pct	9	0.014	0.013	0.024	0.008	9637	0.010	0.008	0.062	0.001						9592	0.013	0.011	0.469	0.001
CAO_XRF_pct	9	0.42	0.24	0.94	0.07	13606	0.54	0.39	25.04	0.02	5	21.01	22.14	33.4	4.21	12807	0.18	0.11	4.48	0.01
CL_XRF_pct	9	0.043	0.008	0.327	0.004	11331	0.010	0.006	2.02	0.001	4	0.005	0.005	0.007	0.004	10523	0.019	0.01	1.7	0.001
CO_XRF_pct	8	0.002	0.002	0.002	0.001	10887	0.004	0.004	0.031	0.001						6391	0.003	0.002	0.015	0.001
CR_XRF_pct	9	0.028	0.029	0.034	0.022	12138	0.033	0.032	0.093	0.002	2	0.003	0.0025	0.003	0.002	10852	0.014	0.013	0.09	0.001
CU_XRF_pct	9	0.009	0.01	0.012	0.006	13581	0.012	0.013	0.028	0.001	3	0.002	0.002	0.002	0.001	12105	0.004	0.004	0.02	0.001
FE_CALC_pct	9	31.38	32.02	37.36	23.94	13606	22.44	21.11	62.37	7.91	5	11.93	5.83	36.39	4.83	12817	31.39	31.12	63.3	10.5
K2O_XRF_pct	9	0.265	0.242	0.411	0.187	13604	0.226	0.245	0.86	0.01	5	0.067	0.047	0.18	0.024	12774	0.301	0.25	1.119	0.005
MGO_XRF_pct	9	0.34	0.34	0.57	0.14	13605	0.60	0.54	8.68	0.02	5	11.66	15.3	18.84	1.97	12796	0.19	0.16	1.27	0.01
MN_XRF_pct	9	0.058	0.05	0.09	0.04	11686	0.086	0.09	0.4	0.02	3	0.040	0.05	0.05	0.02	10685	0.048	0.04	1.25	0.01
MNO_XRF_pct						1455	0.112	0.12	0.38	0.01	1	0.620	0.62	0.62	0.62	1908	0.073	0.05	24.14	0.01
NA_XRF_pct	9	0.101	0.07	0.18	0.03	12124	0.135	0.11	0.88	0.01	4	0.040	0.04	0.06	0.02	10764	0.058	0.05	0.46	0.01
NI_XRF_pct	9	0.007	0.007	0.009	0.005	12137	0.009	0.009	0.084	0.001	2	0.002	0.0015	0.002	0.001	10453	0.004	0.003	0.021	0.001
PB_XRF_pct	3	0.002	0.003	0.003	0.001	6681	0.004	0.003	0.024	0.001	4	0.004	0.0045	0.005	0.003	8931	0.005	0.004	0.027	0.001
SN_XRF_pct	1	0.002	0.002	0.002	0.002	7365	0.002	0.002	0.009	0.001						7936	0.003	0.002	0.011	0.001
SR_XRF_pct	9	0.006	0.006	0.009	0.004	12008	0.006	0.006	0.022	0.001	3	0.005	0.006	0.007	0.003	10792	0.006	0.005	0.021	0.001
SULP_XRF_pct	9	0.029	0.027	0.053	0.018	13606	0.017	0.015	0.262	0.001	5	0.011	0.007	0.027	0.005	12817	0.020	0.018	0.98	0.001
TIO2_XRF_pct	9	0.852	0.95	0.99	0.58	13606	1.325	1.36	1.89	0.08	5	0.190	0.21	0.28	0.04	12817	0.698	0.67	2.13	0.02
V_XRF_pct	9	0.034	0.035	0.044	0.024	12138	0.039	0.036	0.113	0.004	2	0.004	0.0035	0.006	0.001	10851	0.015	0.013	0.09	0.001
ZR_XRF_pct	9	0.010	0.011	0.012	0.008	12137	0.015	0.014	0.033	0.004	4	0.004	0.004	0.005	0.003	10854	0.017	0.016	0.058	0.001
PHOS_XRF_pct	9	0.039	0.039	0.043	0.035	13605	0.028	0.028	0.066	0.001	5	0.009	0.007	0.013	0.005	12817	0.037	0.037	0.135	0.007
SIO2_XRF_pct	9	36.34	36.82	42.9	30.54	13606	40.37	42.175	59.73	6.92	5	14.74	15.38	24.15	3.3	12817	38.27	39.67	62.8	2.09
ZN_XRF_pct	9	0.020	0.019	0.025	0.017	13546	0.022	0.022	0.069	0.001	5	0.002	0.002	0.003	0.001	12431	0.007	0.005	0.145	0.001
MN_D						1455	0.09	0.09	0.29	0.01	1	0.48	0.48	0.48	0.48	1912	0.06	0.04	18.70	0.01

Element/Oxide_Analysis_Units	DET ORE Count	Mean	Median	Maximum	Minimum	DOLERITE Count	Mean	Median	Maximum	Minimum	ANG WASTE Count	Mean	Median	Maximum	Minimum	ANG ORE Count	Mean	Median	Maximum	Minimum
AL2O3_XRF_pct	3751	6.50	6.63	16.57	0.93	147	20.77	22.23	31.2	2.42	4235	11.91	11.92	37.36	0.15	1198	3.85	3.07	27.57	0.64
AS_XRF_pct	1749	0.002	0.002	0.015	0.001	79	0.002	0.002	0.005	0.001	3414	0.005	0.005	0.044	0.001	841	0.003	0.002	0.011	0.001
BA_XRF_pct	1701	0.012	0.005	4.9	0.001	45	0.008	0.008	0.014	0.002	2392	0.015	0.008	0.967	0.001	342	0.004	0.003	0.155	0.001
CAO_XRF_pct	3734	0.08	0.08	1.43	0.01	146	0.08	0.07	0.44	0.01	4187	0.11	0.07	12.71	0.01	1142	0.03	0.03	0.15	0.01
CL_XRF_pct	2613	0.009	0.007	0.072	0.001	139	0.009	0.007	0.053	0.002	3528	0.007	0.006	0.072	0.001	1071	0.007	0.006	0.033	0.001
CO_XRF_pct	1255	0.002	0.002	0.006	0.001	44	0.002	0.002	0.005	0.001	2639	0.003	0.003	0.022	0.001	517	0.002	0.002	0.009	0.001
CR_XRF_pct	2618	0.011	0.011	0.036	0.002	138	0.010	0.01	0.022	0.001	3705	0.010	0.009	0.058	0.001	985	0.005	0.004	0.035	0.001
CU_XRF_pct	2584	0.002	0.002	0.018	0.0005	146	0.010	0.01	0.024	0.001	3478	0.004	0.003	0.025	0.001	764	0.002	0.002	0.023	0.001
FE_CALC_pct	3751	55.90	55.37	66.7	25	147	26.16	23.55	52.29	7.12	4235	33.33	34.36	64.15	1.11	1198	56.85	58.14	65.99	18.1
K2O_XRF_pct	3346	0.026	0.02	0.388	0.001	147	0.210	0.14	0.835	0.005	4186	0.702	0.394	4.104	0.003	1175	0.041	0.02	0.647	0.001
MGO_XRF_pct	3688	0.09	0.08	0.76	0.01	147	0.18	0.14	1.8	0.03	4222	0.51	0.45	10.1	0.01	1195	0.15	0.13	0.43	0.01
MN_XRF_pct	2489	0.027	0.02	1.7	0.01	124	0.067	0.05	0.56	0.02	3390	0.912	0.26	27	0.01	1079	0.130	0.09	6.68	0.02
MNO_XRF_pct	919	0.037	0.03	0.32	0.01	6	0.057	0.055	0.09	0.03	389	0.495	0.11	12.04	0.01	106	0.186	0.15	0.58	0.01
NA_XRF_pct	2207	0.024	0.02	0.25	0.004	112	0.022	0.02	0.19	0.01	3476	0.030	0.03	0.25	0.01	524	0.019	0.02	0.07	0.01
NI_XRF_pct	2121	0.002	0.002	0.028	0.001	115	0.004	0.004	0.009	0.001	3639	0.007	0.006	0.062	0.001	928	0.003	0.002	0.013	0.001
PB_XRF_pct	1935	0.004	0.003	0.023	0.001	46	0.010	0.011	0.017	0.001	2042	0.004	0.004	0.02	0.001	258	0.003	0.002	0.013	0.001
SN_XRF_pct	2076	0.003	0.002	0.012	0.001	97	0.002	0.002	0.006	0.001	2217	0.003	0.002	0.01	0.001	680	0.002	0.002	0.007	0.001
SR_XRF_pct	2346	0.003	0.003	0.02	0.0005	133	0.004	0.004	0.01	0.001	3350	0.005	0.003	0.031	0.001	463	0.002	0.001	0.007	0.001
SULP_XRF_pct	3751	0.026	0.02	0.923	0.006	147	0.009	0.008	0.046	0.001	4235	0.021	0.011	1.18	0.001	1198	0.012	0.009	0.134	0.001
TIO2_XRF_pct	3719	0.672	0.64	2.36	0.06	147	1.544	1.68	2.4	0.12	4228	0.603	0.58	3.83	0.01	1198	0.164	0.12	2.09	0.01
V_XRF_pct	2614	0.010	0.01	0.036	0.001	141	0.033	0.034	0.073	0.002	3705	0.010	0.009	0.052	0.001	892	0.003	0.003	0.034	0.001
ZR_XRF_pct	2619	0.012	0.012	0.034	0.0005	141	0.010	0.01	0.02	0.001	3672	0.011	0.01	0.042	0.001	804	0.004	0.003	0.017	0.001
PHOS_XRF_pct	3751	0.035	0.033	0.122	0.016	147	0.046	0.044	0.186	0.006	4235	0.050	0.046	0.307	0.001	1198	0.049	0.0475	0.136	0.009
SIO2_XRF_pct	3751	9.06	9.18	37.29	1.05	147	28.83	29.55	66.77	9.06	4235	27.89	22.97	95.9	2.58	1198	5.45	4.37	38.21	0.92
ZN_XRF_pct	1938	0.002	0.002	0.045	0.001	120	0.005	0.005	0.014	0.001	3504	0.006	0.005	0.075	0.001	1034	0.003	0.003	0.014	0.001
MN_D	936	0.04	0.02	0.77	0.01	6	0.04	0.04	0.07	0.02	431	0.42	0.11	9.32	0.01	106	0.14	0.12	0.45	0.01

Element/Oxide_Analysis_Units	Crustal Abundance mg/kg	ALLUVIUM Mean	Median	Maximum	Minimum	CLAY Mean	Median	Maximum	Minimum	CALCRETE Mean	Median	Maximum	Minimum	DET WASTE Mean	Median	Maximum	Minimum
AL2O3_XRF_pct	309886																
AS_XRF_pct	1.5	3	3	4	3	3	3	5	2	3	3	3	3	3	3	4	2
BA_XRF_pct	500															2	
CAO_XRF_pct	57367							1		1	1	1					
CL_XRF_pct	130	1		4				6								6	
CO_XRF_pct	20							3								2	
CR_XRF_pct	100			1		1	1	2								2	
CU_XRF_pct	50							1								1	
FE_CALC_pct	41000	2	2	2	1	1	1	3				2		2	2	3	
K2O_XRF_pct	50593																
MGO_XRF_pct	37540									1	1	1					
MN_XRF_pct	950							1								3	
MNO_XRF_pct	1226.665							1		1	1	1	1			7	
NA_XRF_pct	23000																
NI_XRF_pct	80							2									
PB_XRF_pct	14					1		3		1	1	1		1		3	
SN_XRF_pct	2	2	2	2	2	2	2	4	1					3	2	5	1
SR_XRF_pct	370																
SULP_XRF_pct	260							2								4	
TIO2_XRF_pct	9343																
V_XRF_pct	160							2								1	
ZR_XRF_pct	190															1	
PHOS_XRF_pct	1000																
SIO2_XRF_pct	592557.138																
ZN_XRF_pct	75			1				2								3	
MN_D	950							1		1	1	1	1			7	

Element/Oxide_Analysis_Units	DET ORE Mean	Median	Maximum	Minimum	DOLERITE Mean	Median	Maximum	Minimum	ANG WASTE Mean	Median	Maximum	Minimum	ANG ORE Mean	Median	Maximum	Minimum
AL2O3_XRF_pct																
AS_XRF_pct	3	3	6	2	3	3	4	2	4	4	7	2	3	3	5	2
BA_XRF_pct			6								3				1	
CAO_XRF_pct																
CL_XRF_pct			1				1				1					
CO_XRF_pct			1								2				1	
CR_XRF_pct			1								1				1	
CU_XRF_pct			1				1				1				1	
FE_CALC_pct	3	3	3	2	2	1	3		2	2	3		3	3	3	1
K2O_XRF_pct																
MGO_XRF_pct																
MN_XRF_pct			3				1		2		7				5	
MNO_XRF_pct									1		6				1	
NA_XRF_pct																
NI_XRF_pct			1								2					
PB_XRF_pct			3		2	2	3		1		3				2	
SN_XRF_pct	3	2	5	1	2	2	4	1	3	2	5	1	2	2	4	1
SR_XRF_pct																
SULP_XRF_pct			4								4				1	
TIO2_XRF_pct											1					
V_XRF_pct							1				1					
ZR_XRF_pct																
PHOS_XRF_pct											1					
SIO2_XRF_pct																
ZN_XRF_pct			2								2					
MN_D			2						1		6				1	

Element/Oxide_Analysis_Units	ANG HYD Count	Mean	Median	Maximum	Minimum	NEW WASTE Count	Mean	Median	Maximum	Minimum	NEW ORE Count	Mean	Median	Maximum	Minimum	MAC WASTE Count	Mean	Median	Maximum	Minimum
AL2O3_XRF_pct	2524	6.56	5.98	29.28	0.69	5818	1.54	0.74	31.38	0.07	7449	1.96	1.39	29.52	0.25	2087	3.27	2.11	30.19	0.13
AS_XRF_pct	1794	0.003	0.003	0.015	0.001	2356	0.002	0.002	0.009	0.001	2503	0.002	0.002	0.011	0.001	1302	0.002	0.002	0.007	0.001
BA_XRF_pct	686	0.006	0.004	0.092	0.001	1742	0.005	0.004	0.104	0.001	2566	0.004	0.003	0.252	0.001	490	0.011	0.004	0.344	0.001
CAO_XRF_pct	2484	0.06	0.05	0.57	0.01	4330	0.04	0.02	2.9	0.01	5626	0.02	0.02	0.93	0.01	1757	0.06	0.03	8.59	0.01
CL_XRF_pct	2077	0.008	0.006	0.066	0.001	5337	0.006	0.005	0.161	0.001	6384	0.009	0.007	0.149	0.001	1926	0.012	0.009	0.145	0.001
CO_XRF_pct	1058	0.002	0.002	0.01	0.001	1982	0.002	0.002	0.011	0.001	3097	0.002	0.002	0.011	0.001	546	0.002	0.002	0.01	0.001
CR_XRF_pct	2102	0.008	0.007	0.049	0.001	2632	0.003	0.002	0.034	0.001	3608	0.003	0.002	0.034	0.001	1304	0.004	0.003	0.027	0.001
CU_XRF_pct	1606	0.003	0.002	0.016	0.001	3207	0.002	0.001	0.017	0.001	3942	0.002	0.002	0.01	0.001	1649	0.002	0.002	0.029	0.001
FE_CALC_pct	2524	52.37	53.25	65.38	4.52	5818	36.98	36.01	64.16	1.27	7449	61.40	62.57	66.71	15.59	2087	34.07	33.9	58.49	0.74
K2O_XRF_pct	2350	0.048	0.013	2.516	0.001	5616	0.015	0.01	1.63	0.001	6433	0.009	0.005	0.26	0.001	2048	0.072	0.016	6.668	0.002
MGO_XRF_pct	2507	0.13	0.11	1.64	0.01	5731	0.07	0.04	2.69	0.01	7270	0.06	0.05	0.4	0.01	1962	0.12	0.04	7.78	0.01
MN_XRF_pct	1535	0.059	0.03	3.46	0.01	3982	0.034	0.02	1.11	0.02	5926	0.054	0.05	4.38	0.02	1244	0.084	0.02	4.21	0.02
MNO_XRF_pct	352	0.071	0.04	5.6	0.01	352	0.042	0.03	0.43	0.01	1006	0.072	0.06	2.45	0.01	145	0.388	0.03	22.98	0.01
NA_XRF_pct	1253	0.021	0.02	0.19	0.01	2613	0.019	0.02	0.22	0.01	2556	0.017	0.01	0.24	0.01	1233	0.023	0.02	0.18	0.01
NI_XRF_pct	1704	0.003	0.002	0.017	0.001	3137	0.002	0.002	0.013	0.001	3817	0.002	0.002	0.029	0.001	1331	0.002	0.002	0.011	0.001
PB_XRF_pct	676	0.004	0.003	0.023	0.001	3678	0.005	0.003	0.053	0.001	2007	0.003	0.002	0.019	0.001	1008	0.004	0.003	0.017	0.001
SN_XRF_pct	1208	0.002	0.002	0.008	0.001	3878	0.003	0.002	0.011	0.001	4607	0.002	0.002	0.01	0.001	1141	0.002	0.002	0.01	0.001
SR_XRF_pct	1264	0.002	0.002	0.042	0.001	5148	0.004	0.004	0.021	0.001	2952	0.002	0.001	0.029	0.001	1788	0.005	0.005	0.016	0.001
SULP_XRF_pct	2524	0.029	0.017	1.4	0.002	5818	0.011	0.005	2.56	0.001	7449	0.013	0.009	0.43	0.001	2087	0.022	0.013	0.376	0.001
TIO2_XRF_pct	2524	0.502	0.41	7.22	0.01	4879	0.092	0.04	5.3	0.01	7264	0.065	0.04	1.62	0.01	2065	0.146	0.09	1.56	0.01
V_XRF_pct	2062	0.008	0.007	0.042	0.001	2091	0.003	0.002	0.036	0.001	2649	0.002	0.002	0.022	0.001	1151	0.004	0.003	0.03	0.001
ZR_XRF_pct	2029	0.007	0.006	0.066	0.001	3538	0.003	0.002	0.061	0.001	2900	0.002	0.002	0.036	0.001	1491	0.004	0.003	0.045	0.001
PHOS_XRF_pct	2524	0.039	0.038	0.104	0.004	5818	0.046	0.042	0.303	0.002	7449	0.069	0.063	0.433	0.02	2087	0.037	0.032	0.178	0.001
SIO2_XRF_pct	2524	7.76	6.64	44.89	1.25	5818	41.33	43.975	96.83	1.94	7449	3.16	2.03	60.2	0.6	2087	40.75	42.22	94.64	1.68
ZN_XRF_pct	1567	0.005	0.002	0.041	0.001	3320	0.002	0.002	0.035	0.001	4878	0.002	0.002	0.014	0.001	1807	0.004	0.003	0.027	0.001
MN_D	372	0.09	0.03	4.34	0.01	383	0.09	0.02	0.77	0.01	1027	0.07	0.05	1.90	0.01	150	0.32	0.02	17.80	0.01

Element/Oxide_Analysis_Units	MAC ORE Count	Mean	Median	Maximum	Minimum	NAM WASTE Count	Mean	Median	Maximum	Minimum	MM HYD Count	Mean	Median	Maximum	Minimum
AL2O3_XRF_pct	886	3.73	3.1	31.28	0.73	108	1.54	1.08	6.45	0.36	6074	3.78	3.15	33.96	0.38
AS_XRF_pct	514	0.002	0.002	0.006	0.001	60	0.002	0.001	0.006	0.001	3165	0.002	0.002	0.007	0.001
BA_XRF_pct	224	0.006	0.003	0.183	0.001	39	0.007	0.005	0.033	0.001	1800	0.006	0.004	0.31	0.001
CAO_XRF_pct	696	0.03	0.03	0.28	0.01	101	0.25	0.03	5.98	0.01	5731	0.046	0.04	0.99	0.01
CL_XRF_pct	806	0.014	0.011	0.082	0.001	102	0.009	0.008	0.023	0.001	5286	0.012	0.009	0.186	0.001
CO_XRF_pct	342	0.002	0.002	0.02	0.001	36	0.002	0.0015	0.003	0.001	2078	0.002	0.002	0.021	0.001
CR_XRF_pct	645	0.004	0.003	0.015	0.001	40	0.003	0.002	0.008	0.001	4492	0.004	0.003	0.031	0.001
CU_XRF_pct	615	0.002	0.002	0.008	0.001	85	0.002	0.001	0.006	0.001	3305	0.002	0.002	0.016	0.001
FE_CALC_pct	886	56.36	57.23	65.37	12.65	108	26.72	27.235	42.82	1.71	6074	55.82	56.62	65.27	4.02
K2O_XRF_pct	822	0.011	0.007	0.18	0.001	108	0.195	0.0255	3.79	0.007	5636	0.018	0.011	1.467	0.001
MGO_XRF_pct	802	0.05	0.05	0.34	0.01	104	0.40	0.045	5.54	0.01	5910	0.06	0.06	0.62	0.01
MN_XRF_pct	568	0.047	0.02	3.41	0.02	82	0.043	0.02	0.22	0.02	3992	0.042	0.03	4.86	0.02
MNO_XRF_pct	76	0.036	0.03	0.16	0.01	4	0.043	0.04	0.06	0.03	691	0.053	0.04	2.02	0.01
NA_XRF_pct	402	0.017	0.02	0.1	0.01	71	0.026	0.03	0.07	0.01	3391	0.023	0.02	0.18	0.01
NI_XRF_pct	498	0.002	0.002	0.019	0.001	71	0.002	0.002	0.006	0.001	2886	0.002	0.002	0.017	0.001
PB_XRF_pct	165	0.004	0.003	0.019	0.001	72	0.003	0.003	0.012	0.001	1287	0.004	0.003	0.019	0.001
SN_XRF_pct	468	0.002	0.002	0.007	0.001	82	0.002	0.002	0.009	0.001	3314	0.002	0.002	0.01	0.001
SR_XRF_pct	366	0.002	0.002	0.01	0.001	103	0.007	0.007	0.013	0.001	2954	0.002	0.002	0.025	0.001
SULP_XRF_pct	886	0.036	0.023	0.463	0.002	108	0.013	0.01	0.083	0.002	6074	0.032	0.025	0.545	0.001
TIO2_XRF_pct	881	0.136	0.1	0.94	0.01	108	0.082	0.05	0.35	0.02	6059	0.226	0.15	2.6	0.01
V_XRF_pct	558	0.003	0.003	0.021	0.001	37	0.003	0.002	0.007	0.001	4182	0.004	0.003	0.037	0.001
ZR_XRF_pct	591	0.004	0.003	0.02	0.001	72	0.003	0.003	0.008	0.001	4244	0.004	0.003	0.135	0.001
PHOS_XRF_pct	886	0.071	0.069	0.168	0.013	108	0.028	0.025	0.075	0.002	6074	0.054	0.052	0.211	0.005
SIO2_XRF_pct	886	5.09	3.995	42.91	1.1	108	54.58	53.57	94.82	31.88	6074	7.03	5.56	66.2	0.79
ZN_XRF_pct	740	0.004	0.003	0.025	0.001	92	0.002	0.002	0.014	0.001	3064	0.003	0.002	0.039	0.001
MN_D	76	0.03	0.02	0.12	0.01	4	0.03	0.03	0.05	0.02	736	0.086	0.031	1.56	0.008

Element/Oxide_Analysis_Units	Crustal Abundance mg/kg	ANG HYD Mean	Median	Maximum	Minimum	NEW WASTE Mean	Median	Maximum	Minimum	NEW ORE Mean	Median	Maximum	Minimum	MAC WASTE Mean	Median	Maximum	Minimum
AL2O3_XRF_pct	309886																
AS_XRF_pct	1.5	3	3	6	2	3	3	5	2	2	3	5	2	3	3	4	2
BA_XRF_pct	500											1				2	
CAO_XRF_pct	57367																
CL_XRF_pct	130			1				3				2				2	
CO_XRF_pct	20			1				1				1				1	
CR_XRF_pct	100			1				1				1					
CU_XRF_pct	50			1				1								1	
FE_CALC_pct	41000	3	3	3		2	2	3		3	3	3	1	2	2	3	
K2O_XRF_pct	50593																
MGO_XRF_pct	37540																
MN_XRF_pct	950			4				2				4				4	
MNO_XRF_pct	1226.665			4				1				3		1		6	
NA_XRF_pct	23000																
NI_XRF_pct	80											1					
PB_XRF_pct	14			3		1		4				3				3	
SN_XRF_pct	2	2	2	4	1	3	2	5	1	2	2	5	1	2	2	5	1
SR_XRF_pct	370																
SULP_XRF_pct	260			5				6				3				3	
TIO2_XRF_pct	9343			2				1									
V_XRF_pct	160																
ZR_XRF_pct	190			1				1									
PHOS_XRF_pct	1000							1				1					
SIO2_XRF_pct	592557.138																
ZN_XRF_pct	75			1				1								1	
MN_D	950			4				2				3		1		6	

Element/Oxide_Analysis_Units	MAC ORE Mean	Median	Maximum	Minimum	NAM WASTE Mean	Median	Maximum	Minimum	MM HYD Mean	Median	Maximum	Minimum
AL2O3_XRF_pct												
AS_XRF_pct	3	3	4	2	3	2	4	2	3	3	4	2
BA_XRF_pct			1								2	
CAO_XRF_pct												
CL_XRF_pct			2								3	
CO_XRF_pct			2								2	
CR_XRF_pct											1	
CU_XRF_pct											1	
FE_CALC_pct	3	3	3	1	2	2	2		3	3	3	
K2O_XRF_pct												
MGO_XRF_pct												
MN_XRF_pct			4								5	
MNO_XRF_pct											3	
NA_XRF_pct												
NI_XRF_pct												
PB_XRF_pct			3				2				3	
SN_XRF_pct	2	2	4	1	2	2	4	1	2	2	5	1
SR_XRF_pct												
SULP_XRF_pct			3				1				3	
TIO2_XRF_pct												
V_XRF_pct												
ZR_XRF_pct											2	
PHOS_XRF_pct												
SIO2_XRF_pct												
ZN_XRF_pct			1								1	
MN_D											3	

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Element/Oxide	ALLUVIUM					CLAY					CALCRETE					DET WASTE					DET ORE					DOLERITE					ANG WASTE					ANG ORE				
_Analysis_Units	Count	Mean	Median	Maximum	Minimum	Count	Mean	Median	Maximum	Minimum	Count	Mean	Median	Maximum	Minimum	Count	Mean	Median	Maximum	Minimum	Count	Mean	Median	Maximum	Minimum	Count	Mean	Median	Maximum	Minimum	Count	Mean	Median	Maximum	Minimum	Count	Mean	Median	Maximum	Minimum
AL2O3_XRF_pct	8	7.41125	7.255	14.91	1.99	8076	16.45342	15.98	34.16	4.1	45	10.89556	9.65	22.45	1.62	4081	10.35673	9.96	36.11	0.75	1730	7.053977	6.96	17.85	1.19	136	23.5261	22.655	36.32	5.63	2878	10.36735	10	36.19	0.26	599	4.599165	4.3	14.62	0.87
AS_XRF_pct	8	0.0045	0.0045	0.006	0.003	7384	0.001903	0.001	0.023	0.001	18	0.003167	0.001	0.013	0.001	3732	0.00328	0.003	0.024	0.001	1493	0.002661	0.002	0.01	0.001	129	0.001961	0.002	0.005	0.001	2682	0.004412	0.004	0.045	0.001	529	0.003467	0.003	0.015	0.001
BA_XRF_pct	8	0.012	0.014	0.021	0.001	7384	0.008925	0.008	0.077	0.001	18	0.010444	0.005	0.06	0.001	3732	0.010056	0.008	0.232	0.001	1493	0.002967	0.001	0.152	0.001	129	0.008395	0.006	0.06	0.001	2682	0.016768	0.006	0.794	0.001	529	0.005435	0.002	0.167	0.001
CAO_XRF_pct	8	0.33375	0.3	0.89	0.02	8076	0.575058	0.41	23.85	0.02	45	12.88044	7.99	48.07	0.92	4081	0.229544	0.15	21.6	0.02	1730	0.083757	0.07	0.69	0.02	136	0.096985	0.08	0.59	0.03	2878	0.506421	0.07	39.15	0.01	598	0.051706	0.04	1.43	0.01
CL_XRF_pct	8	0.008375	0.008	0.01	0.006	7384	0.015678	0.014	0.175	0.001	18	0.033167	0.0275	0.106	0.001	3732	0.011952	0.01	0.352	0.001	1493	0.009885	0.009	0.042	0.002	129	0.018395	0.018	0.034	0.004	2682	0.015648	0.014	0.129	0.001	529	0.010705	0.01	0.032	0.001
CO_XRF_pct	8	0.002	0.002	0.005	0.001	7384	0.004633	0.005	0.024	0.001	18	0.001944	0.0015	0.004	0.001	3732	0.002077	0.002	0.02	0.001	1493	0.001914	0.001	0.02	0.001	129	0.002581	0.002	0.023	0.001	2682	0.003123	0.003	0.032	0.001	529	0.002399	0.002	0.044	0.001
CR_XRF_pct	8	0.011	0.009	0.023	0.007	7384	0.032293	0.031	0.089	0.001	18	0.007778	0.006	0.024	0.001	3732	0.017832	0.014	0.075	0.001	1493	0.009464	0.009	0.043	0.001	129	0.025434	0.025	0.093	0.001	2682	0.008912	0.008	0.068	0.001	529	0.004692	0.004	0.02	0.001
CU_XRF_pct	8	0.0035	0.0025	0.01	0.001	8069	0.012143	0.013	0.024	0.001	41	0.004122	0.003	0.018	0.001	4055	0.004236	0.003	0.021	0.001	1655	0.002379	0.001	0.017	0.001	136	0.009279	0.006	0.034	0.001	2853	0.003433	0.003	0.051	0.001	580	0.001643	0.001	0.009	0.001
FE_CALC_pct	8	20.5675	19.27	26.1	17.29	8076	22.91271	21.46	56.19	3.31	45	16.25133	13.03	49.24	0.53	4081	32.25676	30.22	59.35	3.56	1730	53.86975	53.545	64.58	33.29	136	16.08772	14.065	53.34	0.78	2878	32.11177	32.025	61.15	0.88	599	55.60995	55.58	64.07	32.77
K2O_XRF_pct	8	0.563375	0.656	0.697	0.156	8074	0.262748	0.2515	1.324	0.004	45	0.481444	0.15	3.09	0.022	4065	0.353856	0.257	2.34	0.001	1646	0.016669	0.01	0.271	0.001	130	0.403369	0.082	4.01	0.008	2876	0.684713	0.408	5.214	0.003	580	0.079162	0.04	0.79	0.001
MGO_XRF_pct	8	0.31125	0.295	0.73	0.09	8076	0.768227	0.64	14.7	0.06	45	7.114889	5.59	19.53	0.63	4081	0.340059	0.28	16.1	0.05	1730	0.172121	0.16	1.61	0.03	136	0.289853	0.22	1.45	0.05	2877	0.731564	0.43	20.76	0.01	598	0.178211	0.15	1.08	0.04
MN_XRF_pct	8	0.09125	0.075	0.22	0.04	7384	0.100649	0.1	0.65	0.01	18	0.09	0.06	0.35	0.01	3732	0.074829	0.06	14.3	0.01	1493	0.057756	0.03	1.78	0.01	129	0.092946	0.04	1.15	0.01	2682	1.430201	0.46	38.1	0.01	529	0.31775	0.17	7.74	0.01
MNO_XRF_pct						692	0.134523	0.14	0.42	0.01	27	0.192222	0.09	1.17	0.03	348	0.197098	0.08	6.94	0.01	226	0.057743	0.03	1.39	0.01	6	0.038333	0.03	0.09	0.01	193	0.664767	0.38	6.28	0.01	67	0.476119	0.15	3.63	0.01
NA_XRF_pct	8	0.06	0.045	0.19	0.02	7384	0.154154	0.12	0.66	0.01	18	0.038333	0.04	0.08	0.01	3732	0.053615	0.04	0.48	0.01	1493	0.020918	0.02	0.14	0.01	129	0.055581	0.05	0.15	0.02	2682	0.031909	0.03	0.18	0.01	529	0.01845	0.02	0.1	0.01
NI_XRF_pct	8	0.004625	0.004	0.011	0.002	7384	0.011232	0.011	0.215	0.001	18	0.003444	0.0025	0.014	0.001	3732	0.005372	0.005	0.053	0.001	1493	0.003384	0.003	0.024	0.001	129	0.008953	0.008	0.023	0.001	2682	0.007977	0.007	0.061	0.001	529	0.004437	0.004	0.022	0.001
PB_XRF_pct	8	0.002125	0.002	0.004	0.001	7862	0.001931	0.001	0.014	0.001	22	0.001682	0.001	0.008	0.001	3966	0.002309	0.001	0.012	0.001	1688	0.00179	0.001	0.016	0.001	136	0.001279	0.001	0.005	0.001	2790	0.001794	0.001	0.013	0.001	580	0.00195	0.001	0.013	0.001
SN_XRF_pct	8	0.0015	0.0015	0.002	0.001	7384	0.001214	0.001	0.006	0.001	18	0.001	0.001	0.001	0.001	3732	0.001185	0.001	0.006	0.001	1493	0.001163	0.001	0.004	0.001	129	0.001287	0.001	0.004	0.001	2682	0.001307	0.001	0.013	0.001	529	0.001365	0.001	0.004	0.001
SR_XRF_pct	8	0.01375	0.014	0.015	0.011	7384	0.011502	0.011	0.037	0.001	18	0.011611	0.0105	0.026	0.004	3732	0.009352	0.009	0.032	0.001	1493	0.004088	0.004	0.023	0.001	129	0.00693	0.007	0.027	0.001	2682	0.009358	0.008	0.085	0.001	529	0.003779	0.004	0.016	0.001
SULP_XRF_pct	8	0.022375	0.023	0.031	0.013	8076	0.019949	0.018	0.319	0.004	45	0.018556	0.021	0.034	0.002	4081	0.030148	0.021	2.15	0.003	1730	0.023632	0.018	0.44	0.004	136	0.017434	0.01	0.309	0.004	2878	0.012871	0.011	0.311	0.001	599	0.012376	0.011	0.049	0.001
TIO2_XRF_pct	8	0.4625	0.455	0.94	0.09	8076	1.264097	1.28	2.67	0.19	45	0.833556	0.8	1.77	0.11	4081	0.66741	0.58	9.9	0.02	1730	0.524503	0.5	2.42	0.05	136	2.149485	1.87	11.1	0.38	2873	0.534389	0.48	12.8	0.01	599	0.228848	0.19	1.43	0.02
V_XRF_pct	8	0.009375	0.008	0.02	0.004	7384	0.038557	0.034	0.12	0.001	18	0.0065	0.0045	0.019	0.001	3732	0.018223	0.013	0.083	0.001	1493	0.010906	0.011	0.047	0.001	129	0.032279	0.032	0.105	0.008	2682	0.009159	0.009	0.066	0.001	529	0.005216	0.004	0.032	0.001
ZR_XRF_pct	8	0.016375	0.017	0.02	0.008	7384	0.014389	0.014	0.029	0.001	18	0.012278	0.011	0.022	0.005	3732	0.012886	0.013	0.085	0.001	1493	0.007334	0.007	0.024	0.001	129	0.018481	0.015	0.094	0.001	2682	0.009788	0.009	0.122	0.001	529	0.004405	0.004	0.013	0.001
PHOS_XRF_pct	8	0.038875	0.038	0.042	0.036	8076	0.030368	0.029	0.228	0.004	42	0.013357	0.011	0.039	0.001	4081	0.036422	0.037	0.215	0.001	1730	0.040951	0.039	0.102	0.007	136	0.030301	0.021	0.187	0.004	2877	0.05557	0.052	0.205	0.002	599	0.055504	0.054	0.118	0.009
SIO2_XRF_pct	8	56.58625	57.525	60.29	50.09	8076	39.96212	42.21	64.14	3.52	45	22.38044	22.86	44.47	3.7	4081	35.10212	38.18	70.34	3.21	1730	6.640353	5.79	38.74	1.46	136	39.5225	38.125	85.37	7.08	2878	29.64018	26.65	95.43	0.81	599	5.949833	5.64	25.89	1.47
ZN_XRF_pct	8	0.008375	0.008	0.018	0.004	8073	0.017028	0.017	0.087	0.001	42	0.004405	0.003	0.019	0.001	4067	0.006581	0.006	0.127	0.001	1703	0.00321	0.002	0.046	0.001	136	0.007316	0.007	0.038	0.001	2871	0.007112	0.006	0.063	0.001	598	0.005431	0.005	0.022	0.001
MN_D						692	0.104188	0.10843	0.32529	0.007745	27	0.148876	0.069705	0.906165	0.023235	349	0.154434	0.06196	5.37503	0.007745	237	0.078594	0.023235	1.076555	0.007745	7	0.136091	0.023235	0.7745	0.007745	196	0.518836	0.298183	4.86386	0.007745	70	0.386144	0.12392	2.811435	0.007745

Element/Oxide	Crustal Abundance	ALLUVIUM				CLAY				CALCRETE				DET WASTE				DET ORE				DOLERITE				ANG WASTE				ANG ORE			
_Analysis_Units	mg/kg	Mean	Median	Maximum	Minimum	Mean	Median	Maximum	Minimum	Mean	Median	Maximum	Minimum	Mean	Median	Maximum	Minimum	Mean	Median	Maximum	Minimum	Mean	Median	Maximum	Minimum	Mean	Median	Maximum	Minimum	Mean	Median	Maximum	Minimum
AL2O3_XRF_pct	309886																																
AS_XRF_pct	1.5	4	4	4	3	3	2	6	2	3	2	5	2	3	3	6	2	3	3	5	2	3	3	4	2	4	4	7	2	3	3	6	2
BA_XRF_pct	500															1				1								3				1	
CAO_XRF_pct	57367							1				2				1												2					
CL_XRF_pct	130							3				2				4				1								2					
CO_XRF_pct	20							3								2				2				2				3				3	
CR_XRF_pct	100					1	1	2								2				1				2				2					
CU_XRF_pct	50							1				1				1				1				2				2					
FE_CALC_pct	41000	1	1	2	1	1	1	3		1	1	3		2	2	3		3	3	3	2	1	1	3		2	2	3		3	3	3	2
K2O_XRF_pct	50593																																
MGO_XRF_pct	37540							1				1				1												1					
MN_XRF_pct	950							2				1				6				3				3		3	1	8		1		5	
MNO_XRF_pct	1226.665							1				2				5				2						1	1	5		1		4	
NA_XRF_pct	23000																																
NI_XRF_pct	80							4								2				1								2					
PB_XRF_pct	14							2				1				2				2				1				2				2	
SN_XRF_pct	2	2	2	2	1	2	1	4	1	1	1	1	1	1	1	4	1	1	1	3	1	2	1	3	1	2	1	5	1	2	1	3	1
SR_XRF_pct	370																																
SULP_XRF_pct	260							3								5				3				2				2					
TIO2_XRF_pct	9343															2								2				3					
V_XRF_pct	160							2								1								2				1					
ZR_XRF_pct	190															1								1				2					
PHOS_XRF_pct	1000																																
SIO2_XRF_pct	592557.138																																
ZN_XRF_pct	75							2								3				2				1				2					
MN_D	950							1				2				5				2				2		1	1	5		1		4	

Element/Oxide	ANG HYD					NEW WASTE					NEW ORE					MAC WASTE					MAC ORE					NAM WASTE					MM HYD				
_Analysis_Units	Count	Mean	Median	Maximum	Minimum	Count	Mean	Median	Maximum	Minimum	Count	Mean	Median	Maximum	Minimum	Count	Mean	Median	Maximum	Minimum	Count	Mean	Median	Maximum	Minimum	Count	Mean	Median	Maximum	Minimum	Count	Mean	Median	Maximum	Minimum
AL2O3_XRF_pct	163	5.642331	5.36	19.23	0.63	2231	1.066916	0.51	24.61	0.12	2260	1.906929	1.38	13.75	0.23	1276	4.110306	2.91	23.7	0.17	415	4.266554	3.74	14.19	0.69	24	1.57625	1.28	5.09	0.65	1510	3.949046	3.47	14.86	0.47
AS_XRF_pct	154	0.003961	0.003	0.017	0.001	2076	0.001199	0.001	0.005	0.001	2034	0.001508	0.001	0.008	0.001	1251	0.001871	0.001	0.01	0.001	409	0.002024	0.002	0.011	0.001	24	0.001	0.001	0.001	0.001	1418	0.001961	0.002	0.008	0.001
BA_XRF_pct	154	0.005968	0.002	0.167	0.001	2076	0.002975	0.001	0.197	0.001	2034	0.004412	0.001	0.914	0.001	1251	0.006921	0.001	0.454	0.001	409	0.005924	0.001	0.367	0.001	24	0.002458	0.001	0.021	0.001	1418	0.004679	0.001	0.914	0.001
CAO_XRF_pct	163	0.042577	0.04	0.12	0.02	2222	0.028794	0.02	1.37	0.01	2244	0.027718	0.02	0.71	0.01	1276	0.078918	0.03	8.25	0.01	414	0.042729	0.04	0.33	0.01	24	0.043333	0.02	0.32	0.01	1507	0.051858	0.04	1.85	0.01
CL_XRF_pct	154	0.01	0.01	0.022	0.002	2076	0.007192	0.007	0.035	0.001	2034	0.007731	0.007	0.035	0.001	1251	0.009548	0.009	0.036	0.001	409	0.011462	0.011	0.032	0.004	24	0.007417	0.007	0.011	0.005	1418	0.010175	0.009	0.044	0.001
CO_XRF_pct	154	0.002396	0.002	0.007	0.001	2076	0.001293	0.001	0.013	0.001	2034	0.001449	0.001	0.05	0.001	1251	0.001738	0.001	0.036	0.001	409	0.00154	0.001	0.02	0.001	24	0.001458	0.001	0.003	0.001	1418	0.001678	0.001	0.046	0.001
CR_XRF_pct	154	0.0055	0.005	0.021	0.001	2076	0.0015	0.001	0.023	0.001	2034	0.002124	0.001	0.018	0.001	1251	0.003415	0.002	0.023	0.001	409	0.003342	0.003	0.014	0.001	24	0.001375	0.001	0.004	0.001	1418	0.003827	0.003	0.021	0.001
CU_XRF_pct	163	0.002356	0.001	0.023	0.001	2126	0.001221	0.001	0.016	0.001	2132	0.001278	0.001	0.028	0.001	1276	0.002238	0.001	0.018	0.001	415	0.001677	0.001	0.007	0.001	24	0.001167	0.001	0.003	0.001	1497	0.001965	0.001	0.013	0.001
FE_CALC_pct	163	52.34221	53.09	62.23	4.83	2231	37.06715	34.96	64.35	3.74	2260	61.2571	62.45	66.39	30.38	1276	34.85852	33.67	59.92	1.99	415	55.47222	56.25	64.15	36.9	24	28.86625	29.22	36.67	18.52	1510	54.3332	55.675	64.83	6.11
K2O_XRF_pct	162	0.156852	0.05	1.772	0.001	2169	0.01087	0.007	0.376	0.001	2110	0.007632	0.003	0.367	0.001	1272	0.052325	0.017	3.372	0.001	410	0.012615	0.008	0.144	0.001	24	0.022583	0.018	0.073	0.01	1460	0.019042	0.012	0.901	0.001
MGO_XRF_pct	163	0.197485	0.17	0.87	0.05	2225	0.06956	0.06	1.35	0.01	2258	0.092817	0.08	0.83	0.01	1276	0.13069	0.07	5.64	0.01	415	0.091133	0.09	0.55	0.01	24	0.0625	0.045	0.39	0.02	1510	0.107172	0.09	0.98	0.01
MN_XRF_pct	154	0.272597	0.205	1.46	0.01	2076	0.078242	0.03	10.4	0.01	2034	0.095924	0.04	11	0.01	1251	0.095196	0.02	6.08	0.01	409	0.098435	0.03	3.63	0.01	24	0.049167	0.03	0.3	0.02	1418	0.072313	0.03	12.9	0.01
MNO_XRF_pct	9	0.333333	0.15	1.09	0.06	146	0.075959	0.035	0.76	0.01	225	0.129111	0.06	2.91	0.01	23	0.048696	0.04	0.12	0.01	6	0.158333	0.16	0.3	0.03						86	0.044651	0.03	0.24	0.01
NA_XRF_pct	154	0.018831	0.02	0.07	0.01	2076	0.014075	0.01	0.22	0.01	2034	0.013623	0.01	0.08	0.01	1248	0.019736	0.02	0.2	0.01	409	0.018386	0.02	0.15	0.01	24	0.018333	0.02	0.05	0.01	1418	0.018695	0.02	0.17	0.01
NI_XRF_pct	154	0.005253	0.004	0.016	0.001	2076	0.001957	0.001	0.023	0.001	2034	0.002345	0.002	0.019	0.001	1251	0.002877	0.002	0.016	0.001	409	0.002763	0.002	0.024	0.001	24	0.002833	0.003	0.006	0.001	1418	0.002631	0.002	0.016	0.001
PB_XRF_pct	160	0.001306	0.001	0.006	0.001	2169	0.001918	0.001	0.011	0.001	2185	0.001648	0.001	0.018	0.001	1276	0.001882	0.001	0.007	0.001	415	0.001378	0.001	0.007	0.001	24	0.001583	0.001	0.004	0.001	1509	0.00148	0.001	0.012	0.001
SN_XRF_pct	154	0.001247	0.001	0.003	0.001	2076	0.001159	0.001	0.004	0.001	2034	0.00129	0.001	0.006	0.001	1251	0.001204	0.001	0.005	0.001	409	0.001264	0.001	0.004	0.001	24	0.001042	0.001	0.002	0.001	1418	0.00124	0.001	0.006	0.001
SR_XRF_pct	154	0.00339	0.003	0.01	0.001	2076	0.007694	0.007	0.024	0.001	2034	0.002583	0.002	0.017	0.001	1251	0.006855	0.007	0.016	0.001	409	0.002785	0.003	0.01	0.001	24	0.007833	0.007	0.011	0.005	1418	0.003847	0.004	0.038	0.001
SULP_XRF_pct	163	0.012693	0.011	0.092	0.004	2231	0.007147	0.004	0.18	0.001	2260	0.011187	0.009	0.201	0.001	1276	0.018616	0.011	0.397	0.001	415	0.024164	0.018	0.192	0.001	24	0.00775	0.0075	0.015	0.004	1510	0.027844	0.022	0.576	0.004
TIO2_XRF_pct	163	0.259877	0.22	0.88	0.02	2216	0.042396	0.02	1.77	0.01	2260	0.079283	0.04	1.57	0.01	1276	0.168174	0.1	2.03	0.01	415	0.162675	0.13	0.9	0.01	24	0.056667	0.045	0.13	0.02	1510	0.184894	0.14	2.3	0.01
V_XRF_pct	154	0.006299	0.006	0.022	0.001	2076	0.001573	0.001	0.039	0.001	2034	0.002382	0.002	0.029	0.001	1251	0.004253	0.003	0.049	0.001	409	0.003279	0.002	0.015	0.001	24	0.001875	0.001	0.006	0.001	1418	0.00427	0.003	0.034	0.001
ZR_XRF_pct	154	0.005097	0.004	0.02	0.001	2076	0.002462	0.002	0.017	0.001	2034	0.001971	0.001	0.017	0.001	1251	0.004101	0.003	0.026	0.001	409	0.003919	0.003	0.015	0.001	24	0.002583	0.002	0.006	0.001	1418	0.004028	0.004	0.022	0.001
PHOS_XRF_pct	163	0.055252	0.051	0.121	0.017	2231	0.039316	0.036	0.17	0.003	2260	0.058702	0.056	0.154	0.022	1276	0.031231	0.028	0.179	0.002	415	0.057388	0.056	0.118	0.017	24	0.032	0.028	0.056	0.017	1510	0.048534	0.048	0.171	0.005
SIO2_XRF_pct	163	8.239509	6.83	89.99	2.28	2231	42.4816	46.39	91.79	2.33	2260	3.727071	2.44	54.61	0.84	1276	38.64757	42.65	91.54	2.63	415	6.19612	5.41	25.16	1.62	24	52.35167	51.795	67.77	39.59	1510	9.020258	6.745	77.53	1.04
ZN_XRF_pct	163	0.005074	0.005	0.016	0.001	2214	0.001859	0.002	0.081	0.001	2247	0.002355	0.002	0.035	0.001	1276	0.004502	0.003	0.091	0.001	415	0.004942	0.004	0.104	0.001	24	0.003167	0.003	0.008	0.002	1509	0.003382	0.002	0.023	0.001
MN_D	9	0.258167	0.116175	0.844205	0.04647	155	0.100385	0.03098	0.7745	0.007745	226	0.102981	0.04647	2.253795	0.007745	25	0.096658	0.03098	0.7745	0.007745	6	0.122629	0.12392	0.23235	0.023235						92	0.082838	0.03098	0.7745	0.007745

Element/Oxide	Crustal Abundance	ANG HYD				NEW WASTE				NEW ORE				MAC WASTE				MAC ORE				NAM WASTE				MM HYD			
_Analysis_Units	mg/kg	Mean	Median	Maximum	Minimum	Mean	Median	Maximum	Minimum	Mean	Median	Maximum	Minimum	Mean	Median	Maximum	Minimum	Mean	Median	Maximum	Minimum	Mean	Median	Maximum	Minimum	Mean	Median	Maximum	Minimum
AL2O3_XRF_pct	309886																											3	
AS_XRF_pct	1.5	4	3	6	2	2	2	4	2	2	2	5	2	3	2	5	2	3	3	5	2	2	2	2	2	3	3		
BA_XRF_pct	500			1				1				3				2				2								1	
CAO_XRF_pct	57367																											3	
CL_XRF_pct	130																												
CO_XRF_pct	20			1				2				4				3				2									
CR_XRF_pct	100																											3	
CU_XRF_pct	50			1				1				1				1													
FE_CALC_pct	41000	3	3	3		2	2	3		3	3	3	2	2	2	3		3	3	3	2	2	2	2	1	3	3		
K2O_XRF_pct	50593																											6	
MGO_XRF_pct	37540																												
MN_XRF_pct	950			3				6				6				5				4				1					
MNO_XRF_pct	1226.665			2				2				3																	
NA_XRF_pct	23000																											2	
NI_XRF_pct	80																			1								4	1
PB_XRF_pct	14			1				2				3				1				1									
SN_XRF_pct	2	2	1	3	1	1	1	3	1	2	1	4	1	2	1	4	1	2	1	3	1	1	1	2	1	2	1	3	
SR_XRF_pct	370																												
SULP_XRF_pct	260			1				2				2				3				2									
TIO2_XRF_pct	9343																												
V_XRF_pct	160															1													
ZR_XRF_pct	190																												
PHOS_XRF_pct	1000																											1	
SIO2_XRF_pct	592557.138																											2	
ZN_XRF_pct	75							2				1				3				3									
MN_D	950			2				2				3				2													

West Angelas Deposit D Global Abundance Index

Element/Oxide_Analysis_Units	CLAY Count	CLAY Mean	CLAY Median	CLAY Maximum	CLAY Minimum	CALCRETE Count	CALCRETE Mean	CALCRETE Median	CALCRETE Maximum	CALCRETE Minimum	DET WASTE Count	DET WASTE Mean	DET WASTE Median	DET WASTE Maximum	DET WASTE Minimum
AL2O3_XRF_pct	1252	15.03	14.58	35.17	2.36	306	6.58	4.865	26.32	0.12	2420	8.77	7.6	28.63	0.77
AS_XRF_pct	1079	0.002	0.002	0.013	0.001	174	0.002	0.001	0.021	0.001	1762	0.002	0.002	0.012	0.001
BA_XRF_pct	1079	0.009	0.008	0.094	0.001	174	0.012	0.001	0.598	0.001	1762	0.008	0.005	0.213	0.001
CAO_XRF_pct	1252	0.51	0.32	26.46	0.04	306	16.11	12.725	48.87	0.18	2420	0.71	0.19	27.23	0.02
CL_XRF_pct	1079	0.019	0.017	0.122	0.002	174	0.014	0.011	0.113	0.001	1762	0.020	0.015	0.241	0.001
CO_XRF_pct	1079	0.004	0.003	0.023	0.001	174	0.001	0.001	0.008	0.001	1762	0.002	0.001	0.009	0.001
CR_XRF_pct	1079	0.030	0.028	0.095	0.003	174	0.005	0.004	0.024	0.001	1762	0.015	0.011	0.065	0.001
CU_XRF_pct	1244	0.009	0.008	0.023	0.001	261	0.003	0.001	0.015	0.001	2306	0.004	0.002	0.022	0.001
FE_CALC_pct	1252	26.40	25.75	54.71	4.33	306	16.66	9.11	53.55	0.26	2420	35.74	36.39	58.72	2.94
K2O_XRF_pct	1252	0.269	0.27	0.94	0.01	305	0.156	0.064	2.52	0.003	2404	0.179	0.15	1.091	0.003
MGO_XRF_pct	1252	0.62	0.5	8.24	0.09	306	7.53	6.11	19.1	0.32	2420	0.58	0.24	18.3	0.01
MN_XRF_pct	1079	0.09	0.09	0.56	0.01	174	0.14	0.05	4.74	0.01	1762	0.06	0.04	2.68	0.01
MNO_XRF_pct	173	0.13	0.13	0.28	0.01	132	0.18	0.11	2.56	0.02	647	0.09	0.07	0.66	0.01
NA_XRF_pct	1079	0.12	0.1	0.71	0.02	174	0.03	0.03	0.09	0.01	1762	0.06	0.05	0.44	0.01
NI_XRF_pct	1079	0.010	0.01	0.036	0.001	174	0.003	0.002	0.014	0.001	1762	0.005	0.004	0.025	0.001
PB_XRF_pct	1171	0.002	0.001	0.009	0.001	248	0.002	0.001	0.009	0.001	2045	0.002	0.001	0.012	0.001
SN_XRF_pct	1079	0.001	0.001	0.004	0.001	174	0.001	0.001	0.005	0.001	1762	0.001	0.001	0.004	0.001
SR_XRF_pct	1079	0.010	0.01	0.037	0.001	174	0.008	0.008	0.023	0.001	1762	0.008	0.008	0.026	0.001
SULP_XRF_pct	1252	0.024	0.016	1.3	0.002	306	0.018	0.016	0.2	0.001	2420	0.025	0.02	0.972	0.004
TIO2_XRF_pct	1252	1.08	1.04	2.83	0.24	299	0.46	0.34	2.4	0.01	2420	0.66	0.57	3.85	0.03
V_XRF_pct	1079	0.030	0.027	0.103	0.003	174	0.007	0.006	0.048	0.001	1762	0.015	0.012	0.08	0.001
ZR_XRF_pct	1079	0.016	0.015	0.03	0.005	174	0.006	0.0055	0.022	0.001	1762	0.013	0.013	0.035	0.001
PHOS_XRF_pct	1252	0.034	0.034	0.063	0.005	298	0.015	0.0115	0.068	0.001	2419	0.036	0.037	0.149	0.003
SIO2_XRF_pct	1252	37.18	38.94	61.96	7.74	306	20.22	14.885	89.84	1.92	2420	31.59	31.52	91.85	4.58
ZN_XRF_pct	1248	0.011	0.01	0.037	0.001	287	0.004	0.002	0.032	0.001	2400	0.005	0.004	0.042	0.001
MN_D	173	0.10	0.1007	0.2169	0.0077	132	0.14	0.0852	1.9827	0.0155	658	0.08	0.0620	0.7745	0.0077

Element/Oxide_Analysis_Units	DET ORE Count	DET ORE Mean	DET ORE Median	DET ORE Maximum	DET ORE Minimum	DOLERITE Count	DOLERITE Mean	DOLERITE Median	DOLERITE Maximum	DOLERITE Minimum	WD Count	WD Mean	WD Median	WD Maximum	WD Minimum	ANG WASTE Count	ANG WASTE Mean	ANG WASTE Median	ANG WASTE Maximum	ANG WASTE Minimum
AL2O3_XRF_pct	1218	5.95	6.045	12.79	0.84	277	20.36	21.13	37.04	2.17	48	7.38	5.855	32.62	0.2	1487	13.14	13.21	40.23	0.24
AS_XRF_pct	858	0.003	0.002	0.011	0.001	225	0.002	0.001	0.007	0.001	48	0.002	0.002	0.005	0.001	1182	0.005	0.005	0.013	0.001
BA_XRF_pct	858	0.003	0.002	0.031	0.001	225	0.006	0.004	0.041	0.001	48	0.008	0.004	0.021	0.001	1182	0.007	0.003	0.2	0.001
CAO_XRF_pct	1218	0.18	0.1	5.15	0.01	277	0.62	0.11	11.32	0.03	48	9.53	0.445	29.5	0.05	1487	0.72	0.1	29.4	0.01
CL_XRF_pct	858	0.014	0.012	0.055	0.001	225	0.027	0.025	0.118	0.008	48	0.011	0.011	0.02	0.002	1182	0.020	0.018	0.144	0.003
CO_XRF_pct	858	0.002	0.001	0.014	0.001	225	0.002	0.001	0.008	0.001	48	0.003	0.002	0.011	0.001	1182	0.002	0.002	0.023	0.001
CR_XRF_pct	858	0.008	0.007	0.038	0.001	225	0.007	0.004	0.032	0.001	48	0.009	0.006	0.049	0.001	1182	0.008	0.007	0.067	0.001
CU_XRF_pct	1060	0.002	0.001	0.007	0.001	277	0.013	0.013	0.04	0.001	48	0.001	0.001	0.006	0.001	1449	0.004	0.003	0.052	0.001
FE_CALC_pct	1218	55.35	55.145	65.43	27.22	277	23.90	21.83	62.47	1.07	48	23.87	28	53.62	1.79	1487	31.55	31.03	61.13	1.11
K2O_XRF_pct	1069	0.024	0.015	0.3	0.001	270	0.300	0.109	2.217	0.004	48	0.407	0.2735	1.632	0.004	1479	0.412	0.203	3.697	0.002
MGO_XRF_pct	1216	0.23	0.17	3.97	0.01	277	0.69	0.22	8.91	0.04	48	7.08	1.455	19.9	0.12	1487	0.92	0.49	19.64	0.04
MN_XRF_pct	858	0.05	0.03	1.27	0.01	225	0.08	0.06	0.56	0.01	48	1.94	0.45	20.7	0.01	1182	0.69	0.38	9.53	0.01
MNO_XRF_pct	354	0.06	0.04	0.56	0.01	52	0.10	0.065	0.55	0.02						302	0.43	0.31	2.85	0.01
NA_XRF_pct	858	0.03	0.02	0.3	0.01	225	0.14	0.05	1.84	0.01	48	0.03	0.02	0.07	0.01	1182	0.04	0.04	0.69	0.01
NI_XRF_pct	858	0.003	0.002	0.015	0.001	225	0.006	0.005	0.024	0.001	48	0.006	0.006	0.018	0.001	1182	0.008	0.007	0.056	0.001
PB_XRF_pct	1026	0.002	0.001	0.011	0.001	238	0.001	0.001	0.009	0.001	48	0.001	0.001	0.004	0.001	1304	0.002	0.001	0.008	0.001
SN_XRF_pct	858	0.001	0.001	0.004	0.001	225	0.001	0.001	0.005	0.001	48	0.001	0.001	0.003	0.001	1182	0.001	0.001	0.005	0.001
SR_XRF_pct	858	0.004	0.004	0.021	0.001	225	0.008	0.007	0.039	0.001	48	0.008	0.005	0.058	0.001	1182	0.009	0.007	0.051	0.001
SULP_XRF_pct	1218	0.037	0.022	1.06	0.004	277	0.023	0.015	0.895	0.001	48	0.009	0.006	0.047	0.001	1487	0.022	0.016	2.36	0.002
TIO2_XRF_pct	1218	0.53	0.52	2.52	0.02	277	1.67	1.8	2.91	0.11	48	0.39	0.27	1.64	0.02	1486	0.67	0.65	5.31	0.01
V_XRF_pct	858	0.013	0.012	0.054	0.001	225	0.042	0.044	0.101	0.006	48	0.009	0.006	0.028	0.001	1182	0.012	0.011	0.062	0.001
ZR_XRF_pct	858	0.009	0.009	0.024	0.001	225	0.013	0.013	0.024	0.001	48	0.007	0.005	0.035	0.001	1182	0.013	0.013	0.05	0.001
PHOS_XRF_pct	1218	0.040	0.036	0.142	0.011	277	0.054	0.051	0.203	0.008	48	0.041	0.04	0.105	0.01	1487	0.060	0.056	0.192	0.004
SIO2_XRF_pct	1218	7.43	6.915	43.41	1	277	31.22	31.13	54.37	2.52	48	16.55	15.885	39.51	1.01	1487	27.48	24.76	90.69	2.27
ZN_XRF_pct	1184	0.002	0.002	0.032	0.001	277	0.005	0.004	0.021	0.001	48	0.003	0.001	0.01	0.001	1477	0.007	0.005	0.044	0.001
MN_D	360	0.05	0.03	0.77	0.01	52	0.07	0.05	0.43	0.02						305	0.34	0.25	2.21	0.01

Element/Oxide_Analysis_Units	Crustal Abundance mg/kg	CLAY Mean	CLAY Median	CLAY Maximum	CLAY Minimum	CALCRETE Mean	CALCRETE Median	CALCRETE Maximum	CALCRETE Minimum	DET WASTE Mean	DET WASTE Median	DET WASTE Maximum	DET WASTE Minimum	DET ORE Mean	DET ORE Median	DET ORE Maximum	DET ORE Minimum	DOLERITE Mean	DOLERITE Median	DOLERITE Maximum	DOLERITE Minimum	WD Mean	WD Median	WD Maximum	WD Minimum	ANG WASTE Mean	ANG WASTE Median	ANG WASTE Maximum	ANG WASTE Minimum
AL2O3_XRF_pct	309886																												
AS_XRF_pct	1.5	3	3	5	2	3	2	6	2	3	3	5	2	3	3	5	2	2	2	4	2	3	3	4	2	4	4	5	2
BA_XRF_pct	500							2				1																1	
CAO_XRF_pct	57367			1				2				1												1				1	
CL_XRF_pct	130			2				2				3				1				2								2	
CO_XRF_pct	20			2				1				1				2				1				1				2	
CR_XRF_pct	100			2								2				1				1				1				2	
CU_XRF_pct	50			1				1				1								2								2	
FE_CALC_pct	41000	2	2	3		1		3		2	2	3		3	3	3	2	1	1	3		1	2	3		2	2	3	
K2O_XRF_pct	50593																												
MGO_XRF_pct	37540							1				1												1				1	
MN_XRF_pct	950			1				5				4				3				1		3	1	7		2	1	6	
MNO_XRF_pct	1226.665							3				1				1				1						1		3	
NA_XRF_pct	23000																												
NI_XRF_pct	80			1								1								1								2	
PB_XRF_pct	14			2				2				2				2				2								1	
SN_XRF_pct	2	2	1	3	1	2	1	4	1	1	1	3	1	2	1	3	1	1	1	4	1	2	1	3	1	2	1	4	1
SR_XRF_pct	370																												
SULP_XRF_pct	260			5				2				4				4				4								5	
TIO2_XRF_pct	9343			1								1								1								1	
V_XRF_pct	160			2				1				1				1				2								1	
ZR_XRF_pct	190																												
PHOS_XRF_pct	1000																												
SIO2_XRF_pct	592557.138																												
ZN_XRF_pct	75			1				1				1				1												1	
MN_D	950							3				2				2				1						1		3	

Element/Oxide_Analysis_Units	ANG ORE Count	ANG ORE Mean	ANG ORE Median	ANG ORE Maximum	ANG ORE Minimum	ANG HYD Count	ANG HYD Mean	ANG HYD Median	ANG HYD Maximum	ANG HYD Minimum	NEW WASTE Count	NEW WASTE Mean	NEW WASTE Median	NEW WASTE Maximum	NEW WASTE Minimum
AL2O3_XRF_pct	588	4.53	3.91	21.8	0.22	139	5.45	4.95	21.04	1	1474	1.61	0.635	22.17	0.11
AS_XRF_pct	359	0.003	0.003	0.013	0.001	138	0.004	0.003	0.01	0.001	1194	0.001	0.001	0.006	0.001
BA_XRF_pct	359	0.003	0.001	0.293	0.001	138	0.003	0.001	0.028	0.001	1194	0.003	0.001	0.179	0.001
CAO_XRF_pct	588	0.10	0.06	7.29	0.01	139	0.11	0.07	0.99	0.03	1471	0.15	0.03	21.25	0.01
CL_XRF_pct	359	0.011	0.011	0.029	0.004	138	0.012	0.0105	0.077	0.003	1194	0.010	0.008	0.085	0.002
CO_XRF_pct	359	0.002	0.001	0.02	0.001	138	0.002	0.002	0.012	0.001	1194	0.001	0.001	0.015	0.001
CR_XRF_pct	359	0.004	0.003	0.029	0.001	138	0.006	0.005	0.023	0.001	1194	0.002	0.001	0.022	0.001
CU_XRF_pct	493	0.002	0.001	0.01	0.001	138	0.002	0.001	0.015	0.001	1287	0.001	0.001	0.01	0.001
FE_CALC_pct	588	55.94	56.84	66.8	16.45	139	52.74	54.72	60.8	18	1474	35.51	34.395	64.6	0.69
K2O_XRF_pct	462	0.032	0.011	1.203	0.001	139	0.033	0.014	0.579	0.001	1346	0.025	0.008	2.044	0.001
MGO_XRF_pct	588	0.22	0.17	5.17	0.03	139	0.28	0.2	2.13	0.07	1459	0.19	0.06	11.8	0.01
MN_XRF_pct	359	0.19	0.12	1.58	0.01	138	0.13	0.095	0.54	0.01	1194	0.07	0.02	3.92	0.01
MNO_XRF_pct	220	0.15	0.09	2.05	0.01	1	0.04	0.04	0.04	0.04	277	0.09	0.04	2.02	0.01
NA_XRF_pct	359	0.02	0.02	0.07	0.01	138	0.02	0.02	0.08	0.01	1194	0.02	0.01	0.1	0.01
NI_XRF_pct	359	0.004	0.003	0.03	0.001	138	0.004	0.003	0.016	0.001	1194	0.002	0.002	0.022	0.001
PB_XRF_pct	479	0.002	0.001	0.011	0.001	138	0.001	0.001	0.005	0.001	1296	0.002	0.001	0.01	0.001
SN_XRF_pct	359	0.001	0.001	0.004	0.001	138	0.001	0.001	0.003	0.001	1194	0.001	0.001	0.004	0.001
SR_XRF_pct	359	0.003	0.002	0.009	0.001	138	0.004	0.003	0.018	0.001	1194	0.007	0.007	0.02	0.001
SULP_XRF_pct	588	0.017	0.014	0.233	0.001	139	0.019	0.015	0.064	0.005	1474	0.012	0.007	0.203	0.001
TIO2_XRF_pct	588	0.24	0.17	2.09	0.01	139	0.33	0.27	1.7	0.02	1459	0.09	0.02	2.15	0.01
V_XRF_pct	359	0.004	0.003	0.025	0.001	138	0.009	0.007	0.03	0.001	1194	0.003	0.001	0.046	0.001
ZR_XRF_pct	359	0.004	0.004	0.02	0.001	138	0.005	0.004	0.02	0.001	1194	0.004	0.003	0.025	0.001
PHOS_XRF_pct	588	0.057	0.052	0.145	0.017	139	0.044	0.04	0.132	0.006	1474	0.041	0.037	0.198	0.001
SIO2_XRF_pct	588	6.32	4.875	59.98	1.09	139	8.55	5.85	53.2	2.14	1474	43.09	46.245	98.13	2.73
ZN_XRF_pct	570	0.003	0.003	0.012	0.001	139	0.004	0.003	0.022	0.001	1440	0.002	0.002	0.017	0.001
MN_D	229	0.14	0.08	1.59	0.01	1	0.03	0.03	0.03	0.03	280	0.08	0.03	1.56	0.01

Element/Oxide_Analysis_Units	NEW ORE Count	NEW ORE Mean	NEW ORE Median	NEW ORE Maximum	NEW ORE Minimum	NAM WASTE Count	NAM WASTE Mean	NAM WASTE Median	NAM WASTE Maximum	NAM WASTE Minimum	NAM ORE Count	NAM ORE Mean	NAM ORE Median	NAM ORE Maximum	NAM ORE Minimum	MM HYD Count	MM HYD Mean	MM HYD Median	MM HYD Maximum	MM HYD Minimum
AL2O3_XRF_pct	2135	1.73	1.21	15.19	0.29	125	0.85	0.38	13.65	0.1	5	1.91	1.68	3.19	0.93	458	3.25	2.795	13.87	0.49
AS_XRF_pct	1596	0.001	0.001	0.006	0.001	125	0.001	0.001	0.003	0.001	5	0.002	0.002	0.002	0.001	345	0.002	0.001	0.005	0.001
BA_XRF_pct	1596	0.004	0.001	0.247	0.001	125	0.001	0.001	0.019	0.001	5	0.003	0.004	0.004	0.002	345	0.008	0.001	0.923	0.001
CAO_XRF_pct	2134	0.04	0.03	2.87	0.01	125	0.06	0.02	1.62	0.01	5	0.03	0.03	0.04	0.01	458	0.09	0.06	2.85	0.01
CL_XRF_pct	1596	0.009	0.008	0.056	0.001	125	0.008	0.007	0.023	0.004	5	0.016	0.018	0.019	0.008	345	0.015	0.012	0.078	0.004
CO_XRF_pct	1596	0.001	0.001	0.013	0.001	125	0.001	0.001	0.009	0.001	5	0.001	0.001	0.002	0.001	345	0.002	0.001	0.044	0.001
CR_XRF_pct	1596	0.002	0.001	0.018	0.001	125	0.001	0.001	0.005	0.001	5	0.001	0.001	0.002	0.001	345	0.003	0.002	0.018	0.001
CU_XRF_pct	1761	0.001	0.001	0.007	0.001	125	0.001	0.001	0.017	0.001	5	0.001	0.001	0.002	0.001	396	0.002	0.001	0.011	0.001
FE_CALC_pct	2135	62.06	63.53	66.78	26.8	125	27.62	29.4	49.08	0.86	5	60.72	60.58	63.44	57.75	458	56.78	57.64	65.29	29.04
K2O_XRF_pct	1733	0.008	0.003	0.34	0.001	125	0.012	0.009	0.094	0.004	5	0.004	0.004	0.005	0.002	412	0.021	0.011	0.3	0.001
MGO_XRF_pct	2087	0.10	0.08	2.02	0.01	125	0.10	0.05	2.2	0.02	5	0.11	0.11	0.14	0.06	445	0.16	0.12	2.36	0.02
MN_XRF_pct	1596	0.09	0.06	5.77	0.01	125	0.02	0.02	0.21	0.01	5	0.03	0.02	0.06	0.02	345	0.10	0.03	7.47	0.01
MNO_XRF_pct	536	0.13	0.07	2.3	0.01											110	0.21	0.05	10.37	0.01
NA_XRF_pct	1596	0.01	0.01	0.1	0.01	125	0.02	0.01	0.27	0.01	5	0.03	0.03	0.04	0.02	345	0.02	0.02	0.06	0.01
NI_XRF_pct	1596	0.002	0.002	0.014	0.001	125	0.002	0.001	0.011	0.001	5	0.002	0.001	0.004	0.001	345	0.002	0.002	0.038	0.001
PB_XRF_pct	1869	0.002	0.001	0.009	0.001	125	0.002	0.001	0.004	0.001	5	0.001	0.001	0.001	0.001	389	0.002	0.001	0.006	0.001
SN_XRF_pct	1596	0.001	0.001	0.005	0.001	125	0.001	0.001	0.002	0.001	5	0.001	0.001	0.002	0.001	345	0.001	0.001	0.003	0.001
SR_XRF_pct	1596	0.003	0.002	0.027	0.001	125	0.008	0.008	0.013	0.001	5	0.009	0.002	0.041	0.001	345	0.004	0.004	0.011	0.001
SULP_XRF_pct	2135	0.012	0.009	0.14	0.001	125	0.009	0.006	0.095	0.001	5	0.018	0.018	0.022	0.014	458	0.031	0.0225	0.247	0.005
TIO2_XRF_pct	2135	0.06	0.03	2.13	0.01	125	0.05	0.02	1.32	0.01	5	0.04	0.02	0.11	0.02	458	0.18	0.13	0.92	0.01
V_XRF_pct	1596	0.002	0.001	0.041	0.001	125	0.002	0.001	0.034	0.001	5	0.001	0.001	0.002	0.001	345	0.006	0.004	0.035	0.001
ZR_XRF_pct	1596	0.002	0.001	0.015	0.001	125	0.002	0.001	0.008	0.001	5	0.001	0.001	0.003	0.001	345	0.004	0.003	0.013	0.001
PHOS_XRF_pct	2135	0.060	0.056	0.236	0.015	125	0.030	0.029	0.063	0.001	5	0.061	0.05	0.098	0.049	458	0.053	0.05	0.136	0.019
SIO2_XRF_pct	2135	3.59	2.07	59	0.74	125	56.92	54.98	96.77	16.98	5	3.10	2.5	4.58	2.37	458	6.84	5.425	49.99	1.25
ZN_XRF_pct	2095	0.002	0.002	0.012	0.001	125	0.002	0.002	0.005	0.001	5	0.002	0.002	0.003	0.001	453	0.003	0.002	0.037	0.001
MN_D	539	0.10	0.05	1.78	0.01											113	0.18	0.04	8.03	0.01

Element/Oxide_Analysis_Units	Crustal Abundance mg/kg	ANG ORE Mean	ANG ORE Median	ANG ORE Maximum	ANG ORE Minimum	ANG HYD Mean	ANG HYD Median	ANG HYD Maximum	ANG HYD Minimum	NEW WASTE Mean	NEW WASTE Median	NEW WASTE Maximum	NEW WASTE Minimum	NEW ORE Mean	NEW ORE Median	NEW ORE Maximum	NEW ORE Minimum	NAM WASTE Mean	NAM WASTE Median	NAM WASTE Maximum	NAM WASTE Minimum	NAM ORE Mean	NAM ORE Median	NAM ORE Maximum	NAM ORE Minimum	MM HYD Mean	MM HYD Median	MM HYD Maximum	MM HYD Minimum
AL2O3_XRF_pct	309886																											3	
AS_XRF_pct	1.5	3	3	5	2	4	3	5	2	2	2	4	2	2	2	4	2	2	2	3	2	3	3	3	2	2	2		
BA_XRF_pct	500			1								1				1												2	
CAO_XRF_pct	57367											1																3	
CL_XRF_pct	130							1				2				1													
CO_XRF_pct	20			2				2				2				2				1									
CR_XRF_pct	100																											3	2
CU_XRF_pct	50							1												1									
FE_CALC_pct	41000	3	3	3	1	3	3	3	1	2	2	3		3	3	3	2	2	2	2		3	3	3	3	3	3		
K2O_XRF_pct	50593																											5	
MGO_XRF_pct	37540											1																5	
MN_XRF_pct	950			3				1				4				5													
MNO_XRF_pct	1226.665			3								3				3												1	
NA_XRF_pct	23000																											1	
NI_XRF_pct	80			1																								3	1
PB_XRF_pct	14			2				1				2				2													
SN_XRF_pct	2	2	1	3	1	1	1	3	1	1	1	3	1	2	1	4	1	1	1	2	1	2	1	2	1	1	1	2	
SR_XRF_pct	370																												
SULP_XRF_pct	260			2								2				1				1									
TIO2_XRF_pct	9343																												
V_XRF_pct	160																												
ZR_XRF_pct	190																												
PHOS_XRF_pct	1000																											1	
SIO2_XRF_pct	592557.138																											5	
ZN_XRF_pct	75																												
MN_D	950			3								3				3													

Element/Oxide _Analysis_Units	ALLUVIUM Count	Mean	Median	Maximum	Minimum	CLAY Count	Mean	Median	Maximum	Minimum	CALCRETE Count	Mean	Median	Maximum	Minimum	DET WASTE Count	Mean	Median	Maximum	Minimum
AL2O3_XRF_pct	88	7.60	6.28	24.68	2.26	5	6.04	5.25	9.5	3.95	7	3.96	3.12	8.44	2.01	173	9.16	7.41	24.79	0.5
CAO_XRF_pct	88	0.59	0.23	6.4	0.03						7	13.42	13.8	27.61	5.56	173	0.37	0.16	6.06	0.01
CU_XRF_pct	81	0.003	0.003	0.012	0.001											128	0.004	0.003	0.015	0.001
FE_CALC_pct	88	35.24	36.69	52.18	10.2	5	46.34	47	53.8	34.9	7	26.68	24.32	41.07	11.66	173	40.07	42.22	58.46	10.49
K2O_XRF_pct	88	0.15	0.15	0.47	0.02						7	0.05	0.05	0.09	0.03	155	0.08	0.06	0.64	0.01
MGO_XRF_pct	88	0.29	0.17	1.1	0.02						7	5.18	5.56	9.53	0.78	172	0.25	0.16	1.86	0.01
MNO_XRF_pct	88	0.06	0.05	0.17	0.02						7	0.06	0.03	0.12	0.02	171	0.06	0.04	0.76	0.01
PB_XRF_pct	14	0.004	0.003	0.007	0.001						5	0.003	0.002	0.006	0.002	35	0.003	0.003	0.009	0.001
SULP_XRF_pct	88	0.027	0.021	0.189	0.007	5	0.018	0.017	0.036	0.008	7	0.023	0.021	0.03	0.018	173	0.029	0.02	0.27	0.001
TIO2_XRF_pct	88	0.53	0.47	1.76	0.12	4	0.46	0.37	0.78	0.32	7	0.47	0.43	0.71	0.26	172	0.64	0.535	1.84	0.03
PHOS_XRF_pct	88	0.033	0.034	0.052	0.011	5	0.038	0.032	0.06	0.02	7	0.011	0.01	0.017	0.004	173	0.030	0.03	0.059	0.002
SIO2_XRF_pct	88	35.13	36.2	50.47	10.38	5	17.08	16.1	31.5	6.1	7	20.54	13.82	37.4	9.22	173	26.35	23.35	63.2	4
ZN_XRF_pct	87	0.006	0.004	0.019	0.001						2	0.001	0.001	0.001	0.001	161	0.005	0.004	0.022	0.001
MN_D	88	0.046	0.039	0.132	0.015						7	0.044	0.023	0.093	0.015	173	0.053	0.031	0.775	0.008

Element/Oxide _Analysis_Units	DET ORE Count	Mean	Median	Maximum	Minimum	DOLERITE Count	Mean	Median	Maximum	Minimum	ANG WASTE Count	Mean	Median	Maximum	Minimum
AL2O3_XRF_pct	208	5.25	5.465	10.72	0.99	5	14.59	14.58	14.85	14.23	200	13.88	13.76	34.87	0.38
CAO_XRF_pct	199	0.14	0.08	3.15	0.02	5	6.71	7.73	9.04	3.82	193	0.32	0.1	7.2	0.02
CU_XRF_pct	128	0.002	0.002	0.009	0.001	5	0.017	0.012	0.027	0.012	167	0.004	0.004	0.017	0.001
FE_CALC_pct	208	56.84	55.98	65.7	43.73	5	11.36	11.03	14.37	10.11	200	35.46	36.22	57.35	6.35
K2O_XRF_pct	95	0.04	0.02	0.19	0.01	5	1.04	1	1.25	0.92	141	0.56	0.41	1.97	0.01
MGO_XRF_pct	197	0.11	0.1	0.43	0.01	5	5.15	6.22	6.41	3.01	193	0.59	0.49	5.49	0.02
MNO_XRF_pct	199	0.06	0.05	0.36	0.01	5	0.55	0.18	1.8	0.17	189	0.65	0.22	10.52	0.01
PB_XRF_pct	34	0.002	0.0015	0.007	0.001						43	0.003	0.003	0.007	0.001
SULP_XRF_pct	208	0.034	0.027	0.324	0.009	5	0.009	0.008	0.019	0.002	200	0.017	0.015	0.056	0.002
TIO2_XRF_pct	203	0.453	0.42	1.3	0.03	5	0.832	0.83	0.85	0.82	196	0.752	0.7	3.12	0.02
PHOS_XRF_pct	208	0.036	0.034	0.087	0.016	5	0.043	0.042	0.046	0.042	200	0.046	0.034	0.153	0.005
SIO2_XRF_pct	208	7.41	6.67	24.22	1.22	5	51.40	51.28	54.79	48.61	200	21.51	19.2	87.38	3.95
ZN_XRF_pct	163	0.003	0.002	0.012	0.001	5	0.020	0.017	0.035	0.01	190	0.007	0.006	0.028	0.001
MN_D	199	0.048	0.039	0.279	0.008	5	0.429	0.139	1.39	0.132	193	0.513	0.186	8.15	0.008

Element/Oxide _Analysis_Units	Crustal Abundance mg/kg	ALLUVIUM Mean	Median	Maximum	Minimum	CLAY Mean	Median	Maximum	Minimum	CALCRETE Mean	Median	Maximum	Minimum	DET WASTE Mean	Median	Maximum	Minimum	DET ORE Mean	Median	Maximum	Minimum	DOLERITE Mean	Median	Maximum	Minimum	ANG WASTE Mean	Median	Maximum	Minimum
AL2O3_XRF_pct	309886																												
CAO_XRF_pct	57367											1																	
CU_XRF_pct	50															1						1		1				1	
FE_CALC_pct	41000	2	2	3		2	2	3	2	2	1	2		2	2	3		3	3	3	2			1		2	2	3	
K2O_XRF_pct	50593																												
MGO_XRF_pct	37540																												
MNO_XRF_pct	1226.665															2						1		3		1		5	
PB_XRF_pct	14			1								1				2				1								1	
SULP_XRF_pct	260			2												2				3									
TIO2_XRF_pct	9343																											1	
PHOS_XRF_pct	1000																												
SIO2_XRF_pct	592557.138																												
ZN_XRF_pct	75																							1				1	
MN_D	950															2						1		3		1		5	

Element/Oxide _Analysis_Units	ANG ORE Count	Mean	Median	Maximum	Minimum	NEW WASTE Count	Mean	Median	Maximum	Minimum	NEW ORE Count	Mean	Median	Maximum	Minimum
AL2O3_XRF_pct	138	4.25	3.475	15.5	1.1	168	1.27	0.6	13	0.08	549	1.63	1.15	10.87	0.34
CAO_XRF_pct	128	0.07	0.05	0.53	0.02	145	0.06	0.03	0.59	0.01	473	0.03	0.02	0.24	0.01
CU_XRF_pct	73	0.002	0.002	0.005	0.001	61	0.002	0.002	0.004	0.001	304	0.002	0.002	0.01	0.001
FE_CALC_pct	138	55.77	57.28	64.6	27.73	168	37.48	36.55	57.99	16.35	549	61.70	63.02	66.4	45.59
K2O_XRF_pct	54	0.03	0.02	0.08	0.01	50	0.04	0.01	0.36	0.01	66	0.03	0.02	0.2	0.01
MGO_XRF_pct	125	0.20	0.16	0.79	0.01	151	0.10	0.06	1.85	0.01	487	0.08	0.07	0.38	0.01
MNO_XRF_pct	126	0.20	0.07	2.08	0.01	148	0.06	0.03	0.45	0.01	499	0.09	0.06	5.29	0.01
PB_XRF_pct	39	0.004	0.003	0.012	0.001	41	0.003	0.003	0.009	0.001	138	0.002	0.003	0.005	0.001
SULP_XRF_pct	138	0.019	0.017	0.082	0.002	168	0.012	0.0085	0.126	0.001	549	0.015	0.012	0.094	0.001
TIO2_XRF_pct	134	0.207	0.14	1.15	0.02	150	0.058	0.02	0.61	0.01	519	0.056	0.03	0.64	0.01
PHOS_XRF_pct	138	0.054	0.05	0.102	0.025	168	0.041	0.036	0.119	0.006	549	0.061	0.056	0.72	0.025
SIO2_XRF_pct	138	5.74	4.37	55.06	1.37	168	40.63	43.09	73.19	4.2	549	3.42	1.98	22.31	0.83
ZN_XRF_pct	124	0.004	0.004	0.02	0.001	142	0.003	0.003	0.013	0.001	461	0.003	0.003	0.012	0.001
MN_D	128	0.161	0.054	1.61	0.008	160	0.101	0.023	0.77	0.008	499	0.073	0.046	4.10	0.008

Element/Oxide _Analysis_Units	MAC WASTE Count	Mean	Median	Maximum	Minimum	MAC ORE Count	Mean	Median	Maximum	Minimum	MM HYD Count	Mean	Median	Maximum	Minimum
AL2O3_XRF_pct	7	4.03	4.77	7.2	0.85	9	3.24	2.76	5.99	1.69	144	3.38	2.915	8.69	0.59
CAO_XRF_pct	7	0.03	0.02	0.05	0.01	9	0.05	0.04	0.07	0.04	141	0.06	0.05	0.28	0.01
CU_XRF_pct	5	0.002	0.001	0.003	0.001	8	0.002	0.002	0.003	0.001	71	0.003	0.002	0.018	0.001
FE_CALC_pct	7	38.98	38.76	49.83	30.85	9	56.44	56.86	59.5	51.55	144	56.67	56.96	66.1	47.19
K2O_XRF_pct	1	0.01	0.01	0.01	0.01	1	0.02	0.02	0.02	0.02	47	0.02	0.02	0.08	0.01
MGO_XRF_pct	7	0.06	0.07	0.11	0.02	9	0.12	0.11	0.23	0.06	134	0.12	0.07	0.67	0.01
MNO_XRF_pct	7	0.04	0.03	0.07	0.02	9	0.05	0.05	0.07	0.04	142	0.09	0.05	0.79	0.01
PB_XRF_pct	1	0.001	0.001	0.001	0.001	4	0.001	0.001	0.002	0.001	11	0.002	0.002	0.002	0.001
SULP_XRF_pct	7	0.011	0.012	0.016	0.005	9	0.027	0.021	0.045	0.017	144	0.039	0.036	0.091	0.01
TIO2_XRF_pct	7	0.163	0.13	0.33	0.03	9	0.150	0.14	0.29	0.04	144	0.182	0.15	0.93	0.02
PHOS_XRF_pct	7	0.055	0.048	0.09	0.033	9	0.096	0.083	0.15	0.051	144	0.048	0.043	0.164	0.008
SIO2_XRF_pct	7	31.97	31.99	46.99	9.92	9	5.43	6.82	8.48	2.03	144	6.24	5.07	19.78	1.57
ZN_XRF_pct	7	0.007	0.007	0.013	0.005	9	0.008	0.007	0.012	0.003	135	0.004	0.003	0.02	0.001
MN_D	7	0.031	0.023	0.054	0.015	9	0.040	0.039	0.054	0.031	142	0.066	0.039	0.612	0.008

Element/Oxide _Analysis_Units	Crustal Abundance mg/kg	ANG ORE Mean	Median	Maximum	Minimum	NEW WASTE Mean	Median	Maximum	Minimum	NEW ORE Mean	Median	Maximum	Minimum	MAC WASTE Mean	Median	Maximum	Minimum	MAC ORE Mean	Median	Maximum	Minimum	MM HYD Mean	Median	Maximum	Minimum
AL2O3_XRF_pct	309886																							1	
CAO_XRF_pct	57367																							3	2
CU_XRF_pct	50																								
FE_CALC_pct	41000	3	3	3	2	2	2	3	1	3	3	3	2	2	2	3	2	3	3	3	3	3	3		
K2O_XRF_pct	50593																							2	
MGO_XRF_pct	37540																								
MNO_XRF_pct	1226.665			3				1				4												1	
PB_XRF_pct	14			2				2				1													
SULP_XRF_pct	260			1				1				1													
TIO2_XRF_pct	9343																								
PHOS_XRF_pct	1000											2													
SIO2_XRF_pct	592557.138																							2	
ZN_XRF_pct	75																								
MN_D	950			3				2				4													

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Element/Oxide		ALLUVIUM					CLAY					CALCRETE					DET WASTE					DET ORE					ANG WASTE			
_Analysis_Units	Count	Mean	Median	Maximum	Minimum	Count	Mean	Median	Maximum	Minimum	Count	Mean	Median	Maximum	Minimum	Count	Mean	Median	Maximum	Minimum	Count	Mean	Median	Maximum	Minimum	Count	Mean	Median	Maximum	Minimum
AL2O3_XRF_pct	66	10.61	9.71	26.94	3.18	52	24.36	25.715	32.34	6.98	3	16.86	16.67	19.01	14.9	200	17.51	17.61	32.76	3.6	135	6.59	6.32	19.87	2.75	63	10.21	9.2	20.99	1.83
CAO_XRF_pct	66	1.02	0.34	7.1	0.03	52	0.28	0.24	0.81	0.05	3	7.58	8.8	10.96	2.97	196	0.29	0.21	4.02	0.01	135	0.09	0.08	0.29	0.02	63	0.10	0.07	0.56	0.02
CU_XRF_pct	61	0.006	0.004	0.016	0.001	51	0.006	0.007	0.015	0.001	3	0.012	0.013	0.013	0.01	174	0.006	0.006	0.019	0.001	47	0.002	0.002	0.015	0.001	51	0.004	0.004	0.008	0.001
FE_CALC_pct	66	34.77	38.97	52.96	10.56	52	18.80	17.675	42.28	6.34	3	16.58	18.39	21.67	9.69	200	31.13	31.14	62.72	6.45	135	55.69	55.68	64.58	31.77	63	35.08	37.44	54.79	5.1
K2O_XRF_pct	66	0.16	0.15	0.47	0.02	51	0.05	0.03	0.23	0.01	3	0.10	0.09	0.11	0.09	157	0.07	0.05	0.43	0.01	78	0.03	0.02	0.12	0.01	42	0.78	0.735	1.96	0.01
MGO_XRF_pct	66	0.62	0.255	5.07	0.03	52	0.36	0.285	1.41	0.07	3	3.77	2.59	6.26	2.46	198	0.41	0.3	3.31	0.01	132	0.10	0.08	0.35	0.01	63	0.41	0.34	1.08	0.01
MNO_XRF_pct	66	0.07	0.06	0.35	0.02	52	0.05	0.035	0.19	0.01	3	0.13	0.13	0.15	0.1	198	0.05	0.04	0.65	0.01	134	0.04	0.03	0.34	0.01	58	0.26	0.1	1.92	0.01
PB_XRF_pct	20	0.003	0.003	0.007	0.001	17	0.003	0.002	0.006	0.001						44	0.003	0.002	0.009	0.001	48	0.003	0.003	0.008	0.001	11	0.002	0.001	0.005	0.001
SULP_XRF_pct	66	0.020	0.016	0.091	0.007	52	0.011	0.01	0.029	0.001	3	0.017	0.016	0.021	0.015	200	0.018	0.016	0.1	0.001	135	0.022	0.018	0.137	0.004	63	0.009	0.007	0.082	0.001
TIO2_XRF_pct	66	0.86	0.75	1.94	0.21	52	1.86	1.88	2.52	0.75	3	1.44	1.29	1.81	1.22	200	1.36	1.395	2.6	0.19	135	0.71	0.74	1.15	0.17	63	0.56	0.57	1.27	0.08
PHOS_XRF_pct	66	0.031	0.032	0.048	0.011	52	0.013	0.012	0.021	0.006	3	0.017	0.02	0.02	0.011	200	0.020	0.02	0.063	0.002	135	0.031	0.03	0.069	0.013	63	0.035	0.029	0.091	0.007
SIO2_XRF_pct	66	30.62	32.26	51.93	8.06	52	36.79	37.265	45.67	17.05	3	30.88	30.85	34.57	27.23	200	28.55	29.51	55.75	3.55	135	8.47	8.03	24.57	2.42	63	28.17	25.51	86.58	5.23
ZN_XRF_pct	66	0.009	0.006	0.023	0.002	49	0.005	0.004	0.01	0.001	3	0.009	0.009	0.011	0.008	187	0.005	0.004	0.033	0.001	106	0.003	0.002	0.026	0.001	61	0.008	0.008	0.02	0.002
MN_D	66	0.06	0.05	0.27	0.02	52	0.04	0.03	0.15	0.01	3	0.10	0.10	0.12	0.08	200	0.05	0.03	0.77	0.01	135	0.04	0.02	0.77	0.01	63	0.25	0.09	1.49	0.01

Element/Oxide	Crustal Abundance	ALLUVIUM					CLAY					CALCRETE					DET WASTE					DET ORE					ANG WASTE			
_Analysis_Units	mg/kg	Mean	Median	Maximum	Minimum		Mean	Median	Maximum	Minimum		Mean	Median	Maximum	Minimum		Mean	Median	Maximum	Minimum		Mean	Median	Maximum	Minimum		Mean	Median	Maximum	Minimum
AL2O3_XRF_pct	309886																													
CAO_XRF_pct	57367																													
CU_XRF_pct	50			1					1										1					1						
FE_CALC_pct	41000	2	2	3			1	1	2			1	1	1			2	2	3			3	3	3	2		2	2	3	
K2O_XRF_pct	50593																													
MGO_XRF_pct	37540																													
MNO_XRF_pct	1226.665																		1										3	
PB_XRF_pct	14			1					1										2					1					1	
SULP_XRF_pct	260			1															1					1					1	
TIO2_XRF_pct	9343																													
PHOS_XRF_pct	1000																													
SIO2_XRF_pct	592557.138																													
ZN_XRF_pct	75			1															1					1						
MN_D	950																		2					2					3	

Element/Oxide		ANG ORE					NEW WASTE					NEW ORE					MAC WASTE					MM HYD			
_Analysis_Units	Count	Mean	Median	Maximum	Minimum	Count	Mean	Median	Maximum	Minimum	Count	Mean	Median	Maximum	Minimum	Count	Mean	Median	Maximum	Minimum	Count	Mean	Median	Maximum	Minimum
AL2O3_XRF_pct	60	4.44	3.79	9.71	1.45	147	1.11	0.51	13.15	0.09	100	1.50	1.04	8.37	0.5	9	1.77	1.52	3.31	0.35	118	2.80	2.5	7.5	0.59
CAO_XRF_pct	60	0.06	0.05	0.15	0.03	141	0.11	0.02	3.03	0.01	100	0.03	0.03	0.24	0.01	9	0.71	0.4	2.14	0.08	104	0.04	0.04	0.22	0.01
CU_XRF_pct	34	0.003	0.002	0.009	0.001	54	0.002	0.001	0.021	0.001	39	0.002	0.002	0.003	0.001	1	0.003	0.003	0.003	0.003	46	0.002	0.002	0.004	0.001
FE_CALC_pct	60	56.21	57.34	61.99	46.11	147	35.24	35.13	59.57	2.5	100	61.69	62.88	65.64	41.61	9	28.68	27.99	32.98	25.8	118	57.17	57.53	63.88	39.35
K2O_XRF_pct	25	0.04	0.02	0.16	0.01	37	0.02	0.01	0.05	0.01	12	0.02	0.01	0.06	0.01	9	0.47	0.32	1.62	0.04	30	0.02	0.015	0.05	0.01
MGO_XRF_pct	59	0.13	0.11	0.45	0.02	128	0.15	0.05	2.52	0.01	99	0.07	0.06	0.27	0.02	9	0.85	0.74	1.87	0.29	110	0.08	0.05	0.55	0.01
MNO_XRF_pct	58	0.12	0.05	0.66	0.01	136	0.05	0.03	0.34	0.01	100	0.10	0.065	1.78	0.02	9	0.14	0.12	0.35	0.04	114	0.07	0.05	1.75	0.01
PB_XRF_pct	26	0.003	0.002	0.008	0.001	27	0.003	0.002	0.007	0.001	36	0.003	0.002	0.01	0.001	1	0.006	0.006	0.006	0.006	30	0.003	0.002	0.01	0.001
SULP_XRF_pct	60	0.017	0.017	0.039	0.003	147	0.011	0.007	0.108	0.001	100	0.008	0.007	0.027	0.001	9	0.005	0.005	0.009	0.002	118	0.026	0.0225	0.079	0.005
TIO2_XRF_pct	60	0.41	0.325	1.05	0.04	92	0.05	0.03	0.3	0.01	98	0.05	0.03	0.33	0.01	9	0.09	0.07	0.18	0.02	118	0.20	0.1	1.2	0.01
PHOS_XRF_pct	60	0.043	0.04	0.081	0.027	147	0.042	0.039	0.132	0.004	100	0.057	0.0535	0.12	0.032	9	0.041	0.045	0.052	0.013	118	0.052	0.05	0.123	0.027
SIO2_XRF_pct	60	6.27	5.66	16.91	2.94	147	44.31	46.33	94.03	4.25	100	3.71	2.46	36.97	1.05	9	49.37	48.43	55.68	41	118	5.76	4.54	33.3	1.43
ZN_XRF_pct	52	0.006	0.004	0.028	0.001	124	0.003	0.002	0.014	0.001	90	0.004	0.004	0.018	0.001	9	0.004	0.003	0.007	0.001	116	0.003	0.003	0.015	0.001
MN_D	60	0.11	0.04	0.77	0.01	147	0.09	0.02	0.77	0.01	100	0.08	0.05	1.38	0.02	9	0.11	0.09	0.27	0.03	118	0.08	0.04	1.36	0.01

Element/Oxide	Crustal Abundance	ANG ORE					NEW WASTE					NEW ORE					MAC WASTE					MM HYD			
_Analysis_Units	mg/kg	Mean	Median	Maximum	Minimum		Mean	Median	Maximum	Minimum		Mean	Median	Maximum	Minimum		Mean	Median	Maximum	Minimum		Mean	Median	Maximum	Minimum
AL2O3_XRF_pct	309886																								
CAO_XRF_pct	57367																								
CU_XRF_pct	50								1																
FE_CALC_pct	41000	3	3	3	2		2	2	3			3	3	3	2		2	2	2	2		3	3	3	2
K2O_XRF_pct	50593																								
MGO_XRF_pct	37540																								
MNO_XRF_pct	1226.665			1										3										3	
PB_XRF_pct	14			1					1					2			1	1	1	1				2	
SULP_XRF_pct	260								1															1	
TIO2_XRF_pct	9343																								
PHOS_XRF_pct	1000																								
SIO2_XRF_pct	592557.138																								
ZN_XRF_pct	75			1																					
MN_D	950			2					2					3										3	

Angelo River Global Abundance Index

Element/Oxide	Alluvium					CLAY					CALCRETE				
_Analysis_Units	Count	Mean	Median	Maximum	Minimum	Count	Mean	Median	Maximum	Minimum	Count	Mean	Median	Maximum	Minimum
AL2O3_XRF_pct	258	13.18236	14.88	30.77	0.52	1868	16.29801	17.105	27.99	0.36	432	4.435347	3.04	26.67	0.34
AS_XRF_pct	258	0.003109	0.003	0.008	0.001	987	0.003652	0.004	0.008	0.001	333	0.002967	0.002	0.018	0.001
BA_XRF_pct	257	0.018518	0.018	0.124	0.001	936	0.014217	0.013	0.089	0.001	267	0.024367	0.006	0.943	0.001
CAO_XRF_pct	258	1.992054	0.14	46.71	0.03	1868	0.630048	0.23	24.51	0.01	432	16.35498	16.565	50.09	0.02
CL_XRF_pct	258	0.00393	0.003	0.145	0.001	984	0.009259	0.005	0.735	0.001	332	0.004843	0.004	0.039	0.001
CO_XRF_pct	256	0.001531	0.001	0.011	0.001	924	0.002482	0.002	0.015	0.001	263	0.001719	0.001	0.007	0.001
CR_XRF_pct	258	0.013519	0.014	0.043	0.001	1005	0.019994	0.017	0.089	0.001	284	0.004908	0.003	0.044	0.001
CU_XRF_pct	258	0.002911	0.003	0.01	0.001	1629	0.005739	0.006	0.017	0.001	282	0.00155	0.001	0.008	0.001
FE_CALC_pct	258	21.59977	17	55.17	1.28	1868	22.22855	19.375	56.74	2.46	432	18.61847	15.48	58.56	0.53
K2O_XRF_pct	258	0.507236	0.66	1.6	0.006	1801	0.386423	0.355	2.03	0.01	409	0.070044	0.033	0.935	0.005
MGO_XRF_pct	258	0.679496	0.28	13.29	0.05	1809	0.768502	0.41	20.74	0.03	410	6.060878	2.665	33.3	0.12
MN_XRF_pct	255	0.139333	0.12	1.48	0.01	1821	0.095376	0.08	3.86	0.01	414	0.148261	0.05	5.78	0.01
MNO_XRF_pct															
NA_XRF_pct	258	0.037519	0.03	0.2	0.01	990	0.049707	0.05	0.28	0.01	286	0.029615	0.02	0.18	0.01
NI_XRF_pct	258	0.003391	0.003	0.012	0.001	1009	0.006568	0.006	0.021	0.001	327	0.002416	0.002	0.018	0.001
PB_XRF_pct	254	0.002252	0.002	0.005	0.001	993	0.002724	0.002	0.012	0.001	294	0.002231	0.002	0.009	0.001
SN_XRF_pct	258	0.001605	0.001	0.006	0.001	755	0.001788	0.002	0.009	0.001	250	0.001808	0.001	0.011	0.001
SR_XRF_pct	258	0.002465	0.002	0.013	0.001	973	0.006804	0.006	0.017	0.001	305	0.004449	0.003	0.026	0.001
SULP_XRF_pct	258	0.007271	0.006	0.045	0.001	1867	0.011875	0.009	0.911	0.001	432	0.009678	0.007	0.044	0.001
TIO2_XRF_pct	258	0.827248	0.93	2.39	0.04	1868	1.205016	1.22	3.65	0.01	431	0.355916	0.22	7.66	0.02
V_XRF_pct	258	0.014484	0.016	0.053	0.001	1006	0.022965	0.021	0.131	0.002	276	0.005493	0.004	0.041	0.001
ZR_XRF_pct	258	0.016605	0.02	0.027	0.001	1006	0.019582	0.021	0.029	0.002	315	0.006841	0.005	0.068	0.001
PHOS_XRF_pct	258	0.034186	0.0365	0.103	0.003	1867	0.031005	0.033	0.169	0.001	426	0.015354	0.011	0.156	0.001
SIO2_XRF_pct	258	42.96349	49.15	93.78	6.56	1868	41.08204	43.395	80.34	3.83	432	21.40289	16.93	89.27	3.02
ZN_XRF_pct	256	0.006773	0.007	0.02	0.001	1650	0.006362	0.006	0.018	0.001	366	0.002612	0.002	0.026	0.001
MN_D															

Element/Oxide	DET WASTE					DET ORE					DOLERITE				
_Analysis_Units	Count	Mean	Median	Maximum	Minimum	Count	Mean	Median	Maximum	Minimum	Count	Mean	Median	Maximum	Minimum
AL2O3_XRF_pct	4691	8.937077	7.72	41.56	0.39	821	6.184884	6.05	17.76	0.62	297	17.50067	20.23	34.44	0.17
AS_XRF_pct	3705	0.003135	0.003	0.03	0.001	306	0.003725	0.0035	0.01	0.001	148	0.005669	0.004	0.058	0.001
BA_XRF_pct	3594	0.010616	0.009	0.249	0.001	255	0.006027	0.005	0.075	0.001	81	0.011617	0.007	0.081	0.001
CAO_XRF_pct	4691	0.455566	0.1	42.89	0.01	820	0.134683	0.09	5.01	0.01	297	3.694747	0.15	28.84	0.03
CL_XRF_pct	3778	0.010341	0.006	0.413	0.001	334	0.012314	0.007	0.063	0.001	166	0.006066	0.005	0.022	0.001
CO_XRF_pct	3253	0.001578	0.001	0.011	0.001	272	0.001787	0.002	0.006	0.001	88	0.005568	0.003	0.023	0.001
CR_XRF_pct	3761	0.012121	0.011	0.082	0.001	334	0.007728	0.007	0.026	0.001	139	0.011597	0.009	0.052	0.001
CU_XRF_pct	4144	0.003022	0.003	0.034	0.001	367	0.001989	0.002	0.009	0.001	255	0.014863	0.014	0.057	0.001
FE_CALC_pct	4691	31.28164	31.66	56.09	0.76	821	54.13611	53.71	65.05	34.85	297	21.20774	19.74	57.86	2.73
K2O_XRF_pct	4464	0.292314	0.16	1.467	0.001	610	0.027187	0.02	0.57	0.002	289	0.711183	0.361	3.74	0.009
MGO_XRF_pct	4481	0.336865	0.17	15.47	0.01	734	0.19139	0.12	4.07	0.01	292	2.811541	0.3	18.5	0.02
MN_XRF_pct	4581	0.078088	0.04	15	0.01	755	0.051311	0.03	1.44	0.01	296	0.335101	0.09	4.55	0.01
MNO_XRF_pct	18	0.051667	0.05	0.19	0.02	16	0.06375	0.05	0.19	0.03					
NA_XRF_pct	3714	0.039327	0.03	0.59	0.01	237	0.024473	0.02	0.16	0.01	125	0.09464	0.02	1.33	0.01
NI_XRF_pct	3778	0.00344	0.003	0.046	0.001	293	0.002188	0.002	0.006	0.001	153	0.008771	0.006	0.05	0.001
PB_XRF_pct	3705	0.003085	0.003	0.02	0.001	324	0.003019	0.002	0.014	0.001	127	0.003614	0.003	0.014	0.001
SN_XRF_pct	3212	0.001941	0.002	0.011	0.001	232	0.002547	0.002	0.006	0.001	94	0.001606	0.002	0.003	0.001
SR_XRF_pct	3766	0.005131	0.003	0.021	0.001	267	0.002266	0.002	0.006	0.001	131	0.00645	0.005	0.024	0.001
SULP_XRF_pct	4690	0.017573	0.0145	0.413	0.001	821	0.025291	0.02	0.436	0.001	297	0.021377	0.006	2.12	0.001
TIO2_XRF_pct	4691	0.653905	0.58	4.74	0.02	821	0.555347	0.51	2	0.01	297	1.316465	1.41	3.53	0.01
V_XRF_pct	3782	0.012301	0.011	0.129	0.001	333	0.009664	0.009	0.026	0.001	137	0.03146	0.031	0.082	0.001
ZR_XRF_pct	3781	0.01424	0.014	0.053	0.001	332	0.009449	0.01	0.035	0.001	139	0.009763	0.01	0.023	0.001
PHOS_XRF_pct	4683	0.035436	0.035	0.377	0.001	821	0.037915	0.034	0.169	0.01	296	0.045216	0.041	0.132	0.004
SIO2_XRF_pct	4691	39.13709	41.18	96.97	4.18	821	9.315213	8.91	31.69	1.21	297	28.66212	29.31	57.61	2.5
ZN_XRF_pct	4237	0.004172	0.003	0.058	0.001	502	0.002791	0.002	0.017	0.001	283	0.009198	0.006	0.088	0.001
MN_D	18	0.040016	0.038725	0.147155	0.01549	16	0.049374	0.038725	0.147155	0.023235					

Element/Oxide	JOF WASTE					JOF HYD					WS WASTE				
_Analysis_Units	Count	Mean	Median	Maximum	Minimum	Count	Mean	Median	Maximum	Minimum	Count	Mean	Median	Maximum	Minimum
AL2O3_XRF_pct	65	2.551385	2.09	14.4	0.26	11	1.186364	1.21	1.67	0.72	471	6.768641	3.79	36.02	0.41
AS_XRF_pct	62	0.0025	0.002	0.007	0.001	11	0.005636	0.006	0.006	0.005	465	0.004342	0.004	0.041	0.001
BA_XRF_pct	65	0.006092	0.005	0.033	0.001	11	0.003727	0.003	0.008	0.001	470	0.010036	0.005	0.207	0.001
CAO_XRF_pct	65	0.391385	0.08	5.32	0.01	11	0.129091	0.11	0.3	0.09	471	0.630425	0.04	25.96	0.01
CL_XRF_pct	65	0.006646	0.005	0.028	0.001	11	0.001273	0.001	0.002	0.001	470	0.012885	0.003	0.156	0.001
CO_XRF_pct	65	0.001231	0.001	0.003	0.001	11	0.001	0.001	0.001	0.001	471	0.001637	0.001	0.043	0.001
CR_XRF_pct	55	0.002691	0.001	0.024	0.001	11	0.001	0.001	0.001	0.001	457	0.009042	0.003	0.433	0.001
CU_XRF_pct	65	0.001492	0.001	0.004	0.001	11	0.001	0.001	0.001	0.001	470	0.001904	0.001	0.02	0.001
FE_CALC_pct	65	39.814	37.99	56.17	8.64	11	55.08636	55.06	56.02	54.14	471	36.2876	39.32	65.9	0.59
K2O_XRF_pct	65	0.039477	0.026	0.372	0.005	11	0.010455	0.009	0.018	0.005	471	0.123879	0.015	3.271	0.001
MGO_XRF_pct	65	0.338308	0.06	2.81	0.02	11	0.280909	0.29	0.42	0.2	471	0.47552	0.1	15.34	0.01
MN_XRF_pct	60	0.046833	0.02	0.52	0.01	11	0.03	0.03	0.05	0.02	456	0.158421	0.02	7.22	0.01
MNO_XRF_pct															
NA_XRF_pct	63	0.015714	0.01	0.04	0.01	11	0.014545	0.01	0.02	0.01	467	0.025353	0.02	0.18	0.01
NI_XRF_pct	65	0.001938	0.002	0.004	0.001	11	0.002091	0.002	0.004	0.001	471	0.002996	0.002	0.022	0.001
PB_XRF_pct	60	0.00215	0.002	0.005	0.001	11	0.001727	0.001	0.003	0.001	462	0.004206	0.003	0.032	0.001
SN_XRF_pct	62	0.001645	0.001	0.004	0.001	11	0.001364	0.001	0.003	0.001	465	0.002538	0.002	0.013	0.001
SR_XRF_pct	65	0.004031	0.002	0.011	0.001	11	0.001	0.001	0.001	0.001	469	0.002774	0.002	0.024	0.001
SULP_XRF_pct	65	0.015523	0.008	0.083	0.002	11	0.002818	0.003	0.004	0.002	471	0.060705	0.009	4.07	0.001
TIO2_XRF_pct	65	0.181231	0.15	0.93	0.02	11	0.082727	0.08	0.14	0.04	471	0.308153	0.22	2.61	0.01
V_XRF_pct	65	0.002769	0.002	0.012	0.001	11	0.001091	0.001	0.002	0.001	471	0.005263	0.004	0.035	0.001
ZR_XRF_pct	65	0.005462	0.005	0.017	0.001	11	0.001818	0.002	0.002	0.001	468	0.009412	0.006	0.089	0.001
PHOS_XRF_pct	65	0.064077	0.056	0.251	0.008	11	0.115727	0.109	0.195	0.063	471	0.101669	0.078	0.494	0.006
SIO2_XRF_pct	65	32.22185	34.98	82.09	6.2	11	8.228182	8.18	9.21	7.24	471	30.40688	23.73	95.95	1.05
ZN_XRF_pct	65	0.001508	0.001	0.005	0.001	11	0.001	0.001	0.001	0.001	470	0.004489	0.002	0.063	0.001
MN_D															

Element/Oxide	DG WASTE					DG ORE					DG HYD					FWZ WASTE				
_Analysis_Units	Count	Mean	Median	Maximum	Minimum	Count	Mean	Median	Maximum	Minimum	Count	Mean	Median	Maximum	Minimum	Count	Mean	Median	Maximum	Minimum
AL2O3_XRF_pct	993	2.445237	1.21	28.53	0.08	239	2.586695	1.67	25.23	0.27	273	3.785458	3.31	27.42	1.09	79	2.966076	2.08	15.31	0.12
AS_XRF_pct	984	0.002711	0.002	0.035	0.001	239	0.003084	0.003	0.013	0.001	273	0.004125	0.004	0.019	0.001	79	0.004101	0.003	0.029	0.001
BA_XRF_pct	983	0.007591	0.004	0.684	0.001	239	0.007469	0.003	0.477	0.001	273	0.009055	0.008	0.039	0.001	79	0.007658	0.003	0.104	0.001
CAO_XRF_pct	993	0.262226	0.02	27.45	0.01	239	0.038787	0.03	0.83	0.01	273	0.052161	0.02	1.58	0.01	79	0.244177	0.04	7.58	0.01
CL_XRF_pct	986	0.005024	0.003	0.076	0.001	239	0.004105	0.002	0.059	0.001	273	0.011714	0.007	0.054	0.001	79	0.003278	0.002	0.016	0.001
CO_XRF_pct	988	0.001248	0.001	0.007	0.001	239	0.001176	0.001	0.003	0.001	273	0.001363	0.001	0.004	0.001	79	0.00119	0.001	0.003	0.001
CR_XRF_pct	963	0.002192	0.001	0.023	0.001	239	0.002816	0.001	0.079	0.001	273	0.003154	0.003	0.015	0.001	79	0.002506	0.001	0.016	0.001
CU_XRF_pct	988	0.001657	0.001	0.02	0.001	239	0.001628	0.001	0.005	0.001	273	0.00156	0.001	0.006	0.001	79	0.00181	0.001	0.006	0.001
FE_CALC_pct	993	37.1076	37.3	65.06	1.23	239	59.3449	60.86	67.47	21.87	273	54.63077	55.37	63.38	18.23	79	34.86114	35.5	54.82	3.63
K2O_XRF_pct	990	0.019285	0.008	0.694	0.001	239	0.005151	0.003	0.054	0.001	273	0.009916	0.007	0.11	0.001	79	0.071468	0.012	1.271	0.002
MGO_XRF_pct	993	0.237492	0.05	18.55	0.01	239	0.063808	0.05	0.2	0.01	273	0.079597	0.05	0.66	0.01	79	0.214304	0.06	3.75	0.01
MN_XRF_pct	975	0.077723	0.02	15.57	0.01	239	0.046234	0.02	2.18	0.01	273	0.032234	0.02	0.29	0.01	79	0.032785	0.02	0.19	0.01
MNO_XRF_pct																				
NA_XRF_pct	984	0.015528	0.01	0.12	0.01	239	0.012887	0.01	0.06	0.01	273	0.021868	0.02	0.08	0.01	79	0.015443	0.01	0.12	0.01
NI_XRF_pct	989	0.001813	0.001	0.021	0.001	239	0.001837	0.001	0.008	0.001	273	0.001769	0.001	0.022	0.001	79	0.002152	0.001	0.025	0.001
PB_XRF_pct	973	0.003077	0.002	0.026	0.001	239	0.00269	0.002	0.01	0.001	273	0.002916	0.002	0.019	0.001	79	0.002582	0.002	0.009	0.001
SN_XRF_pct	975	0.001985	0.002	0.01	0.001	239	0.002059	0.001	0.006	0.001	273	0.002608	0.002	0.007	0.001	79	0.001722	0.001	0.006	0.001
SR_XRF_pct	987	0.002358	0.002	0.04	0.001	239	0.001523	0.001	0.006	0.001	273	0.001982	0.002	0.009	0.001	79	0.003304	0.002	0.017	0.001
SULP_XRF_pct	993	0.012753	0.006	0.181	0.001	239	0.013343	0.006	0.114	0.001	273	0.045766	0.037	0.186	0.002	79	0.02519	0.008	0.485	0.001
TIO2_XRF_pct	993	0.11431	0.05	1.47	0.01	239	0.086067	0.04	0.71	0.01	273	0.218974	0.17	1.07	0.02	79	0.137215	0.1	0.78	0.01
V_XRF_pct	985	0.002339	0.001	0.031	0.001	239	0.002067	0.001	0.01	0.001	273	0.003773	0.003	0.017	0.001	79	0.002405	0.002	0.011	0.001
ZR_XRF_pct	989	0.004087	0.002	0.078	0.001	239	0.002824	0.002	0.019	0.001	273	0.005886	0.005	0.047	0.001	79	0.004557	0.003	0.022	0.001
PHOS_XRF_pct	993	0.091823	0.077	0.498	0.009	239	0.140929	0.136	0.318	0.051	273	0.138429	0.117	0.748	0.023	79	0.084	0.083	0.204	0.013
SIO2_XRF_pct	993	37.91451	40.54	96.67	1.28	239	5.512134	3.5	40.77	0.64	273	8.101136	7.09	39.93	0.81	79	39.52228	41.36	87.48	7.81
ZN_XRF_pct	989	0.003275	0.002	0.066	0.001	239	0.003749	0.003	0.019	0.001	273	0.002549	0.002	0.024	0.001	79	0.005025	0.003	0.022	0.001
MN_D																				

Element/Oxide _Analysis_Units	Crustal Abundance mg/kg	Alluvium Mean	Alluvium Median	Alluvium Maximum	Alluvium Minimum	CLAY Mean	CLAY Median	CLAY Maximum	CLAY Minimum	CALCRETE Mean	CALCRETE Median	CALCRETE Maximum	CALCRETE Minimum	DET WASTE Mean	DET WASTE Median	DET WASTE Maximum	DET WASTE Minimum
AL2O3_XRF_pct	309886																
AS_XRF_pct	1.5	3	3	5	2	4	4	5	2	3	3	6	2	3	3	7	2
BA_XRF_pct	500											3				1	
CAO_XRF_pct	57367			2				1				2				2	
CL_XRF_pct	130			2				5				1				4	
CO_XRF_pct	20			1				2				1				1	
CR_XRF_pct	100			1				2				1				2	
CU_XRF_pct	50							1								2	
FE_CALC_pct	41000	1	1	3		1	1	3		1	1	3		2	2	3	
K2O_XRF_pct	50593																
MGO_XRF_pct	37540			1				1				2				1	
MN_XRF_pct	950			3				4				5				6	
MNO_XRF_pct	1226.665																
NA_XRF_pct	23000																
NI_XRF_pct	80															1	
PB_XRF_pct	14			1				2				2				3	
SN_XRF_pct	2	2	1	4	1	2	2	4	1	2	1	5	1	2	2	5	1
SR_XRF_pct	370																
SULP_XRF_pct	260							4								3	
TIO2_XRF_pct	9343							1				2				1	
V_XRF_pct	160			1				2								2	
ZR_XRF_pct	190											1					
PHOS_XRF_pct	1000															1	
SIO2_XRF_pct	592557.138																
ZN_XRF_pct	75											1				2	
MN_D	950																

Element/Oxide _Analysis_Units	DET ORE Mean	DET ORE Median	DET ORE Maximum	DET ORE Minimum	DOLERITE Mean	DOLERITE Median	DOLERITE Maximum	DOLERITE Minimum	JOF WASTE Mean	JOF WASTE Median	JOF WASTE Maximum	JOF WASTE Minimum
AL2O3_XRF_pct												
AS_XRF_pct	4	3	5	2	4	4	8	2	3	3	4	2
BA_XRF_pct												
CAO_XRF_pct							1					
CL_XRF_pct			1									
CO_XRF_pct			1				2					
CR_XRF_pct							1					
CU_XRF_pct							2					
FE_CALC_pct	3	3	3	2	1	1	3		2	2	3	
K2O_XRF_pct												
MGO_XRF_pct							1					
MN_XRF_pct			3		1		4				1	
MNO_XRF_pct												
NA_XRF_pct												
NI_XRF_pct							2					
PB_XRF_pct			2				2				1	
SN_XRF_pct	3	2	4	1	2	2	3	1	2	1	3	1
SR_XRF_pct												
SULP_XRF_pct			3				5				1	
TIO2_XRF_pct							1					
V_XRF_pct							1					
ZR_XRF_pct												
PHOS_XRF_pct												
SIO2_XRF_pct												
ZN_XRF_pct							2					
MN_D												

Element/Oxide _Analysis_Units	JOF HYD Mean	JOF HYD Median	JOF HYD Maximum	JOF HYD Minimum	WS WASTE Mean	WS WASTE Median	WS WASTE Maximum	WS WASTE Minimum	DG WASTE Mean	DG WASTE Median	DG WASTE Maximum	DG WASTE Minimum
AL2O3_XRF_pct												
AS_XRF_pct	4	4	4	4	4	4	7	2	3	3	7	2
BA_XRF_pct							1				3	
CAO_XRF_pct							1				1	
CL_XRF_pct							3				1	
CO_XRF_pct							3				1	
CR_XRF_pct							4					
CU_XRF_pct							1				1	
FE_CALC_pct	3	3	3	3	2	2	3		2	2	3	
K2O_XRF_pct												
MGO_XRF_pct							1				1	
MN_XRF_pct							5				6	
MNO_XRF_pct												
NA_XRF_pct												
NI_XRF_pct												
PB_XRF_pct					1		3				3	
SN_XRF_pct	2	1	3	1	3	2	5	1	2	2	5	1
SR_XRF_pct												
SULP_XRF_pct							6				2	
TIO2_XRF_pct												
V_XRF_pct												
ZR_XRF_pct							1				1	
PHOS_XRF_pct							1				1	
SIO2_XRF_pct												
ZN_XRF_pct							2				2	
MN_D												

Element/Oxide _Analysis_Units	DG ORE Mean	DG ORE Median	DG ORE Maximum	DG ORE Minimum	DG HYD Mean	DG HYD Median	DG HYD Maximum	DG HYD Minimum	FWZ WASTE Mean	FWZ WASTE Median	FWZ WASTE Maximum	FWZ WASTE Minimum
AL2O3_XRF_pct												
AS_XRF_pct	3	3	5	2	4	4	6	2	4	3	7	2
BA_XRF_pct			2									
CAO_XRF_pct												
CL_XRF_pct			1				1					
CO_XRF_pct												
CR_XRF_pct			2									
CU_XRF_pct												
FE_CALC_pct	3	3	3	1	3	3	3	1	2	2	3	
K2O_XRF_pct												
MGO_XRF_pct												
MN_XRF_pct			3				1					
MNO_XRF_pct												
NA_XRF_pct												
NI_XRF_pct											1	
PB_XRF_pct			2				3				2	
SN_XRF_pct	2	1	4	1	3	2	4	1	2	1	4	1
SR_XRF_pct												
SULP_XRF_pct			1				2				3	
TIO2_XRF_pct												
V_XRF_pct												
ZR_XRF_pct												
PHOS_XRF_pct			1				2					
SIO2_XRF_pct												
ZN_XRF_pct							1					
MN_D												

Element/Oxide	FWZ ORE					MCS					MTS					WD				
_Analysis_Units	Count	Mean	Median	Maximum	Minimum	Count	Mean	Median	Maximum	Minimum	Count	Mean	Median	Maximum	Minimum	Count	Mean	Median	Maximum	Minimum
AL2O3_XRF_pct	7	2.664286	2.36	4.96	1.15	110	9.657636	7.87	30.37	0.68	103	6.938447	6.43	28.49	1.23	845	9.25955	7.44	40.98	0.2
AS_XRF_pct	7	0.002857	0.002	0.007	0.001	110	0.004691	0.004	0.022	0.001	95	0.005316	0.005	0.029	0.001	758	0.00404	0.003	0.035	0.001
BA_XRF_pct	7	0.014571	0.01	0.045	0.005	106	0.007066	0.005	0.045	0.001	90	0.010067	0.007	0.066	0.001	626	0.015621	0.005	1.622	0.001
CAO_XRF_pct	7	0.028571	0.03	0.04	0.02	110	0.272	0.08	3.1	0.02	103	0.464854	0.09	6.47	0.03	845	5.671231	0.35	42.41	0.01
CL_XRF_pct	7	0.001571	0.001	0.003	0.001	110	0.004427	0.003	0.024	0.001	95	0.008758	0.003	0.059	0.001	745	0.006133	0.005	0.055	0.001
CO_XRF_pct	7	0.001	0.001	0.001	0.001	107	0.00129	0.001	0.004	0.001	94	0.001862	0.002	0.007	0.001	660	0.002817	0.002	0.023	0.001
CR_XRF_pct	7	0.001143	0.001	0.002	0.001	110	0.009409	0.004	0.124	0.001	84	0.004702	0.004	0.018	0.001	736	0.007668	0.006	0.055	0.001
CU_XRF_pct	7	0.002571	0.003	0.004	0.001	110	0.002945	0.002	0.018	0.001	103	0.004058	0.002	0.037	0.001	740	0.005354	0.002	0.048	0.001
FE_CALC_pct	7	54.23571	53.95	57.73	50.35	110	29.91918	31.28	54.72	1.18	103	41.05553	41.45	63.31	6.96	845	22.69672	20.96	57.65	0.54
K2O_XRF_pct	7	0.005857	0.005	0.01	0.004	110	0.260373	0.035	4.584	0.004	103	0.209155	0.053	2.867	0.004	836	0.43749	0.137	4.118	0.003
MGO_XRF_pct	7	0.068571	0.07	0.11	0.04	110	0.281909	0.175	1.94	0.02	103	0.321359	0.21	1.6	0.04	835	3.603246	0.69	19.67	0.03
MN_XRF_pct	7	0.08	0.05	0.27	0.02	106	0.155566	0.05	3.66	0.01	95	0.562526	0.21	6.44	0.02	808	0.85875	0.23	26.81	0.01
MNO_XRF_pct																				
NA_XRF_pct	7	0.012857	0.01	0.02	0.01	110	0.021455	0.02	0.08	0.01	93	0.018172	0.01	0.07	0.01	671	0.037124	0.02	0.25	0.01
NI_XRF_pct	7	0.001	0.001	0.001	0.001	110	0.002818	0.002	0.014	0.001	95	0.005242	0.004	0.023	0.001	738	0.004871	0.004	0.052	0.001
PB_XRF_pct	7	0.004	0.003	0.008	0.002	103	0.002699	0.002	0.01	0.001	96	0.00226	0.002	0.009	0.001	652	0.002192	0.001	0.014	0.001
SN_XRF_pct	7	0.004286	0.004	0.006	0.003	107	0.002056	0.001	0.013	0.001	89	0.001663	0.001	0.005	0.001	660	0.001538	0.001	0.006	0.001
SR_XRF_pct	7	0.002286	0.003	0.003	0.001	110	0.003409	0.002	0.019	0.001	95	0.002042	0.001	0.011	0.001	732	0.005336	0.003	0.115	0.001
SULP_XRF_pct	7	0.004	0.003	0.008	0.001	110	0.021064	0.0085	0.372	0.001	103	0.013476	0.007	0.096	0.001	845	0.011679	0.007	0.164	0.001
TIO2_XRF_pct	7	0.137143	0.11	0.26	0.05	110	0.423727	0.395	1.55	0.02	103	0.294563	0.26	0.92	0.05	845	0.633089	0.47	6.45	0.01
V_XRF_pct	7	0.001857	0.002	0.003	0.001	110	0.007736	0.006	0.035	0.001	95	0.005074	0.005	0.01	0.001	739	0.011409	0.008	0.058	0.001
ZR_XRF_pct	7	0.003714	0.003	0.007	0.001	110	0.013273	0.009	0.109	0.001	95	0.006432	0.005	0.018	0.002	747	0.008527	0.008	0.072	0.001
PHOS_XRF_pct	7	0.141714	0.142	0.174	0.116	110	0.060118	0.046	0.255	0.011	103	0.073864	0.079	0.15	0.01	845	0.036871	0.027	0.134	0.002
SIO2_XRF_pct	7	10.01	10.38	19.5	4.19	110	37.773	33.35	90.74	7.46	103	24.85369	18.66	80.57	3.04	845	32.12181	28.36	95.97	0.69
ZN_XRF_pct	7	0.004286	0.005	0.006	0.002	110	0.003827	0.003	0.013	0.001	101	0.00697	0.005	0.026	0.001	782	0.006216	0.004	0.037	0.001
MN_D																				

Element/Oxide	ANG WASTE					ANG ORE					ANG HYD				
_Analysis_Units	Count	Mean	Median	Maximum	Minimum	Count	Mean	Median	Maximum	Minimum	Count	Mean	Median	Maximum	Minimum
AL2O3_XRF_pct	2278	10.07541	8.87	37.67	0.23	213	3.091362	2.6	18.12	0.55	984	5.240213	4.795	23.09	0.79
AS_XRF_pct	1402	0.005138	0.005	0.095	0.001	170	0.003094	0.002	0.017	0.001	421	0.004133	0.004	0.016	0.001
BA_XRF_pct	1003	0.018339	0.007	0.728	0.001	153	0.016046	0.003	0.455	0.001	210	0.008648	0.004	0.172	0.001
CAO_XRF_pct	2277	1.23603	0.13	43.74	0.01	213	0.344085	0.07	7.59	0.02	984	0.176565	0.07	9.75	0.02
CL_XRF_pct	1433	0.004504	0.004	0.069	0.001	173	0.003746	0.003	0.011	0.001	427	0.005173	0.005	0.129	0.001
CO_XRF_pct	1203	0.003064	0.002	0.049	0.001	149	0.001503	0.001	0.004	0.001	356	0.002376	0.002	0.008	0.001
CR_XRF_pct	1424	0.00873	0.008	0.067	0.001	162	0.004623	0.004	0.021	0.001	421	0.005836	0.005	0.049	0.001
CU_XRF_pct	1705	0.004307	0.003	0.046	0.001	160	0.001738	0.002	0.007	0.001	504	0.002371	0.002	0.02	0.001
FE_CALC_pct	2278	32.35797	32.93	64.91	0.93	213	58.26305	59.18	66.17	31.51	984	52.8521	53.635	63.87	13.34
K2O_XRF_pct	1999	0.366759	0.083	3.876	0.003	195	0.024426	0.01	0.38	0.002	653	0.023991	0.012	0.468	0.002
MGO_XRF_pct	2109	0.975965	0.44	18.88	0.01	201	0.191393	0.16	2.24	0.04	875	0.255566	0.16	6.3	0.01
MN_XRF_pct	2222	0.748645	0.18	24.51	0.01	213	0.327465	0.11	21.15	0.01	915	0.124973	0.05	5.48	0.01
MNO_XRF_pct															
NA_XRF_pct	1237	0.032563	0.02	1.25	0.01	103	0.018641	0.01	0.15	0.01	140	0.0155	0.01	0.07	0.01
NI_XRF_pct	1417	0.006558	0.005	0.145	0.001	162	0.002272	0.002	0.007	0.001	365	0.002929	0.002	0.014	0.001
PB_XRF_pct	1221	0.002775	0.002	0.049	0.001	131	0.002076	0.001	0.015	0.001	218	0.002954	0.002	0.013	0.001
SN_XRF_pct	988	0.00163	0.001	0.02	0.001	150	0.00176	0.001	0.005	0.001	263	0.001772	0.002	0.006	0.001
SR_XRF_pct	1295	0.00461	0.003	0.115	0.001	152	0.001855	0.001	0.012	0.001	287	0.002028	0.002	0.008	0.001
SULP_XRF_pct	2267	0.012521	0.008	0.906	0.001	212	0.010594	0.008	0.036	0.001	984	0.018476	0.012	0.614	0.002
TIO2_XRF_pct	2278	0.635799	0.54	10.2	0.01	213	0.152019	0.11	1.21	0.02	984	0.331992	0.26	2.33	0.02
V_XRF_pct	1425	0.012184	0.01	0.084	0.001	167	0.005617	0.004	0.033	0.001	436	0.007933	0.007	0.046	0.001
ZR_XRF_pct	1444	0.00913	0.008	0.073	0.001	159	0.003277	0.002	0.016	0.001	429	0.004382	0.004	0.016	0.001
PHOS_XRF_pct	2277	0.045273	0.038	0.159	0.001	213	0.059404	0.056	0.185	0.017	984	0.044039	0.042	0.15	0.005
SIO2_XRF_pct	2278	28.90473	23.515	95.45	1.59	213	4.865164	3.64	22.45	1.21	984	7.606453	6.23	63.57	1.32
ZN_XRF_pct	1905	0.006277	0.005	0.084	0.001	184	0.003598	0.003	0.019	0.001	659	0.003205	0.003	0.015	0.001
MN_D															

Element/Oxide	NEW WASTE					NEW ORE					MAC WASTE				
_Analysis_Units	Count	Mean	Median	Maximum	Minimum	Count	Mean	Median	Maximum	Minimum	Count	Mean	Median	Maximum	Minimum
AL2O3_XRF_pct	1607	1.940423	0.74	25.89	0.08	1953	1.931198	1.44	19.42	0.3	260	4.650346	2.4	33.57	0.19
AS_XRF_pct	473	0.001992	0.002	0.02	0.001	759	0.00203	0.002	0.007	0.001	86	0.00336	0.003	0.01	0.001
BA_XRF_pct	357	0.005874	0.002	0.361	0.001	600	0.004833	0.003	0.149	0.001	34	0.018206	0.005	0.229	0.001
CAO_XRF_pct	1473	0.235771	0.03	24.37	0.01	1877	0.085631	0.03	12.91	0.01	239	0.086151	0.04	1.81	0.01
CL_XRF_pct	626	0.004027	0.004	0.044	0.001	878	0.005238	0.004	0.093	0.001	90	0.010478	0.004	0.112	0.001
CO_XRF_pct	462	0.001818	0.001	0.012	0.001	744	0.001696	0.002	0.011	0.001	48	0.001875	0.001	0.008	0.001
CR_XRF_pct	490	0.003008	0.002	0.026	0.001	664	0.002351	0.002	0.018	0.001	74	0.008311	0.005	0.058	0.001
CU_XRF_pct	1025	0.002132	0.002	0.018	0.001	1128	0.002145	0.002	0.026	0.001	150	0.0033	0.002	0.016	0.001
FE_CALC_pct	1607	34.95906	34.07	64.8	3.84	1953	61.25858	62.28	67.17	29.82	260	31.36196	31.525	55.94	4.28
K2O_XRF_pct	1077	0.036363	0.01	1.875	0.001	1162	0.012261	0.007	0.22	0.001	195	0.054256	0.02	1	0.003
MGO_XRF_pct	1394	0.155502	0.06	6.15	0.01	1781	0.105008	0.08	3.44	0.01	193	0.13829	0.06	2.49	0.01
MN_XRF_pct	1473	0.077237	0.03	15.05	0.01	1909	0.092771	0.05	7.6	0.01	204	0.077794	0.03	1.37	0.01
MNO_XRF_pct															
NA_XRF_pct	406	0.021749	0.01	1.64	0.01	382	0.016021	0.01	0.09	0.01	63	0.027143	0.02	0.16	0.01
NI_XRF_pct	519	0.001971	0.001	0.014	0.001	730	0.001786	0.001	0.011	0.001	82	0.003159	0.002	0.011	0.001
PB_XRF_pct	791	0.003252	0.002	0.019	0.001	783	0.002828	0.002	0.017	0.001	68	0.002471	0.002	0.006	0.001
SN_XRF_pct	451	0.001663	0.001	0.004	0.001	700	0.001957	0.002	0.005	0.001	58	0.001586	0.001	0.004	0.001
SR_XRF_pct	620	0.003837	0.003	0.017	0.001	616	0.001497	0.001	0.006	0.001	80	0.004688	0.0045	0.012	0.001
SULP_XRF_pct	1582	0.00909	0.005	0.229	0.001	1947	0.011435	0.007	0.379	0.001	255	0.02298	0.014	0.527	0.001
TIO2_XRF_pct	1482	0.107092	0.03	1.72	0.01	1945	0.075126	0.05	1.19	0.01	247	0.312874	0.13	3.71	0.01
V_XRF_pct	458	0.004017	0.002	0.044	0.001	750	0.002583	0.002	0.018	0.001	72	0.011236	0.006	0.069	0.001
ZR_XRF_pct	592	0.003088	0.002	0.02	0.001	613	0.001728	0.001	0.018	0.001	89	0.004719	0.003	0.03	0.001
PHOS_XRF_pct	1607	0.039345	0.036	0.135	0.001	1953	0.059204	0.056	0.152	0.011	260	0.032504	0.031	0.107	0.004
SIO2_XRF_pct	1607	43.16024	46.41	91.53	1.57	1953	3.595141	2.41	31.79	0.79	260	43.4865	45.9	90.63	5.98
ZN_XRF_pct	1067	0.0023	0.002	0.026	0.001	1472	0.002616	0.002	0.015	0.001	168	0.003476	0.003	0.012	0.001
MN_D															

Element/Oxide	MAC ORE					MM WASTE					MM HYD				
_Analysis_Units	Count	Mean	Median	Maximum	Minimum	Count	Mean	Median	Maximum	Minimum	Count	Mean	Median	Maximum	Minimum
AL2O3_XRF_pct	31	3.649355	3.83	9.58	0.59	45	4.822444	4.34	14.45	0.41	747	4.12988	3.83	19.35	0.52
AS_XRF_pct	12	0.001667	0.0015	0.003	0.001	45	0.003	0.003	0.005	0.001	243	0.002288	0.002	0.006	0.001
BA_XRF_pct	8	0.002375	0.002	0.004	0.001	32	0.005031	0.002	0.064	0.001	130	0.004054	0.003	0.025	0.001
CAO_XRF_pct	26	0.059231	0.05	0.22	0.01	38	0.042895	0.03	0.28	0.01	739	0.10525	0.05	5.49	0.01
CL_XRF_pct	17	0.004706	0.005	0.008	0.002	45	0.019511	0.011	0.229	0.004	263	0.006848	0.006	0.063	0.001
CO_XRF_pct	15	0.001733	0.002	0.003	0.001	37	0.001811	0.001	0.008	0.001	198	0.001697	0.0015	0.008	0.001
CR_XRF_pct	12	0.003667	0.0035	0.007	0.001	44	0.00525	0.004	0.013	0.001	256	0.004691	0.004	0.038	0.001
CU_XRF_pct	13	0.002308	0.002	0.006	0.001	44	0.0025	0.002	0.007	0.001	392	0.002291	0.002	0.014	0.001
FE_CALC_pct	31	55.88516	55.09	63.15	45.48	45	34.17267	33.29	52.26	8.5	747	54.46602	54.91	63.95	19.18
K2O_XRF_pct	17	0.012529	0.009	0.049	0.002	45	0.021933	0.017	0.225	0.005	560	0.027559	0.02	0.32	0.002
MGO_XRF_pct	23	0.076087	0.05	0.3	0.01	43	0.05093	0.03	0.42	0.01	688	0.121526	0.08	3.84	0.01
MN_XRF_pct	28	0.046071	0.03	0.14	0.02	34	0.032353	0.01	0.24	0.01	695	0.059583	0.04	1.14	0.01
MNO_XRF_pct															
NA_XRF_pct	4	0.015	0.01	0.03	0.01	34	0.017059	0.02	0.03	0.01	142	0.017183	0.01	0.08	0.01
NI_XRF_pct	5	0.001	0.001	0.001	0.001	45	0.003467	0.003	0.009	0.001	216	0.003065	0.002	0.203	0.001
PB_XRF_pct	4	0.00125	0.001	0.002	0.001	34	0.002382	0.002	0.006	0.001	223	0.002484	0.002	0.014	0.001
SN_XRF_pct	9	0.002222	0.002	0.004	0.001	38	0.001579	0.001	0.004	0.001	195	0.001615	0.001	0.004	0.001
SR_XRF_pct	7	0.001429	0.001	0.003	0.001	45	0.004711	0.004	0.01	0.001	161	0.001981	0.001	0.007	0.001
SULP_XRF_pct	31	0.026742	0.018	0.085	0.004	45	0.038289	0.018	0.403	0.002	747	0.042991	0.03	0.706	0.002
TIO2_XRF_pct	31	0.15129	0.13	0.46	0.01	45	0.28	0.23	0.97	0.02	747	0.258594	0.19	3.48	0.01
V_XRF_pct	10	0.0038	0.003	0.008	0.001	43	0.006744	0.004	0.027	0.001	253	0.006964	0.005	0.034	0.001
ZR_XRF_pct	12	0.003583	0.003	0.009	0.001	45	0.0054	0.005	0.011	0.001	250	0.00408	0.003	0.018	0.001
PHOS_XRF_pct	31	0.054548	0.052	0.108	0.02	45	0.040133	0.037	0.107	0.008	747	0.044834	0.042	0.118	0.008
SIO2_XRF_pct	31	7.571935	7.15	16.34	1.87	45	38.62222	41.22	78.48	7.46	747	8.423788	7.38	33.23	1.39
ZN_XRF_pct	18	0.002333	0.001	0.009	0.001	38	0.003053	0.002	0.016	0.001	526	0.002951	0.002	0.029	0.001
MN_D															

Element/Oxide _Analysis_Units	Crustal Abundance mg/kg	FWZ ORE Mean	FWZ ORE Median	FWZ ORE Maximum	FWZ ORE Minimum	MCS Mean	MCS Median	MCS Maximum	MCS Minimum	MTS Mean	MTS Median	MTS Maximum	MTS Minimum	WD Mean	WD Median	WD Maximum	WD Minimum
AL2O3_XRF_pct	309886																
AS_XRF_pct	1.5	3	3	4	2	4	4	6	2	4	4	7	2	4	3	7	2
BA_XRF_pct	500															4	
CAO_XRF_pct	57367															2	
CL_XRF_pct	130											1				1	
CO_XRF_pct	20											1				2	
CR_XRF_pct	100							3								1	
CU_XRF_pct	50							1				2				2	
FE_CALC_pct	41000	3	3	3	3	2	2	3		2	2	3		1	1	3	
K2O_XRF_pct	50593																
MGO_XRF_pct	37540															1	
MN_XRF_pct	950							4		1		5		2		7	
MNO_XRF_pct	1226.665																
NA_XRF_pct	23000																
NI_XRF_pct	80															2	
PB_XRF_pct	14			1				2				2				2	
SN_XRF_pct	2	3	3	4	3	2	1	5	1	2	1	4	1	2	1	4	1
SR_XRF_pct	370															1	
SULP_XRF_pct	260							3				1				2	
TIO2_XRF_pct	9343															2	
V_XRF_pct	160															1	
ZR_XRF_pct	190							1								1	
PHOS_XRF_pct	1000																
SIO2_XRF_pct	592557.138																
ZN_XRF_pct	75											1				1	
MN_D	950																

Element/Oxide _Analysis_Units	ANG WASTE Mean	ANG WASTE Median	ANG WASTE Maximum	ANG WASTE Minimum	ANG ORE Mean	ANG ORE Median	ANG ORE Maximum	ANG ORE Minimum	ANG HYD Mean	ANG HYD Median	ANG HYD Maximum	ANG HYD Minimum
AL2O3_XRF_pct												
AS_XRF_pct	4	4	8	2	3	3	6	2	4	4	6	2
BA_XRF_pct			3				2				1	
CAO_XRF_pct			2									
CL_XRF_pct			1								2	
CO_XRF_pct			4								1	
CR_XRF_pct			2								1	
CU_XRF_pct			2								1	
FE_CALC_pct	2	2	3		3	3	3	2	3	3	3	1
K2O_XRF_pct												
MGO_XRF_pct			1									
MN_XRF_pct	2		7		1		7				5	
MNO_XRF_pct												
NA_XRF_pct												
NI_XRF_pct			3									
PB_XRF_pct			4				2				2	
SN_XRF_pct	2	1	6	1	2	1	4	1	2	2	4	1
SR_XRF_pct			1									
SULP_XRF_pct			4								3	
TIO2_XRF_pct			2									
V_XRF_pct			1									
ZR_XRF_pct			1									
PHOS_XRF_pct												
SIO2_XRF_pct												
ZN_XRF_pct			2									
MN_D												

Element/Oxide _Analysis_Units	NEW WASTE Mean	NEW WASTE Median	NEW WASTE Maximum	NEW WASTE Minimum	NEW ORE Mean	NEW ORE Median	NEW ORE Maximum	NEW ORE Minimum	MAC WASTE Mean	MAC WASTE Median	MAC WASTE Maximum	MAC WASTE Minimum
AL2O3_XRF_pct												
AS_XRF_pct	3	3	6	2	3	3	4	2	3	3	5	2
BA_XRF_pct			2								1	
CAO_XRF_pct			1									
CL_XRF_pct			1				2				2	
CO_XRF_pct			2				1				1	
CR_XRF_pct											1	
CU_XRF_pct			1				1				1	
FE_CALC_pct	2	2	3		3	3	3	2	2	2	3	
K2O_XRF_pct												
MGO_XRF_pct												
MN_XRF_pct			6				5				3	
MNO_XRF_pct												
NA_XRF_pct												
NI_XRF_pct												
PB_XRF_pct			3				3				1	
SN_XRF_pct	2	1	3	1	2	2	4	1	2	1	3	1
SR_XRF_pct												
SULP_XRF_pct			2				3				3	
TIO2_XRF_pct											1	
V_XRF_pct											1	
ZR_XRF_pct												
PHOS_XRF_pct												
SIO2_XRF_pct												
ZN_XRF_pct			1									
MN_D												

Element/Oxide _Analysis_Units	MAC ORE Mean	MAC ORE Median	MAC ORE Maximum	MAC ORE Minimum	MM WASTE Mean	MM WASTE Median	MM WASTE Maximum	MM WASTE Minimum	MM HYD Mean	MM HYD Median	MM HYD Maximum	MM HYD Minimum
AL2O3_XRF_pct												
AS_XRF_pct	2	2	3	2	3	3	4	2	3	3	4	2
BA_XRF_pct												
CAO_XRF_pct												
CL_XRF_pct							3				1	
CO_XRF_pct							1				1	
CR_XRF_pct											1	
CU_XRF_pct												
FE_CALC_pct	3	3	3	2	2	2	3		3	3	3	1
K2O_XRF_pct												
MGO_XRF_pct												
MN_XRF_pct											3	
MNO_XRF_pct												
NA_XRF_pct												
NI_XRF_pct											4	
PB_XRF_pct							1				2	
SN_XRF_pct	2	2	3	1	2	1	3	1	2	1	3	1
SR_XRF_pct												
SULP_XRF_pct							3				4	
TIO2_XRF_pct											1	
V_XRF_pct												
ZR_XRF_pct												
PHOS_XRF_pct												
SIO2_XRF_pct												
ZN_XRF_pct											1	
MN_D												

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Element/Oxide_	ALLUVIUM					CLAY					CALCRETE					DET WASTE					DET ORE					DOLERITE					WW					UNDF BRK					YS					WS WASTE				
Analysis_Units	Count	Mean	Median	Maximum	Minimum	Count	Mean	Median	Maximum	Minimum	Count	Mean	Median	Maximum	Minimum	Count	Mean	Median	Maximum	Minimum	Count	Mean	Median	Maximum	Minimum	Count	Mean	Median	Maximum	Minimum	Count	Mean	Median	Maximum	Minimum	Count	Mean	Median	Maximum	Minimum	Count	Mean	Median	Maximum	Minimum	Count	Mean	Median	Maximum	Minimum
AL2O3_XRF_pct	1882	7.47	5.22	30.65	0.96	372	17.78	19.035	29.95	2.26	63	11.30	7.18	37.36	0.76	10933	6.28	5.06	31.06	0.19	7393	4.26	3.97	28.15	0.5	4	6.42	3.855	14.6	3.38	313	13.60	13.38	36.06	1.44	16	20.15	23.175	29.13	1.24	18	12.97	11.065	24.65	4.67	16	3.88	2.48	9.98	0.92
AS_XRF_pct	945	0.006	0.005	0.036	0.001	276	0.004	0.004	0.016	0.002	22	0.009	0.0035	0.047	0.001	4497	0.008	0.008	0.156	0.001	576	0.006	0.005	0.025	0.001	4	0.002	0.0015	0.002	0.001	267	0.003	0.003	0.009	0.001	0					0					16	0.002	0.001	0.006	0.001
BA_XRF_pct	847	0.011	0.008	0.111	0.001	172	0.018	0.009	0.111	0.001	22	0.011	0.004	0.044	0.001	3897	0.007	0.006	0.142	0.001	411	0.003	0.002	0.046	0.001	4	0.007	0.004	0.019	0.001	195	0.034	0.03	0.197	0.002	0					0					16	0.019	0.012	0.065	0.003
CAO_XRF_pct	1880	1.11	0.2	28.49	0.02	372	1.47	0.545	22.66	0.03	63	13.60	9.66	37.61	0.06	10923	0.21	0.08	38.34	0.01	7303	0.08	0.06	6.31	0.01	4	1.36	0.61	3.71	0.51	313	0.46	0.13	7.1	0.03	16	0.33	0.39	0.57	0.04	18	0.19	0.095	0.47	0.04	16	0.10	0.065	0.26	0.02
CL_XRF_pct	937	0.015	0.008	0.534	0.001	195	0.005	0.004	0.019	0.001	28	0.009	0.0045	0.028	0.001	4505	0.016	0.013	0.156	0.001	594	0.013	0.012	0.062	0.001	4	0.013	0.0095	0.027	0.004	263	0.008	0.007	0.041	0.001	0					0					16	0.021	0.0235	0.036	0.006
CO_XRF_pct	365	0.002	0.001	0.008	0.001	93	0.003	0.002	0.02	0.001	14	0.001	0.001	0.004	0.001	3601	0.001	0.001	0.008	0.001	488	0.001	0.001	0.005	0.001	4	0.002	0.0015	0.005	0.001	110	0.004	0.003	0.026	0.001	0					0					16	0.001	0.001	0.003	0.001
CR_XRF_pct	959	0.009	0.009	0.114	0.001	242	0.004	0.003	0.027	0.001	33	0.006	0.003	0.02	0.001	4453	0.007	0.006	0.085	0.001	590	0.005	0.005	0.028	0.001	4	0.005	0.003	0.01	0.002	164	0.007	0.004	0.032	0.001	0					0					16	0.001	0.001	0.004	0.001
CU_XRF_pct	1682	0.003	0.003	0.026	0.001	281	0.002	0.002	0.009	0.001	42	0.002	0.002	0.006	0.001	8490	0.003	0.002	0.034	0.001	3925	0.002	0.002	0.037	0.001	4	0.006	0.0035	0.015	0.001	253	0.003	0.002	0.02	0.001	13	0.002	0.002	0.005	0.001	18	0.003	0.003	0.014	0.001	16	0.001	0.001	0.002	0.001
FE_XRF_pct	481	25.57	26.63	47.13	2.91	264	14.98	12.53	51.97	1.56	38	10.66	7.42	38.31	1.79	3508	32.68	31.41	62.36	3.21	429	55.28	54.69	65.55	29.82	4	24.52	27.01	30.1	13.95	233	14.18	10.79	54.77	0.68	0					0					16	14.23	8.23	37.52	1.52
K2O_XRF_pct	1881	0.36	0.27	3.98	0.01	372	0.28	0.12	4.30	0.01	63	0.32	0.07	3.34	0.01	10667	0.29	0.18	3.19	0.001	5267	0.03	0.02	0.87	0.001	4	0.62	0.38	1.56	0.15	313	1.16	0.15	7.00	0.005	16	0.12	0.10	0.41	0.02	18	0.04	0.03	0.17	0.01	16	0.03	0.02	0.09	0.01
MGO_XRF_pct	1878	0.38	0.24	8.04	0.01	372	0.94	0.8	16.8	0.03	63	3.22	1.41	19.4	0.07	10859	0.23	0.15	19.7	0.01	7252	0.09	0.08	1.96	0.01	4	2.77	2.84	3.79	1.59	313	0.74	0.28	6.49	0.01	15	0.44	0.44	0.75	0.05	17	0.27	0.17	0.71	0.02	16	0.53	0.26	1.88	0.02
MN_XRF_pct	922	0.06	0.05	0.54	0.02	259	0.11	0.05	1.75	0.02	26	0.03	0.02	0.16	0.01	4462	0.04	0.03	0.6	0.01	617	0.04	0.02	0.73	0.01	4	0.12	0.13	0.16	0.04	220	0.08	0.04	2.04	0.02	0					0					16	0.06	0.03	0.25	0.01
MNO_XRF_pct	887	0.07	0.06	0.68	0.01	50	0.05	0.03	0.45	0.01	21	0.02	0.02	0.08	0.01	6131	0.05	0.04	1.7	0.01	6550	0.04	0.03	0.56	0.01	0					13	0.08	0.07	0.12	0.01	16	0.06	0.04	0.3	0.02	18	0.06	0.03	0.46	0.01	0				
NA_XRF_pct	935	0.048	0.04	1.33	0.01	306	0.073	0.04	2.07	0.01	33	0.039	0.03	0.1	0.01	4299	0.038	0.03	0.23	0.01	499	0.019	0.02	0.08	0.01	4	0.598	0.095	2.16	0.04	284	0.429	0.03	3.55	0.01	0					0					16	0.029	0.03	0.05	0.01
NI_XRF_pct	930	0.003	0.003	0.02	0.001	266	0.003	0.002	0.009	0.001	36	0.002	0.002	0.005	0.001	4186	0.003	0.003	0.022	0.001	494	0.002	0.002	0.017	0.001	4	0.002	0.001	0.006	0.001	224	0.003	0.002	0.015	0.001	0					0					16	0.001	0.001	0.003	0.001
PB_XRF_pct	1336	0.004	0.003	0.022	0.001	157	0.003	0.002	0.01	0.001	33	0.004	0.003	0.009	0.001	7269	0.004	0.004	0.51	0.001	4042	0.004	0.003	0.022	0.001	4	0.002	0.0025	0.003	0.001	204	0.004	0.003	0.009	0.001	7	0.003	0.002	0.009	0.001	17	0.007	0.007	0.012	0.002	16	0.003	0.003	0.005	0.001
SN_XRF_pct	660	0.003	0.002	0.012	0.001	216	0.002	0.002	0.009	0.001	32	0.002	0.002	0.004	0.001	3880	0.002	0.001	0.014	0.001	522	0.002	0.002	0.009	0.001	4	0.002	0.001	0.003	0.001	221	0.003	0.003	0.01	0.001	0					0					16	0.002	0.001	0.003	0.001
SR_XRF_pct	981	0.007	0.008	0.03	0.001	298	0.007	0.006	0.041	0.001	25	0.005	0.005	0.01	0.001	4458	0.008	0.007	0.036	0.001	509	0.003	0.002	0.015	0.001	4	0.004	0.0015	0.011	0.001	294	0.008	0.007	0.029	0.001	0					0					16	0.001	0.001	0.002	0.001
SULP_XRF_pct	1882	0.039	0.023	1.002	0.001	372	0.023	0.012	0.762	0.003	63	0.019	0.015	0.063	0.003	10933	0.035	0.025	1.03	0.001	7393	0.027	0.022	1.514	0.001	4	0.199	0.2085	0.352	0.027	313	0.012	0.007	0.212	0.001	16	0.021	0.0165	0.049	0.008	18	0.036	0.027	0.111	0.007	16	0.009	0.009	0.017	0.004
TIO2_XRF_pct	1882	0.50	0.32	3.65	0.03	372	1.24	1.34	3.28	0.12	63	0.67	0.52	2.87	0.05	10932	0.39	0.31	3.58	0.02	7393	0.32	0.29	3.7	0.03	4	0.52	0.28	1.28	0.22	313	0.83	0.59	3.9	0.05	16	1.10	1.24	1.74	0.08	18	1.01	0.86	2.03	0.23	16	0.35	0.30	0.89	0.02
V_XRF_pct	989	0.015	0.012	0.085	0.001	296	0.017	0.015	0.063	0.001	32	0.013	0.008	0.073	0.001	4536	0.008	0.007	0.087	0.001	594	0.006	0.005	0.069	0.001	4	0.016	0.009	0.038	0.007	269	0.014	0.01	0.052	0.001	0					0					16	0.003	0.002	0.009	0.001
ZR_XRF_pct	989	0.019	0.013	0.099	0.002	310	0.047	0.047	0.098	0.007	42	0.027	0.018	0.081	0.001	4501	0.010	0.009	0.1	0.001	594	0.008	0.007	0.081	0.001	4	0.004	0.003	0.007	0.002	300	0.028	0.023	0.132	0.003	0					0					16	0.007	0.005	0.018	0.002
PHOS_XRF_pct	1882	0.043	0.042	0.102	0.004	372	0.025	0.021	0.12	0.006	63	0.018	0.014	0.064	0.005	10933	0.045	0.043	0.224	0.004	7393	0.046	0.044	0.203	0.019	4	0.075	0.0735	0.104	0.05	313	0.044	0.035	0.178	0.006	16	0.021	0.0145	0.059	0.007	18	0.033	0.0335	0.068	0.007	16	0.014	0.012	0.037	0.001
SIO2_XRF_pct	1882	41.18	42.43	87.88	2.59	372	40.89	43.48	80.6	6.57	63	26.80	21.89	71.27	3.04	10933	35.21	33.81	92.97	1.01	7393	10.24	9.23	46.79	0.64	4	46.81	47.01	49.82	43.39	313	52.20	53.95	88.34	4.57	16	37.02	38.73	45.48	21.05	18	17.59	13.18	34.39	3.36	16	70.53	80.90	92.41	35.07
ZN_XRF_pct	1786	0.006	0.006	0.078	0.001	249	0.004	0.003	0.03	0.001	51	0.003	0.003	0.012	0.001	10059	0.006	0.005	0.125	0.001	5563	0.003	0.002	0.099	0.001	4	0.008	0.0075	0.012	0.005	276	0.008	0.007	0.032	0.001	14	0.002	0.002	0.004	0.001	17	0.003	0.002	0.01	0.001	16	0.002	0.001	0.005	0.001
MN_D	892	0.06	0.046	0.775	0.008	62	0.18	0.02	0.77	0.01	21	0.018	0.015	0.062	0.008	6350	0.065	0.031	1.32	0.008	6736	0.048	0.023	0.775	0.008	0					13	0.060	0.054	0.093	0.008	16	0.045	0.027	0.232	0.015	18	0.047	0.019	0.356	0.008	0				

Element/Oxide_ Analysis_Units	Crustal Abundance	ALLUVIUM				CLAY				CALCRETE				DET WASTE				DET ORE				DOLERITE				WW				UNDF BRK				YS				WS WASTE			
	mg/kg	Mean	Median	Maximum	Minimum	Mean	Median	Maximum	Minimum	Mean	Median	Maximum	Minimum	Mean	Median	Maximum	Minimum	Mean	Median	Maximum	Minimum	Mean	Median	Maximum	Minimum	Mean	Median	Maximum	Minimum	Mean	Median	Maximum	Minimum	Mean	Median	Maximum	Minimum	Mean	Median	Maximum	Minimum
AL2O3_XRF_pct	309886																																								
AS_XRF_pct	1.5	4	4	7	2	4	4	6	3	5	3	7	2	5	5	9	2	4	4	6	2	2	2	3	2	3	3	5	2									3	2	4	2
BA_XRF_pct	500																											1													
CAO_XRF_pct	57367			1				1				2				2																									
CL_XRF_pct	130			4												3				1								1													
CO_XRF_pct	20			1				2								1												3													
CR_XRF_pct	100			2												2												1													
CU_XRF_pct	50			1												2				2				1				1													
FE_CALC_pct	41000	2	2	2		1	1	3				2		2	2	3		3	3	3	2	1	2	2	1	1		3										1		2	
K2O_XRF_pct	50593																																								
MGO_XRF_pct	37540							1				1				1																									
MN_XRF_pct	950			1				3								2				2								3													
MNO_XRF_pct	1226.665			1				1								3				1																1					
NA_XRF_pct	23000																																								
NI_XRF_pct	80																																								
PB_XRF_pct	14			3				2				2				7				3								2				2		1	1	2				1	
SN_XRF_pct	2	3	2	5	1	2	2	4	1	2	2	3	1	2	1	5	1	2	2	4	1	2	1	3	1	3	3	5	1									2	1	3	1
SR_XRF_pct	370																																								
SULP_XRF_pct	260			4				4								4				5		2	2	3				2								1					
TIO2_XRF_pct	9343			1				1				1				1				1								1													
V_XRF_pct	160			1				1				1				1				1								1													
ZR_XRF_pct	190			1				1				1				1				1								2													
PHOS_XRF_pct	1000																																								
SIO2_XRF_pct	592557.138																																								
ZN_XRF_pct	75			2				1								3				3								1													
MN_D	950			2				2								3				2																1					

Element/Oxide_	DG WASTE					DG ORE					DG HYD					FWZ WASTE					FWZ ORE					MCS					MTS					WD					ANG WASTE					ANG ORE				
Analysis_Units	Count	Mean	Median	Maximum	Minimum	Count	Mean	Median	Maximum	Minimum	Count	Mean	Median	Maximum	Minimum	Count	Mean	Median	Maximum	Minimum	Count	Mean	Median	Maximum	Minimum	Count	Mean	Median	Maximum	Minimum	Count	Mean	Median	Maximum	Minimum	Count	Mean	Median	Maximum	Minimum	Count	Mean	Median	Maximum	Minimum	Count	Mean	Median	Maximum	Minimum
AL2O3_XRF_pct	209	4.55	3.15	27.86	0.17	210	2.21	1.725	13.05	0.41	461	4.55	4.4	20.31	0.59	72	3.23	2.195	18.02	0.48	69	3.48	2.89	9.56	0.69	1605	12.77	11.68	39.31	0.13	253	7.67	6.58	33.61	0.37	508	12.40	11.37	46.77	0.14	154	21.94	20.69	40.87	1	6	9.39	9.45	10.28	8.45
AS_XRF_pct	168	0.005	0.003	0.021	0.001	146	0.003	0.002	0.018	0.001	396	0.008	0.007	0.036	0.001	56	0.004	0.003	0.011	0.001	63	0.003	0.003	0.01	0.001	1103	0.011	0.008	0.179	0.001	78	0.014	0.0105	0.048	0.002	426	0.010	0.006	0.111	0.001	146	0.014	0.005	0.227	0.001	6	0.029	0.027	0.038	0.025
BA_XRF_pct	147	0.009	0.004	0.29	0.001	148	0.005	0.004	0.056	0.001	300	0.005	0.001	0.393	0.001	47	0.005	0.004	0.027	0.001	40	0.005	0.004	0.013	0.001	1007	0.014	0.006	0.355	0.001	76	0.012	0.005	0.087	0.001	361	0.012	0.012	0.073	0.001	134	0.016	0.0145	0.051	0.002	0				
CAO_XRF_pct	190	0.05	0.03	0.53	0.01	201	0.05	0.02	1.67	0.01	458	0.11	0.05	7.27	0.01	50	0.02	0.02	0.08	0.01	53	0.02	0.02	0.04	0.01	1595	0.69	0.07	30.78	0.01	235	0.26	0.05	14.52	0.01	498	6.00	0.11	43.73	0.01	133	0.05	0.03	0.58	0.01	1	0.01	0.01	0.01	0.01
CL_XRF_pct	190	0.014	0.009	0.135	0.001	174	0.008	0.006	0.051	0.001	399	0.011	0.01	0.054	0.001	71	0.010	0.008	0.028	0.003	69	0.015	0.011	0.073	0.001	1136	0.018	0.014	0.148	0.002	78	0.018	0.01	0.104	0.001	432	0.014	0.011	0.09	0.001	154	0.016	0.009	0.111	0.003	6	0.011	0.011	0.012	0.01
CO_XRF_pct	131	0.001	0.001	0.004	0.001	146	0.001	0.001	0.009	0.001	358	0.001	0.001	0.006	0.001	41	0.001	0.001	0.004	0.001	56	0.001	0.001	0.002	0.001	865	0.002	0.001	0.03	0.001	51	0.001	0.001	0.003	0.001	239	0.002	0.002	0.007	0.001	55	0.001	0.001	0.003	0.001	2	0.001	0.001	0.001	0.001
CR_XRF_pct	165	0.004	0.002	0.034	0.001	132	0.002	0.001	0.012	0.001	395	0.004	0.003	0.231	0.001	48	0.002	0.0015	0.01	0.001	49	0.003	0.003	0.009	0.001	1136	0.015	0.011	0.324	0.001	78	0.014	0.004	0.141	0.001	372	0.022	0.016	0.378	0.001	152	0.031	0.023	0.349	0.001	6	0.017	0.013	0.045	0.009
CU_XRF_pct	186	0.002	0.001	0.011	0.001	177	0.001	0.001	0.008	0.001	431	0.002	0.001	0.008	0.001	67	0.002	0.001	0.005	0.001	67	0.002	0.002	0.004	0.001	1389	0.004	0.003	0.074	0.001	187	0.004	0.003	0.012	0.001	378	0.005	0.004	0.091	0.001	140	0.005	0.004	0.019	0.001	6	0.002	0.002	0.003	0.002
FE_XRF_pct	120	38.15	38.6	56.6	3.28	138	60.35	61.66	65.99	42.45	348	53.01	54.18	64.54	19.31	49	45.85	46.02	60.23	29.2	37	58.07	58.13	65.7	46.29	647	32.99	35.96	61.82	1.85	48	21.37	16.405	55.91	2.12	7	8.21	2.75	27.79	1.25	0					0				
K2O_XRF_pct	198	0.17	0.01	3.62	0.001	178	0.009	0.005	0.262	0.001	439	0.08	0.05	0.59	0.001	72	0.009	0.007	0.083	0.001	69	0.01	0.01	0.08	0.001	1583	0.87	0.28	8.31	0.002	242	0.38	0.13	3.20	0.01	507	1.20	0.39	6.48	0.007	154	2.11	2.11	6.04	0.02	6	0.03	0.02	0.06	0.01
MGO_XRF_pct	203	0.11	0.07	1.28	0.01	206	0.07	0.05	0.61	0.01	461	0.13	0.11	3.12	0.01	68	0.05	0.04	0.33	0.01	69	0.05	0.05	0.11	0.01	1605	0.74	0.28	20.4	0.01	251	0.31	0.14	8.39	0.01	508	4.13	0.92	20.09	0.03	154	0.60	0.57	1.59	0.03	6	0.07	0.07	0.09	0.05
MN_XRF_pct	182	0.05	0.02	2.84	0.01	168	0.05	0.03	0.6	0.01	388	0.08	0.04	2.89	0.01	60	0.04	0.02	0.15	0.01	58	0.04	0.02	0.26	0.01	1000	0.12	0.03	4.21	0.01	70	0.05	0.02	0.55	0.01	348	0.20	0.06	2.66	0.02	64	0.03	0.02	0.1	0.02	1	0.02	0.02	0.02	0.02
MNO_XRF_pct	16	0.05	0.04	0.24	0.02	36	0.03	0.03	0.12	0.01	50	0.07	0.03	0.57	0.01	0					0					343	0.05	0.03	1.36	0.01	139	0.04	0.03	0.21	0.01	53	0.04	0.04	0.11	0.01	0					0				
NA_XRF_pct	167	0.022	0.02	0.1	0.01	136	0.014	0.01	0.04	0.01	340	0.018	0.01	0.26	0.01	35	0.018	0.01	0.08	0.01	40	0.019	0.02	0.05	0.01	1089	0.038	0.03	0.16	0.01	66	0.025	0.02	0.09	0.01	407	0.042	0.04	0.15	0.01	140	0.035	0.03	0.14	0.01	0				
NI_XRF_pct	164	0.002	0.001	0.014	0.001	138	0.002	0.001	0.012	0.001	353	0.003	0.002	0.017	0.001	41	0.002	0.002	0.006	0.001	50	0.002	0.001	0.006	0.001	1062	0.005	0.004	0.051	0.001	72	0.003	0.002	0.018	0.001	407	0.005	0.005	0.036	0.001	151	0.005	0.005	0.03	0.001	4	0.002	0.0015	0.003	0.001
PB_XRF_pct	170	0.003	0.002	0.014	0.001	146	0.002	0.002	0.011	0.001	331	0.002	0.001	0.027	0.001	55	0.005	0.003	0.015	0.001	32	0.003	0.002	0.011	0.001	1281	0.004	0.003	0.04	0.001	186	0.005	0.004	0.016	0.001	275	0.005	0.004	0.027	0.001	105	0.005	0.003	0.033	0.001	0				
SN_XRF_pct	164	0.002	0.002	0.007	0.001	163	0.002	0.001	0.008	0.001	346	0.001	0.001	0.004	0.001	65	0.003	0.002	0.01	0.001	68	0.002	0.002	0.008	0.001	1019	0.003	0.002	0.013	0.001	76	0.004	0.0035	0.013	0.001	256	0.003	0.003	0.011	0.001	129	0.003	0.003	0.006	0.001	6	0.002	0.002	0.003	0.001
SR_XRF_pct	186	0.003	0.002	0.013	0.001	139	0.002	0.002	0.025	0.001	324	0.002	0.001	0.01	0.001	63	0.003	0.002	0.007	0.001	33	0.002	0.001	0.008	0.001	1110	0.005	0.004	0.049	0.001	76	0.006	0.006	0.014	0.001	372	0.005	0.004	0.018	0.001	129	0.006	0.005	0.049	0.002	3	0.002	0.002	0.003	0.001
SULP_XRF_pct	209	0.031	0.019	0.333	0.002	210	0.029	0.022	0.151	0.006	461	0.037	0.031	0.223	0.005	72	0.050	0.043	0.174	0.009	69	0.033	0.022	0.195	0.01	1605	0.042	0.026	4.44	0.001	253	0.049	0.031	0.83	0.005	508	0.043	0.018	1.35	0.001	154	0.061	0.0205	1.45	0.003	6	0.070	0.061	0.124	0.052
TIO2_XRF_pct	203	0.16	0.1	0.73	0.01	204	0.09	0.05	0.73	0.01	461	0.21	0.19	0.91	0.01	72	0.10	0.07	0.7	0.01	67	0.12	0.1	0.43	0.01	1604	0.57	0.52	3.05	0.02	251	0.35	0.27	2.39	0.01	493	0.58	0.53	2.83	0.01	154	0.94	0.88	2.56	0.03	6	0.64	0.5	1.38	0.4
V_XRF_pct	160	0.004	0.003	0.027	0.001	131	0.002	0.001	0.009	0.001	386	0.004	0.003	0.029	0.001	48	0.003	0.002	0.011	0.001	49	0.003	0.003	0.007	0.001	1128	0.011	0.01	0.058	0.001	77	0.008	0.004	0.033	0.001	394	0.013	0.012	0.103	0.001	152	0.019	0.016	0.076	0.001	6	0.018	0.015	0.039	0.01
ZR_XRF_pct	186	0.005	0.003	0.08	0.001	156	0.003	0.002	0.028	0.001	393	0.005	0.004	0.031	0.001	71	0.004	0.003	0.017	0.001	60	0.005	0.003	0.021	0.001	1128	0.011	0.01	0.038	0.001	76	0.010	0.008	0.037	0.001	388	0.012	0.012	0.035	0.001	150	0.014	0.0135	0.039	0.001	6	0.013	0.0125	0.018	0.009
PHOS_XRF_pct	209	0.075	0.067	0.299	0.011	210	0.113	0.1055	0.228	0.046	461	0.067	0.059	0.193	0.009	72	0.095	0.088	0.197	0.015	69	0.134	0.117	0.259	0.068	1605	0.036	0.03	0.219	0.002	253	0.033	0.029	0.138	0.004	494	0.025	0.02	0.145	0.001	154	0.025	0.02	0.122	0.004	6	0.043	0.043	0.055	0.036
SIO2_XRF_pct	209	34.22	33.81	87.96	2.75	210	4.24	2.47	33.85	0.65	461	9.44	7.32	63.98	1.31	72	27.41	28.91	57.89	3.55	69	4.6	3.6	16.6	1.01	1605	28.18	21.38	89.89	0.97	253	34.70	28.13	93.86	1.72	508	34.56	31.31	92.11	0.22	154	52.78	49.54	91.84	1.78	6	5.27	4.61	9.78	2.84
ZN_XRF_pct	200	0.005	0.003	0.025	0.001	200	0.004	0.003	0.031	0.001	442	0.008	0.006	0.076	0.001	68	0.005	0.004	0.019	0.001	68	0.005	0.0045	0.014	0.001	1496	0.009	0.006	0.113	0.001	250	0.007	0.005	0.189	0.001	431	0.006	0.004	0.035	0.001	145	0.005	0.002	0.093	0.001	6	0.005	0.0055	0.006	0.003
MN_D	19	0.157	0.039	0.775	0.015	36	0.023	0.023	0.093	0.008	57	0.141	0.031	0.775	0.008	0					0					455	0.219	0.031	1.05	0.008	175	0.183	0.031	0.775	0.008	58	0.098	0.031	0.775	0.008	0					0				

Element/Oxide_ Analysis_Units	Crustal Abundance	DG WASTE				DG ORE				DG HYD				FWZ WASTE				FWZ ORE				MCS				MTS				WD				ANG WASTE				ANG ORE			
	mg/kg	Mean	Median	Maximum	Minimum	Mean	Median	Maximum	Minimum	Mean	Median	Maximum	Minimum	Mean	Median	Maximum	Minimum	Mean	Median	Maximum	Minimum	Mean	Median	Maximum	Minimum	Mean	Median	Maximum	Minimum	Mean	Median	Maximum	Minimum	Mean	Median	Maximum	Minimum	Mean	Median	Maximum	Minimum
AL2O3_XRF_pct	309886																																								
AS_XRF_pct	1.5	4	3	6	2	3	3	6	2	5	4	7	2	4	3	5	2	3	3	5	2	5	5	9	2	5	5	7	3	5	4	8	2	5	4	9	2	6	6	7	6
BA_XRF_pct	500			1								2												2																	
CAO_XRF_pct	57367																							1								2									
CL_XRF_pct	130							1				1								1				2				2				2				2					
CO_XRF_pct	20							1				1												3								1									
CR_XRF_pct	100			1								3												4				3				4		1		4				1	
CU_XRF_pct	50																							3								3				1					
FE_CALC_pct	41000	2	2	3		3	3	3	2	3	3	3	1	2	2	3	2	3	3	3	2	2	2	3		1	1	3				2									
K2O_XRF_pct	50593																																								
MGO_XRF_pct	37540																							1								1									
MN_XRF_pct	950			4				2				4												4				1				4									
MNO_XRF_pct	1226.665											1												2																	
NA_XRF_pct	23000																																								
NI_XRF_pct	80																							2								1				1					
PB_XRF_pct	14			2				2				3		1		2				2				4		1		2		1		3		1		3					
SN_XRF_pct	2	2	2	4	1	2	1	4	1	2	1	3	1	3	2	5	1	2	2	4	1	3	2	5	1	3	3	5	1	3	3	5	1	3	3	4	1	2	2	3	1
SR_XRF_pct	370																																								
SULP_XRF_pct	260			3				1				2				2				2				6				4				5				5				1	
TIO2_XRF_pct	9343																							1								1									
V_XRF_pct	160																							1								2				1					
ZR_XRF_pct	190			1																																					
PHOS_XRF_pct	1000																																								
SIO2_XRF_pct	592557.138																																								
ZN_XRF_pct	75			1				1				2												3				4				1				3					
MN_D	950			2								2												2				2				2									

Appendix 4 – Lowest DEC/EPA trigger value analysis

Table 33 - Analysis of West Angelas Deposit A median concentrations compared to the lowest DEC/EPA trigger values

	Ba (mg/kg)	Co (mg/kg)	Cr (mg/kg)	Cu (mg/kg)	Mn (%)	Ni (mg/kg)	P (%)	Pb (mg/kg)	S (%)	V (mg/kg)	Zn (mg/kg)
GAI Trigger	6000	240	1200	600	1.14	960	1.2	168	0.31	1920	900
DEC/EPA Trigger	330	13	26	28	0.022	38	0.2	11	0.06	7.8	46
DET Was	60	20	300	60	0.05	80	0.03	5	0.02	300	60
DET ORE	40	10	90	10	0.03	20	0.05	5	0.02	110	10
CLAY	10	20	270	20	0.01	85	0.03	10	0.03	200	20
DOR	5	5	20	120	0.06	40	0.07	5	0.01	360	50
ANG ORE	5	10	40	10	0.08	20	0.05	5	0.02	20	30
ANG WASTE	10	20	80	30	0.12	40	0.05	5	0.02	90	40
NEW ORE	10	5	20	10	0.04	10	0.06	5	0.01	5	20
NEW WASTE	5	10	30	10	0.02	10	0.05	5	0.01	10	10
MAC ORE	10	5	10	10	0.02	10	0.08	5	0.02	10	30
MAC WASTE	10	10	30	10	0.02	20	0.05	5	0.01	20	30
NAM WASTE	10	20	10	10	0.06		0.02	10	0.08	10	30

Table 34 - Analysis of West Angelas Deposit B median concentrations compared to the lowest DEC/EPA trigger values

	Ba (mg/kg)	Co (mg/kg)	Cr (mg/kg)	Cu (mg/kg)	Mn (%)	Ni (mg/kg)	P (%)	Pb (mg/kg)	S (%)	V (mg/kg)	Zn (mg/kg)
GAI Trigger	6000	240	1200	600	1.14	960	1.2	168	0.31	1920	900
DEC/EPA Trigger	330	13	26	28	0.022	38	0.2	11	0.06	7.8	46
ALLUVIUM	60	25	230	90	0.08	70	0.04	30	0.03	260	190
CLAY	40	30	330	80	0.04	90	0.02	20	0.02	310	70
CALCRETE	130	40	60	40	0.08	70	0.01	10	0.01	30	100
DET WASTE	30	20	190	50	0.05	50	0.03	10	0.03	190	50
DET ORE	20	10	110	20	0.03	20	0.04	10	0.03	100	30
ANG WASTE	30	30	90	40	0.30	70	0.05	10	0.03	100	90
ANG ORE	10	20	30	10	0.14	40	0.06	10	0.02	20	70
ANG HYD	10	10	50	20	0.05	30	0.04	10	0.03	40	50
NEW WASTE	10	10	10	10	0.03	10	0.04	10	0.01	10	30
NEW ORE	10	10	10	10	0.05	20	0.06	10	0.01	10	40
MAC WASTE	10	10	20	10	0.03	20	0.03	20	0.02	20	60
MAC ORE	10	10	30	20	0.02	20	0.05	10	0.04	20	70
NAM WASTE	10	10	10	10	0.02	20	0.03	20	0.02	10	30
NAM ORE	10	20	20	10	0.03	20	0.05	10	0.05	20	80
MM HYD	20	10	30	10	0.03	10	0.05	10	0.03	20	30

Table 35 - Analysis of West Angelas Deposit C median concentrations compared to the lowest DEC/EPA trigger values

	Cu (mg/kg)	Mn (%)	P (%)	Pb (mg/kg)	S (%)	Zn (mg/kg)
GAI Trigger	600	1.14	1.2	168	0.31	900
DEC/EPA Trigger	28	0.022	0.2	11	0.06	46
ALLUVIUM	30	0.04	0.03	30	0.02	40
CLAY			0.03		0.02	
CALCRETE		0.02	0.01	20	0.02	10
DET WASTE	30	0.03	0.03	30	0.02	40
DET ORE	20	0.04	0.03	15	0.03	20
DOLERITE	120	0.14	0.04		0.01	170
ANG WASTE	40	0.19	0.03	30	0.02	60
ANG ORE	20	0.05	0.05	30	0.02	40
NEW WASTE	20	0.02	0.04	30	0.01	30
NEW ORE	20	0.05	0.06	30	0.01	30
MAC WASTE	10	0.02	0.05	10	0.01	70
MAC ORE	20	0.04	0.08	10	0.02	70
MM HYD	20	0.04	0.04	20	0.04	30

Table 36 - Analysis of West Angelas Deposit D median concentrations compared to the lowest DEC/EPA trigger values

	Ba (mg/kg)	Co (mg/kg)	Cr (mg/kg)	Cu (mg/kg)	Mn (%)	Ni (mg/kg)	P (%)	Pb (mg/kg)	S (%)	V (mg/kg)	Zn (mg/kg)
GAI Trigger	6000	240	1200	600	1.14	960	1.2	168	0.31	1920	900
DEC/EPA Trigger	330	13	26	28	0.022	38	0.2	11	0.06	7.8	46
CLAY	80	30	280	80	0.09	100	0.03	10	0.02	270	100
CALCRETE	10	10	40	10	0.05	20	0.01	10	0.02	60	20
DET WASTE	50	10	110	20	0.04	40	0.04	10	0.02	120	40
DET ORE	20	10	70	10	0.03	20	0.04	10	0.02	120	20
DOLERITE	40	10	40	130	0.06	50	0.05	10	0.02	440	40
WD	40	20	60	10	0.45	60	0.04	10	0.01	60	10
ANG WASTE	30	20	70	30	0.38	70	0.06	10	0.02	110	50
ANG ORE	10	10	30	10	0.12	30	0.05	10	0.01	30	30
ANG HYD	10	20	50	10	0.10	30	0.04	10	0.02	70	30
NEW WASTE	10	10	10	10	0.02	20	0.04	10	0.01	10	20
NEW ORE	10	10	10	10	0.06	20	0.06	10	0.01	10	20
NAM WASTE	10	10	10	10	0.02	10	0.03	10	0.01	10	20
NAM ORE	40	10	10	10	0.02	10	0.05	10	0.02	10	20
MM HYD	10	10	20	10	0.03	20	0.05	10	0.02	40	20

Table 37 - Analysis of West Angelas Deposit E median concentrations compared to the lowest DEC/EPA trigger values

	Ba (mg/kg)	Co (mg/kg)	Cr (mg/kg)	Cu (mg/kg)	Mn (%)	Ni (mg/kg)	P (%)	Pb (mg/kg)	S (%)	V (mg/kg)	Zn (mg/kg)
GAI Trigger	6000	240	1200	600	1.14	960	1.2	168	0.31	1920	900
DEC/EPA Trigger	330	13	26	28	0.022	38	0.2	11	0.06	7.8	46
ALLUVIUM	110	20	100	30	0.04	30	0.04	20	0.02	100	40
CLAY	100	20	130	40	0.05	40	0.04	20	0.02	150	60
DET WASTE	60	10	90	20	0.04	20	0.04	20	0.03	80	30
DET ORE	40	20	80	20	0.03	20	0.04	20	0.02	80	20
ANG WASTE	70	30	80	30	0.43	70	0.06	10	0.01	80	70
ANG ORE	30	20	40	10	0.13	20	0.06	10	0.01	20	30
ANG HYD	30	20	70	20	0.05	30	0.04	10	0.02	70	20
NEW ORE	40	20	20	10	0.06	20	0.06	20	0.01	10	20
NEW WASTE	30	20	10	10	0.03	20	0.04	20	0.01	10	20
MAC WASTE	20	10	20	10	0.05	20	0.03	10	0.02	10	40
MAC ORE	30	20	30	20	0.02	20	0.07	20	0.02	20	30
NAM WASTE	10	10	10	10	0.03	10	0.03	10	0.16	10	20
MM HYD	50	20	30	10	0.04	20	0.05	20	0.04	20	20

Table 38 - Analysis of West Angelas Deposit F median concentrations compared to the lowest DEC/EPA trigger values

	Ba (mg/kg)	Co (mg/kg)	Cr (mg/kg)	Cu (mg/kg)	Mn (%)	Ni (mg/kg)	P (%)	Pb (mg/kg)	S (%)	V (mg/kg)	Zn (mg/kg)
GAI Trigger	6000	240	1200	600	1.14	960	1.2	168	0.31	1920	900
DEC/EPA Trigger	330	13	26	28	0.022	38	0.2	11	0.06	7.8	46
ALLUVIUM	130	20	290	100	0.05	70	0.04	30	0.03	350	190
CLAY	80	40	320	130	0.09	90	0.03	30	0.02	360	220
CALCRETE			25	20	0.05	15	0.01	45	0.01	35	20
DET WASTE	110	20	130	40	0.04	30	0.04	40	0.02	130	50
DET ORE	50	20	110	20	0.02	20	0.03	30	0.02	100	20
DOLERITE	80	20	100	100	0.05	40	0.04	110	0.01	340	50
ANG WASTE	80	30	90	30	0.26	60	0.05	40	0.01	90	50
ANG ORE	30	20	40	20	0.09	20	0.05	20	0.01	30	30
ANG HYD	40	20	70	20	0.03	20	0.04	30	0.02	70	20
NEW WASTE	40	20	20	10	0.02	20	0.04	30	0.01	20	20
NEW ORE	30	20	20	20	0.05	20	0.06	20	0.01	20	20
MAC WASTE	40	20	30	20	0.02	20	0.03	30	0.01	30	30
MAC ORE	30	20	30	20	0.02	20	0.07	30	0.02	30	30
NAM WASTE	50	15	20	10	0.02	20	0.03	30	0.01	20	20
MM HYD	40	20	30	20	0.03	20	0.05	30	0.03	30	20

Table 39 - Analysis of West Angelas Deposit A West median concentrations compared to the lowest DEC/EPA trigger values

	Ba (mg/kg)	Co (mg/kg)	Cr (mg/kg)	Cu (mg/kg)	Mn (%)	Ni (mg/kg)	P (%)	Pb (mg/kg)	S (%)	V (mg/kg)	Zn (mg/kg)
GAI Trigger	6000	240	1200	600	1.14	960	1.2	168	0.31	1920	900
DEC/EPA Trigger	330	13	26	28	0.022	38	0.2	11	0.06	7.8	46
ALLUVIUM	140	20	90	25	0.08	40	0.04	20	0.02	80	80
CLAY	80	50	310	130	0.10	110	0.03	10	0.02	340	170
CALCRETE	50	15	60	30	0.06	25	0.01	10	0.02	45	30
DET WASTE	80	20	140	30	0.06	50	0.04	10	0.02	130	60
DET ORE	10	10	90	10	0.03	30	0.04	10	0.02	110	20
DOLERITE	60	20	250	60	0.04	80	0.02	10	0.01	320	70
ANG WASTE	60	30	80	30	0.46	70	0.05	10	0.01	90	60
ANG ORE	20	20	40	10	0.17	40	0.05	10	0.01	40	50
ANG HYD	20	20	50	10	0.21	40	0.05	10	0.01	60	50
NEW WASTE	10	10	10	10	0.03	10	0.04	10	0.00	10	20
NEW ORE	10	10	10	10	0.04	20	0.06	10	0.01	20	20
MAC WASTE	10	10	20	10	0.02	20	0.03	10	0.01	30	30
MAC ORE	10	10	30	10	0.03	20	0.06	10	0.02	20	40
NAM WASTE	10	10	10	10	0.03	30	0.03	10	0.01	10	30
MM HYD	10	10	30	10	0.03	20	0.05	10	0.02	30	20

Table 40 - Analysis of West Angelas Deposit G median concentrations compared to the lowest DEC/EPA trigger values

	Cu (mg/kg)	Mn (%)	P (%)	Pb (mg/kg)	S (%)	Zn (mg/kg)
GAI Trigger	600	1.14	1.2	168	0.31	900
DEC/EPA Trigger	28	0.022	0.2	11	0.06	46
ALLUVIUM	40	0.05	0.03	30	0.02	60
CLAY	70	0.03	0.01	20	0.01	40
CALCRETE	130	0.10	0.02	0	0.02	90
DET WASTE	60	0.03	0.02	20	0.02	40
DET ORE	20	0.02	0.03	30	0.02	20
ANG WASTE	40	0.09	0.03	10	0.01	80
ANG ORE	20	0.04	0.04	20	0.02	40
NEW WASTE	10	0.02	0.04	20	0.01	20
NEW ORE	20	0.05	0.05	20	0.01	35
MAC WASTE	30	0.09	0.05	60	0.01	30
MM HYD	20	0.04	0.05	20	0.02	30

Table 41 - Analysis of Angelo River median concentrations compared to the lowest DEC/EPA trigger values

	Ba (mg/kg)	Co (mg/kg)	Cr (mg/kg)	Cu (mg/kg)	Mn (%)	Ni (mg/kg)	P (%)	Pb (mg/kg)	S (%)	V (mg/kg)	Zn (mg/kg)
GAI Trigger	6000	240	1200	600	1.14	960	1.2	168	0.31	1920	900
DEC/EPA Trigger	330	13	26	28	0.022	38	0.2	11	0.06	7.8	46
ALLUVIUM	180	10	140	30	0.12	30	0.04	20	0.01	160	70
CLAY	130	20	170	60	0.08	60	0.03	20	0.01	210	60
CALCRETE	60	10	30	10	0.05	20	0.01	20	0.01	40	20
DET WASTE	90	10	110	30	0.04	30	0.04	30	0.01	110	30
DET ORE	50	20	70	20	0.03	20	0.03	20	0.02	90	20
DOLERITE	70	30	90	140	0.09	60	0.04	30	0.01	310	60
JOF WASTE	50	10	10	10	0.02	20	0.06	20	0.01	20	10
JOF HYD	30	10	10	10	0.03	20	0.11	10	0.00	10	10
WS WASTE	50	10	30	10	0.02	20	0.08	30	0.01	40	20
DG WASTE	40	10	10	10	0.02	10	0.08	20	0.01	10	20
DG ORE	30	10	10	10	0.02	10	0.14	20	0.01	10	30
DG HYD	80	10	30	10	0.02	10	0.12	20	0.04	30	20
FWZ WASTE	30	10	10	10	0.02	10	0.08	20	0.01	20	30
FWZ ORE	100	10	10	30	0.05	10	0.14	30	0.00	20	50
MCS	50	10	40	20	0.05	20	0.05	20	0.01	60	30
MTS	70	20	40	20	0.21	40	0.08	20	0.01	50	50
WD	50	20	60	20	0.23	40	0.03	10	0.01	80	40
ANG WASTE	70	20	80	30	0.18	50	0.04	20	0.01	100	50
ANG ORE	30	10	40	20	0.11	20	0.06	10	0.01	40	30
ANG HYD	40	20	50	20	0.05	20	0.04	20	0.01	70	30
NEW WASTE	20	10	20	20	0.03	10	0.04	20	0.01	20	20
NEW ORE	30	20	20	20	0.05	10	0.06	20	0.01	20	20
MAC WASTE	50	10	50	20	0.03	20	0.03	20	0.01	60	30
MAC ORE	20	20	35	20	0.03	10	0.05	10	0.02	30	10
MM WASTE	20	10	40	20	0.01	30	0.04	20	0.02	40	20
MM HYD	30	15	40	20	0.04	20	0.04	20	0.03	50	20

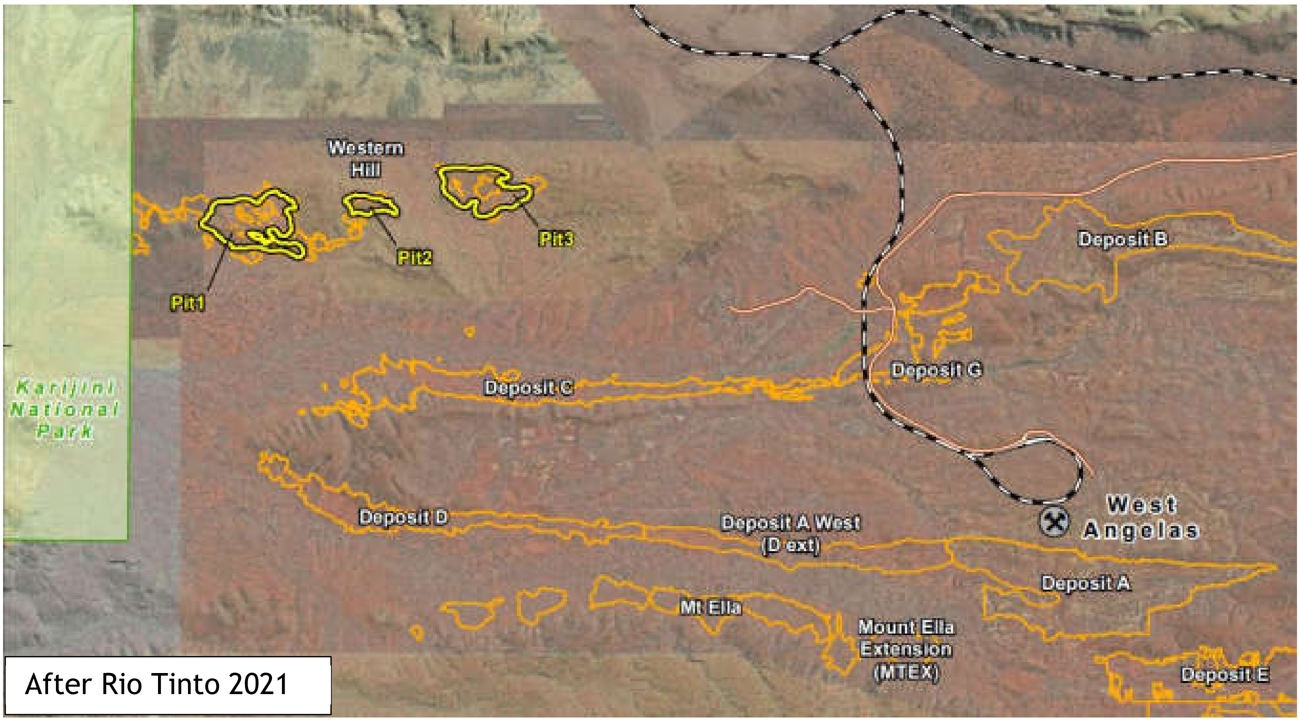
Table 42 - Analysis of West Angelas EL 709, 797, 798 and 986 combined median concentrations compared to the lowest DEC/EPA trigger values

	Ba (mg/kg)	Co (mg/kg)	Cr (mg/kg)	Cu (mg/kg)	Mn (%)	Ni (mg/kg)	P (%)	Pb (mg/kg)	S (%)	V (mg/kg)	Zn (mg/kg)
GAI Trigger	6000	240	1200	600	1.14	960	1.2	168	0.31	1920	900
DEC/EPA Trigger	330	13	26	28	0.022	38	0.2	11	0.06	7.8	46
ALLUVIUM	80	10	90	30	0.05	30	0.04	30	0.02	120	60
CLAY	90	20	30	20	0.05	20	0.02	20	0.01	150	30
CALCRETE	40	10	30	20	0.02	20	0.01	30	0.02	80	30
DET WASTE	60	10	60	20	0.03	30	0.04	40	0.03	70	50
DET ORE	20	10	50	20	0.02	20	0.04	30	0.02	50	20
DOLERITE	40	15	30	35	0.13	10	0.07	25	0.21	90	75
WW	300	30	40	20	0.04	20	0.04	30	0.01	100	70
UNDF BRK				20			0.01	20	0.02		20
YS				30			0.03	70	0.03		20
WS WASTE	120	10	10	10	0.03	10	0.01	30	0.01	20	10
WS HYD	50	10	30	10	0.07	10	0.05	20	0.02	60	30
DG WASTE	40	10	20	10	0.02	10	0.07	20	0.02	30	30
DG ORE	40	10	10	10	0.03	10	0.11	20	0.02	10	30
DG HYD	10	10	30	10	0.04	20	0.06	10	0.03	30	60
FWZ WASTE	40	10	15	10	0.02	20	0.09	30	0.04	20	40
FWZ ORE	40	10	30	20	0.02	10	0.12	20	0.02	30	45
MCS	60	10	110	30	0.03	40	0.03	30	0.03	100	60
MTS	50	10	40	30	0.02	20	0.03	40	0.03	40	50
WD	120	20	160	40	0.06	50	0.02	40	0.02	120	40
ANG WASTE	145	10	230	40	0.02	50	0.02	30	0.02	160	20
ANG ORE		10	130	20	0.02	15	0.04		0.06	150	55

C.10: West Angelas Western Hill Project Groundwater Assessment Peer Review

West Angelas Western Hill Project Groundwater Assessment Peer Review

Prepared for:	Rio Tinto Iron Ore	15 September 2022



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CONTENTS

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Author	Hugh Middlemis; hugh@hydrogeologic.com.au	
Version 1	14 September 2022	Initial draft
Version 2	15 September 2022	Final draft after clarifying discussion with RTIO modelling team

THIS REPORT SHOULD BE CITED/ATTRIBUTED AS:

Middlemis H (2022). West Angelas Western Hill Project Groundwater Assessment Peer Review. Prepared by HydroGeoLogic for Rio Tinto Iron Ore. 15 September 2022.

1. INTRODUCTION

1.1 West Angelas Western Hill Project Overview

Rio Tinto Iron Ore (RTIO) propose to develop the Western Hill project, located about 17 km north-west of the West Angelas mining operations in the Pilbara region of Western Australia (RTIO 2021).

Conventional open cut mining is planned (2024-2036) for the Brockman Iron Formation (BIF) deposit (Mineralised Dales Gorge Member). Most other deposits at West Angelas (A to G) are Marra Mamba deposits.

The Western Hill deposit consists of three discrete orebodies along a roughly 8 km east-west trending synclinal structure, with minor mineralisation present in overlying (unsaturated) detritals (Figure 1).

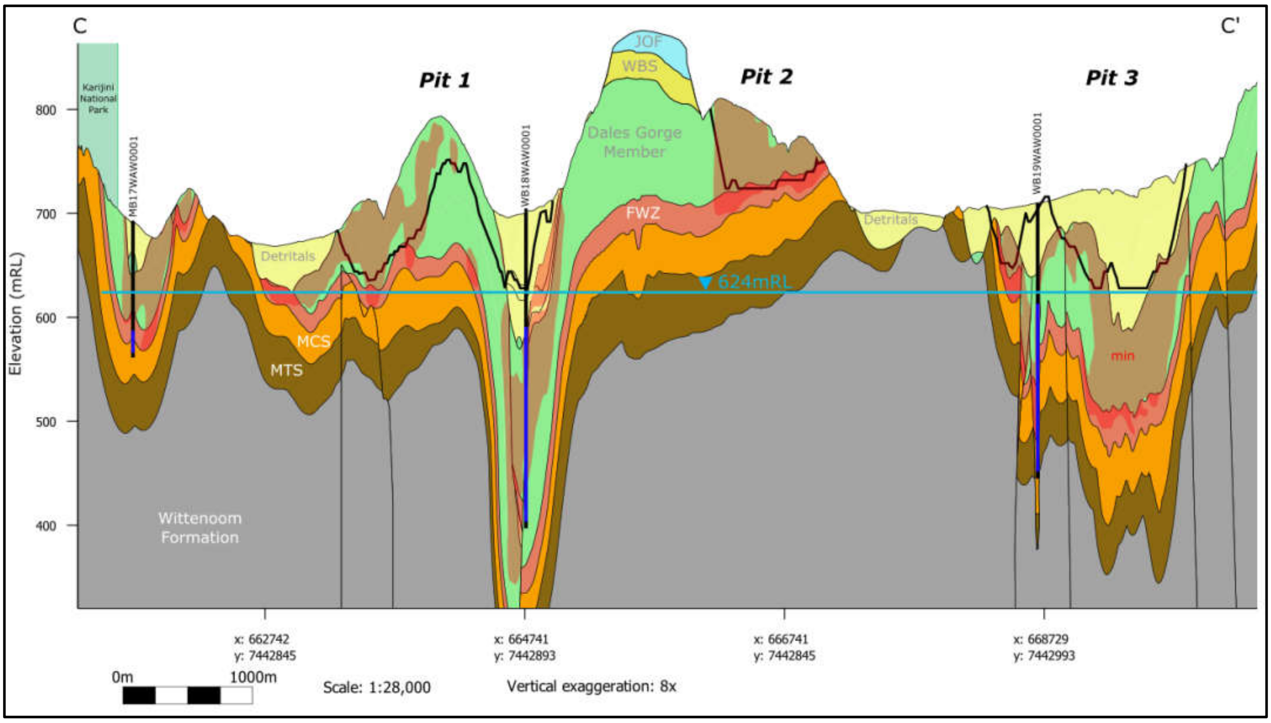

Figure 1 – Western Hill project geological and groundwater schematic (after RTIO 2021)

Although mineralisation below water table (BWT) does exist at two of these pits, no mine dewatering is proposed at Western Hill due to the potential for impact to the nearby, high conservation significance, Karijini National Park (KNP), located about 1.5 km to the west of the western-most Pit 1 (see report cover for locations).

Groundwater abstraction at 1 ML/d (0.36 GL/a) is proposed for water supply to support construction and operational demands from 2024 to 2036, with the caveat of imposing no drawdown at the KNP boundary (RTIO 2021).

1.2 Peer Review Methodology

This report documents the findings of an independent peer review of the groundwater and modelling investigations that form the quantitative basis for the Western Hill Project groundwater assessment (RTIO 2021). The desktop peer review was conducted in September 2022 by Hugh Middlemis (Principal Groundwater Engineer, HydroGeoLogic), an independent consultant specialising in groundwater modelling:

- Hugh holds a degree in civil engineering and a masters in hydrology and hydrogeology, with more than 40 years' experience. Hugh was principal author of the first Australian groundwater modelling guidelines (Middlemis et al. 2001) that formed the basis for the latest guidelines (Barnett et al. 2012). He is co-author of recent guidance reports on modelling uncertainty (Middlemis and Peeters 2018 (2022 update in prep.); Middlemis et al. 2019).
- Hugh has experience in the Pilbara region, notably on investigations conducted by Aquaterra at Hope Downs, Mining Area C and Marillana Creek (for BHP, 1995-2002), at West Angelas (for Robe River, 1998), and on the Central Pilbara Groundwater Study (for WRC; Aquaterra 2000).
- More recently, Hugh has completed independent peer reviews for Rio Tinto at Yandi (2015-16), Silvergrass (2018), and at Koodaideri (2020).

Declaration: We assert no conflict of interest in relation to this work. Mr Middlemis has not worked on the Western Hill project nor for Rio Tinto, other than in a review role, since founding HydroGeoLogic as an independent consultancy in 2013.

The best practice principles and procedures of the Australian Groundwater Modelling Guideline (Barnett et al. 2012) were applied to this review, as there are no standard procedures for peer reviews of groundwater investigations and impact assessments as such. Consideration was also given to recent guidance on uncertainty analysis (Middlemis and Peeters, 2018; update in prep. 2022), including GMDSI resources (www.GMDSI.org).

The main evidentiary basis for this desktop review was the West Angelas Western Hill Hydrogeological Impact Assessment (RTIO 2021). Reports on previous investigations in the area were also considered (see References list). The review considered the hydrogeological conceptual model (HCM), its implementation in the computational groundwater model and its fitness for the purpose of groundwater impact assessment via simulations of the effects of groundwater abstraction for water supply. Conformance with best practice guidelines was assessed in relation to: HCM and model design, grid and boundaries; layering and parameterisation; model calibration performance and non-uniqueness; and predictive uncertainty scenarios and results.

This peer review report provides advice on whether the groundwater assessments made, or conclusions reached, are supported by the evidence presented, and/or whether additional information, monitoring, assessment and/or modelling may be required to inform the assessment. The review outcomes are summarised in section 2, including the modelling guideline compliance summary checklist (Table 1), while some elements are discussed in more detail in section 3.

2. WESTERN HILL PEER REVIEW OUTCOME SUMMARY

Table 1 - Groundwater Model Compliance: 10-point essential summary: Western Hill

Question	Y/N	Comments re Western Hill groundwater model (RTIO 2021)
1. Are the model objectives and model confidence level classification clearly stated?	Yes	Objectives clearly stated for groundwater assessment and modelling of the effects of abstraction for water supply. Model confidence level target not reported, but this review assesses that Class 1/2 is achieved. The quantitative uncertainty analysis conducted surpasses the need for a qualitative confidence level characterisation, now regarded as outmoded (see section 3.1).
2. Are the objectives satisfied?	Yes	Modelling design and execution consistent with best practice, notably including quantitative uncertainty analysis.
3. Is the hydrogeological conceptual model (HCM) consistent with objectives and confidence level?	Yes	HCM consistent with data and objectives, suitable for mining project impact assessment, and documented very well. HCM integrates data on geology, hydrogeology and hydrochemistry. Includes regional dyke, other conservative assumptions (eg. high permeability mineralised BIF is extensive) and does not constrain drawdown effects on KNP (eg. allows for fault offset hydraulic connections between BIF orebody and Wittenoom aquifers). HCM adopts a storage depletion context, whereby abstraction drawdown effects are assessed on a flat water table; consistent with groundwater level data (0.5-1m variability 2018-2020). The quantitative uncertainty analysis conducted surpasses the outmoded qualitative confidence level.
4. Is the conceptual model based on all available data, presented clearly and reviewed by an appropriate reviewer?	Yes	Extensive knowledge base from investigations 2016-2020, plus regional knowledge across West Angelas operations over many years. Site-specific Western Hill drilling and testing data, including 2x10-day pumping tests @ 40-50L/s, analysed in detail and well-summarised (RTIO 2021, Tables 3-6, Figures 5-12). Expert reviews in-house, plus this external peer review.
5. Does the model design conform to best practice?	Yes	The model software (AnAqSim), extent (about 20x10 km), boundaries and parameters, and overall design and uncertainty methodology are consistent with best practice design/execution.
6. Is the model calibration satisfactory?	Yes	Model not calibrated in the traditional sense, but the 1000 realisations all achieved an initial flat groundwater level of about 624 mAHD, consistent with the boundary conditions applied and the monitoring data available. This is satisfactory as the basis for the uncertainty analysis.
7. Are the calibrated parameter values and estimated fluxes plausible?	Yes	Model parameter values/fluxes are consistent with drilling and testing data, and benchmarked to West Angelas operational data.
8. Do the model predictions conform to best practice?	Yes	5-year simulations of 1 ML/d water supply abstraction over 1000 realisations show 5% probability of groundwater level at KNP falling below 623.6 mAHD, with a minimum of 623.51 mAHD. These effects are associated with parameter values for the regional Wittenoom aquifer (low specific yield Sy<2%; and high permeability K ~2-8 m/d). The 0.5m drawdown extents for 50% and 80% probability cases largely constrained to orebody areas.
9. Is the uncertainty associated with the simulations/predictions reported?	Yes	Uncertainty analysis via 1000 realisations of parameters with justified distributions (log-normal Kh and normal Sy) and value ranges applied to the three aquifer domains (BIF, Mount McCrae Shale and Wittenoom aquifers; RTIO 2021, Table 7 and Figure 15).
10. Is the model fit for purpose?	Yes	My professional opinion is that the Western Hill groundwater modelling assessment has been conducted consistent with best practice, including quantitative uncertainty analysis.

3. DISCUSSION

The groundwater assessment report (RTIO 2021) is well-written and provides high quality graphics and explanations of the hydrogeological setting, the conceptual model, the computational model design and execution, the pumping stresses and simulations, the uncertainty analyses and the predicted impacts.

3.1 'Model Confidence Level' and Quantitative Uncertainty

The 'model confidence level classification' set out in the Australian Groundwater Modelling Guidelines ('AGMG'; Barnett et al. 2012) is an outmoded qualitative characterisation that is currently being revised. The classification considers the level of data available, responses to hydrological stresses, the conceptualisation and calibration process and performance, and the manner in which the predictions are formulated. The AGMG is currently being revised and we understand that this qualitative assessment is being discontinued.

In any case, it is a common misconception that the model confidence level assessment is mandatory for every model. The AGMG actually recommends the confidence level method for application to situations when a formal uncertainty analysis has not been conducted. In this case, an uncertainty analysis has been conducted, so the AGMG confidence level class is not strictly applicable.

That said, the uncertainty guidance provided in the 2012 AGMG was updated and augmented in the recent uncertainty analysis guidance report (Middlemis and Peeters, 2018). This included the important principle that "a model should be able to quantify its own reliability [via a well-executed uncertainty analysis], rather than relying on the AGMG confidence level scheme, which is prone to misinterpretation". This was warranted in the sense of concerns that the AGMG were being used inappropriately in some cases to justify 'indiscriminate complexification' of models, rather than the 'effective simplification' that is warranted for application to uncertainty analysis, and has been applied in this case at Western Hill.

Similarly, the Groundwater Modelling Decision Support Initiative (GMDSI.org) is curating the latest uncertainty analysis methods. This includes the key principles of designing models with an optimum balance of complexity and simplicity, and using uncertainty analysis to objectively quantify the likelihood of an unwanted outcome (eg. drawdown impacts) rather than adopting qualitative confidence frameworks.

The 2018 uncertainty guidance frames uncertainty analysis as an integral part of risk management, in that it informs and complements other aspects such as risk assessment, investigating mitigations/treatments, developing management and monitoring plans, communicating outcomes and prioritising efforts to reduce uncertainty. It requires a balance to be struck between model simplicity and complexity for the purpose of uncertainty evaluation, commensurate with the risk/consequence profile of the project.

These principles have been applied to the Western Hill model, and to the monitoring and management plans that are informed by the modelling outcomes.

The 2012 AGMG and the 2018 uncertainty guidance are both in the process of being updated. This peer reviewer is advised that the AGMG revision will involve the rejection of the 'model confidence level' framework and its formal replacement with uncertainty analysis methodologies. The quantitative uncertainty analysis conducted for the Western Hill modelling is consistent with existing/recent guidance and should be consistent with the new guides (expected in late 2022).

For the record, while the Western Hill groundwater assessment report does not discuss the model confidence level classification, this review has considered the issues and concludes that the model conforms to 'Class 1/2'.

3.2 Model Design, Parameterisation and Uncertainty Analysis

A parsimonious approach has been applied to the Western Hill model design and parameterisation, in terms of the analytical element model software and the spatially uniform aquifer property zones representing the three aquifer domains (BIF, Mount McCrae Shale and Wittenoom aquifers; see RTIO 2021, Table 7 and Figure 15).

The analytical element model software (AnAqSim) is a well-tested, documented and respected package that is suitable for application to this investigation. It is sometimes described as a sound alternative to the more well-known but potentially more complex Modflow numerically modelling package.

The application of spatially uniform parameter zones to represent the three aquifer domains is consistent with best practice modelling principles (Barnett et al. 2012; Guiding Principle 3.1 and related commentary):

- 'The level of detail within the conceptual model should be chosen, based on the modelling objectives, the availability of quality data, knowledge of the groundwater system of interest, and its complexity.'
- 'In regional problems where the focus is on predicting flow, predictions depend on large scale spatial averages of hydraulic conductivity rather than on local variability. Moreover, in large regions there may be insufficient data to resolve or support a more variable representation of hydraulic conductivity. A parsimonious approach may be reasonable, using constant properties over large zones, or throughout a hydrostratigraphic unit.'
- 'Model predictions that integrate larger areas are often less uncertain because characterisation methods are well-suited to discern bulk properties, and field observations directly reflect bulk system properties.'

Furthermore, the Western Hill modelling has applied a wide range of aquifer parameter values and probability distributions (log-normal Kh and normal Sy) to the 1000 Monte Carlo realisations. This is all well justified and consistent with best practice uncertainty analysis, including Middlemis and Peeters (2018), and methodologies promulgated by the Groundwater Modelling Decision Support Initiative (GMDSI.org).

4. CONCLUSIONS

This review finds that the Western Hill groundwater modelling has been conducted competently and is consistent with best practice methods, including uncertainty analysis. The uncertainty analysis results provide a sound estimate of the range of groundwater-related impacts due to water supply abstractions.

Ongoing monitoring and other investigations will provide additional data for future model refinements, improvements in performance and further uncertainty analysis. Such progressive updates would help support future monitoring and management.

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