OLAROZ RESOURCE UPDATE APRIL 2022

REPORT NO. 202011

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OLAROZ LITHIUM FACILITY STAGE 2 TECHNICAL STUDY

Jujuy Province, Argentina

HYDROMINEX GEOSCIENCE

REPORT FOR ALLKEM

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VERSION 4

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1 SUMMARY

Introduction and Ownership

Allkem is operator and majority owner of the Olaroz Project (the **Olaroz Project** or the **Project**), a lithium chemicals production joint venture in Jujuy province, in Northern Argentina. Allkem holds 66.5% of the Olaroz Project joint venture company, Sales de Jujuy S.A. (**SdJ**), with the remaining project ownership held by Toyota Tsusho (**TTC** - 25%) and the Jujuy provincial government mining investment company (**JEMSE** - 8.5%). As part of the joint venture TTC is the exclusive sales agent for product from the Olaroz Project, with Allkem and TTC exercising shared decision making over marketing, product allocation and sales terms.

The joint venture holds mining properties that cover the majority of the Salar de Olaroz salt lake. Allkem commenced exploration on the Olaroz Project in 2008 and has been extracting lithium since 2013 and producing lithium carbonate since 2015 from the Stage 1 operations of the Olaroz Project.

In addition to its stake in SdJ, Allkem also owns 100% of other properties immediately north and south of the joint venture. Properties in the far north of the salt lake and over gravel sediments of the Rosario River delta and surrounding alluvial material are interpreted to overlie a deeper extension of the salt lake.

Additionally, Allkem's 100% subsidiary, Advantage Lithium SA, owns the Cauchari Project immediately south of the Olaroz Lithium Facility Stage 1 operations in the Salar de Cauchari, which has 4.8 Mt of Measured and Indicated resources and 1.5 Mt of Inferred resources (Cauchari Olaroz Project). These resources are not discussed in this report but are open both at depth and to the south of this defined resource. Further information is available on the Allkem website or at Advantage NI43-101. None of the 100% owned Allkem properties are in production, with further exploration drilling and test work required to confirm the scale of lithium potential of these properties.

Report Context

This technical report provides details of the exploration activities that have been carried out since the Olaroz Project's inception, resulting in completion of a Technical Report dated 13 May 2011 and that was issued prior to commencement of construction of Stage 1 of the Olaroz Project (**2011 Technical Report**). Stage 1 consisted of brine evaporation ponds and a carbonate processing plant designed to produce 17,500 tonnes per annum, of Lithium Carbonate. Construction of Stage 1 was completed in 2015.

The primary objective of this Technical Report is to document a substantial update to the Olaroz Project resource, following significantly deeper drilling to 650 m depth, that has been conducted by SDJ to support the Stage 2 expansion of the Olaroz Project.

In addition, this Technical Report provides a summary of the 25,000 tpa Stage 2 development of the Olaroz Project, including an economic assessment of Stage 2 which is currently under construction and scheduled to commence production in H2 2023.

This report has been prepared in conformance with the requirements of National Instrument 43-101 Standards of Disclosure for Mineral Projects and the associated

Companion Policy 43-101CP and Form 43-101F1 of the Canadian Securities Administrators. In preparing this report the associated Best Practice Guidelines for Industrial Minerals and Mineral Processing and the Best Practice Guidelines for Resource and Reserve Estimation for Lithium Brines, as issued by the Canadian Institute of Mining and Metallurgy, were taken into account, along with discussion by Houston et. al., (2011).

The resource update is an interim resource that will be further updated when ongoing drilling for Stage 2 has been completed.

The report has been prepared by Murray Brooker and Mike Gunn, who are Qualified Persons under the requirements of NI43-101 and who are independent of the Allkem group of companies.

Olaroz Project Setting

The Salar de Olaroz is located in the high-altitude Puna region of northwest Argentina, where extensive lithium brine resources are present beneath salt lakes. The Olaroz Project was only the second lithium brine project to be developed in Argentina and the first in 20 years, as part of the recent wave of lithium exploration related to the electrification of transportation and energy storage.

The Olaroz Project is located in the province of Jujuy at 3900 m altitude, adjacent to the paved international highway (RN52) that links the Jujuy Provincial capital, San Salvador de Jujuy with ports in the Antofagasta region of Chile that are used to export the lithium carbonate product and to import key chemicals used in the production of lithium carbonate (such as soda ash). The Olaroz Project is also located close to an existing gas pipeline, from which a spur line was constructed to supply the Olaroz Project, providing a well-priced energy source. The Olaroz Project is approximately 5 hours by light vehicle from San Salvador de Jujuy.

Properties and Infrastructure

The joint venture tenements cover 53,919 ha and consist of 32 minas and five cateos.

In addition to properties held through SdJ. Allkem owns an additional 9,475 ha in 5 properties in the north of the Olaroz salar through the 100% owned company Olaroz Lithium S.A. A further 28,584 hectares in 22 minas are held in the Allkem Cauchari Olaroz Project, immediately south of Olaroz.

Allkem, as operator, developed Stage 1 of the Olaroz Project from 2012 to 2014, with the installation of production wells, water and gas supplies, power generation, 4.5 square km of evaporation ponds and a processing plant with 17,500 tpa lithium carbonate capacity. Stage 2 commenced construction in 2019 and is scheduled to commence production in H2 2023. Stage 2 comprises an additional 9 square km of evaporation ponds and an additional standalone processing facility for producing 25,000 tpa of lithium carbonate.

Olaroz Basin and Drilling

The initial exploration conducted at Olaroz indicated the Olaroz Project contained a very significant brine volume that would support multiple stages of development. The Stage 1 development of 17,500 tpa lithium carbonate was based on drilling conducted to a depth of 200 m, supported by interpretation of the Olaroz basin by gravity and electrical geophysics. The geophysical data indicated the salt lake occupies a deep basin, which has now been confirmed by drilling to have a depth greater than 1400 metres, at least locally.

Drilling to support Stage 2 of the Olaroz Project has been to depths between 450 and 650 metres, depending on the location within the basin. This deeper drilling has provided further information around sedimentation during basin filling and confirmed that deposition of coarser grained higher porosity and permeability sediments has been principally from the western side of the basin.

Given the greater depth of exploration and improved geological understanding the geological interpretation has been simplified to five major hydrogeological units (UH1 to UH5), consisting of the upper halite sequence of the salt lake (UH1), underlying sand silt and clay units (UH3), a halite dominated sequence (UH4), a lower sequence with more sandy units (UH5) and a more surficial unit of alluvial sediments that surround the salt lake (UH2). Drilling has not yet intersected the basement rocks beneath the Salt Lake, despite drilling a 1400 m deep exploration hole in one of the deeper locations in the basin.

Drilling undertaken to support the Stage 2 Project and resource upgrade has consisted of installation of production wells and limited HQ diamond exploration holes. Limited accommodation at the Olaroz Project site due to restrictions related to Covid-19 has resulted in drilling of only three of the planned 650 m deep HQ diamond holes as monitoring wells to date. Eleven new production wells have been installed, with ten commissioned. Production wells have been installed on a 1 km grid, as for the original wellfields.

Porosity Sampling

Porosity samples from diamond holes were sent to the Geosystems Analysis laboratory in Tucson, Arizona, USA for porosity testing using the Rapid Brine Release (RBR) test method to measure specific yield (drainable porosity). Check porosity samples were analysed in the DB Stephens and Associates laboratory in Albuquerque, New Mexico USA.

One of the diamond holes and the majority of the Stage 2 production wells were profiled with geophysical logging tools, including a Borehole Magnetic Resonance (BMR) tool, that provided in-situ measurements of porosity and permeability. The geophysical logging confirms the correlation of individual sub-units across the salt lake. An analysis of the BMR data, together with laboratory porosity data from recent and historical cores at Olaroz and core samples collected by Allkem in the Cauchari Project to the south, in the southern extension of the Olaroz basin, provided the basis for assignment of porosity values for the resource estimate.

Laboratory drainable porosity (Sy) values vary between 9%+/-8% for sandy units, 6%+/-5% for silt mixes, 4%+/-2% for halite and 2%+/-2% for clay dominated material, as determined by laboratory samples. The overall drainable porosity of sediments to 650 m is lower than in the 2011 resource, due to the presence of the halite dominated unit (UH4) and lesser sand units below the upper 200 m, with the exception of the deeper sand unit.

Brine Sampling

Drilling has confirmed the previously defined lateral zoning in brine concentrations broadly continues at depth, and it is likely that brine will continue to the base of the basin. The new production wells are producing at concentrations from 598 mg/L (E09) to 780 mg/L Li (E12) and flow rates from over 10 l/s to over 50 l/s (E09 and E17), providing samples representative of the aquifers intersected by these wells. Brine samples are available from the weekly analysis of samples from the original (PP series) and expansion (E series) production wells and from check samples in external laboratories.

Brine samples from historical exploration drilling were analysed in a number of commercial laboratories, principally the Alex Stuart laboratory in Mendoza, Argentina. Since construction of the Olaroz Project brine samples have been analysed in the Olaroz site laboratory, with check samples sent to the Alex Stuart laboratory in Jujuy, Argentina.

The resource was estimated using the historical sonic and diamond drilling, recent diamond drilling and results from production wells, to maximise use of the available information. SDJ has operated production wells installed and operating to depths of between 300 and 450 m for up to 5 years, and these provide important production history and continuity of brine concentration over this period to support the updated resource estimation to 650 m.

Updated Resource Estimate

This 2022 Interim Resource update has resulted in a substantial expansion in the resource base at Olaroz from 6.4 million tonnes (Mt) lithium carbonate equivalent (LCE) in the 2011 resource to a new total of 16.2 Mt LCE. The updated resource includes 5.1 Mt of Measured resources to 200 m depth and 4.6 Mt of Indicated resources to depths of 450 m in the south and central of Olaroz and 350 m in the north, where there is less and shallower drilling information. The remainder of the resource below depths of 450 or 350 m (base of the Indicated resources) to the base of the unit UH5, defined in the geological model from gravity geophysics, is classified as Inferred resources until further drilling is completed to define the base of the basin.

The lithium grade of the Measured resource (0-200 m) across the Olaroz salar is 648 mg/L (646 mg/L in the SdJ properties, 673 mg/L in the Olaroz Lithium properties). The underlying Indicated resource (200-350 or 450 m, depending on location) is 657 mg/L (between 560 and 830 mg/L, depending on the area). The Inferred resource underlies the M&I resources across the salt lake, with a grade of 663 mg/L (between 642 and 732 mg/L, depending on the area).

The 2022 Interim Resource is estimated to the base of the basin, as defined by the gravity geophysics. No holes drilled to date have intersected the basement rocks. The deeper part of the basin and extensions of the brine beneath adjacent areas of gravel allow for potential further expansion of production capacity in a third stage of the Olaroz Project beyond 42,500 tonnes per annum. However, it is anticipated this third stage would utilise brine that has not yet been quantified in the north of the Olaroz salar.

The 2022 Interim Resource is restricted to solely beneath the Olaroz salar surface. Exploration carried out by Allkem and Advantage Lithium demonstrated brine at potential economic concentrations continues over extensive areas south of Olaroz, underneath the Archibarca alluvial fan, towards Allkem's Cauchari Resource and north beneath the Rosaria delta and surrounding alluvium.

Sediments beneath the salar comprise aquifers with different porosities and permeabilities. The surface outline of the salar is used to delimit the area of the resource estimate, which is similar to the area of the 2011 Resource. However, this 2022 Interim Upgraded Resource covers properties acquired by Olaroz Lithium since the 2011 resource and includes some small properties east of and outside the main body of the properties, covering a combined total of 113 km^2 for this resource estimate. The brine saturated sediments are known to extend beneath alluvial sediments surrounding the salar but to date insufficient drilling has been carried out in these areas to support resource estimation there.

The resource estimate is limited laterally by the property boundaries with other minority property owners (Lithium Americas Corp and other owners) in the salar to the east and north of the properties owned by Allkem and SDJ.

Inputs and Estimation Methodology

The distribution of lithium and other elements was estimated from point sampling data from the upper 200 m of the model where samples are typically spaced every 6 m in the 200 m holes and 3 m or less in the 54 m holes. Below the upper 200 m the resource was estimated based on the pumped samples from the production wells, with a single average value per hole representing the average pumped value.

The block model was constructed with 500 by 500 by 20 m blocks with blocks only reported inside of the resource area for the portion of the block within the salar outline. The resource estimate was undertaken using Datamine software with variograms developed for the point samples from the upper 200 m. Estimation was undertaken using ordinary kriging. The ordinary kriging method is the most commonly used kriging method.

The resource was estimated using 4 passes with the search strategy. The results of the first two passes are nominally equated to blocks classified as Measured and Indicated, with the latter two passes equating to blocks classified as Inferred. The Measured and Indicated resources extend to the salar outline and the depths are controlled by the density of drilling and sampling and the history of production. Inferred resources are defined below 450 m (or 350 m in the north of the salar), where drilling below these depths is limited. Additional drilling in the ongoing program is expected to significantly increase the classification of Measured and Indicated resources.

Classification	Area km^2	Thickness m	Sediments Million m^3	Mean Specific Yield Porosity %	Brine Million m^3	Li mg/L	Tonnes Li	Tonnes LCE
Allkem SdJ JV								
Measured 0-200 m	103.2	200	20,452	6.5%	1,338	646	864,000	4,600,000
Indicated 200-450 m	79.8	250	19,117	5.7%	1,095	667	730,000	3,890,000
Indicated 200-350 m	23.4	150	3,273	4.8%	157	560	88,000	470,000
M&I	103.2	350/450	42,842	6.0%	2,590	650	**1,682,000**	**8,960,000**
Inferred total > 350/450 m	103.2	Variable	29,656	5.3%	1,570	654	**1,030,000**	**5,470,000**
Olaroz Lithium (Allkem 100%)								
Measured 0-200 m	9.6	200	1,913	7.7%	148	673	100,000	530,000
Indicated 200-450 m	6.7	250	723	4.2%	30	830	25,000	130,000
Indicated 200-350 m	2.9	150	925	4.1%	38	631	24,000	130,000
M&I	9.6	350/450	3,562	6.1%	216	687	**149,000**	**790,000**
Inferred total > 350/450 m	9.6	Variable	6,267	4.0%	249	718	**180,000**	**950,000**
M&I TOTAL	112.8						1,831,000	**9,750,000**
Inferred TOTAL	112.8						1,210,000	**6,420,000**
GRAND TOTAL	112.8						3,041,000	**16,170,000**

- CIM definitions were followed for mineral resources.
- The Competent Person for this Mineral Resource estimate is Murray Brooker, MAIG, MIAH.
- No internal cut-off concentrations have been applied to the resource estimate.
- Numbers may not add due to rounding
- Lithium is converted to lithium carbonate (Li_2CO_3) with a conversion factor of 5.32.

This 2022 Interim Resource supersedes the 2011 Resource completed as part of the Olaroz Feasibility study resource. This 2022 Interim Resource does not discount production to date from within the resource.

Further exploration potential

The resource is open laterally and at depth below the base of unit UH5 defined in the geological model. Laterally, the resource area is limited to within the salar border. Drilling suggests the basin is deeper than interpreted, based on the gravity survey. Previous limited drilling and extensive geophysical surveys indicate the brine body is likely to extend both north and south of the salar. This is beneath the Archibarca fan to Cauchari, where drilling by the now 100% owned Advantage Lithium defined a resource in 2019, and north under the Rio Rosario delta. These areas are to be further evaluated to support a third stage of the Olaroz Project.

One deep exploration hole has been drilled to 1,408 m slightly north of the current northern production wellfield, and has not intersected the basement bedrock. The gravity survey supports a large area of similar depth in this part of the basin. To date no drilling in the Olaroz basin has intersected basement bedrock.

Capital Cost Summary for the Stage 2 Expansion

The total capital cost estimate is US$376 million, consisting of US$347 million in direct capital costs and US$29 million in indirect capital costs. This represents an increase over the US$330 million estimated in late 2019. As previously announced, this is attributable to additions to the project scope (camp, roads and water supply increases) and the lengthy delays incurred due to Covid-19. The table below shows the breakdown of the capital cost.

Direct Capex		
Wells	US$m	27
Brine Handling	US$m	26
Ponds	US$m	111
Liming Plant	US$m	22
LCP & SAS	US$m	122
BOP	US$m	21
Camps	US$m	18
Total Direct	US$m	**347**
Indirect Capex		
Indirect costs	US$m	11
Contingency	US$m	18
Total Indirect	US$m	**29**
Total Capital Cost Direct + Indirect	US$m	**376**
Capital Intensity	US$/tpa Cap	15,032

Funding

Funding for Stage 2 comprises a US$180 million project finance facility with the balance provided by shareholder loans (75% AKE, 25% Toyota Tsusho Corporation).

Operating Costs for Stage 2

Site operating cash costs for the LOM are estimated at US$3,206/t. This cost represents an improvement on pre-covid estimates due to more favourable consumable unit rates.

The operating cost estimate for the Stage 2 expansion was prepared by Worley in collaboration with Allkem. The cost estimate excludes indirect costs such as distributed corporate head office costs for corporate management and administration, marketing and sales, exploration, general project and technical developments; and other centralised corporate services.

The Table below provides a summary of the estimated LOM annual unitary cost by category. No inflation or escalation provisions were included. Subject to the exceptions and exclusions noted below, the aggregate annual FOB cash operating costs for the Stage 2 Project are estimated to be approximately US$80 million per year for a nominal year of operation.

Reagents represent the largest operating cost category (44.5%), then labour (19.3%) followed by operating consumables (7.7%) and maintenance (7.6%).

Lithium Market Outlook

Wood Mackenzie lithium industry consultants expect there to be an increasingly tight market for lithium products over the next two years, with a gradual growth in supply in response to growing demand. This is expected to provide a positive price environment for the Stage 2 Olaroz Project and ongoing Olaroz Project development.

SDJ has expanded the pond area by 9 km^2 for the expansion, which is scheduled to produce an additional 25,000 tpa of lithium carbonate using a modified and refined version of the original process.

LOM Operating Cash Cost		
Costs		
Lime	US$/t LCE	438
Soda Ash	US$/t LCE	989
Electricity	US$/t LCE	169
Natural Gas	US$/t LCE	189
Operating Consumables	US$/t LCE	247
Packaging	US$/t LCE	75
Labour	US$/t LCE	620
Maintenance	US$/t LCE	243
Camp	US$/t LCE	136
Freights & Customs	US$/t LCE	19
G&A	US$/t LCE	80
Total Operating Costs	US$/t LCE	**3,206**
Cost Breakdown		
Variable Costs	US$/t LCE	1,691
Fixed Costs	US$/t LCE	1,514
Total Operating Costs	US$/t LCE	**3,206**

Stage 2 Expansion Economic Evaluation Results

The current project execution schedule considers achieving full production beginning CY24 and average annual technical grade lithium carbonate production is anticipated to be 25,000 t/yr, for Stage 2 only from an average annual wellfield head grade of 0.067% Lithium. A 40 year life has been assumed for the project, which is based on the substantial resources defined in the project. No residual value has been included in the analysis. Product sales are assumed to be free-on-board South America.

The key outcomes of the economic analysis are shown in the table below.

Recommendations

The authors recommend the planned diamond drilling program is completed and monitoring wells are installed for ongoing evaluation of long-term changes in brine levels and brine concentrations across the salar. Subsequent additional diamond drilling should be conducted in the area of planned Stage 3 expansion, prior to installation of any production wells in that area. All drill holes should be geophysically logged to obtain the maximum possible information from drilling and to assist geological correlation between holes. Physical porosity samples should continue to be taken for comparison with BMR geophysical logs.

Once additional exploration drilling has been conducted and the geological model updated to reflect the improved understanding from this additional drilling the Olaroz Project resource should be updated. Additional pumping test wells should be installed in the area of expanded exploration drilling, to provide information on aquifer conditions. Once pumping tests and the resource model are updated A mineral reserve should be defined for the Olaroz Project, based on the updated geological model and pumping test information. The Olaroz Project production schedule should be updated based on this information.

Summary Economics		
Production		
LOM	yrs	40
First Production	Date	H2 CY22
Ramp Up	months	12-18
Capacity	tpa	25,000
Investment		
Development Capital Costs	US$m	376
Development Capital Intensity	US$/tpa Cap	15,036
Cash Flow		
Operating Costs	US$/t LCE	3,206
Avg Sale Price (TG)	US$/t LCE	14,440
Wood Mackenzie 1Q 2022		
Financial Metrics		
NPV @ 10% (Pre-Tax)	US$m	2,674
NPV @ 10% (Post-Tax)	US$m	1,704
NPV @ 8% (Post-Tax)	US$m	2,051
IRR (Pre-Tax)	%	192%
IRR (Post-Tax)	%	137%
Payback from production start	yrs	1.7
Tax Rate	%	35%

2 INTRODUCTION

2.1 Background to the Report

The Olaroz Project is located in the Salar de Olaroz, in the Puna region of the province of Jujuy (Figure 4.1), at an altitude of 3900 m above sea level, 230 km northwest of the capital city of Jujuy.

The Olaroz Project site is adjacent to the paved highway RN52 which passes through the international border with Chile, 50 km to the northwest (Jama Pass), continuing on to the major mining center of Calama, and the port of Mejillones, near Antofagasta in northern Chile.

Approximately 35 kms to the north of the plant site there is a dehumidifying and compression station where the local gas pipeline crosses the N-S road continuing north from the west side of Salar de Olaroz. A dedicated pipeline connects the Olaroz Project to this gas pipeline which provides electricity and heat for the Project.

Approximately 60 kms to the south of the Olaroz Project site a railway crosses from northern Argentina to Chile, providing potential access to a number of ports in northern Chile. There are a number of local villages within 50 kms of the Olaroz Project site and the regional administrative centre of Susques (population 2000) is within an hour's drive.

Allkem holds an extensive property position across the Olaroz and Cauchari salars (Figure 4.2). At Olaroz, Allkem owns 66.5% of properties via SDJ a joint venture company with TTC (25%) and JEMSE (8.5%). Allkem holds additional properties on the western and eastern sides of the Salar de Cauchari, which is a southern continuation of the Salar de Olaroz.

An estimate of the Olaroz resource was undertaken in 2011 as part of the Olaroz Project Feasibility Study, prior to commencement of construction of Stage 1 of the Olaroz Lithium Facility. The estimate identified a Measured and Indicated Resource of 6.4 Mt of LCE over an area of 93 km^2 from surface to a maximum depth of 200 metres (the 2011 Resource). Subsequent to development of the Olaroz Project additional drilling has been conducted, resulting in the resource update outlined in this report.

Allkem contracted QP Murray Brooker (Hydrominex Geoscience) to prepare this report to document the resources of the Olaroz Project. This report details the exploration and development that has been undertaken to date on the properties and the development of the updated resource for the Olaroz Project.

This report has been prepared in conformance with the requirements of National Instrument 43-101 Standards of Disclosure for Mineral Projects and the associated Companion Policy 43-101CP and Form 43-101F1 of the Canadian Securities Administrators and the associated Best Practice Guidelines for Industrial Minerals and Mineral Processing, as issued by the Canadian Institute of Mining and Metallurgy.

The Report also includes technical judgment of appropriate additional technical parameters to accommodate specific characteristics of minerals contained in brine, as outlined in Best Practice Guidelines for Resource and Reserve Estimation for Lithium Brines (CIM), the Australian AMEC brine guidelines and the considerations discussed by Houston (Houston et al, 2011).

2.2 Experience of the QP's

This report was prepared by Mr Murray Brooker of Hydrominex Geoscience and Mr Mike Gunn of Gunn Metallurgy. Mr Brooker is a Member of the Australian Institute of Geoscientists (AIG), a Registered Professional Geoscientist in Australia (RPGeo) and a member of the International Association of Hydrogeologists (IAH). Mr Brooker is an independent consultant to the lithium industry and a Qualified Person (QP) as defined by NI43-101 criteria. Mr Gunn is a Chartered Professional Fellow of the Australasian Institute of Mining and Metallurgy (MAusIMM). Mr Gunn is an independent consultant to the lithium industry and a Qualified Person (QP) as defined by NI43-101 criteria.

Mr Murray Brooker has worked extensively on lithium and potash salt lakes since the beginning of 2010, working on projects in Argentina, Chile, Australia and China. His roles have included acting as a consultant for lithium producers, providing advice on wellfield development, undertaking and managing drilling projects, installing exploration and production wells for lithium extraction, undertaking geological modelling and supervising the development of groundwater models and the definition of lithium resources and reserves. Mr Brooker is familiar with the Olaroz Project area and has visited the Olaroz Project many times prior to 2020. He has not visited the site in the last two years as part of the preparation of this report, due to Covid travel restrictions

Mr Michael Gunn holds a B.App.Sc. in Metallurgy from UNSW, Australia, and has 45 years of work experience in the mineral processing industry, specializing in mineral processing operations and process design. Work has been undertaken in a wide range of metals with large and small mining houses in both line operational roles and as a design or project commissioning consultant. Feasibility study and process design skills were gained working in various roles with major engineering and consulting groups. A broad range of mineral processing and hydrometallurgy design and process consulting assignments have been completed overseas and in Australia. Mr Gunn is familiar with the Olaroz Project area and has visited the Olaroz Project many times prior to 2020. He has not visited the site in the last two years as part of the preparation of this report, due to Covid travel restrictions.

2.3 Sources of Information

Extensive information is available at the Olaroz Project from drilling dating back to 2008, when exploration for lithium commenced on the Olaroz Project. There is also extensive information available further to the south, conducted by Allkem subsidiary Advantage Lithium and to the west by Lithium Americas Corp. The geology in these areas appears very similar to that encountered on the Olaroz Project. Reports referred to include:

- Internal reports containing geological and geophysical logging data and assays;
- Prefeasibility Study of the Cauchari JV Lithium Project Jujuy Province, Argentina. Report prepared by Worley Parsons and FloSolutions (Chile) for Advantage Lithium Corp. October 22, 2019;
- Olaroz Project Large Exploration Target Defined Beneath Current Resource. Orocobre news release October 23, 2014;
- The Evaluation of Brine Prospects and the Requirement for Modifications to Filing Standards. Houston et. al., 2011. Economic Geology V106 pp 1225-1239; and
- Technical Report on the Salar de Olaroz Lithium-Potash Project Jujuy Province, Argentina. NI 43-101 report prepared for Orocobre Ltd. by John Houston and Mike Gunn, May 13, 2011.

Additional more general information has been obtained from public data sources such as maps produced by the Argentine Geological Survey (Servicio Geológico Minero Argentino [SEGEMAR]), satellite imagery from sources such as Google Earth, and published scientific papers in geological journals by Argentine and international scientists.

2.4 Specific Characteristics of Lithium Brine Projects

Although extensive exploration and development of new lithium brine projects has been underway for the last decade it is important to note there are essential differences between brine extraction and hard rock lithium, base or precious metal mining. Brine is a fluid hosted in an aquifer and thus can flow and mix with adjacent fluids once pumping of the brine commences. An initial in-situ resource estimate is based on knowledge of the geometry of the aquifer, and the variations in porosity and brine grade within the aquifer.

Brine deposits are exploited by pumping the brine to the surface and extracting the lithium in a specialist production plant, generally following solar evaporation of the brine in large evaporation ponds. To assess the recoverable reserve, further information on the permeability and flow regime in the aquifer and the surrounding area is necessary to be able to predict how the lithium contained in brine will change over the Olaroz Project life. These considerations are examined more fully in Houston et. al., (2011) and in the CIM and JORC reporting code brine reporting guidelines and the reader is referred to these key publications for further explanation of the details of brine deposits.

Hydrogeology is a specialist discipline which involves the use of a number of specialized terms which are used frequently throughout this document. The reader is referred to the glossary in the following section for a definition of terms.

2.5 Units and Abbreviations

- BG: Battery grade (high purity) lithium
- CARG: Compound annual growth rate
- CO3: Carbonate
- °C: Degrees Celsius unit of temperature
- Dmt: Dry metric tonnes
- EV: Electric vehicle
- g: Gram = 1000 mg
- g/cm3: Grams per cubic centimetre = 1,000,000 mg/L
- g/L: Grams per litre = 1000 mg/L
- ha: Hectare = 10,000 m2 = 0.01 km2
- kg: kilogram = 1,000 g
- kT: Kilotonne = 1,000 T
- ktpa : Kilotonne per annum
- km^2: Square kilometre = 1,000,000 m2
- L: Litre unit of volume
- LCE: Li2CO3 or Lithium carbonate equivalent
- Li: Lithium
- Metric measurement units are used in this report unless otherwise noted.
- m2: Square m unit of area
- m3: Cubic meter = 1,000 L
- mg: Milligram unit of mass
- mg/L: Milligram per litre unit of concentration
- Ma: Megaannum or million years ago
- MT: Million tonnes = 1,000,000 T
- mm/d: Millimetres per day rate of rainfall
- mm/yr: Millimetres per year rate of rainfall
- mm/yr: Millimetres per year rate of exhumation and sedimentation
- m/kyr: Metres per thousand years = 1,000 mm/yr
- m/Myr: Meters per million years = 1,000 m/kyr
- NI 43-101: Canadian National Instrument 43-101 report
- NaCl: Halite

- Ωm: Ohm-metre (ohm) unit of resistivity
- ppm: Parts per million = mg/L
- Sy: Specific yield or Drainable Porosity unit of porosity (a fraction equivalent to a percentage)
- T: Tonne = 1,000 kg or 1,000,000 grams
- Technical grade (TG): Lithium product with lower purity than battery grade
- $: United States dollar unit of currency
- wt%: Weight percent =10,000 ppm
- yr: year unit of time

2.6 Units and Currency

Units in the report are metric. The currency is the US dollar, unless otherwise mentioned.

3 RELIANCE ON OTHER EXPERTS

The preparation of a technical report of this nature requires multiple technical disciplines; the authors have relied on other experts in items related to the legal status of mining properties, environmental affairs and background maps and topography.

Legal – For the purpose of this report, the author has relied on ownership information provided by Allkem Limited. This includes a report by independent lawyer, Mr Santiago Saravia Frias of Saravia Frias lawyers. The report is dated December 30th, 2021, and includes information regarding the legal status of the Allkem properties, the area of the properties, the investment plans and payment of the annual canon fee. This document applies to information in Section 4 and related summaries in its entirety. The independent QP's have not investigated title or mineral rights of the Olaroz Project and express no legal opinion as to the ownership status of the Properties.

Environmental – The independent QP's have not investigated the environmental status of the properties and express no legal opinion as to the environmental status of the Properties. SdJ legal personnel provided information for this report and manage the environmental impact of the Olaroz Project with respect to the construction and environmental permits that are held by SdJ and submit regular environmental reports to the regulators.

Topography - The authors also rely on public topographic information obtained from publicly available data.

Technical – the authors have relied on information filed on SEDAR by Lithium Americas Corp and Advantage Lithium relating to geological information on the adjacent properties referred to in sections 7 and 23. This information, such as drilling logs and geophysical data, has not been verified by the authors.

Market Studies – The authors have relied on market studies provided by Allkem that were prepared by Roskill, Wood Mackenzie who updated its near and long-term price outlooks for all products in 4Q 2021 based on a correction in the coming years although not down to the levels seen in 2020. That price forecast has been utilised in this analysis.

4 PROPERTY DESCRIPTION AND LOCATION

4.1 Location

The Olaroz Project is located in the Puna region of the province of Jujuy (Figure 4.1), at an altitude of 3900 m above sea level, 180 km west-northwest of the capital city of Jujuy, San Salvador de Jujuy.

The Olaroz Project site is adjacent to the paved highway RN52 which passes through the international border with Chile, 50 km to the northwest (Jama Pass), continuing on to the major mining center of Calama, and the port of Mejillones, near Antofagasta in northern Chile.

Approximately 35 kms to the north of the Olaroz Project there is a dehumidifying and compression station on a regional gas pipeline, reached by the N-S road along the west side of Salar de Olaroz. A dedicated spur pipeline supplies gas to the Olaroz Project.

Approximately 60 kms to the south of the Olaroz Project site a railway crosses from northern Argentina to Chile, providing potential access to a number of ports in northern Chile. There are a number of local villages within 50 kms of the Olaroz Project site and the regional administrative centre of Susques (population 2000) is within half an hour's drive.

4.2 Argentina Licensing System

Two tenement types exist in the Argentine mining regulations, Cateos and Minas. Cateos (Exploration Permits) are licenses that allow the holder to explore the tenement for a period of time that is proportional to its size. An Exploration Permit of 1 unit (500 hectares) is granted for a period of 150 days. For each additional unit (500 hectares) the period is extended by 50 days. The maximum allowed permit size is 20 units (10,000 hectares) and which is granted for a period of 1,100 days. The period begins 30 days after granting of the permit. A relinquishment must be made after the first 300 days, and a second one after 700 days. The applicant should pay a canon fee of $1,600 Argentine pesos per unit (500 hectares) and submit an exploration work plan and environmental impact assessment.

Minas (Mining/exploitation Permits) are licenses which allow the holder to exploit the property (tenement) subject to regulatory environmental approval. Minas are of unlimited duration, providing the property holder meets its obligations under the Mining Code. The Olaroz properties are predominantly minas. Requirements to maintain licences in good standing include:

- Paying the annual rent (canon) payments;
- Completing a survey of the property boundaries;
- Submitting a mining investment plan; and
- Meeting the minimum investment commitment.

Additional details related to the properties are as follows:

- According to information provided in the applications for mining rights, all of the Olaroz Project properties are located on Fiscal Lands. Fiscal Lands are state-owned lands, and allow for access for exploration and mining companies.

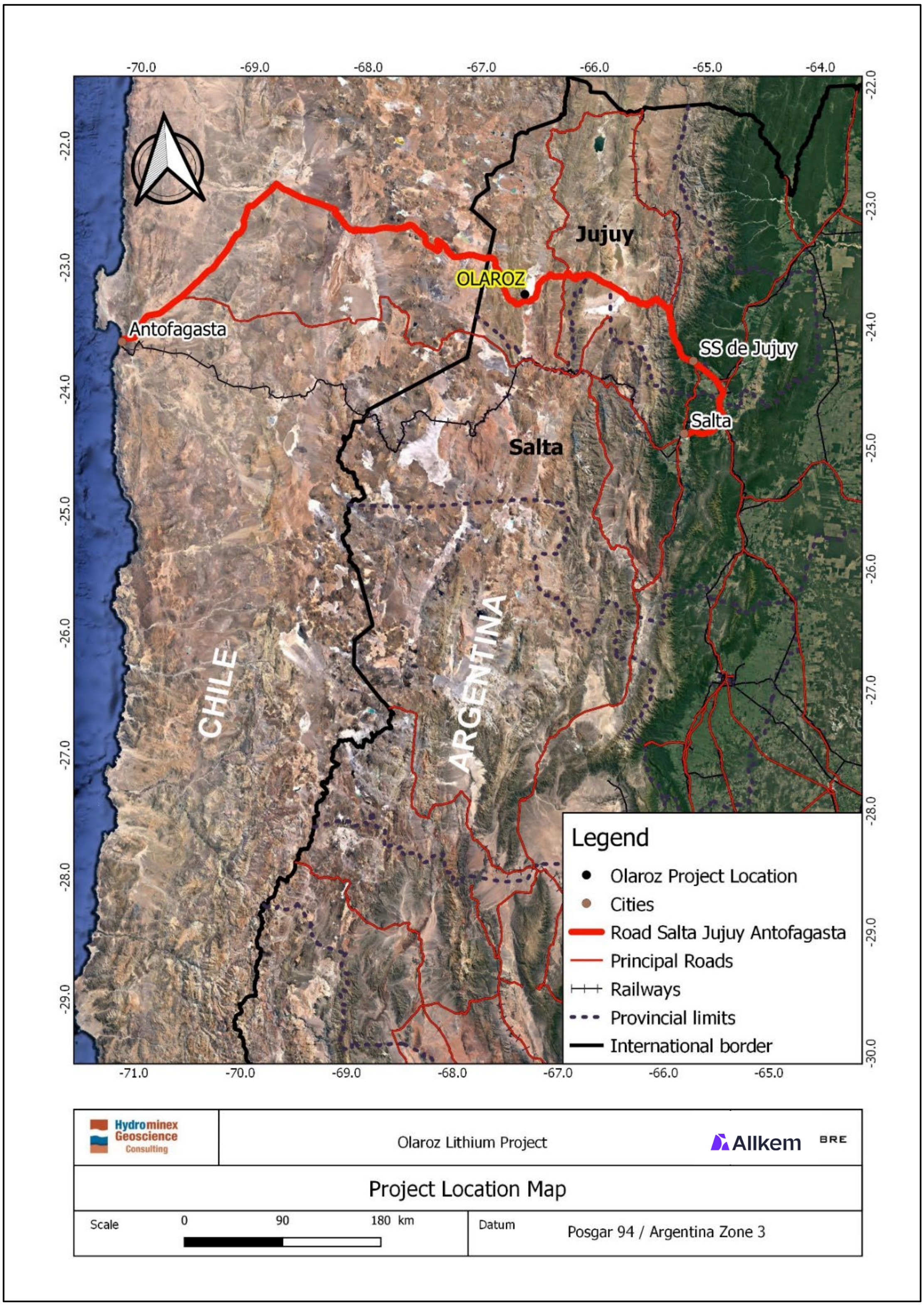


Figure 4.1: Location of the Olaroz Project relative to regional infrastructure

- All claims within a given property must be surveyed, and the maximum claim area is 100 ha;
- Investment Plans, including detailed expenditures, must be filed with the granting authority, which is the Jujuy province Department of Mines. The expenditure commitment detailed in the Investment Plans must be met within five years of filing the application for the properties. Twenty percent of the aggregated forecasted investments shall be incurred in each of the 1st and 2nd year of the plan;
- The Annual Mining Fee must be paid in advance, in two equal instalments due on December 31st and June 30th;
- The total required fees and expenditures are shown in Argentine pesos. The exchange rate at the close of business Monday 10 January, 2022 was 108.5 (seller) = US$1 dollar, as provided by the Argentine National Bank (Banco de la Nación Argentina), as published on its website (http://www.bna.com.ar/);
- An Environmental Impact Report (IIA) must be submitted and approved before exploration work commences and must be updated every 2 years and
- Investment Plans must be filed for properties.

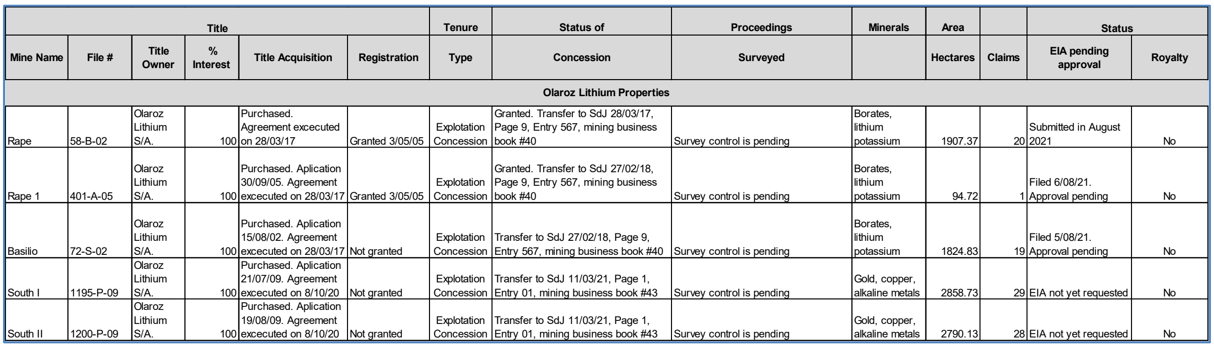
4.3 Coordinate System

The SdJ properties are shown in Figure 4.2. The property co-ordinates (and all other co-ordinates used in this report) are in the Argentine coordinate system, which uses the Gauss Krueger Transverse Mercator Olaroz Projection and the Argentine Posgar 94 datum. The properties are located in Argentine GK Zone 3.

4.4 Property Status

- SdJ holds 32 mining licences and 5 exploration properties (Cateos) in the Olaroz Basin covering the surface of the salt lake and surrounds in the Olaroz JV with TTC and JEMSE. Allkem also holds five additional properties 100% in the north of the salar through Olaroz Lithium S.A. The mining licences are summarised in Tables 4.1 and 4.2 below, with the property names, file numbers and details of the approvals related to each of the licences; and
- All information regarding the legal status of the properties was provided by Mr Saravia Frias, a lawyer in the province of Salta, for Saravia Frias lawyers. The status of properties has not been independently verified by the QP's, who take no responsibility for the legal status of the properties.

Title						Tenure	Status of	Proceedings	Minerals	Area		Status	
Mine Name	File #	Title Owner	% Interest	Title Acquisition	Registration	Type	Concession	Surveyed		Hectares	Claims	EIA pending approval	Royalty
SdJ Properties													
Cateo	257-R-04	SR	100%	Filed 12/10/04	Registered	Exploration	Yes. Granted 3/08/2007	Converted to 963-R-08 and 964-R-08 exploitation rights	Borates, Lithium	1999.92	4		No
San Antonio Norte	943-R-08	SDJ	100%	Filed 6/05/08	Registered	Explotation Concession	Transfer registered 10/05/12 to SdJ. Page 14 Entry 464, business book #34. Granted/registed 23/07/12 and published 3rd to 17th september 2012	Survey submitted 16/10/12 and 12/11/12. Final legal survey pending. SdJ confirmed 15/03/21 who will complete the legal survey.	Borates, Lithium, salts	563.79	6		No
San Antonio Sur	944-R-09	SDJ	100%	Filed 6/05/08	Registered	Explotation Concession	Transfer registered 10/05/12 to SdJ. Page 14 Entry 464, business book #34. Granted/registed 23/07/12 and published 3rd to 17th september 2012	Survey submitted 16/10/12 and 12/11/12. Final legal survey pending. SdJ confirmed 15/03/21 who will complete the legal survey.	Borates, Lithium, salts	432.06			No
San Juan Norte	963-R-08	SDJ	100%	Filed 6/05/08	Registered	Explotation Concession	Transfer registered 10/05/12 to SdJ. Page 14 Entry 464, business book #34. Granted/registed 23/07/12 and published 3rd to 17th september 2012	Survey submitted 16/10/12 and 12/11/12. Final legal survey pending. Survey confirmed 22/12/15. On 26/11/21 Mining surveyor reviewing the survey	Borates, Lithium, salts	1195	12	Ammended and submitted 12/03/21. Approval pending.	No
San Juan Sur	964-R-09	SDJ	100%	Filed 6/05/08	Registered	Explotation Concession	Transfer registered 10/05/12 to SdJ. Page 14 Entry 464, business book #34. Granted/registed 23/07/12 and published 3rd to 17th september 2012	Survey submitted 16/10/12 and 12/11/12. Final legal survey pending. Survey confirmed 22/12/15. Mining surveyor reviewing the survey	Borates, Lithium, salts	805.06	9	Ammended and submitted 12/03/21. Approval pending.	No
Cateo	390-R-04	SR	100%	Filed 24/08/05	Registered	Exploration	Yes. Granted 8/04/2010	Converted to 1137-R-09 and 1136-R-09 exploitation rights.	Borates, Lithium, salts	2401.86	5		No
San Antonio Oeste I	1137-R-09	SDJ	100%	Filed 25/02/09	Registered	Explotation Concession	Transfer registered 10/05/12 to SdJ. Page 14 Entry 464, business book #34. Granted/registed 23/07/12 and published 3rd to 17th september 2012	Survey submitted 16/10/12 and 12/11/12. Mining surveyor reviewing the survey as of 18/02/21. Final legal survey confirmation pending.	Borates, Lithium, salts	1199.34	12	Ammended and submitted 12/03/21. Approval pending.	No
San Antonio Oeste II	1137-R-09	SDJ	100%	Filed 25/02/09	Registered	Explotation Concession	Transfer registered 10/05/12 to SdJ. Page 14 Entry 464, business book #34. Granted/registed 23/07/12 and published 3rd to 17th september 2012	Survey submitted 16/10/12 and 12/11/12. Mining surveyor reviewing the survey as of 18/02/21. Final legal survey confirmation pending.	Borates, Lithium, salts	1198.58	12	Ammended and submitted 12/03/21. Approval pending.	No
Cateo	391-R-05	SR	100%	Filed 24/08/05	Registered	Exploration	Yes. Granted 8/04/2010	Converted to 1134-R-09 and 1135-R-09 exploitation rights	Borates, Lithium, salts	1992.97	4		No
San Fermin Norte	1134-R-09	SDJ	100%	Filed 25/02/09	Registered	Explotation Concession	Transfer registered 10/05/12 to SdJ. Page 14 Entry 464, business book #34. Granted/registed 23/07/12 and published 3rd to 17th september 2012	Survey submitted 16/10/12 and 12/11/12. Mining surveyor reviewing the survey as of 22/12/15. Final legal survey confirmation pending.	Borates, Lithium, salts	895.7	9	Ammended and submitted 12/03/21. Approval pending.	No
San Fermin Sur	1135-R-09	SDJ	100%	Filed 25/02/09	Registered	Explotation Concession	Transfer registered 10/05/12 to SdJ. Page 14 Entry 464, business book #34. Granted/registed 23/07/12 and published 3rd to 17th september 2012	Survey submitted 16/10/12 and 12/11/12. Mining surveyor reviewing the survey as of 22/12/15. Final legal survey confirmation pending.	Borates, Lithium, salts	1098.98	11	Ammended and submitted 12/03/21. Approval pending.	No
San Miguel II	945-R-08	SDJ	100%	Filed 6/05/08	Pending	Explotation Concession	Transfer registered 10/05/12 to SdJ. Page 14 Entry 464, business book #34. Not yet granted. 25/08/21 and 7/12/21 Mining Deparment requested the EIA filing approval.	Not yet surveyed	Borates, Lithium, salts	1493.97		EIA pending approval	No
Oculto Norte	946-R-08	SDJ	100%	Filed 5/05/08	Provisional, 17/11/2017.	Explotation Concession	Pending final conferal of rights due to third party appeal	Not yet surveyed	Borates, Lithium, salts	331.76		EIA yet to be submitted, as not officially granted yet.	No
Santa Julia	1842-S-12	SDJ	100%	Filed 23/11/12	Registered	Explotation Concession	Registered 27/09/19, published 21/10/19 and 30/10/19.	Survey submitted 5/02/20 and 26/05/20. Mining surveyor reviewing the survey as of 04/08/21. Final legal survey confirmation pending.	Borates, Lithium, salts	2988.19	30	Ammended and submitted 12/03/21. Approval pending.	No
Cateo	1274-P-09	SDJ	100%	Filed 21/10/09	Registered	Exploration	Accepted by SdJ on notification 26/07/18. Amended EIA required.		Borates, Lithium, salts	5972.09		Submission of ammended EIA pending	No
Mercedes III	319-T-2005	SDJ	100%	Purchased 13/10/09	Registered	Explotation Concession	Transfer registered 13/10/09 to SdJ 172 As 398, business book #31. Granted/registed 23/07/12 and published 31 August to 7th and 14th September 2012	Survey submitted 16/10/12 and 12/11/12. Final legal survey confirmation pending.	Borates, Lithium, salts	1473.97	15	Ammended and submitted 12/03/21. Approval pending.	No
La Nena	29-M-96	SDJ	100%	Purchased July 2009	Registered	Explotation Concession	Transfer registered 7/06/11 to SdJ Page 33, Entry 4333, business book #33. Granted/registed 15/09/21 a SDJ	Surveyor appointed by SdJ 29/05/20. Survey pending.	Borates,	99.95		Ammended and submitted 12/03/21. Approval pending.	No
Demian	039-M-98	SDJ	100%	Purchased July 2009	Registered	Explotation Concession	Granted 2005. Transfer registered 7/06/11 to SdJ Page 33, Entry 4333, business book #33. Granted/registed 15/09/21 a SDJ	22/10/21 Requested professional acceptance to do the legal survey	Borates,	98.4		Ammended and submitted 12/03/21. Approval pending.	No
Juan Martin	40-M-98	SDJ	100%	Purchased July 2009	Registered	Explotation Concession	Granted 2005. Transfer registered 7/06/11 to SdJ Page 33, Entry 4333, business book #33. Granted/registed 15/09/21 a SDJ	Ratification of the legal survey request filed, but survey still pending	Borates, lithium and potasium	100		Submission of renewal pending.	No
Maria Norte	393-B-44	SDJ	100%	Purchased July 2009	Registered	Explotation Concession	Granted 2002. Transfer registered 7/06/11 to SdJ Page 33, Entry 4333, business book #33.	Surveyed August 2001	Borates, lithium and potasium	99.92		Ammended and submitted 12/03/21. Approval pending.	No
Analia	131-I-86	SDJ	100%	Purchased July 2009	Registered	Explotation Concession	Granted 2005. Transfer registered 7/06/11 to SdJ Page 33, Entry 4333, business book #33. Granted/registed 15/09/21 a SDJ	Surveyed August 2002	Borates, lithium	100		Ammended and submitted 12/03/21. Approval pending.	No
Mario	125-S-44	SDJ	100%	Purchased 1/10/09	Registered	Explotation Concession	Granted. Transfer registered March 2011 to SdJ F. 410, A. 412 mining, business book #31. Granted/registed 1/10/09 a SDJ	Surveyed 16/01/98	Borates	99.93		Ammended and submitted 12/03/21. Approval pending.	No
Ernesto	112-G-04	SDJ	100%	Purchased 1/10/09	Registered	Explotation Concession	Granted. Transfer registered March 2011 to SdJ F. 410, A. 412 mining, business book #31. Granted/registed 1/10/09 a SDJ	Survey approved 20/06/05	Borates, lithium and potasium	99.99		Ammended and submitted 12/03/21. Approval pending.	No
Josefina	114-V-44	SDJ	100%	Purchased 1/10/09	Registered	Explotation Concession	Granted. Transfer registered March 2011 to SdJ F. 410, A. 412 mining, business book #31. Granted/registed 1/10/09 a SDJ	Survey approved 20/06/05	Borates, lithium and potasium	99.79		Ammended and submitted 12/03/21. Approval pending.	No
Humberto	117-A-44	SDJ	100%	Purchased 1/10/09	Registered	Explotation Concession	Granted. Transfer registered March 2011 to SdJ F. 410, A. 412 mining, business book #31. Granted/registed 1/10/09 a SDJ	Survey approved 20/06/05	Borates, lithium and potasium	99.8		Ammended and submitted 12/03/21. Approval pending.	No
Lisandro	126-T-44	SDJ	100%	Purchased 1/10/09	Registered	Explotation Concession	Granted. Transfer registered March 2011 to SdJ F. 410, A. 412 mining, business book #31. Granted/registed 1/10/09 a SDJ	Survey approved 20/06/05	Borates, lithium and potasium	100		Ammended and submitted 12/03/21. Approval pending.	No
Cateo	498-B-06	SDJ	100%	Purchased	Registered	Explotation Concession	Complex legal history. 3/10/16 the mining judge ruled in favour of SdJ.	Not surveyed. Also covered by SdJ mining properties	Borates	10,000			Yes. US$100,00/year if in production. Borax retains an usufruct for borates for 20 years.
Riolitio	1205-P-2009	SDJ	100%	Filed 21/08/09	Pending	Explotation Concession	Not yet granted. Covers area not overlapping with Cateo 498.	Not yet surveyed	Borates, lithium and potasium	339.18		Not yet submitted	No
Rioros I	12605-P-2009	SDJ	100	Filed 21/08/09	Pending	Explotation Concession	Not yet granted	Not yet surveyed	Borates, lithium and potasium	2,983		Not yet submitted	No
Rioros II	1215-p-2009	SDJ	100	Filed 21/08/09	Pending	Explotation Concession	Not yet granted	Not yet surveyed	Borates, lithium and potasium	339		Not yet submitted	No
Potosi III	520-L-06	SDJ	100	Purchased. Filed 22/05/06 Purchased 13/08/18, after ammended agreement 24/10/13.	Pending	Explotation Concession	Not yet granted. Transfer to SdJ 25/09/18, Page 180, Entry 583, mining business book #40	Not yet surveyed	Gold, silver, lithium	1896.52		Filed 6/05/21, resubmission required.	No
Potosi IV	521-L-06	SDJ	100	Purchased. Filed 22/05/06 Purchased 13/08/18, after ammended agreement 24/10/13.	Pending	Explotation Concession	Not yet granted. Transfer to SdJ 25/09/18, Page 180, Entry 583, mining business book #40	Not yet surveyed	Gold, silver, lithium	2048.99		Filed 6/05/21, resubmission required.	No
Potosi V	522-L-06	SDJ	100	Purchased. Filed 22/05/06 Purchased 13/08/18, after ammended agreement 24/10/13.	Pending	Explotation Concession	Not yet granted. Transfer to SdJ 25/09/18, Page 180, Entry 583, mining business book #40	Not yet surveyed					
Potosi VI	147-L-03	SDJ	100	Purchased. Filed 22/05/06 Purchased 13/08/18, after ammended agreement 24/10/13.	Granted	Explotation Concession	Granted. Transfer to SdJ 25/09/18, Page 180, Entry 583, mining business book #40	Surveyed 1/04/09	Gold, silver, lithium	1933.81		Filed 21/05/21, resubmission required.	No
Potosi VIII	725-L-07	SDJ	100	Purchased. Filed 26/04/07 Purchased 13/08/18, after ammended agreement 24/10/13.	Pending	Explotation Concession	Not yet granted. Transfer to SdJ 25/09/18, Page 180, Entry 583, mining business book #40		Gold, silver, lithium	2940.43		Filed 21/05/21, resubmission required.	No
Potosi IX	726-L-07	SDJ	100	Purchased. Filed 26/04/07 Purchased 13/08/18, after ammended agreement 24/10/13.	Granted 29/10/21	Explotation Concession	Granted. Transfer to SdJ 25/09/18, Page 180, Entry 583, mining business book #40	Survey pending	Gold, silver, copper, lithium	2889.98		Filed 21/05/21, resubmission required.	No
Regreso	1671-S-2011	SDJ	100	Filed 24/10/11.	Not granted	Explotation Concession		Survey pending	Borates, lithium, alkali metals	1507.45		Not yet requested	No



Title						Tenure	Status of	Proceedings	Minerals	Area		Status	
Mine Name	File #	Title Owner	% Interest	Title Acquisition	Registration	Type	Concession	Surveyed		Hectares	Claims	EIA pending approval	Royalty
Olaroz Lithium Properties													
Rape	58-B-02	Olaroz Lithium S/A.	100	Purchased. Agreement excecuted on 28/03/17	Granted 3/05/05	Explotation Concession	Granted. Transfer to SdJ 28/03/17, Page 9, Entry 567, mining business book #40	Survey control is pending	Borates, lithium potassium	1907.37	20	Submitted in August 2021	No
Rape 1	401-A-05	Olaroz Lithium S/A.	100	Purchased. Aplication 30/09/05. Agreement excecuted on 28/03/17	Granted 3/05/05	Explotation Concession	Granted. Transfer to SdJ 27/02/18, Page 9, Entry 567, mining business book #40	Survey control is pending	Borates, lithium potassium	94.72	1	Filed 6/08/21. Approval pending	No
Basilio	72-S-02	Olaroz Lithium S/A.	100	Purchased. Aplication 15/08/02. Agreement excecuted on 28/03/17	Not granted	Explotation Concession	Transfer to SdJ 27/02/18, Page 9, Entry 567, mining business book #40	Survey control is pending	Borates, lithium potassium	1824.83	19	Filed 5/08/21. Approval pending	No
South I	1195-P-09	Olaroz Lithium S/A.	100	Purchased. Aplication 21/07/09. Agreement excecuted on 8/10/20	Not granted	Explotation Concession	Transfer to SdJ 11/03/21, Page 1, Entry 01, mining business book #43	Survey control is pending	Gold, copper, alkaline metals	2858.73	29	EIA not yet requested	No
South II	1200-P-09	Olaroz Lithium S/A.	100	Purchased. Aplication 19/08/09. Agreement excecuted on 8/10/20	Not granted	Explotation Concession	Transfer to SdJ 11/03/21, Page 1, Entry 01, mining business book #43	Survey control is pending	Gold, copper, alkaline metals	2790.13	28	EIA not yet requested	No

Table 4.1: Olaroz Project property details and areas

			Investment Plan		Mining Canon	
No	Property	File	Submitted	Accepted	Amount	Payment
SdJ Properties						
1	San Antonio Norte	943-R-08	6/11/2013	28/12/18 request to SdJ of invested amount. Filing by SdJ 22/07/19. As of 10/11/21 investment plan approval awaited.		Paid for 2021 and prior
2	San Antonio Sur	944-R-09	6/11/2013	02/08/18 request to SdJ of invested amount. Filing by SdJ 17/03/21. As of 10/11/21 investment plan approval awaited.		Paid for 2021 and prior
3	San Juan Norte	963-R-08	6/11/2013	15/03/21 SdJ explained the investment plan. 26/11/21 department reviewing the investment plan.		Paid for 2021 and prior
4	San Juan Sur	964-R-08	6/11/2013	15/03/21 SdJ explained the investment plan. 26/11/21 department reviewing the investment plan.		Paid for 2021 and prior
5	San Antonio Oeste I	1137-R-09	6/11/2013	Investment plan approved 3/03/21, resolution 4-J-21		Paid for 2021 and prior
6	San Antonio Oeste II	1136-R-09	6/11/2013	Investment plan approved 3/03/21, resolution 3-J-21		Paid for 2021 and prior
7	San Fermin Norte	1134-R-09	6/11/2013	Investment plan details provided 29/04/21. Approval of plan pending		Paid for 2021 and prior
8	San Fermin Sur	1135-R-09	6/11/2013	30/11/21 department reviewing the investment plan.		Paid for 2021 and prior
9	San Miguel II	945-R-08	Pending	Not submitted		
10	Oculto Norte	946-R-08	Pending	Not submitted		
11	Santa Julia	1842-S-12	6/11/2013	27/09/21 department reviewing the investment plan.		Paid for 2021 and prior
12		1274-P-09		Not submitted		
13	Mercedes III	319-T-2005	6/11/2013	Pending, following review of investment plan		Paid for 2021 and prior
14	La Nena	29-M-96	9/03/2010	Pending, following review of investment plan		Paid for 2021 and prior
15	Demian	039-M-98	28/12/2011	Pending, following review of investment plan		Paid for 2021 and prior
16	Juan Martin	40-M-98	28/12/2011	Pending, following review of investment plan		Paid for 2021 and prior
17	Maria Norte	393-B-44	28/12/2011	Pending, following review of investment plan		Paid for 2021 and prior
18	Analia	131-I-86	28/12/2011	Pending, following review of investment plan		Paid for 2021 and prior
19	Mario	125-S-44	SDJ	Pending, following review of investment plan		Paid for 2021 and prior
20	Ernesto	112-G-04	SDJ	Pending, following review of investment plan		Paid for 2021 and prior

			Investment Plan		Mining Canon	
No	**Property**	**File**	**Submitted**	**Accepted**	**Amount**	**Payment**
21	Josefina	114-V-44	SDJ	Pending, following review of investment plan		Paid for 2021 and prior
22	Humberto	117-A-44	SDJ	Pending, following review of investment plan		Paid for 2021 and prior
23	Lisandro	126-T-44	SDJ	Pending, following review of investment plan		Paid for 2021 and prior
24	Cateo	498-B-06	SDJ	Pending, following review of investment plan		Paid for 2021 and prior
25	Riolitio	1205-P-2009	SDJ	Pending, following review of investment plan		Paid for 2021 and prior
26	Rioros I	12605-P-2009	SDJ	Pending, following review of investment plan		Paid for 2021 and prior
27	Rioros II	1215-p-2009	SDJ	Pending, following review of investment plan		Paid for 2021 and prior
28	Potosi III	520-L-06	SDJ	Pending, following review of investment plan		Paid for 2021 and prior
29	Potosi IV	521-L-06	SDJ	Pending, following review of investment plan		Paid for 2021 and prior
30	Potosi V	522-L-06	SDJ	Pending, following review of investment plan		Paid for 2021 and prior
31	Potosi VI	147-L-03	SDJ	Pending, following review of investment plan		Paid for 2021 and prior
32	Potosi VIII	725-L-07	SDJ	Pending, following review of investment plan		Paid for 2021 and prior
33	Potosi IX	726-L-07	SDJ	Pending, following review of investment plan		Paid for 2021 and prior
34	Regreso	1671-S-2011	SDJ	Pending, following review of investment plan		Paid for 2021 and prior
Olaroz Lithium Properties						
35	Rape	58-B-02	Olaroz Lithium	Pending, following review of investment plan		Paid for 2021 and prior
36	Rape 1	401-A-05	Olaroz Lithium	Pending, following review of investment plan		Paid for 2021 and prior
37	Basilio	72-S-02	Olaroz Lithium	Pending, following review of investment plan		Paid for 2021 and prior
38	South I	1195-P-09	Olaroz Lithium	Pending, following review of investment plan		Paid for 2021 and prior
39	South II	1200-P-09	Olaroz Lithium	Pending, following review of investment plan		Paid for 2021 and prior

Table 4.2: Summary of mining fees and investment

4.5 Environmental Liabilities

The properties where extraction of lithium is ongoing are subject to the environmental approval for the Olaroz Project JV, with ongoing monitoring of water levels and water quality conducted throughout the properties and the surrounding area. Annual or more frequent reports on the environmental condition of the properties are required to be prepared. The properties outside the area where production is underway have been subject to very limited or no exploration drilling. Environmental permits are held for these properties, although no significant exploration has yet been conducted.

4.6 Permits

Environmental impact reports have been submitted to allow drilling and other activities on the properties. Environmental approvals for drilling are issued for a period of 2 years and can be renewed subsequent to the original approval. Additional approvals are required for mining to begin, principally submission and approval of a comprehensive Olaroz Project EIA.

4.7 Royalties

There is a 3 percent mine mouth (boca de mina) royalty on the value of production to the provincial Jujuy government, considered the value of the brine after the deduction of the costs of extraction, processing and transportation.

In addition to the royalty JEMSE, the Jujuy provincial mining body holds an 8.5% interest in the Olaroz Project, which is to be paid back from their share of the Olaroz Project profit. There are no other royalties, back in rights or remaining payments or encumbrances on the Allkem SdJ JV or 100% owned Olaroz Lithium properties.

There is an export fee of 8% on the FOB price by a mining company, as regulated by Decree Nr. 785/20.

4.8 Other Significant Factors and Risks

A number of general risk factors are associated with the Olaroz Project. These risks include, but are not limited to:

- Properties. The risk that properties might not be fully granted or maintained, due to administrative errors or failure to make the annual property payments;
- Assays. The risk that assay results are not representative of the fluid present in sediments within the properties, due to the relatively small number of samples taken during deeper drilling, despite consistent results between drill holes;
- Geophysics. Interpretation of the base of the salt lake is heavily reliant on gravity geophysics, for which multiple interpretations of the data are possible. Definition of the limits of the Olaroz brine body depends on the AMT and VES geophysics. Consequently, there is a risk that the actual geology and thickness of the sediments is different to that interpreted from the geophysical data; and
- Fluid sampling. Brine sampling during diamond drilling entails risks of contamination from drilling fluid. Although results from pumping tests on rotary drill holes installed as production wells suggest this is not the case, depth specific brine samples from diamond holes can potentially be contaminated by drilling fluid.

More generally there are risks that:

- Necessary licences and permits will not be received from the necessary authorities in a timely manner on acceptable terms or at all;
- Changes in federal or provincial laws and their implementation, impacting activities on the properties;
- Unseasonal rainfall could occur, which could temporarily delay planned exploration;
- Future changes in lithium price, which could affect the economics of lithium production in the event that sufficient lithium was defined in the Olaroz Project area that could potentially be produced economically;

- Economic and political conditions in Argentina could change, such that the country risk profile is different to that which is currently assessed by relevant experts; and
- Covid or other pandemics result in delays and changes to activities, due to government requirements, impacts from government requirements, unavailability of people and equipment or sickness.

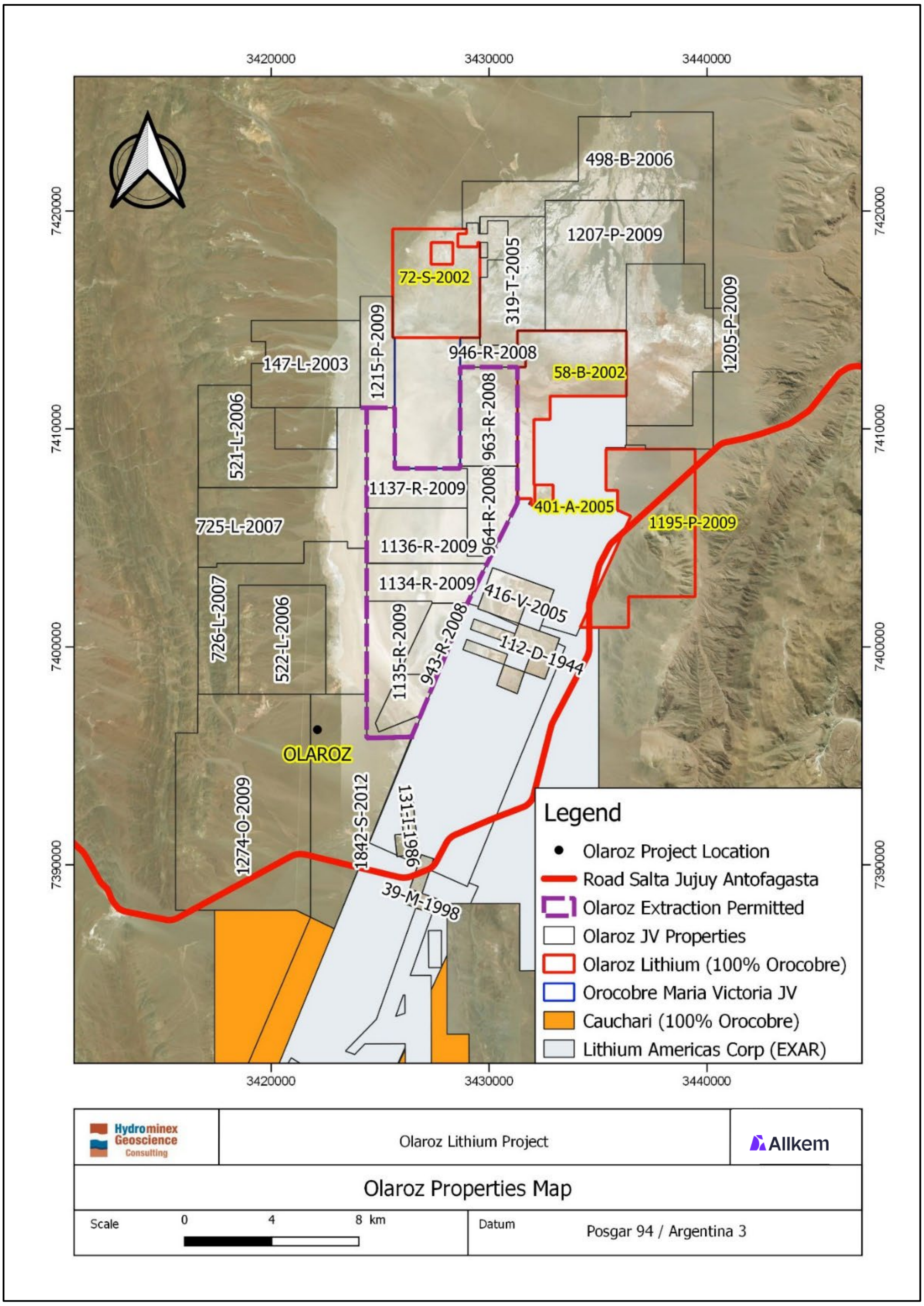


Figure 4.2: Location of the Olaroz properties and neighbouring properties

5 ACCESSIBILITY, CLIMATE, LOCAL RESOURCES, INFRASTRUCTURE AND PHYSIOGRAPHY

5.1 Accessibility, Local Resources and Infrastructure

The most straightforward route to access the Olaroz Project area is from the city of San Salvador de Jujuy. The route RN 9 follows northwest approximately 60 km to Purmamarca. From here the RN 52 road ascends steeply to the Puna Plateau and continues on from 150 km to the regional town of Susques. From Susques the international road to Chile continues to climb, before descending on the eastern side of the salar de Olaroz. This paved road continues around the southern end of Olaroz, crossing the divide with the Cauchari salar to the South. The entrance road to the Olaroz processing plant is reached by a gravel road (Route 70) that turns off the international road and continues north along the western side of the salar for 6 km. The entrance to the Olaroz Project is on the right, on the alluvial gravels that slope down to the salar.

An alternative way to reach the Olaroz Project is from Salta, which has an international airport and a range of hotels and services. To drive from Salta, one follows mostly paved Route 51 ~170 km northwest from Salta to the town of San Antonio de los Cobres, continuing on the gravel provincial highway Route 51 to the town of Olacapato, before continuing north along the west (Route 70) or east side (new alternative route) of the Cauchari salar, reaching the international road that leads to Chile. The gravel road (Route 70) to the Olaroz plant entry is a continuation of Route 70 on the western side of the Cauchari salar. From the road along the east of the Cauchari salar the turn off to Olaroz along Route 70 is 6.5 km to the west along the paved international road, in the direction of the Chilean border (Figure 5.1).

Both Jujuy and Salta have international airports with regular flights to Buenos Aires. The Olaroz Project has full infrastructure available including water, gas, and electricity. The Puna gas pipeline crosses to the north of Salar de Olaroz and Allkem has constructed a connection to this pipeline for the Olaroz Project. A railway line connecting northern Argentina to Chile passes along the southern end of Salar de Cauchari, approximately 60 kilometers to the south of the Olaroz Project site.

5.2 Local Population Centers and Accommodation

There are a number of local villages within approximately 50 kilometers of the Olaroz Project site. These include: Olaroz Chico (18 km north), Huancar (35 km east), Pastos Chicos (40 km southeast), El Toro (50 km north), Catua (40 km southwest), Puesto Sey (53 km southwest) and Olacapato 62 km south. The regional administration is located in the town of Susques (population ~2,000) some 45 km northeast of the Olaroz Project site. Susques has a regional hospital, petroleum and gas services, and a number of hotels. A year-round camp exists at the Olaroz Project site and provides all services and accommodations for the Olaroz Project operations.

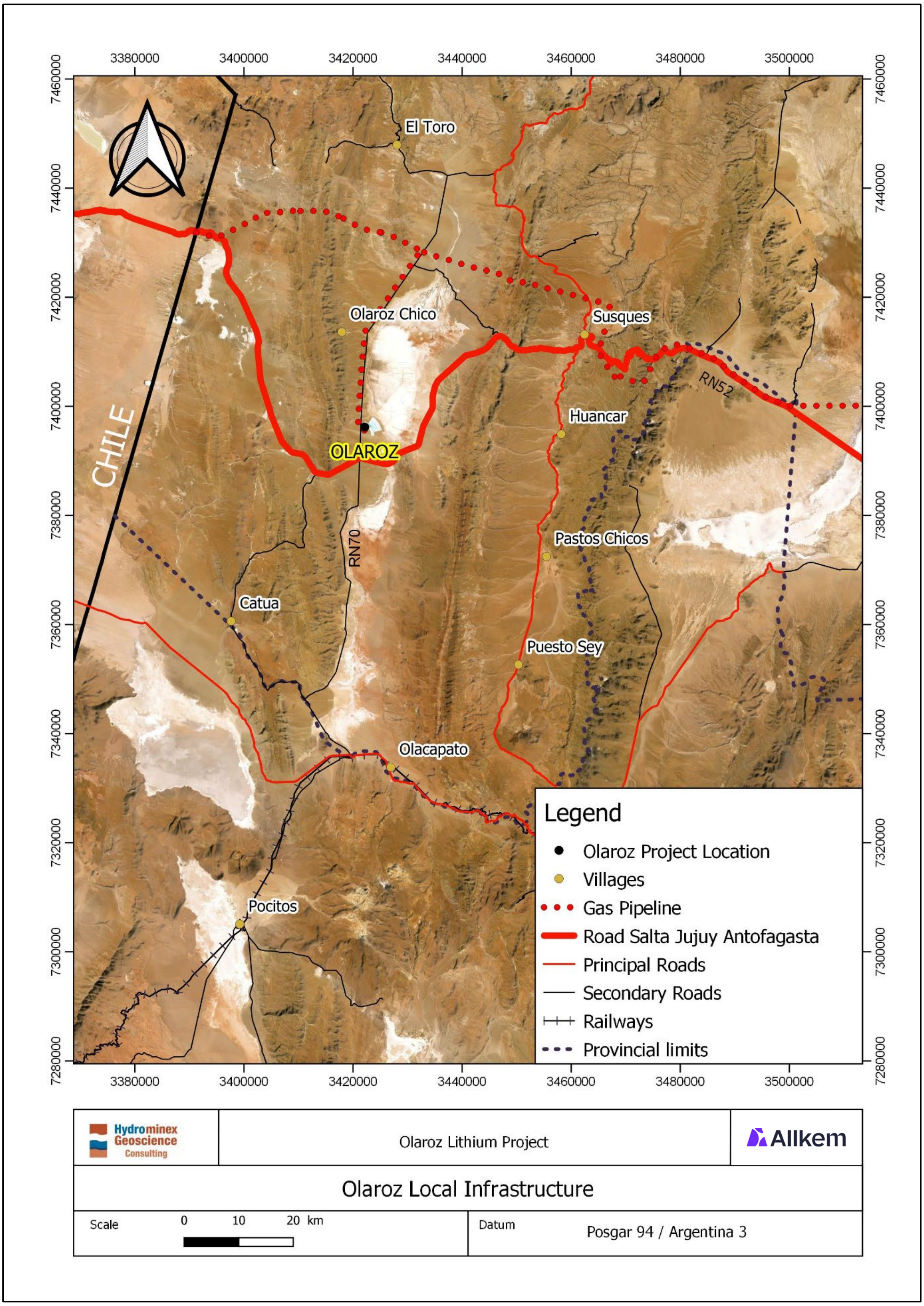


Figure 5.1:Olaroz Project location and local population centers

5.3 Physiography

The Altiplano-Puna is an elevated plateau within the central Andes (see Figure 5.1 above and Figure 4.1). The Puna covers part of the Argentinean provinces of Jujuy, Salta, Catamarca, La Rioja and Tucuman with an average elevation of 3,700 masl (Morlans, 1995; Kay et. al., 2008).

The Altiplano-Puna Volcanic Complex (APVC) is associated with numerous stratovolcanoes and calderas. Investigations have shown that the APVC is underlain by an extensive magma chamber at 4-8 km depth (de Silva et al., 2006).

The physiography of the region is characterized by generally north-south trending basins and ranges, with canyons cutting through the Western and Eastern Cordilleras. There are numerous volcanic centers in the Puna, particularly in the Western Cordillera, where volcanic cones are present along the border of Chile and Argentina.

Dry salt lakes (salars) in the Puna occur within many of the closed basins (see Figure 5.2 below), which have internal (endorheic) drainage. Inflow to these salars is from summer rainfall, surface water runoff and groundwater inflows. Discharge is though evaporation.

Physiographic observations regarding Salar de Olaroz include:

- The drainage divide between the Olaroz salar to the north and the Cauchari salar to the south is coincident with the international Hwy RN 52 crossing between these salars and continuing west to link Argentina to Chile at the Jama pass.
- The large Archibarca alluvial fan is present on the southwestern side of Salar de Olaroz and in part separates the Salar de Olaroz and Cauchari. There are a number of smaller alluvial fans along the western side of the Salar de Olaroz, with larger alluvial fans on the margins of the salar in the north. Alluvial fans are also developed further south in Salar de Cauchari.
- The Rio Rosario enters the Salar de Olaroz from the north and flows south towards the center of the Salar, only causing flooding in the salar in wetter years. This is the major freshwater flow into the Salar de Olaroz.
- The Rio Ola enters the Cauchari-Olaroz drainage basin from the west and flows through the Archibarca alluvial fan, infiltrating into the gravels of the alluvial fan.
- The Olaroz- Cauchari drainage basin covers some 6,000 km^2 with the nucleus of Salar de Olaroz covering approximately 160 km^2 as shown as zones I, II and III in Figure 7.2.
- The surface of the salar de Olaroz is essentially flat and comprised of several different types of salt crust, which reflect the different history of the salt crust.

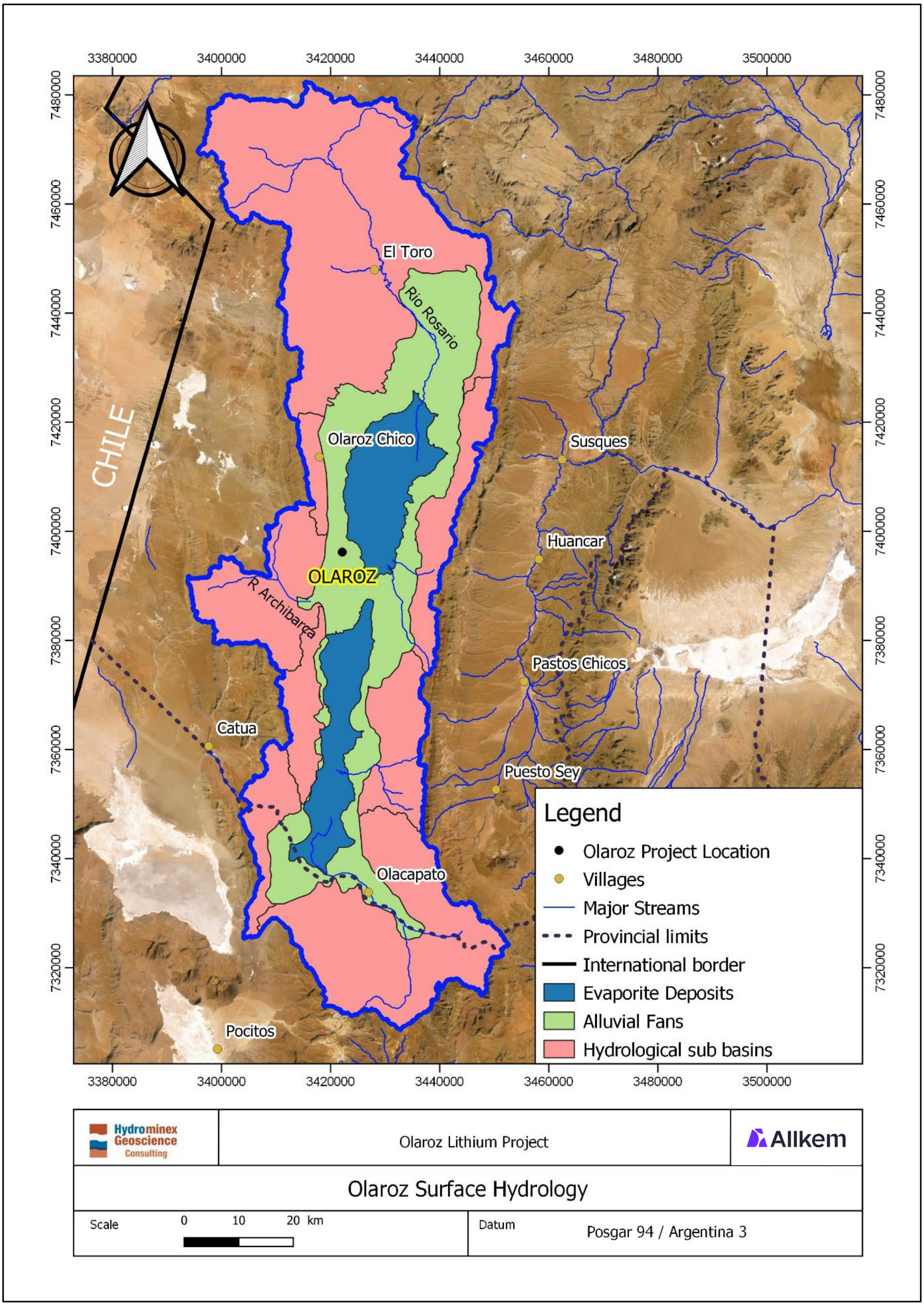


Figure 5.2: Basin hydrology with major streams and drainages

5.4 Climate

Introduction

The climate in the Olaroz Project area is severe and can be described as typical of a continental, cold, high-altitude desert, with resultant scarce vegetation. Daily temperature variations may exceed 25°C. Solar radiation is intense, especially during the summer months of October through March, leading to high evaporation rates. The rainy season is between the months of December to March. Occasional flooding can occur in the Salar during the wet season.

There are three weather stations operating for the Olaroz Project since 2012, with one station located in Salar de Cauchari and two stations located further north in Salar de Olaroz. The stations maintain a continuous record of temperature, atmospheric pressure and liquid precipitation, among other meteorological variables of interest. There is no continuous record of direct evaporation measurements, and therefore evaporation is calculated indirectly from other parameters.

In addition to these stations, the National Institute of Agricultural Technology INTA has historical monthly rainfall data in northwestern Argentina, for the period 1934-1990 (Bianchi, 1992), of which three stations (Susques, Sey and Olacapato) are located near the Cauchari-Olaroz hydrological basin.

The locations of the relevant weather stations for the Olaroz Project are shown in Figure 5.3 and Table 5.1 provides summary information for each of the stations.

Precipitation

The rainy season is between the months December and March when most of the annual rainfall occurs often in brief convective storms that originate from Amazonia to the northeast. The period between April and November is typically dry. Annual rainfall tends to increase towards the northeast, especially at lower elevations. Significant control on annual rainfall is exerted by ENSO (El Niño-Southern Oscillation) (Houston, 2006a) with significant yearly differences in rainfall linked to ENSO events. Figure 5.4 shows the average monthly rainfall data at the ponds monitoring site on the Olaroz Project and Figure 5.5 shows annual rainfall for relevant weather stations shown in Figure 5.3. The average annual precipitation is approximately 49.5 mm for the Olaroz Project site from 2015-2020. Figure 5.6 shows the long-term rainfall for weather stations in Figure 5.3 with actual or factored data.

Temperature

Temperature records are available from the Liming and Piletas stations since 2012. Average monthly temperature data are available from the Olacapato, Susques and Sey stations for the period between 1950 and 1990. Table 5.2 shows the average monthly temperature for the five stations in the Olaroz Project area, with temperatures varying from 1.2 to 11.1 degrees at the Piletas site. Figure 5.7 shows the average monthly temperature distribution throughout the year.

Evaporation

Various approaches have been carried out to determine the evaporation for Salar de Olaroz. Measurements for Salar de Olaroz include sampling and monitoring of fresh water and brine Class A evaporation pans since 2008 (Figure 5.3).

The pan evaporation data are plotted in Figure 5.8 and show that the maximum evaporation rates occur during October, November and December. During the summer months of January through March, a decrease in wind speed and increase in cloud cover tend to decrease the effective evaporation. The minimum evaporation takes place during the winter months, when lower temperatures have a direct impact on evaporation. The data also shows that the evaporation of brine is lower than freshwater with differences of 21% in winter months and up to 47% in the summer months.

Station	Easting Zone 3 Posgar 94	Northing Zone 3 Posgar 94	Elevation M asl	Period	Owner	Location	Frequency
Cauchari	*3425500*	*7374877*	*3918*	*2015-2020*	*OC*	*Argentina*	*Diario*
Coranzuli	3459000	7453684	4100	1972-1996	INTA	Argentina	Mensual
Cusi-Cusi	3451924	7531180	3930	1978-1990	INTA	Argentina	Mensual
La Quiaca	3534396	7557054	3492	1934-1990	SMN	Argentina	Mensual
Liming	*3426176*	*7402920*	*3904*	*2012-2020*	*OC*	*Argentina*	*Diario*
Metboros	3435630	7406343	3915	2010-2011	LAC	Argentina	Diario
Metsulfatera	3418421	7377459	3915	2010-2011	LAC	Argentina	Diario
Olacapato	3427142	7333569	3820	1950-1990	INTA	Argentina	Mensual
Piletas	*3422503*	*7396002*	*3942*	*2015-2018*	*OC*	*Argentina*	*Diario*
Rinconada	3484558	7520173	3950	1972-1996	INTA	Argentina	Mensual
Salar de Pocitos	3398548	7303853	3600	1950-1990	INTA	Argentina	Mensual
San Antonio de los Cobres	3466484	7320058	3775	1949-1990	INTA	Argentina	Mensual
Sey	3442302	7355790	3920	1973-1990	INTA	Argentina	Mensual
Susques	3463204	7411974	3675	1972-1996	INTA	Argentina	Mensual
Vaisala	342222013	7379986	3900	2010-2020	LAC	Argentina	Diario
Camar	3299434	7410812	2700	1975-2019	DGA	Chile	Diario
Paso Jama	3325456	7465028	4680	2016-2019	DGA	Chile	Diario
Paso Sico	3353273	7365648	4295	2016-2019	DGA	Chile	Diario
Socaire	3306888	7391046	3251	1975-2019	DGA	Chile	Diario
Talabre	3306698	7421187	3300	1975-2019	DGA	Chile	Diario

Table 5.1: Location of SdJ and surrounding weather stations

Figure 5.7 was prepared with PAN A Bis data from the Piletas (ponds) station, which has a composition of 70% freshwater and 30% brine (to prevent freezing in winter), which is the fluid composition most similar to freshwater used in the evaporation pan measurements.

The Piletas and Vaisala stations present absolute values of maximum evaporation in the area, given they are in the centre of the basin, where climatic conditions are more favourable for evaporation in the nucleus of the salar. The Olacapato station is at the south of the salar in an alluvial zone. For the water balance the potential evaporation from each sector of the basin has been calculated. The sectors are defined as lower alluvial and marginal domains (with similar sedimentological characteristics), salar nucleus and upper level alluvial sediments (coarser gravels). This information has been used to develop the water balance for the basin.

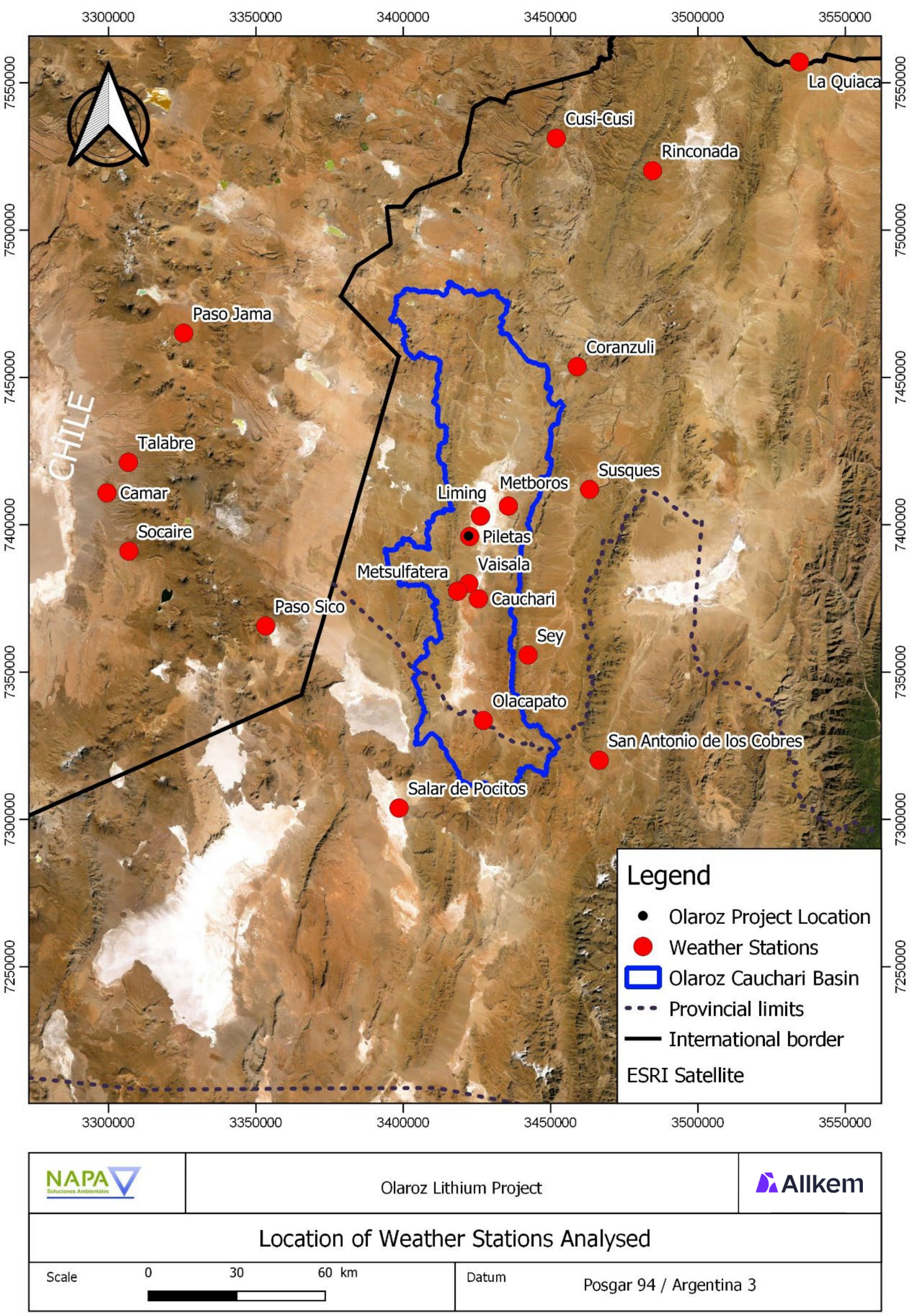


Figure 5.3: Location of weather stations in the vicinity Olaroz. The Liming, Piletas and Cauchari stations are operated by SdJ. Other stations include historical government stations

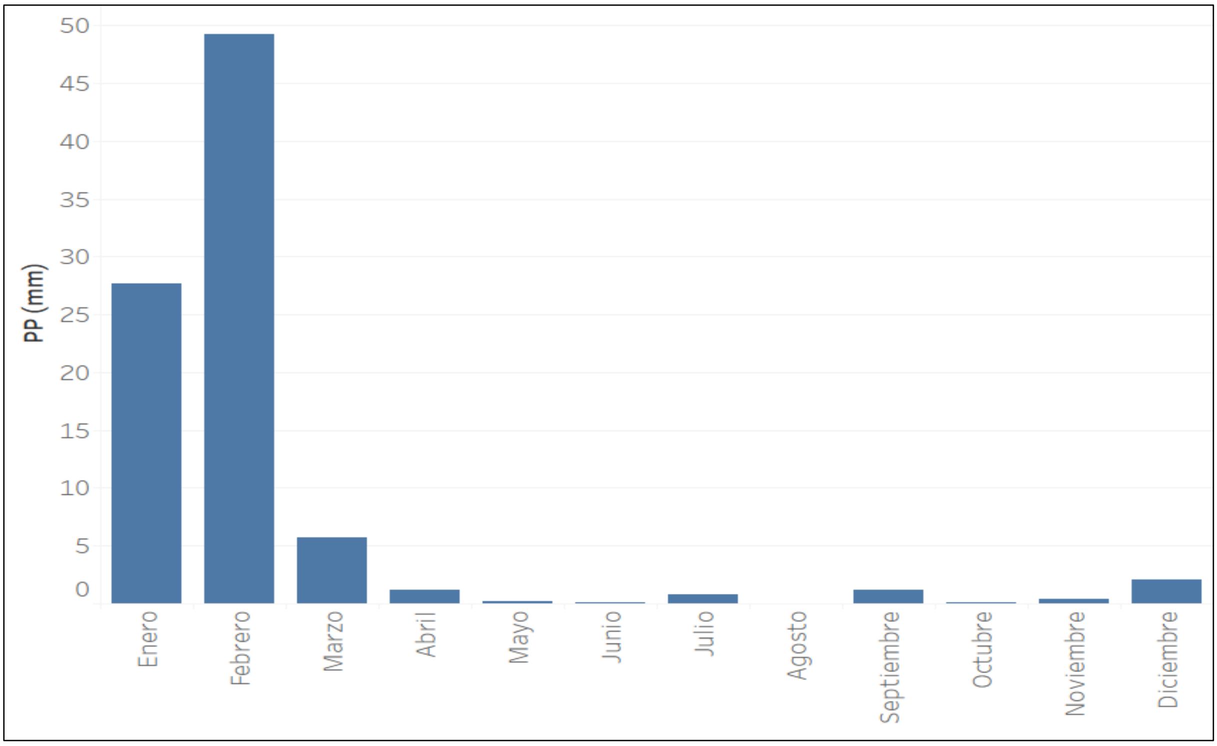


Figure 5.4: Average monthly rainfall, Piletas (ponds) weather station from 2015 – 2020

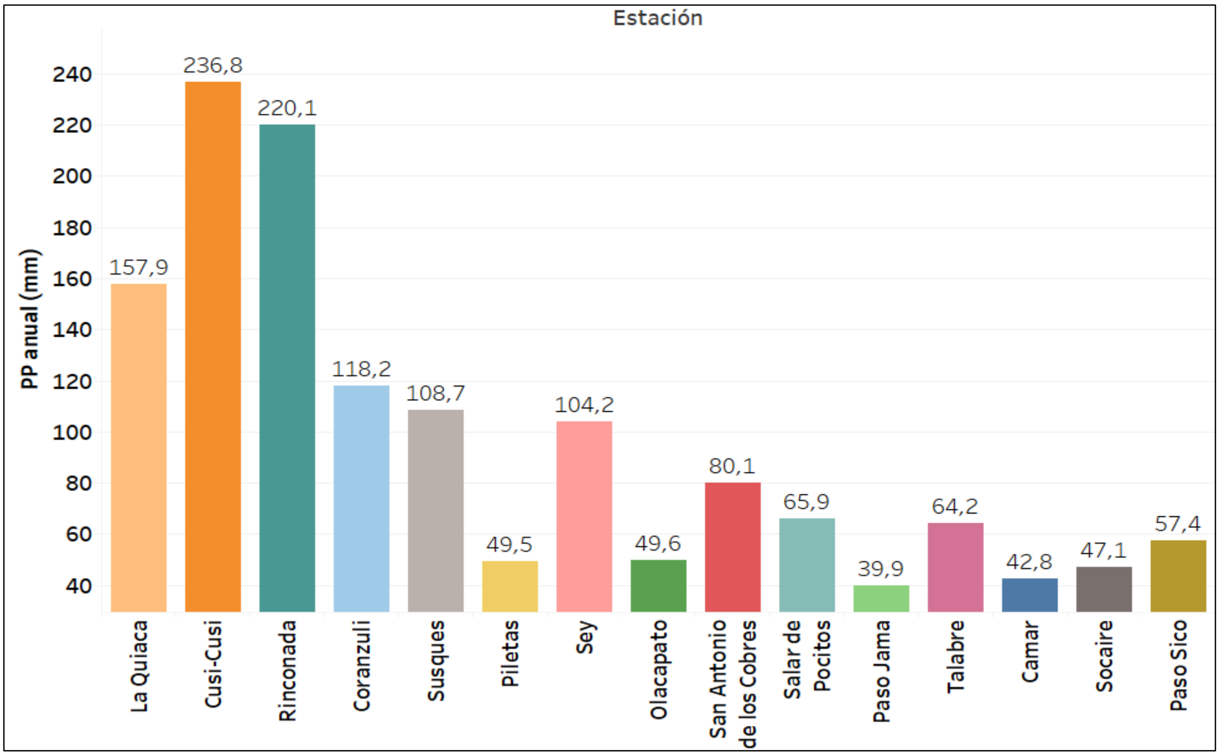


Figure 5.5: Average annual rainfall (mm) at stations across the Puna region in Argentina and Chile (after NAPA, 2021)

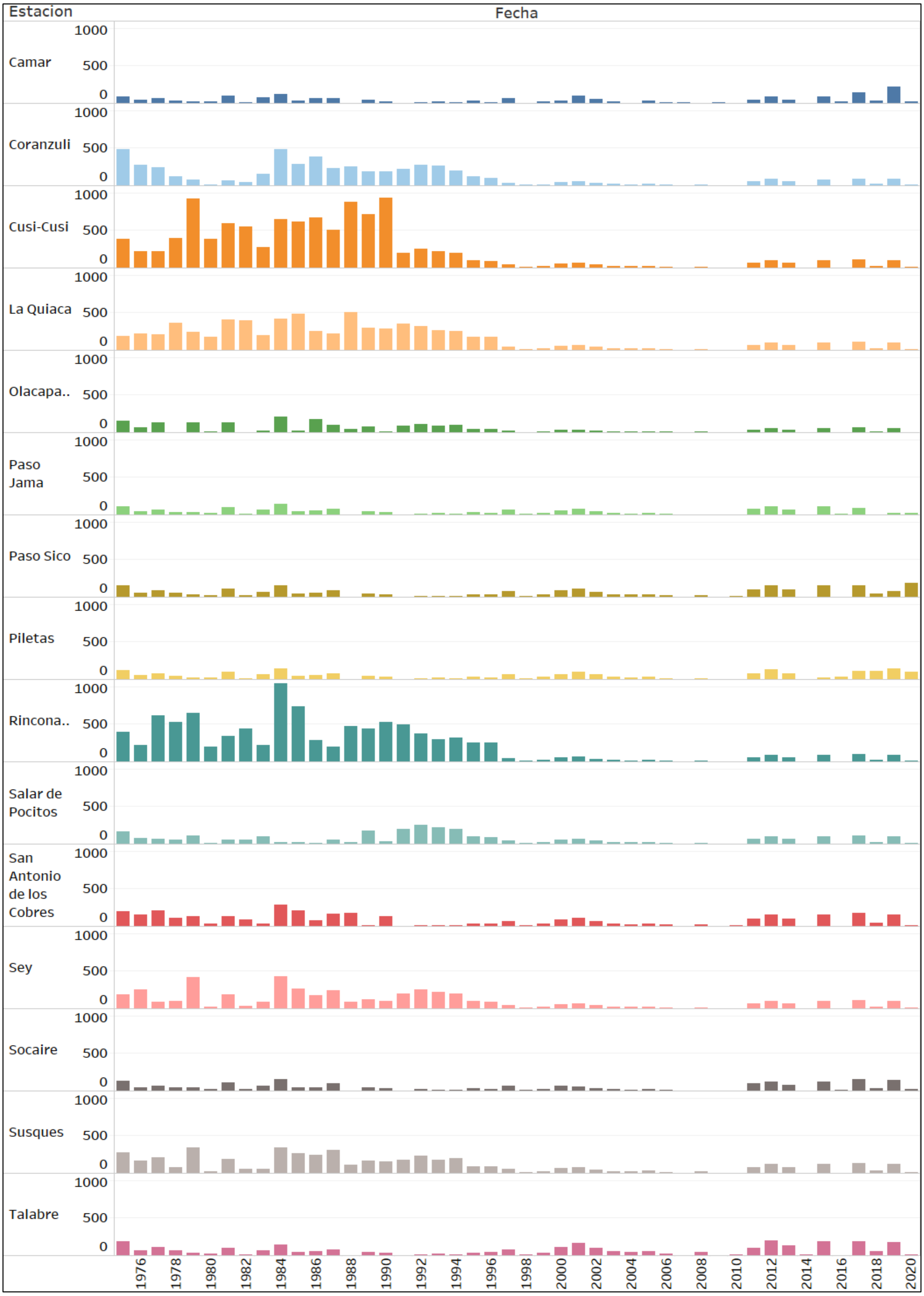


Figure 5.6:Long term rainfall at the weather stations shown in Figure 5.3 (after NAPA, 2021)

Temperature °C												
Station	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Piletas	11.12	10.60	10.03	7.26	3.83	1.90	1.22	2.82	5.71	7.08	8.36	9.77
Liming	10.69	10.36	9.33	6.19	2.56	0.48	-0.26	1.69	4.58	6.88	8.41	10.73
Olacapato	10.80	10.70	9.90	7.50	4.20	2.20	1.60	3.90	5.90	8.20	9.90	10.60
Sey	10.20	10.10	9.40	7.00	3.70	1.80	1.30	3.40	5.40	7.60	9.20	9.90
Susques	11.30	11.20	10.50	8.10	4.90	3.00	2.50	4.60	6.60	8.90	10.40	11.10

Table 5.2: Average daily temperature data

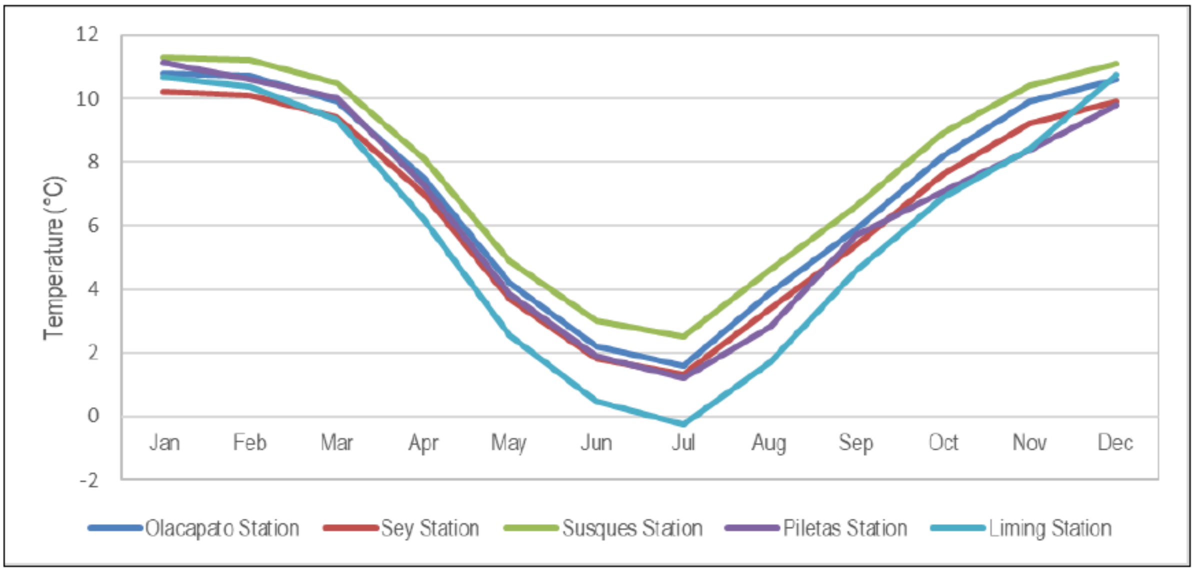


Figure 5.7: The average monthly temperature at different weather stations (after Flow Solutions, 2019)

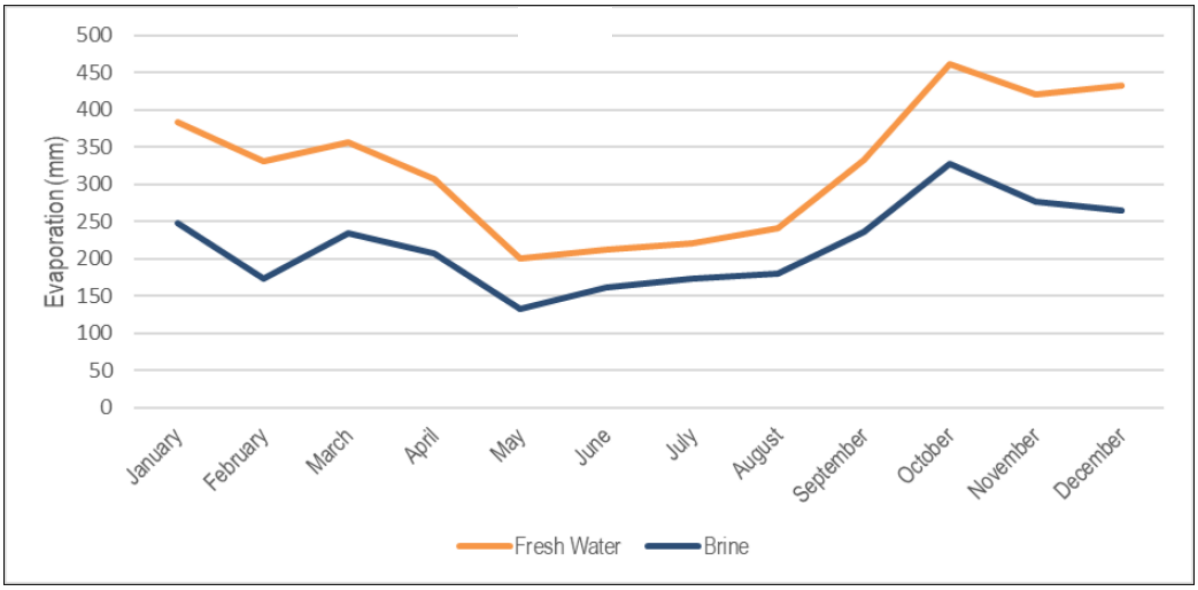


Figure 5.8: Average monthly evaporation (mm/month) Measured from evaporation pan data at the Piletas (ponds) stations (after Flow Solutions, 2019)

Evaporation mm/year													
Density (g/cm^3)	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Total**
1.000	383	331	356	307	201	213	221	242	332	461	421	433	**3,900**
1.198	248	173	234	208	133	162	173	180	236	327	276	265	**2,614**

Table 5.3: Class A freshwater and brine pan evaporation data from Olaroz

Wind

Strong winds are frequent in the Puna, reaching speeds of up to 80 km/hr during warm periods in the dry season. During summer, the wind is generally pronounced after midday, usually calming during the night. During this season, the winds are warm to cool. During winter wind velocities are generally higher and wind is more frequent, with westerlies the predominant wind direction.

Vegetation

Due to the extreme weather conditions in the region, the predominant vegetation is of the high-altitude xerophytic type adapted to high levels of solar radiation, winds and severe cold. The vegetation is dominated by woody herbs of low height from 0.40 - 1.5 m, grasses, and cushion plants. With high salinity on its surface, the nucleus of the salar is devoid of vegetation.

In compliance with local regulations, SdJ undertakes ongoing environmental monitoring. The different vegetation areas are summarized below:

- Bushy steppes
- Mixed steppes
- Salar

Fauna is adapted to the extreme living conditions of high aridity, intense sunlight and very low nightly temperatures. Many animals are nocturnal or have acquired certain physiological features and behaviours that allow them to survive in the harsh environment. The most significant mammals in the region are the vicuña (Vicugna Vicugna) and llama (Lama Glama - which are domesticated) cameloid species, foxes (Dusicyon, Lycalopex) are present and prey on small rodents such as the mole (Oculto or Tuco-Tuco - Ctenomys Opimus) and the Puna mouse (Auliscomys Sublimis). The Olaroz Project is located within the Reserva Provincial de Fauna y Flora Olaroz-Cauchari (a regional flora and fauna reserve) and vicuñas are often seen in the vicinity of the Olaroz Project or within the Olaroz Project area.

6 HISTORY

6.1 Orocobre (now Allkem) pitting and drilling program 2008

Orocobre/Allkem undertook pit sampling of the Olaroz salar on a variable grid between March and May 2008, to evaluate lithium concentrations and the superficial salar geology. The initial sampling included a total of 62 brine samples from 60 pits. The results of the sampling were positive and justified the development of exploration drill holes to define a resource on the Olaroz Project.

Allkem undertook a drilling program between 4 September and 2 December 2008 using Falcon Drilling. Twenty-two HQ3 diamond core holes were drilled, totalling 1496.3 m. Drillhole locations were based on handheld GPS readings and their location is shown in Figure 10.1, together with other later drill holes. The initial 16 HQ3 diamond drill holes (core diameter 61 mm) in the program were drilled on a variable grid, to an average depth of 60 m. Two holes in this program were drilled to greater depths of 125.4 and 199 m. Six further HQ3 holes were drilled as monitoring wells for the hydrogeological test work.

Diamond drilling was carried out using triple tubes. However, core recoveries were low, with an average recovery of only 44%. The poor core recovery was attributed to the unconsolidated nature of the salar deposits and loss of the sand and other unconsolidated layers during drilling. Lithological units encountered include sand, silt, clay, halite and ulexite (borate).

Geophysical logs, self-potential, short and long resistivity, and natural gamma were run in the 7 holes which had been cased to significant depths. The logging was limited to the upper sections of these holes because of fine sediment filling the basal sections through the slotted casing. Geophysical logs, together with geological logs of the recovered material provided the basis of the geological interpretation. Since the geophysical logs did not extend to the full depth of most holes, the interpretation of the deeper lithologies relied solely upon the core logging.

The drill logs were interpreted to show a near-surface halite layer, termed Zone 1. Beneath the halite unit zone 2 consisted of mixed clays, sands and silts down to around 45-60 m below the salar surface. For holes deeper than 60 m, the underlying units were assigned to Zone 3, which showed a significant change being more consolidated, with higher clay content.

The core drill holes were reamed out with a tricone bit to a diameter of 165 mm (6 ½ inches) and a well screen of 100 mm (4”) diameter PVC was installed from 0.5 m below surface to the total depth of the hole, with 2-3 cm long slots. Subsequent to completion of the wells, they were developed by airlifting to establish data on potential yields, to ensure that all drilling fluid and cuttings were removed, and the brine bearing zones were in good hydraulic connection with the test well.

During airlift development and subsequent testing, airlift flow rates were monitored with a V notch weir, or more normally by filling a known volume. The airlift flow data established wells with high yields and several with low yields. This information was used to plan the subsequent pumping tests. Brine sampling was undertaken by Company staff in December 2008, with re-sampling of some wells during February 2009.

At three of the test wells, two additional holes drilled were constructed as observation wells for pumping tests carried out by Company staff. Pump testing consisted of three constant rate drawdown tests of between 5.5 and 24 hours duration, and five pumped well recovery tests. Airlift yields of up to 4.9 l/s were achieved. Australian Groundwater Consultants (2009) analyzed the results, which indicated permeability ranging from 0.5-5 m/d, and specific yield from 0.02-0.26.

6.2 Allkem maiden resource 2009

An initial resource estimate was undertaken by Geos Mining (2009). The estimate was based on only two interpreted horizontal Zones: Zone1 with an average thickness of 11 m and Zone 2 with an average thickness of 54 m. Values of specific yield were assigned to these zones based on observed field characteristics and literature values. Average values of 0.22 were used for sand lithologies, 0.05 for halite and 0.01 for clays. A lithology-thickness weighted specific yield was calculated for each hole for the estimate. Assays used were based on sampling conducted in 2008 and 2009.

The product of equivalent brine thickness and the average concentration in each hole provided an estimate of tonnage for each drillhole site. These values were then contoured using the minimum curvature method and the total volume calculated. These were then combined with the average lithium concentration of 787 mg/L to define the contained maiden lithium resource.

6.3 Preliminary Economic Assessment 2009

An initial scoping study, equivalent to a Preliminary Economic Assessment study under NI 43-101, was carried out by Allkem in May 2009, following completion of the drilling, testing and the initial resource estimate. This was undertaken when Allkem was only listed on the Australian Securities Exchange and subject to different reporting regulations and terminology.

The study was an internal Allkem exercise, summarizing the work undertaken, the potential process route, the financial assumptions and costs for capital items. Inputs into the study were provided by staff and consultants with experience on similar salar projects. The objective of the study was to ascertain if the Olaroz Project had economic potential and set the scope for further investigations. The positive outcome of the scoping study led to planning of additional drilling and test work for the Olaroz Project as part of a definitive feasibility study undertaken in 2010/11.

The Preliminary Economic Assessment was preliminary in nature, included Inferred Mineral Resources that by definition are considered too speculative geologically to have the economic considerations applied to them that would enable them to be categorized as mineral reserves, and there was no certainty the preliminary assessment would be realized.

6.4 Feasibility Study 2011

Allkem undertook an extensive program of geophysics and drilling in 2010 and 2011 to deliver the Olaroz Project feasibility study. This involved extensive field work, laboratory process testing and updated resource estimation and engineering design.

6.4.1 Satellite image interpretation

Satellite images were interpreted to assist with the surface geological mapping in the vicinity of the salar. Satellite imagery was also used to define different geomorphic zones on the salar which have different evaporation rate characteristics (evaporation zonation). Satellite imagery also provided information regarding the surface hydrology and freshwater inflows into the salar.

6.4.2 Surface geophysics

Surface geophysics was conducted by Contractor Wellfield Services to evaluate the geometry of the basin and brine body. They undertook measurement of three gravity lines and four AMT lines across the salar and in the area surrounding the salar. The gravity data was modelled to assess the depth of the basin.

The Salar de Olaroz is underlain by a deep basin (gravity data suggests up to 1.2 km deep) bounded by a pair of N-S reverse faults that thrust Cretaceous and Ordovician basement rocks over the basin margins. The basin is infilled with Cenozoic sediments. Pliocene to Recent sediments form a multi-layered aquifer that acts as a host to the brine. The brine contains elevated levels of dissolved elements in solution that are of economic interest: lithium, potassium and boron. Whilst the ultimate origin of the lithium and other species is not fully known, they are likely to be associated with the Altiplano-Puna magma body that underlies the whole region.

6.4.3 Drilling

- Sonic drilling consisted of twenty wells to 54 m depth to investigate the geology and obtain core and brine samples;
- Triple tube diamond drilling consisted of six wells to 197 m depth to investigate the geology and obtain core and brine samples;
- Core logging was undertaken for geology description and selection of samples for testing for porosity parameters;
- Geophysical logging was undertaken to support lithological characterization, correlation and porosity evaluation;
- Brine sampling and analysis was undertaken to determine brine chemistry and lithium concentrations,
- Pumping tests of up to five months duration were undertaken to investigate flow conditions, determine aquifer properties, and to confirm the ability of wells to produce stable grades, and
- Off-salar well drilling, water sampling and monitoring was undertaken to assist with development of the water balance and production forecasting for brine extraction.

6.5 Agreement with Toyota Tyusho

The Olaroz Lithium Facility was built in partnership with Japanese trading giant Toyota Tsusho Corporation (TTC) and the mining investment company owned by the provincial Government of Jujuy, Jujuy Energia y Mineria Sociedad del Estado (JEMSE).

The partnership with TTC began in January 2010, through the execution of a definitive joint venture agreement to develop the Olaroz Project. This agreement provided a comprehensive financing plan structured to secure TTC's direct participation in, and support for, funding the planned development at Olaroz. In turn, TTC's participation in the Olaroz Project was through a 25% equity stake at Olaroz Project level. In a business where product quality is paramount, TTC's investment provided a strong endorsement of the quality of the Olaroz resource and the high purity battery grade product produced at the Olaroz Lithium Facility.

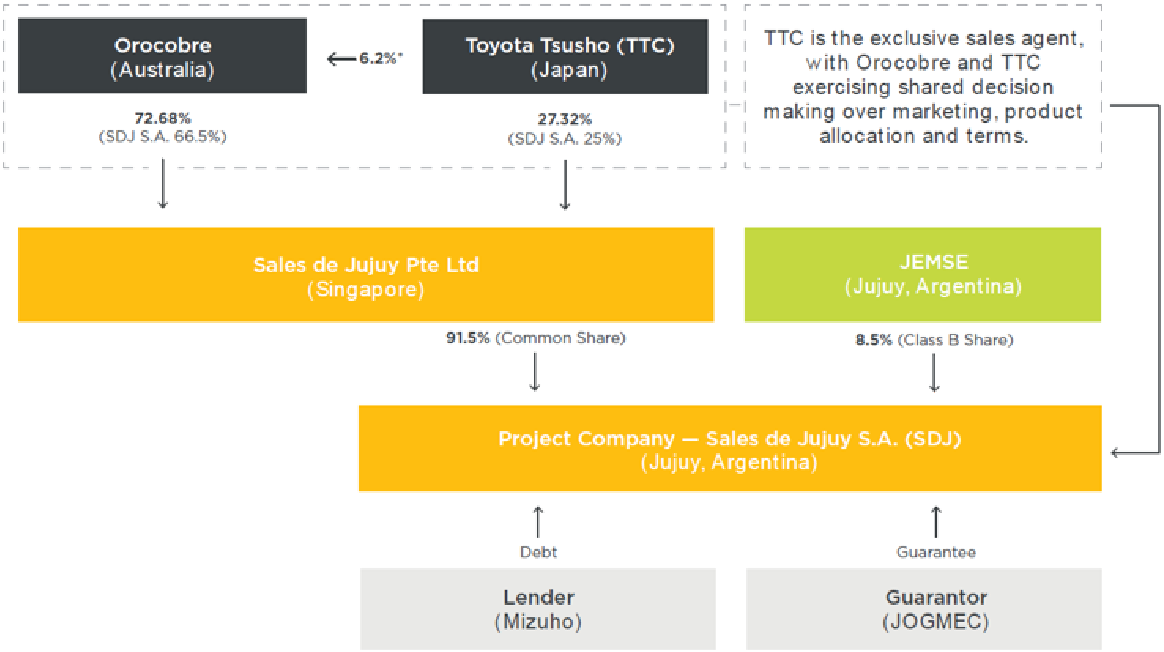


Figure 6.1: Allkem ownership and Olaroz Project structure

6.6 Agreement with JEMSE

JEMSE became a Olaroz Project partner in June 2012. JEMSE's participation in the Olaroz Project is held through an 8.5% equity stake at Olaroz Project level which provides the Provincial Government with a direct interest in the development of the Olaroz Lithium Facility.

The Olaroz Lithium Facility is managed through the operating company, Sales de Jujuy S.A. The shareholders are Sales de Jujuy Pte. Ltd. and JEMSE. The corporate structure is shown above in Figure 6.1.

7 GEOLOGICAL SETTING AND MINERALIZATION

7.1 Regional Geology

The Olaroz salar is located in the elevated Altiplano-Puna plateau of the Central Andes (Allmendinger et al., 1997). The Puna plateau of north-western Argentina comprises a series of dominantly NNW to NNE trending reverse fault-bounded ranges up to 5000-6000 m high, with intervening internally drained basins with an average elevation of 3700 m. The plateau is approximately 300 km wide at the latitude of the Olaroz Project area and is bounded to the west by the Central Volcanic Zone magmatic arc of the Western Cordillera, and to the east by the reverse faulted Eastern Cordillera (Jordan et al., 1983). This elevated plateau is a continental hinterland basin that has developed behind the main magmatic arc since the late Oligocene approximately 28 Ma (B. Carrapa et al., 2005; DeCelles and Horton, 2003; Horton, 2012; Jordan et al., 1983). The distribution of Precambrian to recent salar sediments is shown in Figure 7.1.

Uplift and exhumation of the hinterland commenced in the late Oligocene when deformation was transferred from the west to the east towards the South American craton, compartmentalizing the former foreland region of the arc into reverse fault-bounded ranges and intervening internally drained basins, and transferring foreland sedimentation further east to what is today the Eastern Cordillera (Bosio et al., 2010; Carrapa et al., 2005; Coutand et al., 2001, 2006; Gorustovich et al., 2011).

Timing of deformation and exhumation of each basement range in the hinterland appears to have been controlled by local structural or volcanic conditions (Alonso, 1992; Segerstrom and Turner, 1972; Vandervoort, 1993). Four main phases of deformation have been recognised: D1 28-25 Ma, D2 20-17 Ma, D3 13-9 Ma, and D4 5-2 Ma (Carrapa et al., 2005). Rapid uplift and exhumation of the hinterland since the mid Miocene may be related to mantle delamination (Allmendinger et al., 1997; DeCelles et al., 2015; Kay and Kay, 1993; Kay et al., 1994; Wang et al., 2015), with the plateau reaching up to 2500 m by 10 Ma, and 3500 m by 6 Ma (Garzione et al., 2008).

During the late Oligocene to middle Miocene continental red bed sediments approximately 1-6 km thick were deposited in the isolated, internal drained depocenters separated by mountain ranges within the hinterland, bounded in turn by the major watersheds of the Cordilleras to the west and east (Alonso, 1992; Boll and Hernández, 1986; B. Carrapa et al., 2005; Coutand et al., 2001; DeCelles et al., 2015; Gorustovich et al., 2011; Jordan and Alonso, 1987). Sedimentation in the basins consisted of alluvial fans formed from the uplifted ranges with progressively finer fluvial sedimentation and lacustrine sediments deposited towards the low energy centers of the basins.

Deformation in the mid to late Miocene, D3 13-9 Ma (Carrapa et al., 2005), established significant topography in the Eastern Cordillera (Deeken et al., 2006), which created the establishment of humid conditions along the eastern Puna margin and a sustained arid to hyper-arid climate within the plateau itself (Alonso et al., 2006).

During the late Miocene to Pliocene most tectonic deformation was transferred further east to the sub-Andean Santa Barbara thrust and fold belt (Echavarria et al., 2003; Jordán et al., 1983). However, uplift and exhumation related to mantle delamination

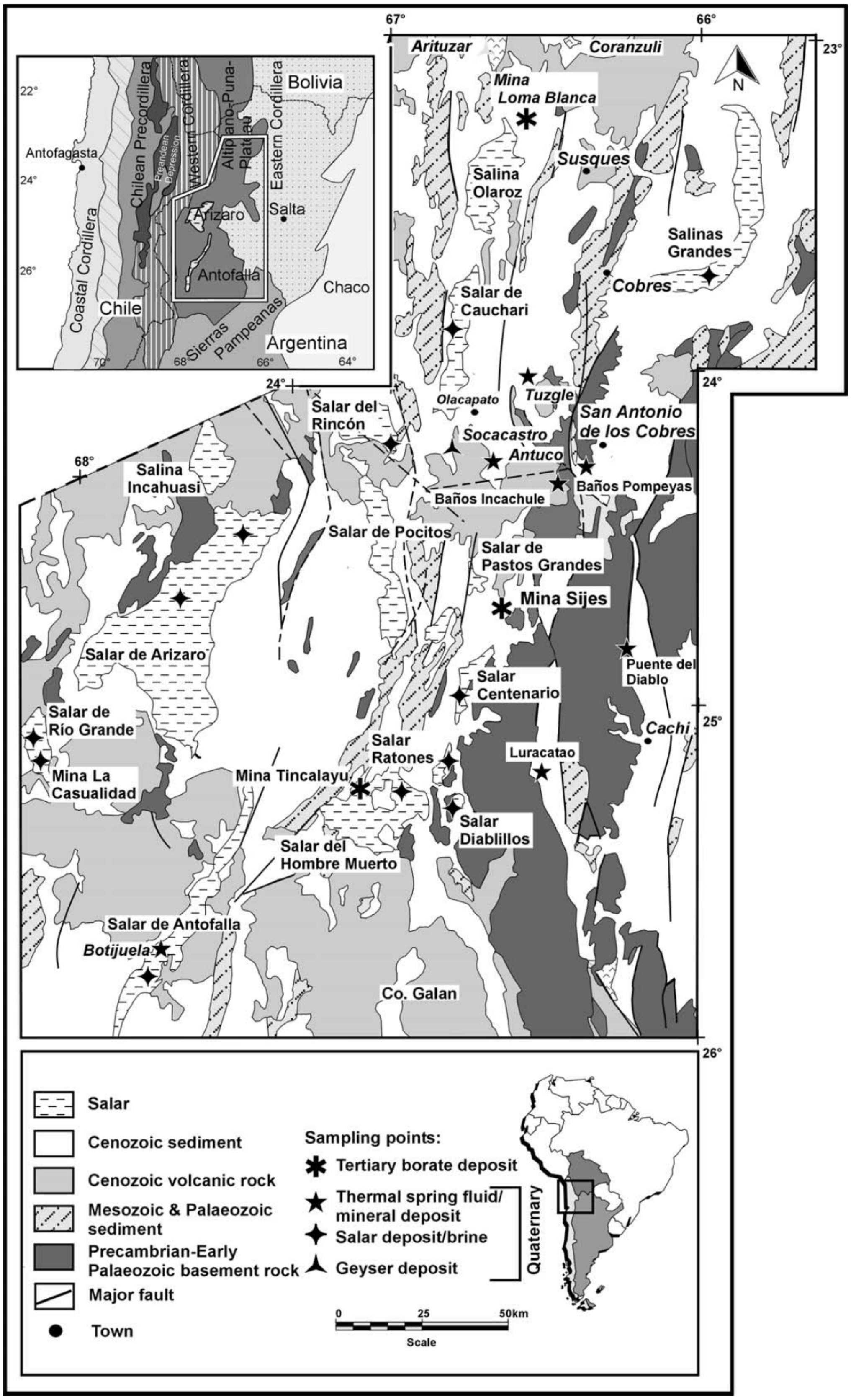


Figure 7.1: Simplified regional geology map (from Kasemann et al., 2004)

continued during this time and another 1-5 km of red bed sediments have accumulated in the hinterland basins in the last 8 Myr (Alonso, 1992; Boll and Hernández, 1986; Coutand et al., 2001; DeCelles et al., 2015)

High evaporation together with reduced precipitation has led to the deposition of evaporites in many of the Puna basins since 15 Ma, with borate deposition occurring for the past 8 Myr (Alonso et al., 1991). Precipitation of salts and evaporites has occurred in the center of basins (Figure 7.2) where evaporation is the only means of water escaping from the hydrological system. Evaporite minerals including halite (NaCl), gypsum (CaSO4.2H2O) and ulexite (B5O9CaNa.8H2O) occur disseminated within clastic sequences in the salar basins and as discrete evaporite beds. In some mature salars, such as the Hombre Muerto salar, very thick halite sequences up to 900 m have also formed (Vinante and Alonso, 2006).

Several Miocene-Pliocene volcanic centers, known as the Altiplano-Puna Volcanic Complex (De Silva, 1989), cross the plateau along NW-SE crustal megafractures (Allmendinger et al., 1983, 1997; Chernicoff et al., 2002; Riller et al., 2001). It has been suggested that the Miocene-Pliocene volcanism, particularly tuffs and ignimbrites, are the source of lithium, potassium, and boron, which is released into the salar basins (Figure 7.1) from hot springs leaching these elements from the volcanic sequences (Godfrey et al., 2013; Risacher and Fritz, 2009).

Large changes in moisture availability also occurred on ~100 ka (eccentricity) cycles, synchronous with global glacial cycles. This is most clearly observed in drill cores from Lake Titicaca that record advances of glaciers in the Eastern Cordillera of the Andes and positive water balance in the lake coincident with global glacial stages, whereas glacial retreat and major lake-level decline was coincident with global interglacial periods (Fritz et al., 2007). In contrast, the tropical Andes north of the equator were cold and dry, with low lake levels, during glacial stages and wet and warm in the interglacial stages (Torres et al., 2013). The global glacial stages apparently were also the wettest periods in the western Amazon (Cheng et al., 2013).

In their speleothem record, Cheng et al. (2013) found that the highest d18O values of the last 250 ka occurred during the mid-Holocene, implying that this was the interval of lowest precipitation over that period. In the Lake Titicaca drill core records, based on the abundance of saline diatom taxa and calcium carbonate, earlier interglacial periods were more saline than the Holocene and based on unconformities observed in seismic data (D'Agostino et al., 2002), lake levels were far lower during Marine Isotope Stage 5 than during the mid-Holocene. These low lake levels and highly elevated salinities are a result of negative water balance for a sustained period, requiring a combination of low precipitation and high evaporation, conditions that dropped lake-level below its outlet and caused the gradual build-up of dissolved solids (Cross et al., 2000; Fritz et al., 2007). The greater extremes of salinity and lake levels relative to the mid Holocene could reflect more extreme aridity, but more likely reflects longer-lasting aridity in the former period relative to the latter.

7.2 Structural Setting

The Olaroz basin is a major north-south trending basin, which together with the Cauchari basin as the southern continuation, has a north south extent of approximately 170 km. The basin is approximately 35 km wide in the Olaroz section. The basin is bounded by Ordovician metasediments and younger sediments, including extensive Tertiary terrestrial sediments, that are present in bands along the eastern and western margins of the basin (Figure 7.2). These units are superimposed by a series of thrusts, trending north-south, that have generated the mountain ranges bounding the salars, with the salars subsiding relative to the uplifted mountain ranges. The younger lithologies are generally closest towards the salar. The Olaroz salar has been confirmed by gravity geophysics and drilling to extend to greater than 1 km deep, with the deepest hole to date drilled to 1400 m, to confirm the basin stratigraphy. The salar basin has subsided in response to uplift of the surrounding ranges, with normal faulting likely to control the basin subsidence in a consistent orientation through the basin. The structural control of basin development has resulted in consistent patterns of sedimentation in the basin related to uplift and erosion.

7.3 Local Geology

The deposits of the Olaroz - Cauchari basin consist of Cenozoic age sediments with a thickness greater than 1,000 m in some sectors, surrounded by two main fault systems oriented N-S, that affect the Ordovician and Cretaceous basement.

During much of the Miocene, the basin was slowly filled by coarse-grained alluvial fans and sediments from the erosion of mountain ranges. Alluvial fill interdigitates with sediments that entered the basin from the deltaic fluvial system of the Rosario River to the north or from alluvial fan systems located on the east and west flanks of the Olaroz - Cauchari basin. The Rosario River system is more extensive compared to the alluvial fan systems, covering approximately a 2,000 km^2 catchment area to the north. The best developed active alluvial fan system is the Archibarca fan, which originates in the extreme west of the basin and has a catchment area of approximately 1,200 km^2.

As the deposition space in the basin narrowed, the sedimentary sequences were reworked, and the sediments became progressively finer higher up in the sequence. During the Pliocene, different sedimentary architectures such as river flats or alluvial fans can be seen, which give rise to predominantly sandy units. With a progressively more arid climate during this period, evaporitic deposits appeared, with abundant halite. This unit is probably of Pleistocene age, and a continuation towards the south, into the Cauchari salt lake, is observed, which suggests both sub-basins (Olaroz and Cauchari) operate hydrologically as a single entity.

The halite units suggest a continuous subsidence in the centre of the basin, linked to variable climatic conditions. Units are developed where mainly clayey sediments dominate, although it is common to observe intercalations of sandy layers and silty sheets and halite layers that would indicate a change in lake facies to fluvial facies, probably linked to the succession of different energy episodes in the Basin. The main source of sedimentation appears to have been the Río Rosario watershed to the north. However, in the middle sector of the basin it is observed that during the formation of the clayey and saline unit sediment began to be supplied into the southwestern part of the salar from the Archibarca sub-basin. The upper layer of the sedimentary sequence is predominantly clayey and silty, with intercalations of sand and carbonate layers. In addition, it is common to find levels of halite and ulexite intercalated.

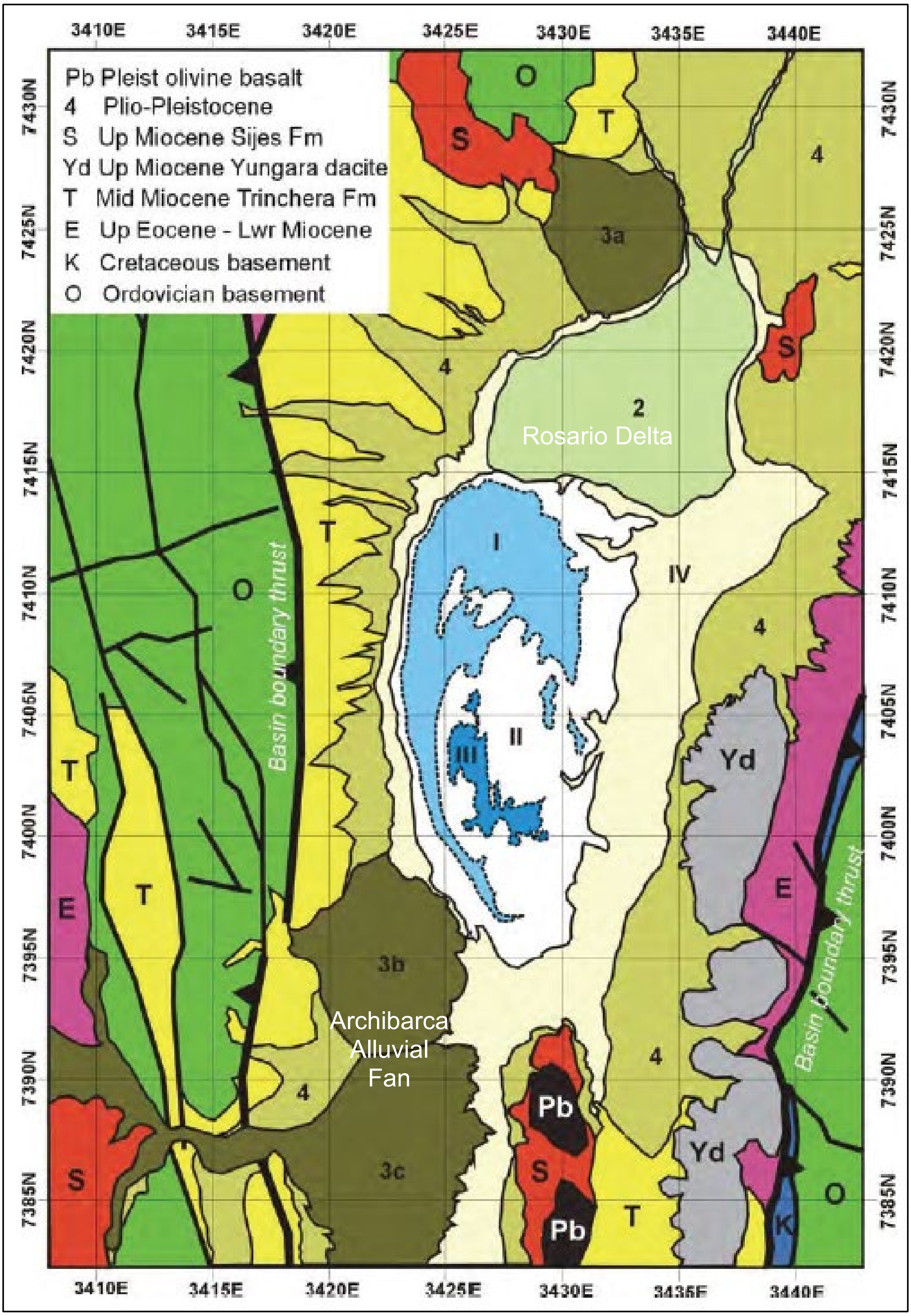


Figure 7.2: Geological map of the Olaroz area, based in part on mapping by Segemar

Age period		Ma	Rock types	Geological environment	Tectonic events	1:250,000 Map Sheet	
						Susques (2366-III)	San Martin (23664)
Quaternary	Holocene	0.01	Alluvial deposits, salars	Closed basins, salars	Post Quechua deformation	Salar deposits, lacustine, colluvial and alluvial sediments (40-44)	Salar deposits, lacustine, colluvial and alluvial sediments (25c-30)
	Pleistocene	2.6	Alluvial, colluvial, lacustrine , ignimbrites	Closed basins, fan deposits, volcanic centres	NE-SW shortening (from 0.2 Ma) due to strike-slip faulting continuing to present day	Tuzgle ignimbrite (38-39)	Alluvial and glacial deposits (5a, 25b, 26)
Neogene	Pliocene	5.3	Continental sediments +/- ignimbrites	Some volcanic complexes developed in continental sediments	Major volcanic centres and calderas 8-6 Ma	Jama volcanic rocks (36-37). Andesite, dacite lavas, ignimbrites; Atana ignimbrite	Malmar, Uquia and Jujuy Formations. Continental sediments - sandstone, conglomerate +/- mudstone (19, 22-24)
	Miocene		Andesitic to dacitic volcanics	Volcanic complexes in continental sediments		Volcanic complexes (35)	Formations Oran (16 Ma - 0.25 Ma), Callegua, Formation Agua Negra. Continental sandstones, with clay interbeds (19, 20-21)
			Ignimbrites			Coyaguayma & Casabindo dacite Ignimbrites (33 & 34)	
			Continental sediments & tuffs		Start of thrusting, with WNW-ESE directed thrusting from 13-4 Ma	Sijes Formation (32) ~7-6.5 Ma sandstones, mudstones and tuffs	
			Continental sediments, tuffs, volcanic breccias		End of Quechua phase event finished by 9-15 Ma, with associated folding	Chimpa volcanic complex (31) andesites & dacites, lavas/ignimbrites. Pastos Chicos Fm ~10-7 Ma with unnamed tuff 9.5.	
			Dacite domes, pyroclastics, intrusives			Yungara dacite domes (30) & subvolcanics (SE side Olaroz)	
			Rhyolitic, dacitic volcanic complexes, continental sediments			Volcanic complexes (23-29), Cerro Morado, San Pedro, Pairique, Cerro Bayo and Aguiliri, Pucara Formation. Andesite to dacite lavas, domes and ignimbrites. Susques Ignimbrite ~10 Ma	
			Continental sediments			Vichacera Superior (22b). Sandstones and conglomerates, with tuffs & ignimbrites	
		23.8				Vichacera Inferior (22a). Sandstones and interbedded claystones	
Paleogene	Oligocene	33.9	Continental sediments	Red bed sequences	Incaic Phase II - Compression, resulting in folding	Rio Grande Fmn Superior (21b). Red aeolian sandstones	Casa Grande and Rio Grande Formations (18). Continental sandstones, conglomerates, siltstones and claystones
	Eocene					Rio Grande Fmn Inferior (21a). Alternating coarse conglomerates and red sandstones	
		55.8	Continental sediments, locally marine and limey	Local limestone development, local marine sequences		Santa Barbara subgroup (20). Fluvial and aeolian alternating conglomerates and red sandstones	Santa Barbara subgroup. (17)continental limy sandstones, siltstones, claystones
							Balbuena subgroup (16). - see below
BASEMENT - PRETERTIARY UNITS (MARINE)							
Mesozoic	Cretaceous		Continental sediments, locally marine and limey		Peruvian phase - extension and deposition of marine sediments	Balbuena Subgroup (19). Sandstones, calcareous sandstones, limestones, mudstones (Marine).	Balbuena subgroup (16). Continental/marine calcareous sandstones
			Continental sediments			Piruga Subgroup (16). Alluvial and fluvial sandstone & conglomerate	Piruga subgroup (15). Red sandstones, silty claystones and conglomerates
						Granites, syenites, granodiorite (15, 17, 18)	Granites, monzogranite (11-14)
Paleozoic	Carboniferous - Silurian		Marine sediments	Marine platform and turbidite deposits	Isoclinal folding on NW/SE trending axes, extending to early Cretaceous	Upper Paleozoic marine sediments (14)	Machareti and Mandiyuti Groups (10). Sandstones, conglomeratic sandstones, siltsones and diamictites. Silurian Lipeon & Barite Formations (9). claystones and diamicties
						Multiple Paleozoic intrusive suites (6-13)	El Moreno Formation (8). Porphyritic dacite
	Ordovician		Marine sediments	Marine delta and volcanic deposits/domes		Ordovician sandstones (3-5) , volcaniclastic sediments & Ordovician turbidites	Guayoc Chico Group (7) & Santa Victoria Groups (6). Marine sandtones, mudstones and limey units
	Cambrian	540		Marine sediments		Meson Group (2). sandstones and mudstones	Meson Group (5). Marine sandstones
	PreCambrian		Schists, slate, phyllite	Metamorphosed turbidites		Puncoviscana Formation (1) tubidites	Puncoviscana Formation (1) tubidites - metamorphosed and intruded by plutons

Table 7.1: Legend for the Olaroz area geological map

Three major depositional cycles occurred during what is presumed to be largely the Pleistocene-Holocene. The first (deepest) cycle represents clastic sediments deposited in shallow freshwater conditions in much of the salar, influenced by the alluvial and deltaic fans located around the margins of the salar. This cycle is overlain by a layer that is considered to represent a short but significant transition to more humid conditions. This second (shallower) cycle consists of evaporites (predominantly halite) and suggests salt lake conditions, with some sediment supply of volcanic or hydrothermal origin.

The third and final cycle of sediments consists of the most superficial deposits in the basin, and suggests a return to relatively arid conditions, coinciding with clastic sediments and a surficial halite layer largely confined to the centre of the basin.

The surficial salt crust can be subdivided into three types, depending on its age and development. The oldest crust appears with a rough pinnacle morphology (<0.5m), as described in other salt flats. A recent crust is represented by halite with well-developed or shrinkage polygons. A further type of crust is reworked by the precipitation of halite and smooth with high reflectance, and represents areas that recently suffered flooding due to precipitation or from surface water inflows onto the salar. This texture is most strongly developed along the western side of the salar.

7.4 Geomorphology

The Olaroz properties are located over the large Salar de Olaroz, which has dimensions of 20 km north-south and 9 km east west, for an area of approximately 160 km^2. The salar is at an altitude of approximate 3940 m above sea level. The salar is a large salt pan that is surrounded by alluvial fans on the east and west and by a large delta built around the Rosario River in the north. The southern end of the Olaroz salar is delimited by the international road, which crosses the connection with the Salar de Cauchari to the south, which continues down the valley occupied by both salars to the township of Olacapato.

The southern extent of the Olaroz salar is also delimited by the Archibarca alluvial fan, a large alluvial fan which progrades into the Olaroz salar and has been an important source of coarser sediments in the salar. The Archibarca fan is built from sediments that are transported by the Rio Ola, which breaches the mountain range which forms the western limit of the Olaroz basin, sourced from a sub-basin further to the west. This sub-basin is the source for freshwater recharge to the Archibarca alluvial fan.

The Olaroz properties are located in the Olaroz basin, although some properties extend over the range to the west. In the north of the Olaroz basin is the Coyaguaima volcano, which is snow covered in winter. Snowmelt and runoff from the northern part of the basin is the major source of inflow to the Olaroz basin.

The Olaroz salt lake consists of four different geomorphic zones that were previously identified as having different characteristics related to halite development, seasonal flooding and evaporation characteristics. These zones are shown in the Figure 7.3.

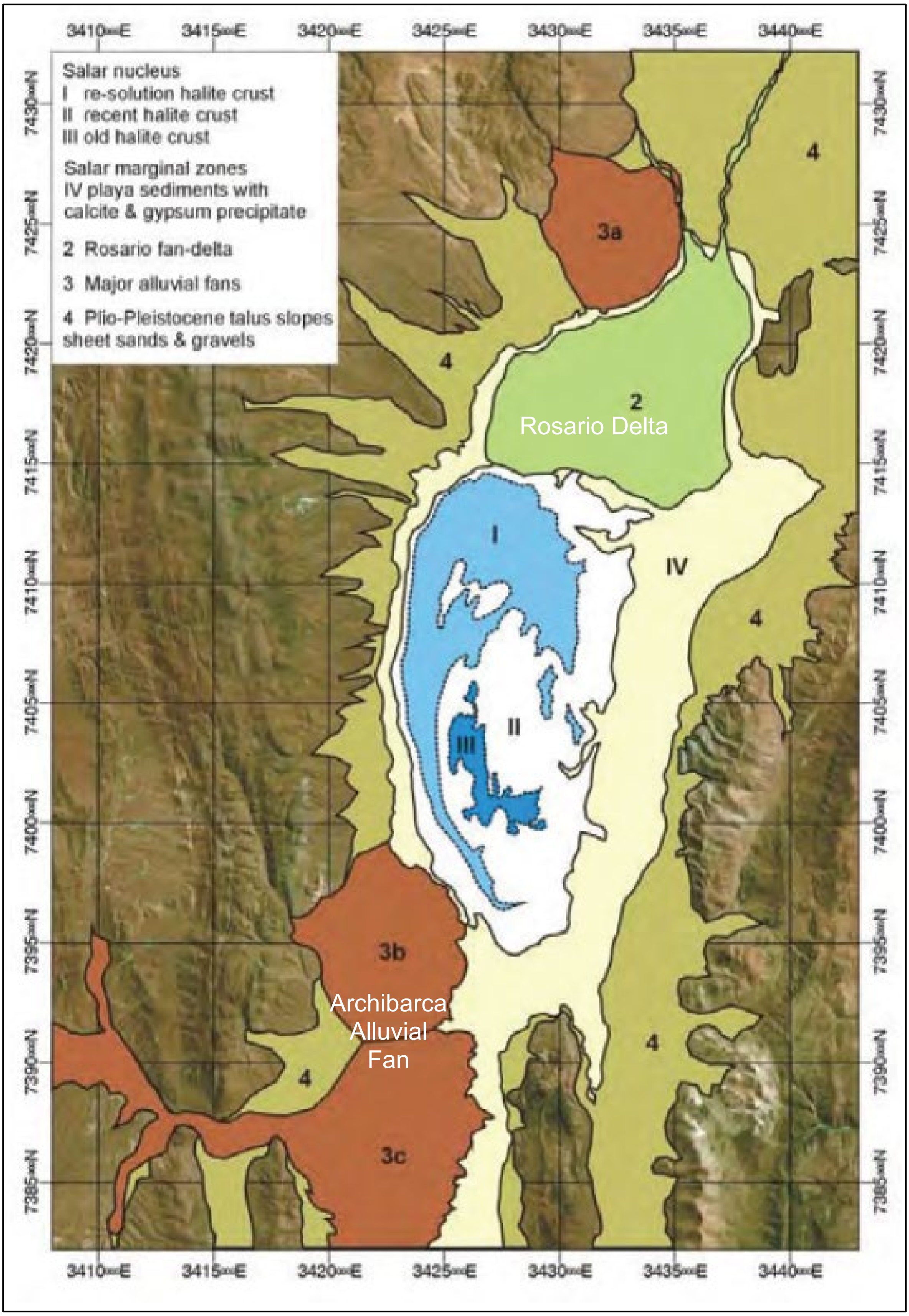


Figure 7.3: Olaroz basin geomorphic features

7.5 Geological Units

The stratigraphy of the Olaroz and Cauchari basins has been controlled by syntectonic sedimentation, due to the N-S orientated faults in the basin and the movements of minor fault systems that tilt the basin in a north direction. This results in a variation in the thickness of the sedimentary units, which can vary from 50-200m south of the Archibarca alluvial fan to 300-400m thick to the north in Olaroz.

Lithological information from the drilling (with holes drilled to 650 m depth for the expansion wellfield) has defined the following sedimentary units, which represent the different facies encountered. Lithological units were previously defined by Houston and Gunn (2011) to 200 m depth, with letters A to G. These have now been summarised into hydrostratigraphic units (numbered UH 1 to 5) based on the more recent drilling to 650 m depth.

A hydrostratigraphic unit does not generally have the same lithology everywhere, as lithology changes laterally across a salar basin. The hydrostratigraphic units are defined on the basis of geological correlation, continuity, porosity and permeability – with down hole geophysical logging contributing important information to define the units. The location of cross sections showing hydrostratigraphic units is shown in Figure 7.5. The lateral distribution of the different UH units is shown in Figure 7.6. The cross sections in Figures 7.7 to 7.10 show the different unit in different locations across the salar.

Houston's original (2011) hydrogeological units consisted of the following units, defined to 200 m. superseded by the division into the units shown in Table 7.2:

- Units A, B, C and D: These units are sequentially surficial halite, clay, a thin sand unit and clayey sediments and represent the deposits localised in the Olaroz salar, with deeper deposits common between Olaroz and Cauchari;
- Unit of sand and gravels in alluvial and deltaic fans: Fd1 through Fd3, F1 and F2 -unconsolidated clastic deposits;
- Unit E: Mixed unit of clay and sand;
- Unit F: Mixed unit of clay, halite and sand; and
- Unit G: Unit with clay containing deep sand intervals.

UH	Geological summary	Lithology
1	Surficial halite	Lacustrine & evaporative deposits, halite, sulphates, borates - Historical Unit A
2	Alluvial gravel fans	Unconsolidated deposits with blocky material, gravels, sands, silts and evaporites - Historical units Fd0 to Fd3, F1 and F2
3	Clay and sand unit	Lacustrine & evaporite deposits, predominantly clay and sand - Historical units B, C, D, E, F
4	Clay, halite and sand unit	Lacustrine & evaporite deposits, principally halite, with sand and clay - Historical unit G
5	Lower sandy unit	Alluvial deposits related to a deeper transgressive cycle of sedimentation as the basin subsided - not intersected in Historical (2011) drilling

Table 7.2: Summary of Olaroz salar hydrostratigraphic units

Hydrostratigraphic Unit 1 (UH1)

This includes Unit A. the modern facies of the Salar de Olaroz (late Holocene). On the surface, it is made up of a layer of salt that reaches a thickness of up to approximately 18 m (in historical hole C14). It forms a shallow basin with the main depocenter in the central southern part of the salar. It is dominated by halite with over 80% halite in the northwest and 50% in the southwest, and an increasing sand fraction to the southeast (to 15%), and clay fraction to the northeast (to 98%). Rare, thin beds (<20 cm) of ulexite and gypsum occur towards the northeast associated with the clays (Figure 7.4).

Hydrostratigraphic Unit 2 (UH2)

This unit includes unconsolidated deposits of alluvial, fluvial and deltaic origin, originating from the alluvial fans located both east and west of the salar and the Rosario Delta developed to the north of the salar. These units correspond to the F1, F2, Fd0, Fd1, Fd2 y Fd3 units defined by Houston and Gunn (2011). It consists of gravels, breccias, sands and silts, with sandy, clayey and halite groundmass, whose ages are estimated as Pleistocene to the Holocene. This unit includes the active deposits of the Rosario River delta, consisting of carbonates, sands, silts and clays. It has a variable thickness, with recognized thickness exceeding 150m in the Archibarca sector and no significant drilling below 50 m depth in the Rosario Delta. These deposits are found interdigitating with shallow evaporite deposits of Unit 1.

Hydrostratigraphic Unit 3 (UH3)

Unit UH3 comprises most of the units defined previously by Houston, combined into this much thicker package. Unit B reaches maximum thicknesses of 36.2 m (in sonic drill hole C05). It is a unit of interbedded sediments dominated by clay (>75%) over the whole salar, with a sand fraction reaching 30% in the northeast, and halite reaching 18% in the central east. The clays are plastic, red-brown, green or black and organic rich. They are frequently laminated, silty, with thin sand lenses. The sand in the northeast is generally fine grained and silty. Halite is fine grained and mixed with silt and clay.

Unit C is a well-defined sand bed, occurring in all wells throughout the salar and interdigitating with the Rosario fan delta in the north and Archibarca delta in the southwest. Unit C ranges in thickness from 6.6 m (historical well C17) to 0.1 m (in historical well C07), tending to be thicker in the north and south and thinner in the centre of the salar. The sand fraction averages 80% and reaches 100%.

Unit D occurs in all wells except those in the northeast. It is likely that Unit D is replaced by Fd2 in the northeast and F2 in the southwest, associated with the Rosario fan delta and Archibarca fan respectively. The thickness of Unit D increases from 20 m in the central east to over 32 m in the west and northwest. Unit D comprises interbedded sediments dominated by clay and silty clay (>60%), with lesser fractions of sand and thin beds of carbonate (calcrete or travertine). There are rare lenses of halite and ulexite (less than 0.5 m thick) towards the south.

In the extreme north of the salar, Unit D represents the influence of the overflows generated by the deltaic fan of the Rosario River in times of flooding of this river and its superposition towards the nucleus of the Salar de Olaroz.

Unit UH3 corresponds to facies associated with a stage of variable climatic conditions, consisting of predominantly clayey sediments with intercalations of very fine sand layers and bands of halite, with a thickness much greater than one hundred meters. These lithofacies suggest they formed during fluvial-marsh to lake conditions. Unit UH3 corresponds to the Units B, C D, E and F defined by Houston and Gunn (2011) and is the predominant unit in which the original Olaroz Northern Wellfield is established in.

The clays are red, brown or green, sometimes black with entrained organic matter. They are frequently interbedded with silts, sands and even gravel. Carbonates as discrete beds up to 10 m thick (historical hole CD02) are composed of crystalline calcite with an overgrowth of calcite cement. Druses cavities are occasionally present with microcrystalline calcite interiors. They contain some clastic material as lithics and thin silts beds.

The lithofacies of Unit E suggest mixed fluvio-palustrine and lacustrine conditions; the former prevailing to the north and west, the latter towards the south and east.

Figure 7.4: Clay material in Unit UH 1, showing bioturbated clayey sediments (from Houston and Gunn, 2011)

Hydrostratigraphic Unit 4 (UH4)

Deeper drilling to 650 m has defined the thickness and extent of the halite dominated unit more effectively, with drilling showing Unit G of Houston and Gunn (2011) is thickest in the east of the salar, with the thickness increasing south towards Cauchari. The unit consists of halite intercalated with clays, which are distinguished in the geophysical logging based on resistivity and other characteristics.

This unit corresponds to facies associated with a stage of hyperarid climate. The structure and disposition of this unit during its formation, suggests an active subsidence of the basin, with the unit continuing into the Cauchari salar. This unit is dominated by layers of banded halites and massive halite. The halite crystals that make up the lenses maybe corroded or dissolved, resulting in highly porous horizons.

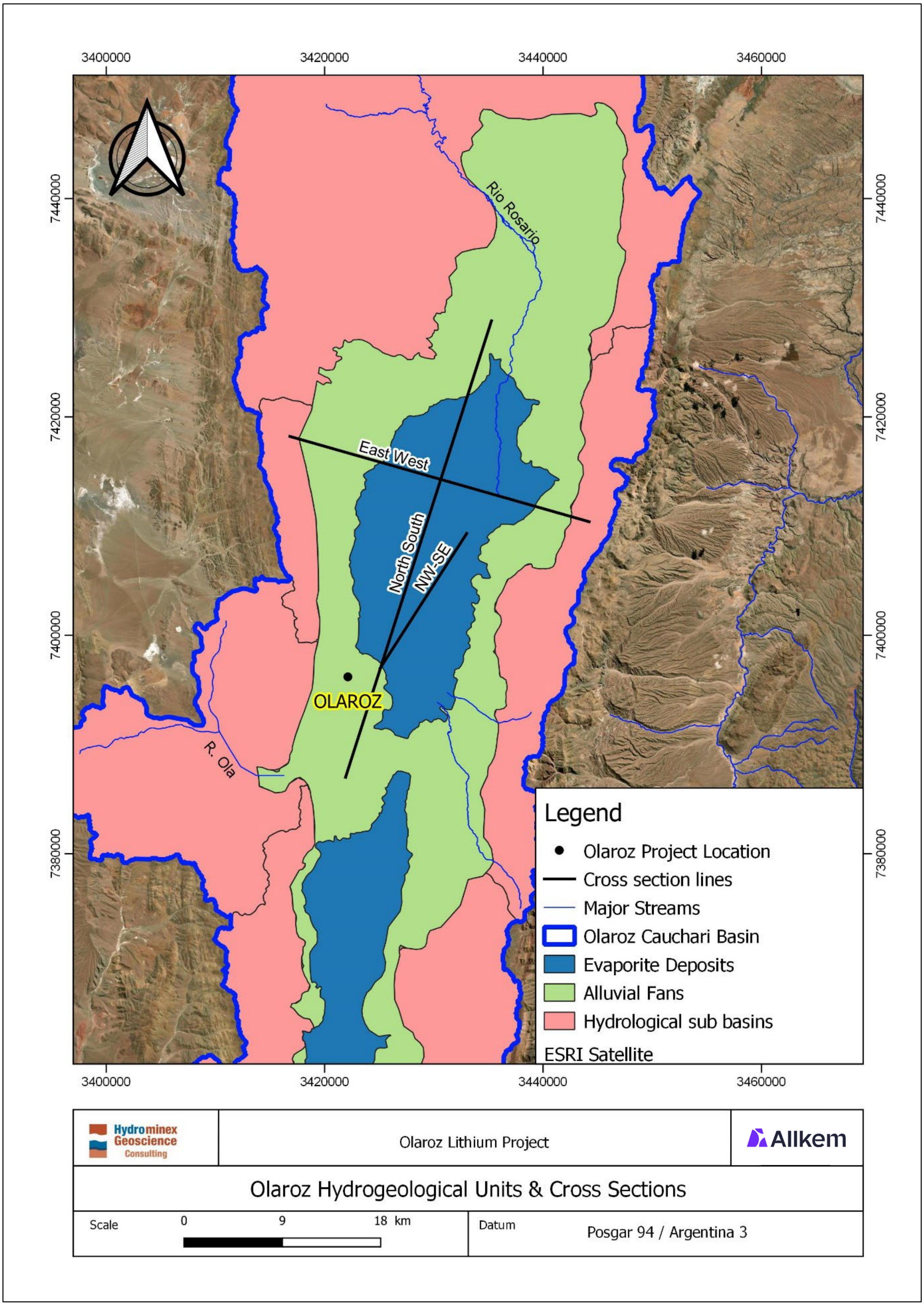


Figure 7.5: Location of the salar evaporite deposits, alluvial fans and surrounding sub basins

Hydrostratigraphic Unit 5 (UH5)

This corresponds to a unit composed of layers of clay and silt, alternating with massive and laminated fine-grained sand. The grain size of the sand appears to be coarser at greater depth. The mineralogy of the sands indicates a source of volcanic origin. The thickness of this unit is variable, with lesser thickness in the east of the basin and the greatest thickness in the southwest of the basin, where an early version of the Archibarca alluvial fan appears to have been active, shedding coarser grained sediment into the basin and developing important high porosity and permeability units. The base of this unit has not yet been recognized. The 1400 m deep stratigraphic hole drilled in the east of Olaroz encountered coarse gravels at depth, which prevented continuation of the hole.

This unit is likely to be the lateral equivalent to the deep sand unit encountered in drilling at Cauchari, where sandy material has been sourced from the western side of the basin, as appears to be the case at Olaroz.

Basement

The basement rocks have not been intersected in drilling at Olaroz. There may be more extensive units of sand and gravel at the base of the basin than have been intersected in drilling to date. The basement rocks in the central part of the salar are likely to be Cretaceous to Ordovician in age, with younger tertiary sediments around the edges of the salar, although further drilling would be required to confirm the nature of the basement rocks beneath the salar.

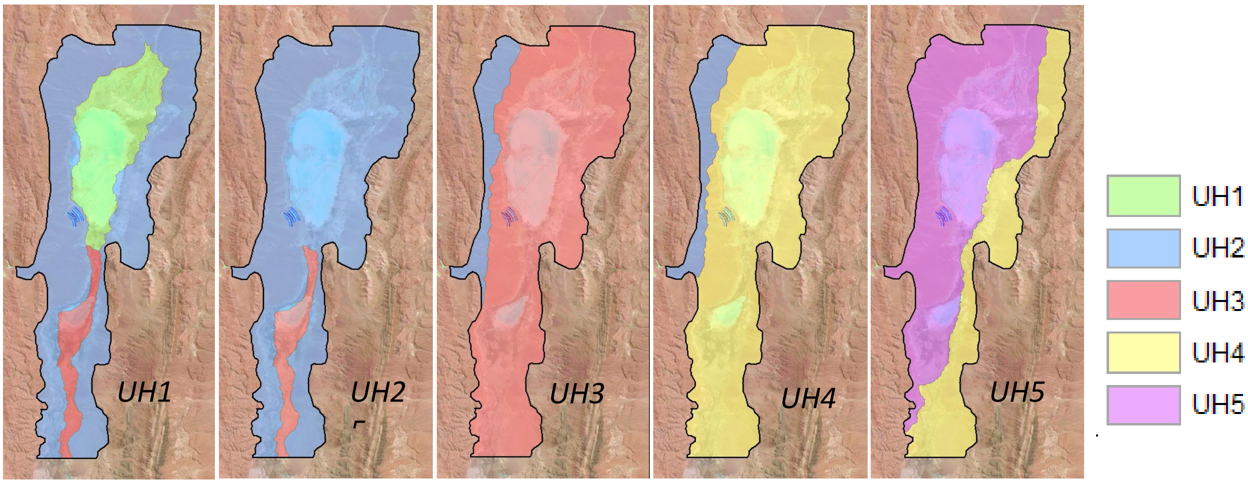


Figure 7.6: Distribution of the different hydrostratigraphic units in the Olaroz basin

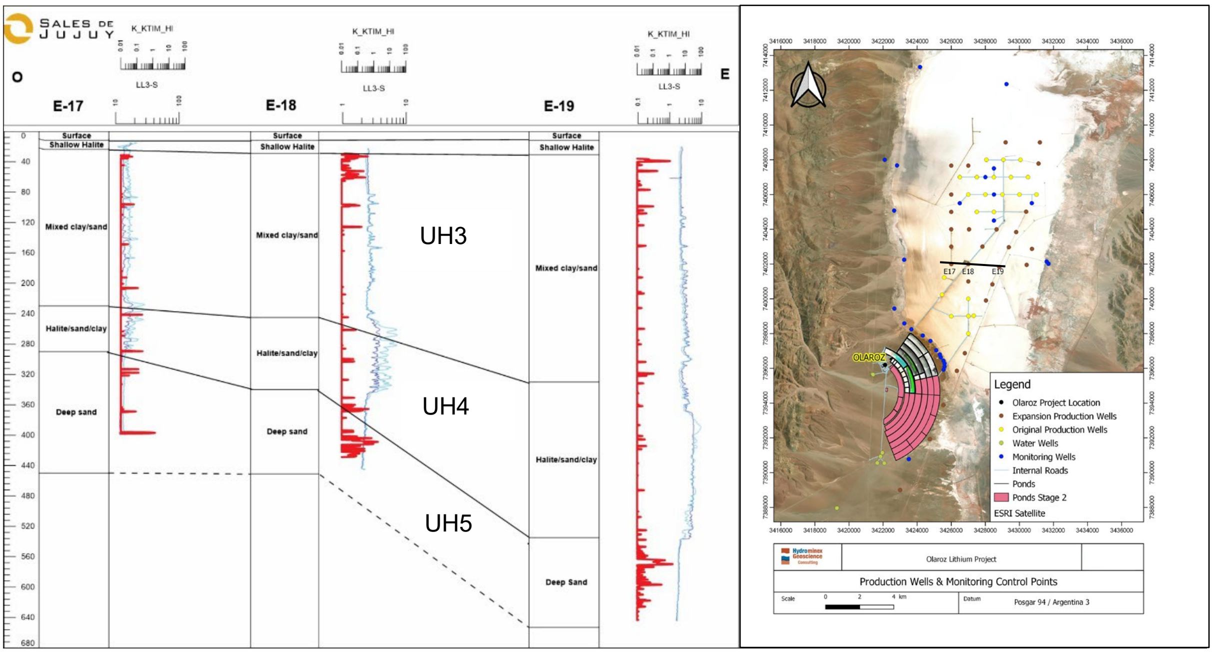


Figure 7.7: Cross section looking north through the salar, showing the distribution of different units in expansion drill holes E17, E18 and E19

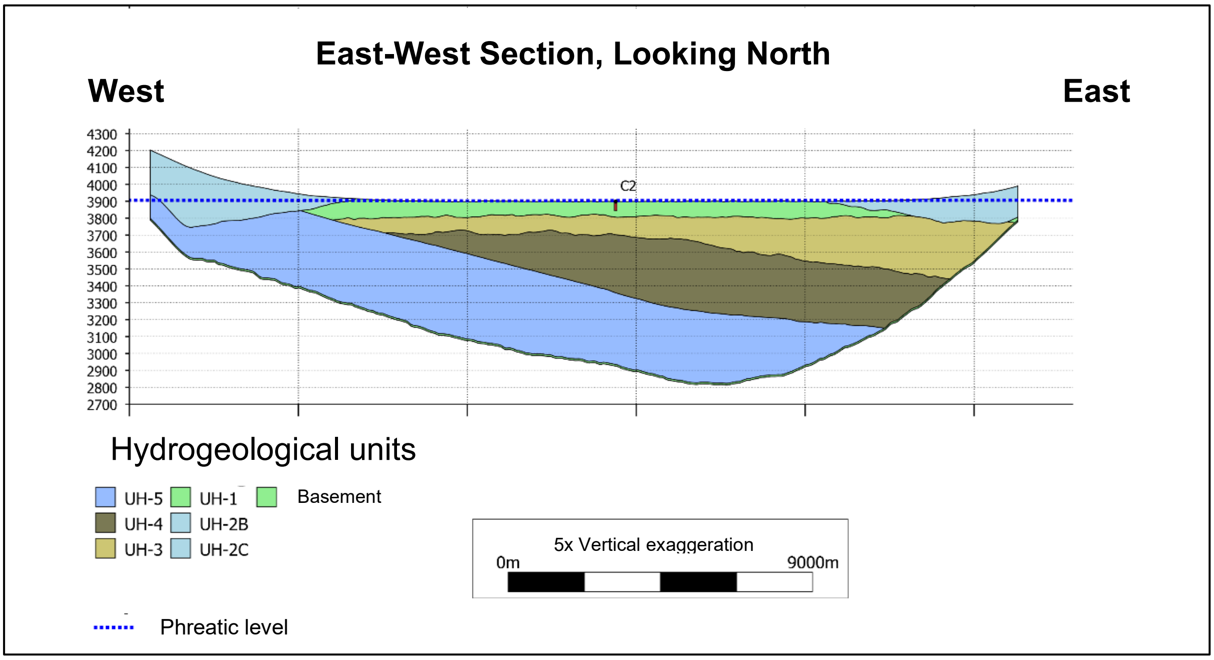


Figure 7.8: Hydrostratigraphic units defined from more recent drilling at Olaroz

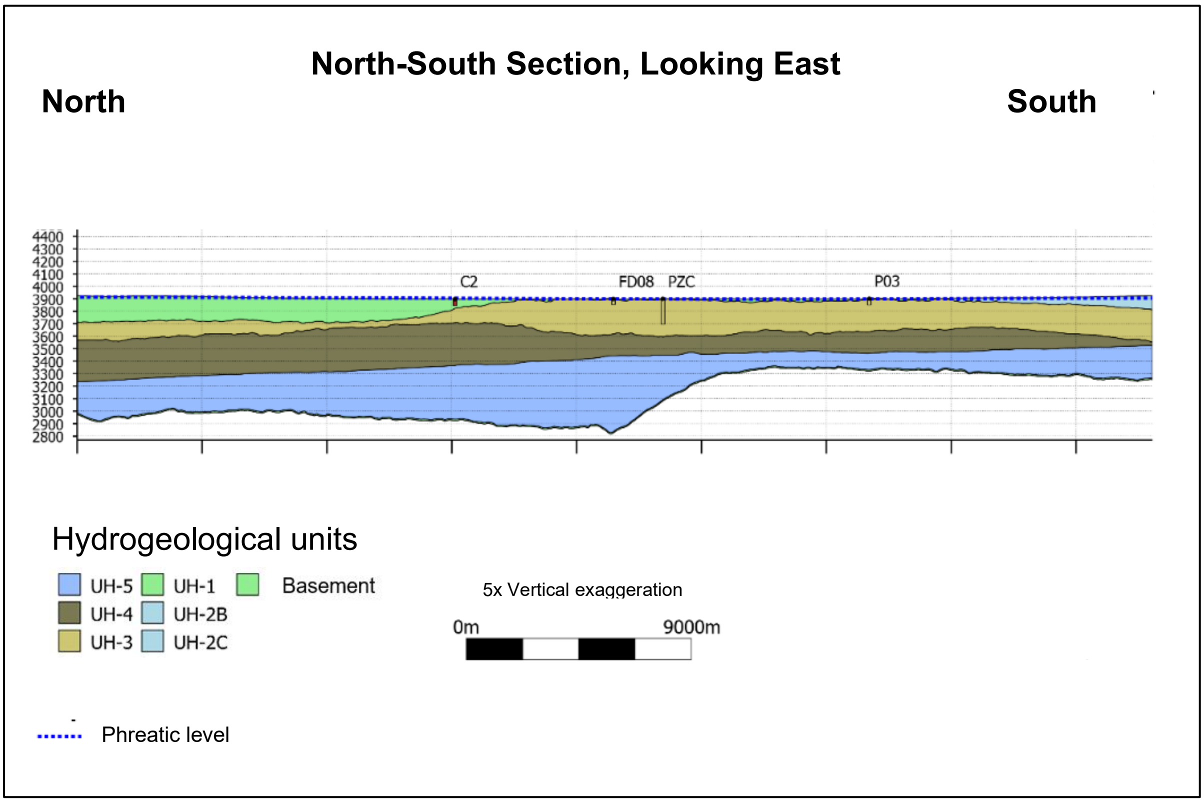


Figure 7.9:Cross section north to south through Olaroz, showing the hydrostratigraphic units

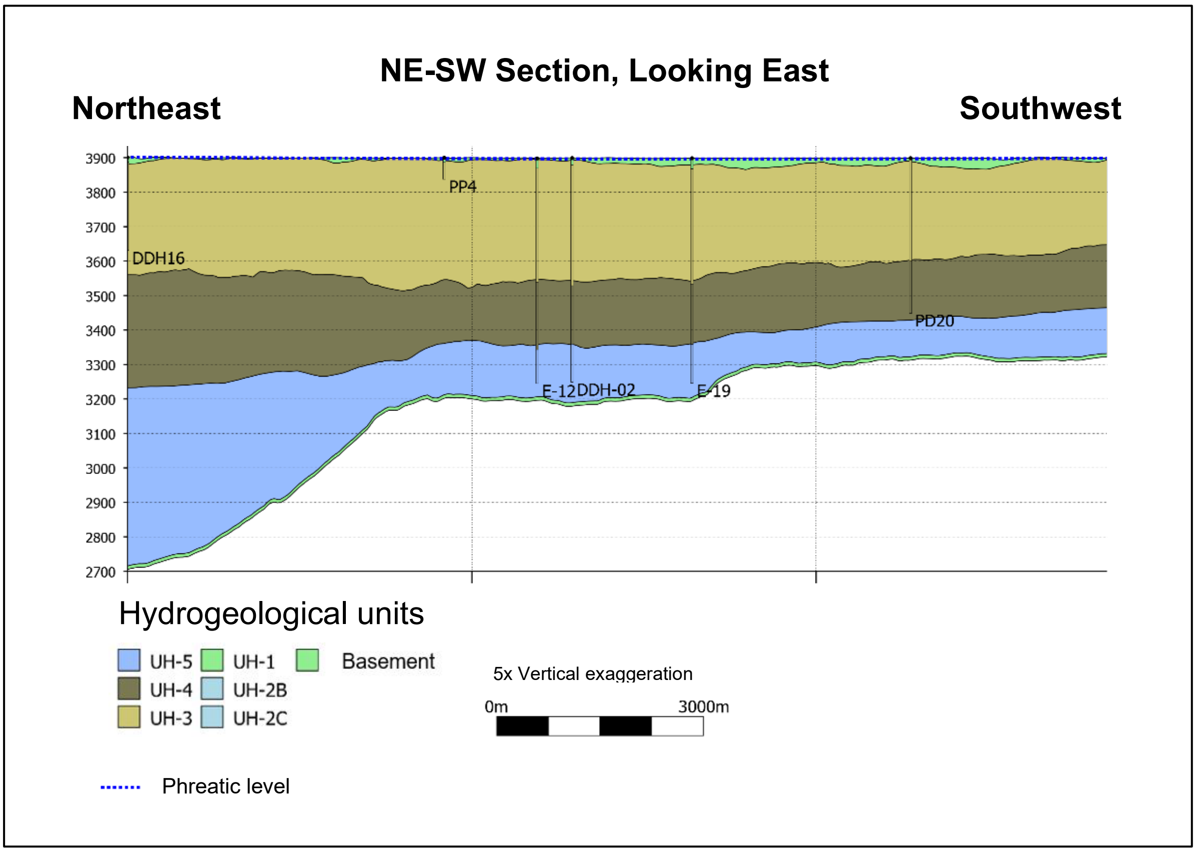


Figure 7.10: Hydrostratigraphic units, showing drill holes (DDH02 – 650 m deep)

7.6 Mineralization

As previously discussed, brine projects differ from hard rock base, precious and industrial mineral projects due to the fluid nature of the mineralisation. Therefore, the term 'mineralisation' should be considered to include the physical and chemical properties of the fluid (brine), as well as the flow regime controlling fluid flow.

The brines from Olaroz are solutions nearly saturated in sodium chloride with an average concentration of total dissolved solids (TDS) of 290 g/L and average fluid density of 1.20 g/cm3. In addition to extremely high concentrations of sodium and chloride typical in these salar settings the Olaroz brine also contains significant concentrations of Li, K, Mg, Ca, Cl, SO_4 and B.

The Olaroz salar is large and the brine is rather homogeneous, although there are some trends in the concentrations of lithium and other elements through the salar sediments. Brine concentrations are lower close to the margins of the salar and in areas where there is significant recharge by runoff. The Mg/Li ratio averages 2.3, with the SO4/Li ratio averaging 23.

Table 7.3 shows a breakdown of the principal chemical constituents in the Olaroz brine including maximum, average, and minimum values, based on brine samples used in the brine resource estimate that were collected from the production wells.

Analyte	Li	K	Mg	Na	Ca	B	SO4	Cl
Units	**mg/l**	**mg/l**	**mg/l**	**mg/l**	**mg/l**	**mg/l**	**mg/l**	**mg/l**
Maximum	1238	10311	3054	138800	988	2439	36149	202982
Mean	728	5183	1668	115437	453	1336	16760	181805
Minimum	465	1716	859	101000	217	673	4384	149207
Std Deviation	124	984	374	3991	84	190	3685	6664

Table 7.3: Average Olaroz Brine Chemistry from 2017-2021 pumping data

Figures in Section 14 show the kriged distribution of lithium concentrations in the Salar. Concentrations of lithium and potassium show a high degree of correlation. As production of KCl fertiliser is not planned as a by-product only lithium has been included in the estimation. The kriged three-dimensional distribution of lithium concentrations was used in the updated resource model as further described in Section 14.

Brine quality is evaluated through the relationship of the elements of commercial interest lithium and potassium and the consideration of other elements that must be removed to provide a high-quality lithium product. Other components of the brine constitute impurities, including Mg, Ca, B and SO4. The calculated ratios for the averaged brine chemical composition are presented in Table 7.4.

Li	K	Mg	Ca	SO_4	B	Mg/Li	K/Li	SO4/Li
728	5,183	1,668	453	16,760	1,336	2	7	23

Table 7.4: Average values and ratios of key components of the Olaroz brine (mg/L) 2017-2021 pumping data

The precipitation of salts during evaporation of the brine can be represented on a phase diagram known as the Janecke projection, which considers an aqueous quinary system (Na+, K+, Mg++, SO4=, Cl–) at 25°C and saturated in sodium chloride. This can be used when adjusted for the presence of lithium in the brines, with the Janecke projection $MgLi_2$-SO_4-K_2 in mol % is used to make this adjustment. The Olaroz brine composition is represented in the Janecke Projection diagram in Figure 7.11 along with the brine compositions from other salars. The Olaroz brine composition is compared with those of Silver Peak, Salar de Atacama, Salar del Hombre Muerto, Salar de Rincon and Salar de Uyuni in Table 7.5 below (values in weight percent, from Houston and Gunn, 2011, not mg/L).

	Salar de Olaroz (Argentina)	**Salar de Cauchari (Argentina)**	**Silver Peak (USA)**	**Salar de Atacama (Chile)**	**Hombre Muerto (Argentina)**	**Salar de Maricunga (Chile)**	**Salar del Rincon (Argentina)**	**Salar de Uyuni (Bolivia)**
Li	0.057	0.043	0.023	0.15	0.062	0.094	0.033	0.035
K	0.5	0.37	0.53	1.85	0.617	0.686	0.656	0.72
Mg	0.14	0.11	0.03	0.96	0.085	0.61	0.303	0.65
Ca	0.04	0.04	0.02	0.031	0.053	1.124	0.059	0.046
SO_4	1.53	1.59	0.71	1.65	0.853	0.06	1.015	0.85
Density (g/cm^3)	1.21	1.19	N/A	1.223	1.205	1.2	1.22	1.211
Mg/Li	2.46	2.56	1.43	6.4	1.37	6.55	9.29	18.6
K/Li	8.77	8.6	23.04	12.33	9.95	7.35	20.12	20.57
So_4/Li	26.8	37	30.87	11	13.76	0.64	31.13	24.28
So_4/Mg	10.93	14.45	23.67	1.72	10.04	0.097	3.35	1.308
Ca/Li	0.7	0.93	0.87	0.21	0.86	9.5	1.79	1.314

Table 7.5: Comparison of Olaroz and other brine compositions in weight percent (after Houston and Gunn, 2011)

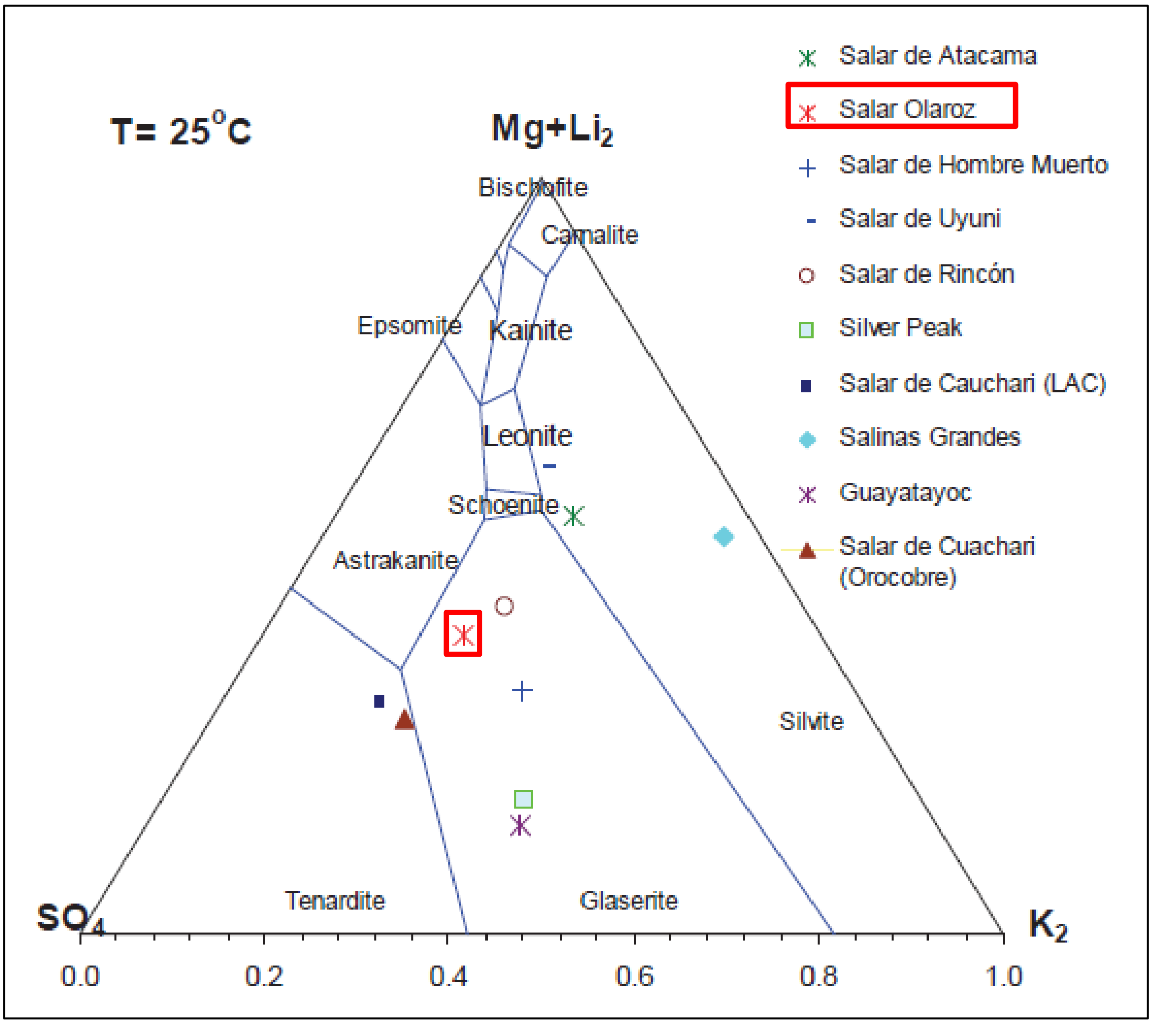


Figure 7.11 : Janecke phase diagram showing the composition of Olaroz relative to other salars (from Houston and Gunn, 2011)

8 DEPOSIT TYPES

8.1 Salar Types

Lithium is found in a number of different geological deposit types. The most common are pegmatite bodies, associated with granitic intrusive rocks, and continental brines in salt lakes (salars).

Pegmatite bodies are found in a diverse range of countries, including Australia, Canada, Congo, Russia, USA and Zimbabwe, with the largest deposits often located in Archean or Proterozoic rocks. Pegmatites are mined by conventional hard rock mining and the spodumene ore is subsequently processed, generally producing lithium hydroxide. In addition to pegmatites lithium is also found in other settings.

Continental lithium brines in salars settings (salt lakes) are found principally in Argentina, Chile, Bolivia and China, with lithium carbonate or lithium chloride produced from these projects. Lithium is rarely found in continental oilfields, where the accompanying produced water is enriched in lithium, probably deriving lithium from evaporite sequences in the stratigraphy.

Lithium is also found in geothermal systems, rarely at concentrations that may be economic, one example being the Salton Sea geothermal field. A related type of mineralisation is lithium present in tuffs or clays in volcanic sequences, where the lithium has likely resulted from geothermal or hydrothermal activity, with examples in the Western USA and Mexico.

Lithium production from salar brines has a number of advantages over hard rock mining of pegmatites and sediments. The principal advantage is the lower operating costs for lithium salar operations, based on the economics of the operating lithium salar producers in Chile and Argentina (Lagos, 2009; Yaksic, 2008, Benchmark Minerals and CRU data).

Salar Types

Lithium brine projects can also be subdivided into two broad ‘deposit types’ with different characteristics (Houston et. al., 2011 – Figure 8.1), which consist of:

- Mature salars (those containing extensive thicknesses – up to hundreds of meters - of halite (salt), such as the Salar de Atacama (Chile), and the Livent Hombre Muerto operation (northern Catamarca, Argentina); and
- Immature salars, which are dominated by clastic sediments, with limited thicknesses of halite, such as the Olaroz salar in Jujuy Argentina and the Silver Peak deposit in Nevada, USA, where brine is extracted from porous volcanic ash units.

Historical development of salar lithium brine projects in Chile and Argentina focused on the development of large Mature salars, as these required only shallow drilling and provided excellent brine flow rates from shallow wells. Projects developed at this time (Lithium production from the Salar de Atacama, in northern Chile, and from the Salar del Hombre Muerto in Argentina dates from 1984 and 1997 respectively) had the most favorable brine chemistry of the Mature salars. More recent developments of salar projects are predominantly Immature salars, which are more common and which can host extractable brine resources to depths of hundreds of metres.

The characteristics of these two different salar types influence the distribution of the contained brine and brine extraction. It should be noted there may be immature and mature areas within the same salar basin (such as in the Hombre Muerto salar in Argentina, where Livent, Posco and Galaxy (now part of the Allkem group) have projects.

Mature salars

Brine in mature salars is hosted in pore spaces, caverns and fractures within salt (halite) which has been deposited by the evaporation of brines to produce salt through natural evaporation. Mature salt dominated salars (i.e. Atacama salar) are characterized by having porosities in the 8 to 12% range within the salt units (Houston et. al., 2011), with the porosity and permeability decreasing with depth, such that by a depth of approximately 50 m the drainable porosity in matures salars has decreased to several percent (Houston et al., 2011).

In these salars the brine resources are principally contained between surface and 50 m below surface, as below this depth there is reduced permeability in the salt, due to salt recrystallization and cementation of fractures.

Immature salars

Immature salars conversely have brine hosted in pore spaces controlled by the porosity and permeability associated with individual layers within the salar sequence. A degree of compaction occurs with increasing depth below surface, but unlike in mature samples significant porosity and permeability characteristics may continue to depths of hundreds of meters in these salars (such as the producing Olaroz salar and the adjacent Cauchari salar in Northern Argentina and at the Silver Peak lithium brine mine in Nevada).

The porosity and permeability characteristics may be variable between units, and units with low productivity for brine extraction can alternate with more productive units, due to differences between sediments such as sand and gravel and finer grained silts and clays. The presence of different stratigraphic units in clastic salars typically results in differences in the distribution of the contained brine and influences the recovery of brine as reserves from the defined brine resource, with lower resource to reserve conversion ratios than are typical in hard rock mining situations. It is very important to consider the characteristics of the host aquifers in each salar, together with the aquifer geometry and physical properties, particularly specific yield and specific storage hydrogeological characteristics.

The characteristics of lithium production from the Silver Peak deposit in Nevada are of importance to salar bine developers, as many salar deposits currently under evaluation are immature salars which face the same challenges as Silver Peak, which has been operating since 1966 (Lagos, 2009).

The typical architecture of Puna salar basins (after Houston et. al. 2011) consists of:

- Coarser grained sediments on the margins of a salar basin, with successive inner shells of finer grained clastic units; and
- Where evaporation is highest an inner nucleus of halite occurs in the approximate centre of the salar (depending on the salar topography) and is surrounded by deposits of mixed sulphate and carbonate deposits, together with fine grained clastic sediments.

Buried salars

Salars contain sequences of sedimentary deposits with clastic sediments (clay, silt, sand, gravel) and evaporites (principally salt). These sediments progressively accumulate and the surface of the salar consists of salt or fine sediments such as clays. In some cases, due to changes in climate or tectonic events salars are buried by alluvial fan sediments prograding from the margins of basins. In extreme cases salars may be entirely covered by alluvial fan sediments, such that there is no salar surface in the middle of a closed drainage basin. However, brine can remain in place in the sequence of salar or clastic sediments beneath the alluvial fans which will often contain fresh to brackish water.

The Olaroz Project contains buried targets beneath the Archibarca alluvial fan in the southwest of the basin and in the north of the basin, where AMT electrical geophysics suggests the presence of brine beneath the Rosario Delta. These areas off the surface of the salar have not yet been explored at Olaroz, but are likely to contain significant volumes of brine in addition to that defined directly below the surface of the salar.

8.2 Surface Water Inflows

The Salar de Olaroz is a closed (endorheic) basin, meaning that there are no surface or groundwater outlets. Consequently, all water that enters the Salar from the surrounding basins must be lost by evaporation under natural conditions. Numerous surface water catchments drain to the Salar (Figure 8.2, showing drainages), the most important being the Rio Rosario through the northern fan-delta and the Rio Ola which enters the basin from the west via the Archibarca alluvial fan (Figure 8.3, showing topography). The Rio Ola flows infiltrates into the gravels of the Archibarca alluvial fan before reaching the Olaroz salar.

The Rio Rosario and Rio Ola have been monitored over the last decade, since exploration commenced on the Olaroz salar. Measurements of flow are taken regularly and compared with rainfall.

Rio Rosario

At the point where the Rio Rosario enters the salar nucleus the catchment area is approximately 2,000 km^2. The significant catchment relief which varies from >5,000 m where it rises on the flanks of Volcan Coyaguaima, to 4,000 m at the Salar, result in significant precipitation and significant runoff. Flow monitoring has been undertaken since 2008 where the river disgorges from bedrock at 3,995 m and starts to infiltrate the basin sediments.

Rio Ola

The Rio Ola (Figure 8.4) enters the Salars de Olaroz and Cauchari through the Archibarca alluvial fan from the west. Its catchment area is approximately 1,200 km^2, but relief is much lower than the Rosario catchment, with a maximum elevation of 4,400 m. Flow monitoring where the river leaves the catchment and infiltrates the fan at 4,000 m indicates a variable rate of flow between 4-14 L/s. Peak flows occur during the winter months (Figure 8.5) when evaporation is at a minimum.

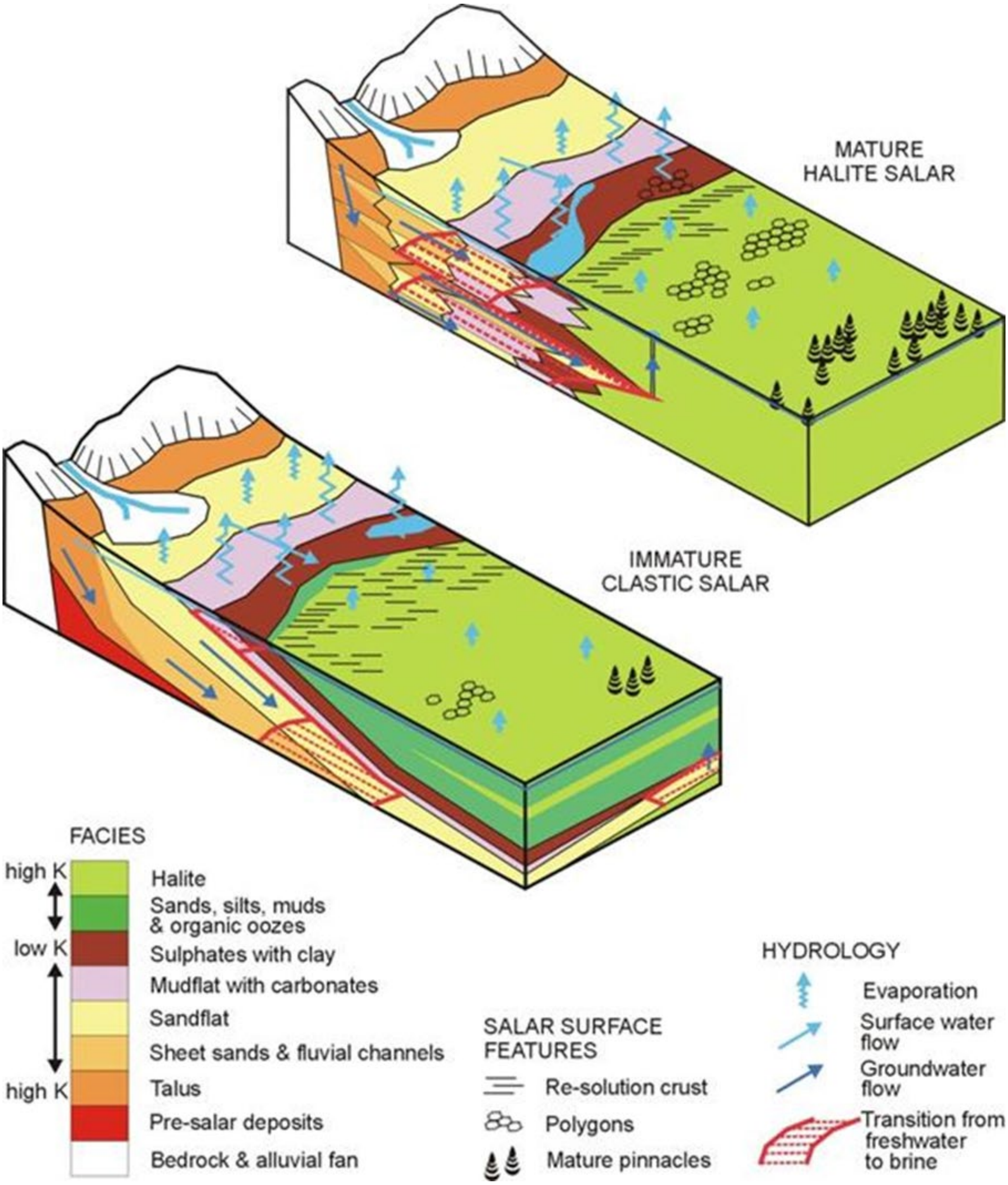


Figure 8.1: Model showing the difference between mature and immature salars (from Houston et al., 2011)

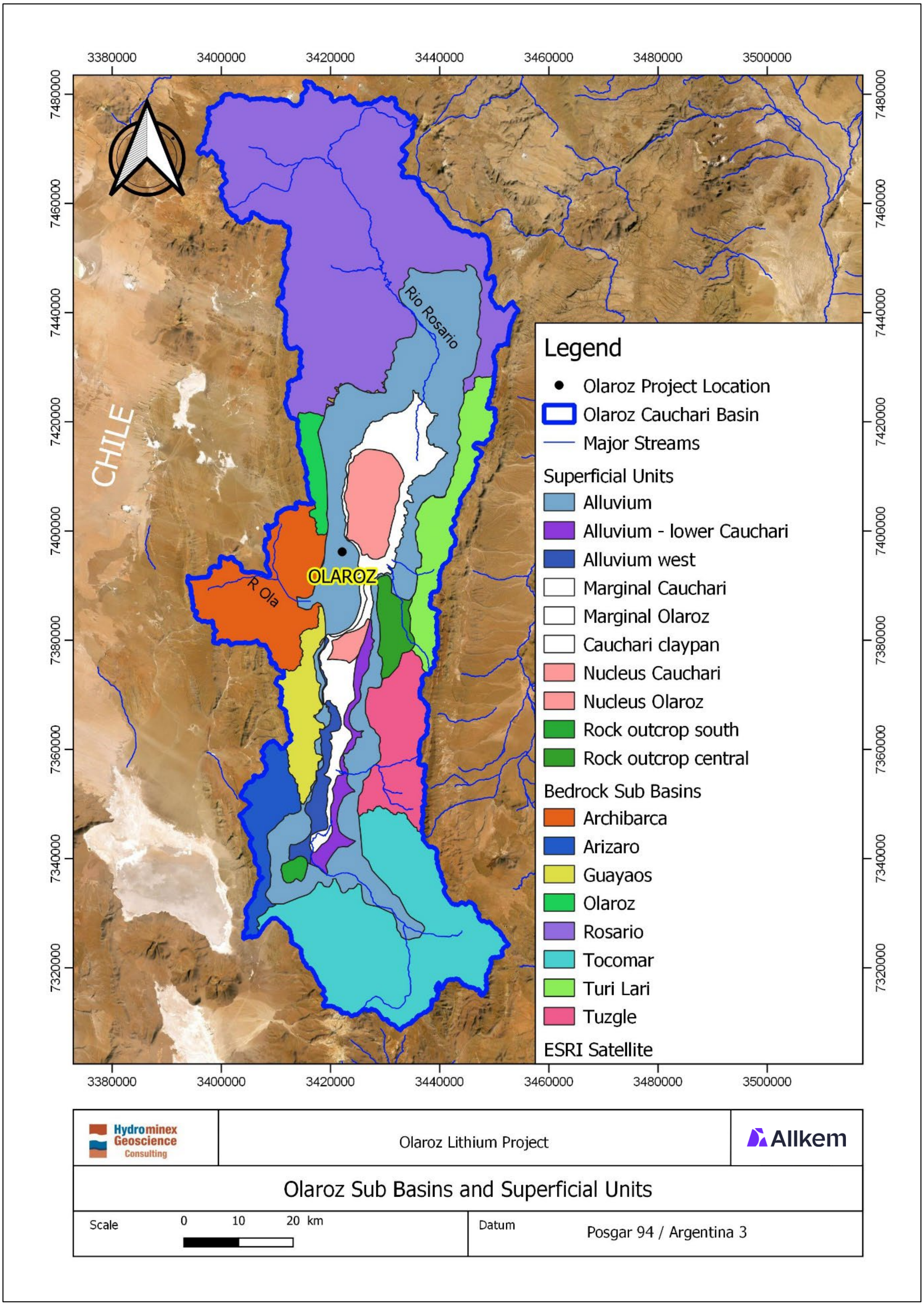


Figure 8.2: Sub basins and surface areas in the Olaroz-Cauchari basin (after Napa 2021)

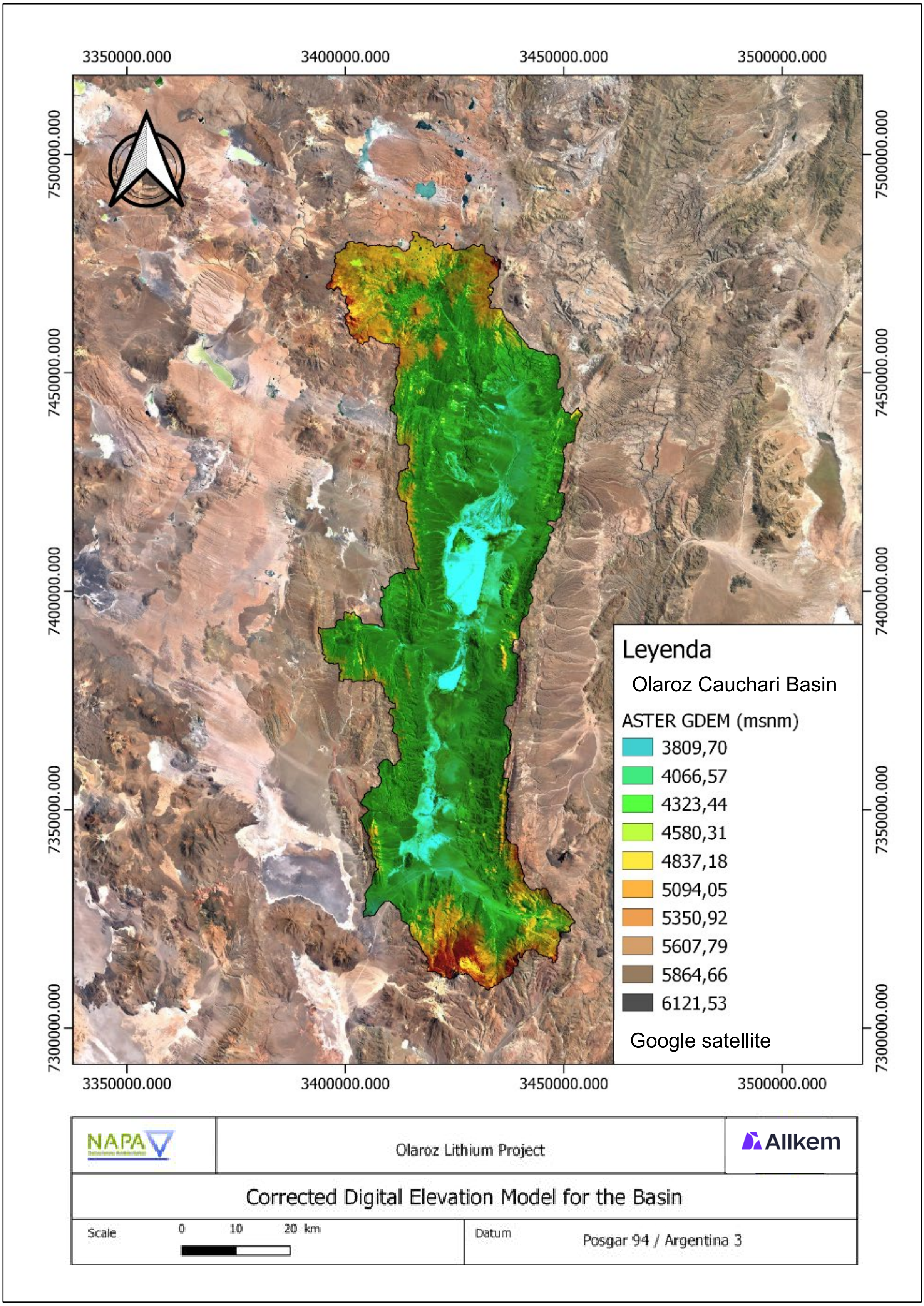


Figure 8.3: Digital elevation model of the Olaroz Cauchari basin, showing the major surface water drainages (Napa 2021)

Figure 8.4: The Rio Ola channel in November 2018. The channel crosses a bedrock pass and enters the Archibarca alluvial fan, where it infiltrates before entering the salar (after Flosolutions 2019, Advantage Lithium PFS)

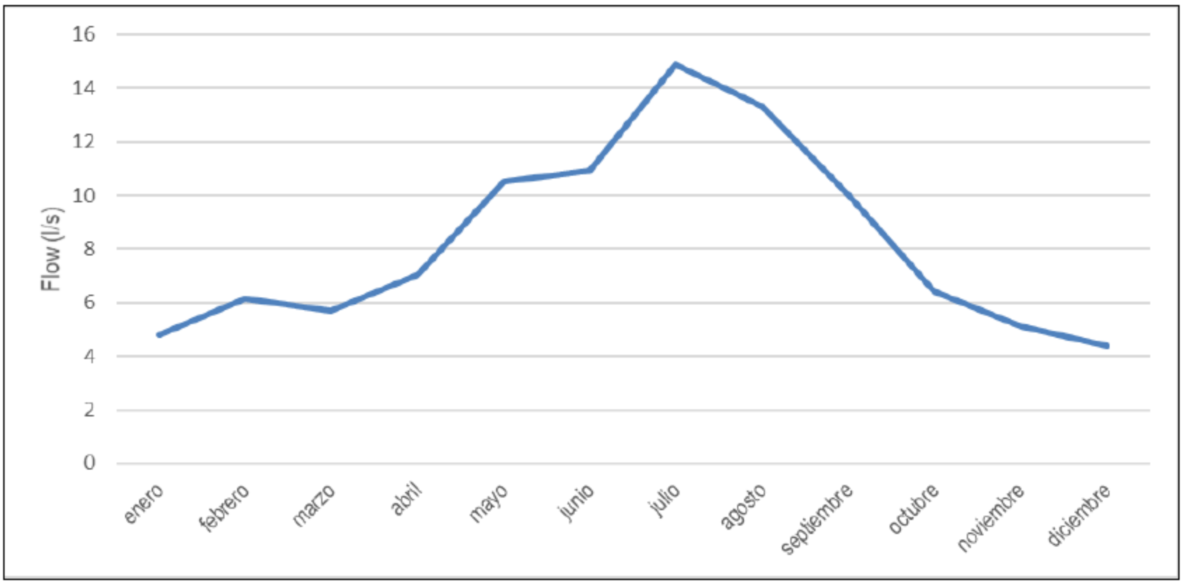


Figure 8.5: Monthly average flows in liters/second in the Rio Ola (after Flosolutions 2019, Advantage Lithium PFS)

8.3 Hydrogeology

Salars form in arid environments, with the deposition of chemical sediments, with deposition controlled by the concentration of elements in brine and saturation of brine with respect to different minerals which precipitate progressively. Salars typically have an inner nucleus of halite, that is surrounded by marginal zones on the sides of the salar where sulphates and carbonates are deposited.

Fine grained clastic sediments such as clays and muds are typically deposited in salars, some of which may contain organic material from decomposed vegetation. Coarser grained sediments generally occur on the margins of basins and may prograde into the basins from the sides during wetter periods when coarse sediments were transported further.

Drilling at Olaroz has defined the five major hydrogeological units that are discussed in section seven. The general geological environments at Olaroz that relate to the hydrogeological units are as follows:

Alluvial fans

These are best developed on the western margin of the Olaroz salar, with the largest being the Archibarca alluvial fan, a composite fan developed from the southeast of the Olaroz basin. This consists of coarse gravel, generally with a sandy matrix, with interbeds of more clayey material between thicker and more massive gravel units. The Archibarca fan progrades into the Olaroz and Cauchari salars and forms the boundary between the two salars. The alluvial fan receives significant recharge from seasonal rain and snowmelt and hosts a resource of fresh water that is used for the Olaroz Project water supply. The freshwater overlies brackish water and brine below the gravels.

Drilling shows that historically the Archibarca alluvial fan deposited sediment into the basin from west to east. Coarser sediment from this source was deposited in unit UH5, which can be correlated across the salar and which supports the highest pumping rates to date in wells such as P302 and E17. In many salars a lower unit with more sand and gravel clastic material is observed, which is likely to reflect different climatic conditions in the Puna region at that time and coarser sedimentation deposited in the earlier stage of basin development.

Clay and silt

Clay and silt units form much of units UH3 and UH4, with interbedded sand units. These units cover the central part of the salar and are interbedded with coarser sediments from alluvial fans along the western margin of the salar. These units act as thick leaky aquifers, which release brine continuously, but at lower rates than units with thicker sequences of sand and gravel.

Halite

Halite is typically deposited in salar basins and in Olaroz is developed most consistently in unit UH4, where it forms a thick sequence that is interbedded with clay and silt. The halite (salt) unit is distinct in geophysical logs, as the unit is generally compact and less permeable. However, interbedded coarser grained clastic layers can have higher permeabilities.

8.4 Drainable Porosity

Porosity is highly dependent on the host lithology, with different types of porosity related to the size of pores and how brine (fluid) can be extracted from the pores.

It is important to understand the terminology relating to porosity (Figure 8.6). Total porosity (Pt) relates to the volume of pores contained within a unit volume of aquifer material. Except in well-sorted sands some of the pores are isolated from each other and only the pores that are in mutual contact may be drained. This interconnected porosity is known as the effective porosity (Pe). Assuming the Pe is totally saturated, only part may be drained under gravity during the pumping process. This part of the porosity is known as the specific yield, or the drainable porosity (Sy). A portion of the fluid in the pores is retained as a result of adsorption and capillary forces and is known as specific retention (Sr).

Total porosity (Pt) is much higher in finer grained sediments, whereas the reverse is true for Sy, due to the high Sr in these sediments. Lithology is highly variable, with sand-silt-clay mixes spanning the full spectrum of possible porosities. It is only possible to discriminate the dominant lithology, for example, sand dominant or clay dominant. Consequently, the porosity of sand dominant, or clay dominant lithologies have a wide range with considerable overlap (Table 8.1).

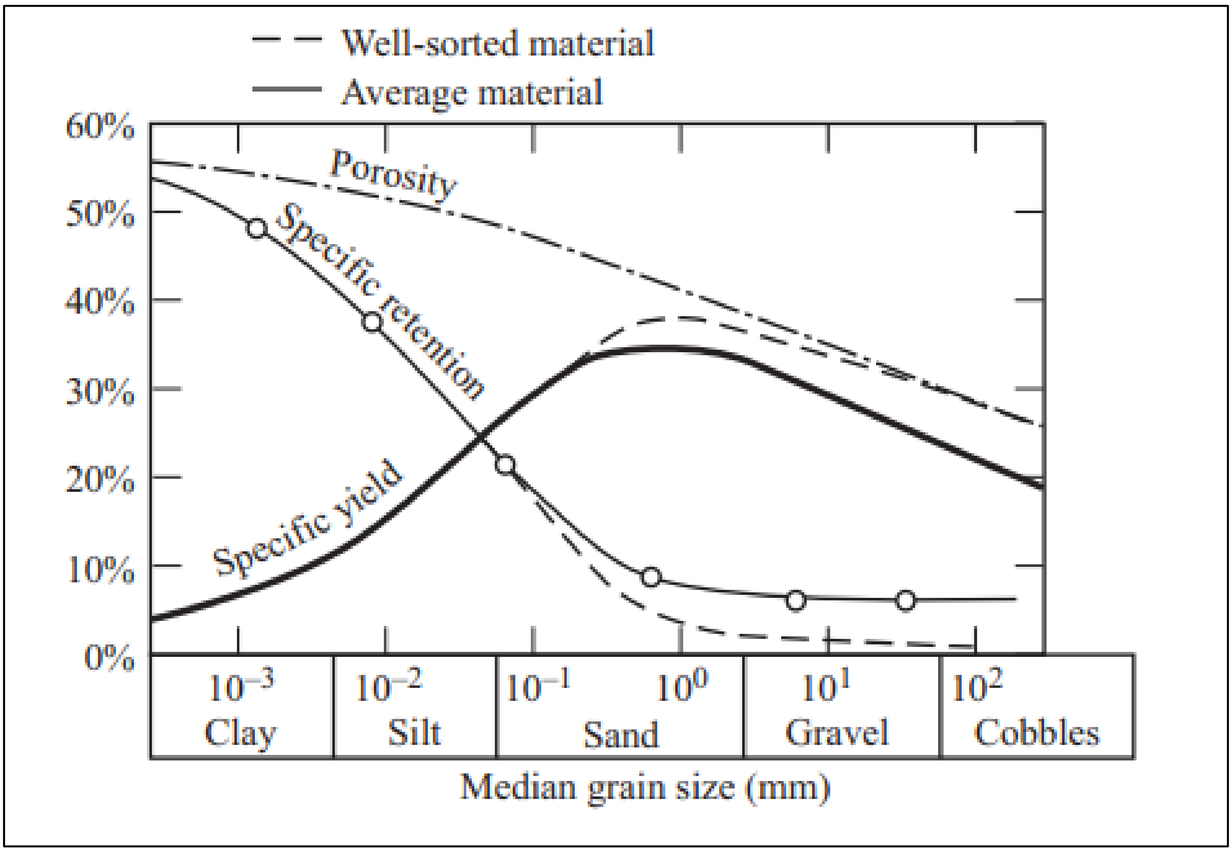


Figure 8.6:Relationship between total porosity, specific yield and specific retention for different grain sizes

Drainable porosity analysis was carried out on undisturbed core samples from the partially completed diamond drilling program at Olaroz. Primary samples were analysed by the Geosystems Analysis laboratory in Tucson, USA. Check samples were analysed at the DB Stephens laboratory, in Albuquerque, USA. Extensive historical porosity data is also available from porosity sample testing at Olaroz in 2010-11 and from test work conducted at the Orocobre Cauchari project between 2011 and 2018 in equivalent sediments.

Results of the drainable porosity (specific yield) analysis are summarized in Table 8.1, with results from recent and historical sample analyses.

Lithology type	Total Porosity Pt	Specific Yield Sy
Olaroz 2021		
Sand variants	0.20+/-0.12	0.09+/-0.08
Silt mixes	0.35+/-0.09	0.06+/-0.05
Halite dominant	0.08+/-0.07	0.04+/-0.02
Olaroz 2011		
Sand dominant	0.31 ±0.06	0.13 ±0.07
Silt and sand-clay mixe	0.37 ±0.08	0.06 ±0.04
Clay dominant	0.42 ±0.07	0.02 ±0.02
Halite dominant	0.27 ±0.14	0.04 ±0.02
Cauchari 2017-18		
Sand dominant		0.19+/-0.06
Sand-clay mixes		0.07+/-0.04
Clay dominant		0.03+/-0.02
Halite dominant		0.04+/-0.03

Table 8.1: Porosity results from laboratory test work

8.5 Permeability Testing

Permeability (hydraulic conductivity) is also highly dependent on lithology. Generally finer grained sediments such as clays have lower permeability than coarser grained sediments such as sands and gravels. Near surface halite is often highly permeable, due to a network of fractures, although halite becomes progressively more compact and less permeable with depth. However, cavities and fracture networks are observed in some deeper halite units. The sequence of sediments in the Olaroz salar exceeds 650 m thickness. Extraction from below 50 m is from semi-confined to confined aquifers.

Permeability for extraction purposes is best measured by conducting pumping tests and evaluating changes in the water level in the pumped well and observation wells. Pumping tests were carried out on wells installed for the expansion program, with variable rates and constant rate pumping tests conducted over periods of up to 48 hours. The results of the pumping tests are summarized in Table 10.2 and Figure 8.7 below.

From the available information the heterogeneity of the mixed clay and sand unit in Olaroz is clear. The highest hydraulic conductivity (K) values are generally related to unconsolidated deposits, in particular the Archibarca alluvial fan. Pumping test results show values of between 3.4 and 67 m/d in this material.

The unconsolidated deposits have a range of storage coefficient in the order of $4x10^{-4}$ to $2x10^{-1}$ related to unconfined to semiconfined parts of the aquifers. The deeper semi-confined to confined units composed of clays, silts and sands have values in the order of $1x10^{-3}$ to $3x10^{-6}$. Permeability values defined for the hydrostratigraphic units are shown in Table 8.2.

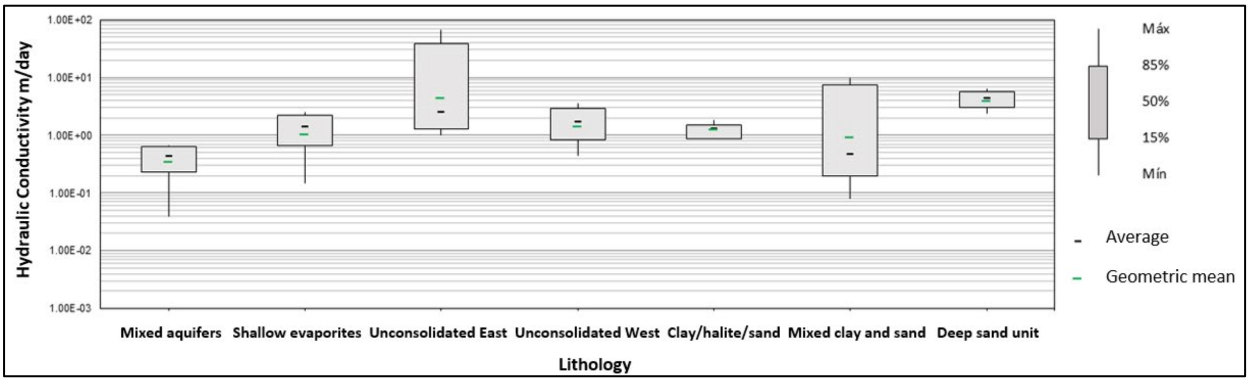


Figure 8.7: Hydraulic conductivity by sediment type

Unit	Hydraulic conductivity range m/day	Storage Coefficient range
UH1	0.15-2.5	10-15 %
UH2	0.5-67	1-20%
UH3	0.87-1.8	1E-6 to 0.1
UH4	8E-2 to 10	1E-7 to 0.1
UH5	2.4 to 6.3	1E-7 to 0.15

Table 8.2: Hydraulic parameters by hydrostratigraphic unit

8.6 Groundwater Levels

Groundwater levels were measured in initial exploration of the salar, with the water table within 1 metre of surface across the salar surface. Off the salar, the groundwater level in the alluvial fan sediments is deeper, as the topography rises around the salar and where fresh to brackish water is present.

SDJ has established a monitoring well network around and within the salar, from which regular information is collected on changes in water level (Figure 8.8 below and Figure 9.11). Hydrographs from the monitoring network around the edges of the salar generally show there is seasonal decline in the groundwater level due to discharge to the salar and evaporation, with recharge from seasonal summer rainfall (and possibly snow melt) resulting in a rise in the groundwater level (Figure 8.8). These dynamic changes will depend on yearly and long-term rainfall and snow patterns and could potentially be influenced by pumping activities.

Within the salar pumping has generated a drawdown cone that is centred around the northern and southern wellfields, which appears to have developed a stabilized drawdown level.

8.7 Water Balance

In most enclosed basins, in absence of any major groundwater abstraction, it is assumed the long-term water balance is in equilibrium, with groundwater recharge from precipitation equal to the groundwater discharge and evaporation. Groundwater recharge in high desert basins is generally difficult to quantify, due to scarcity of precipitation measurements (liquid and solid) and the uncertainties in the soil infiltration and potential sublimation rates, and runoff coefficients.

Groundwater recharge was estimated from groundwater inflow into the salar from surrounding sub-basins for which infiltration was calculated through a surface water model developed by consultants NAPA.

Groundwater discharge in enclosed basins takes place through evaporation, which is a function of soil type (grainsize/permeability), depth to the phreatic level, water (brine) density and climatic factors (both seasonal and longer term). Soil evaporation rates were determined as a function of these parameters using evaporation domes and data collection from shallow auger holes in December 2018 in Cauchari. With this information three evaporation curves were established with respect to depth, for the nucleus, marginal and alluvial zones. This data was applied to equivalent areas of the Olaroz salar by consultants NAPA, in order to estimate the long term evaporation there. The evaporation data was then used to estimate the natural water losses from the basin and how they compare with water inputs. The NAPA model has a difference of less than 2% and is considered to adequately represent the basin water balance.

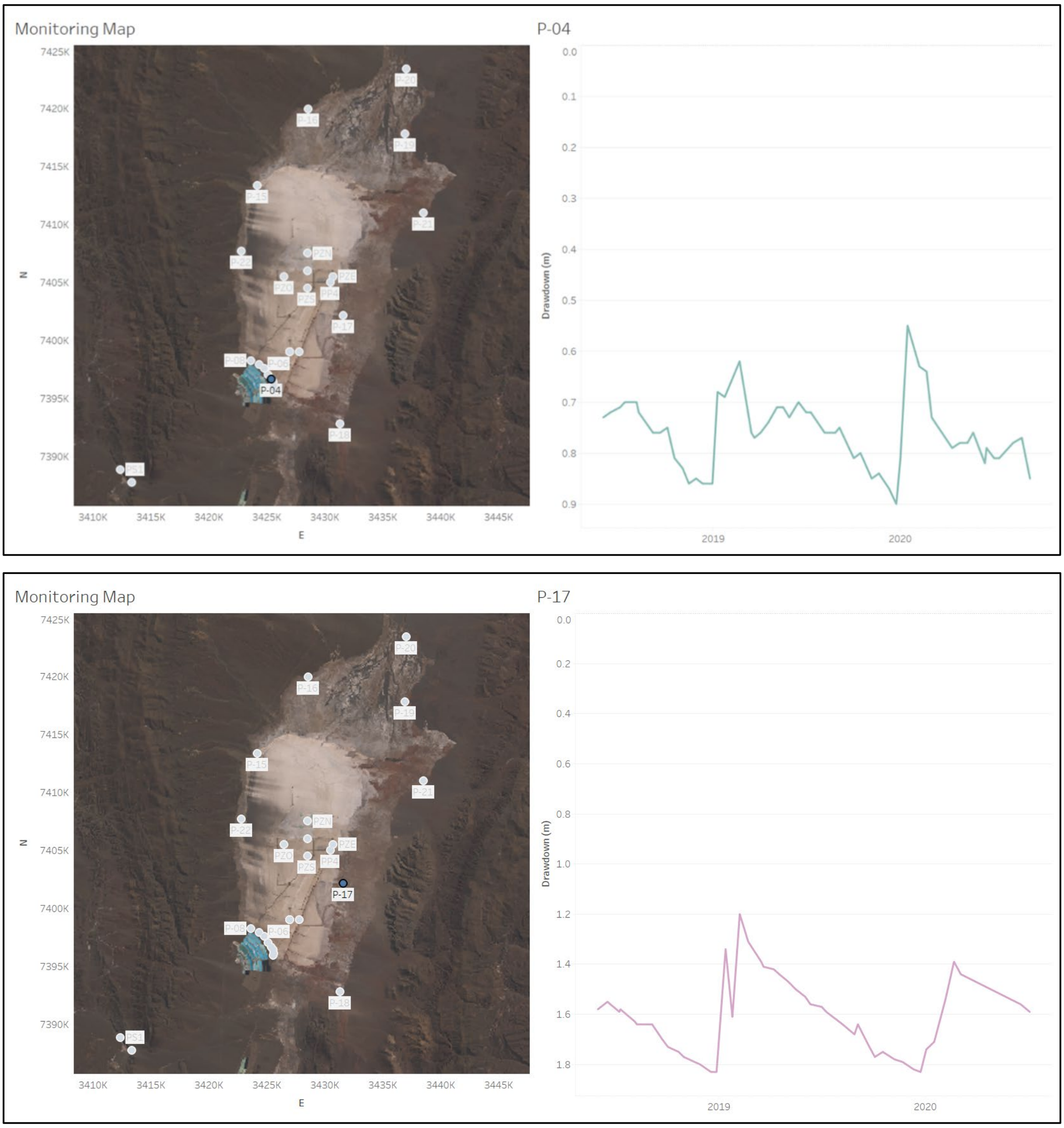


Figure 8.8: Shallow hydrographs from the Olaroz monitoring network, with P04 in the south at the base of the Archibarca alluvial fan and P17 on the eastern side of the salar

9 EXPLORATION

9.1 Overview

From 2008 to 2011 Orocobre undertook exploration at Olaroz that culminated in the definition of a resource to a depth of 200 m across the salar and the completion of a feasibility study for the construction of a new lithium carbonate project, the first in approximately 20 years, following the early salt lake developments in South America.

An extensive array of work was undertaken to support the Olaroz Project development and that is outlined below. Subsequent exploration was undertaken in 2014 and from 2019 onward to explore and develop the deeper levels of the Olaroz basin.

A summary of the Orocobre exploration work is provided in the following sections. Activities included:

- Shallow brine pit sampling (2008);
- Shallow diamond drilling (2008), to a maximum depth of 199 m, with all but two holes < 95 m deep;
- Gravity geophysical profiling (26 km in 2009);
- AMT electrical surveying (34 km in 2009);
- Catchment assessment and sampling of surface water (2009 onward);
- Sonic drilling (2010/11) in 18 holes to a maximum depth of 54 m;
- Diamond drilling (2010/11) in six holes to a maximum depth of 200 m;
- Installation of monitoring wells and pumping test wells (2011) and pumping tests on 50 m and 200 m wells;
- Drilling of two production wellfields to 200 m (2012-2014);
- Drilling of two test production wells below 200 m (2014);
- Vertical Electric Sounding (VES) Survey (2016), deepening and installation of new production wells to 450 m;
- Detailed gravity and magnetic survey (2017);
- Installation of shallow monitoring wells (2019);
- Drilling of expansion Olaroz Project production wells (2019-2021); and
- Preparation of this NI43-101 report.

Other information sources in the area include:

- A NI 43-101 compliant technical report prepared for Advantage Lithium (now 100% owned by Allkem) in 2019.
- A NI 43-101 compliant technical report prepared for Lithium Americas in 2020 and earlier reports dating to 2010.

9.2 Pit Sampling 2008

Shallow pit sampling was carried out across the Olaroz salar and confirmed the elevated concentration of lithium in brine. These initial sampling results were the basis for Allkem acquiring the properties that form the Olaroz Project.

9.3 Shallow Drilling, Resource Estimate and PEA 2008

Allkem undertook a drilling program between 4 September and 2 December 2008. Twenty-two HQ3 diamond core holes were drilled, totalling 1496.3 m. Drillhole locations were based on handheld GPS readings. The initial 16 HQ3 diamond drill holes (core diameter 61 mm) in the program were drilled on a variable grid, to an average depth of 60 m. Two holes in this program were drilled to greater depths of 125.4 and 199 m. Six further HQ3 holes were drilled as monitoring wells for the hydrogeological test work. Geophysical logs, self-potential, short and long resistivity, and natural gamma were run in the 7 holes which had been cased to significant depths.

These, together with geological logs of the recovered material provide the basis of the geological interpretation and subsequent maiden resource estimate in 2009. The drill logs were interpreted to show a near-surface halite layer. Beneath the halite unit a zone of mixed clays, sands and silts was defined down to around 45-60 m below the salar surface. For those holes greater than 60 m deep, the underlying units showed a significant change being more consolidated, with higher clay content. Pumping tests were carried out on three of the test holes, with two additional monitoring wells. The pumping was carried out by airlifting.

The maiden inferred resource for the Olaroz Project was estimated in 2009 using the results of diamond drilling and porosity values assigned to sediments based on field observations and literature values (values of specific yield as 0.22 for sand, 0.05 for halite and 0.01 for clay). The Inferred Resource was estimated as 1.5 Mt of lithium carbonate equivalent. Based on the results of this work a Preliminary Economic Assessment (PEA) was prepared for the Olaroz Project.

9.4 Gravity Survey 2009

Gravity techniques measure the local value of the acceleration, which after correction, can be used to detect variations of the gravitational field on the earth's surface that may then be attributed to the density distribution in the subsurface. Since different rock types have different densities, it is possible to infer the likely subsurface structure and lithology, although various combinations of thickness and density can result in the same measured density; a problem known as non-uniqueness.

Data was acquired at a total of 130 gravity stations spaced at 200 m, coupled with high precision GPS survey data (Figure 9.1). A Scintrex CG-5 gravimeter (the most up-to-date equipment available) was used, and measurements taken over an average 15 minute period in order to minimise seismic noise. A base station was established with readings taken at the beginning and end of each day's activities in order to establish and subsequently eliminate from the data the effects of instrument drift and barometric pressure changes. The daily base stations were referred to the absolute gravity point PF-90N, close to Salta where a relative gravity of 2149.136 mGal was obtained.

Since this point is distant from the Salar de Olaroz, intermediate stations were used to transfer the absolute gravity to Pastos Chicos (on the east of the Olaroz salar) where a relative gravity base station was established with a value of 1425.313 mGal.

To measure the position and elevation of the stations, a GPS in differential mode was used with post-processing (Trimble 5700). This methodology allows centimeter accuracies, with observation times comparable to or less than the gravity observation. Using a mobile GPS (Rover) the gravity station position data is recorded. Simultaneously, another GPS (Fixed) records variation at a base station located within a radius of 10 to 20 km, to correct the Rover GPS. Both data sets are post-processed to obtain a vertical accuracy of 1 cm.

The raw data was subjected to a tidal correction and corrections for drift, instrument height, ellipsoid, free air, latitude, bouguer and topography.

The Bouguer anomaly can be modelled to represent the subsurface geology (Figure 9.2). However, any model is non-unique and it is essential to take into account the known geology and rock density. A four layer model was developed for the salar based on these original profiles.

9.5 AMT Survey 2009

AMT measures temporary variations in the electromagnetic field caused by electrical storms (high frequencies >1 Hz), and the interaction between the solar wind and the terrestrial magnetic field (low frequencies <1 Hz), which allows variations in the electrical subsurface to depths of 2 km or more. The electrical properties of the subsurface depend on Archie’s Law. Hence, it is possible to infer the subsurface variations in fluid resistivity and porosity, although it is important to note that once again the problem of a non-unique solution always exists.

Data at a total of 136 AMT stations, spaced at 250 m intervals was acquired using Phoenix Geophysics equipment within a range of 10,000-1 Hz, using up to 7 GPS synchronized receptors. The equipment includes a V8 receptor with 3 electrical channels and 3 magnetic channels that serves also as a radio controller of auxiliary RXU-3E acquisition units. Three magnetic coils of different size and hence frequency are used at each station, and non-polarizable electrodes that improve signal to noise ratios. The natural geomagnetic signal during the acquisition period remained low (the Planetary A Index was <= 6 for 90% of the acquisition time) requiring 15-18 hours of recording at each station.

- All stations were surveyed in using differential GPS to allow for subsequent topographic corrections. AMT requires a Remote Station, far from the surveyed area, in a low level noise location to act as a baseline for the acquired data. In Olaroz the remote station had two different locations during the Olaroz Project depending on the sub sector where work was being undertaken.
- Processing of the AMT data requires the following stages:
- Filtering and impedance inversion of each station;
- 1D inversion for each station;
- Development of a resistivity pseudosection; and

- 2D profile inversion (including topographic 3D net)

An example of the 2D model results is presented below in Figure 9.3. Assuming that the major controlling factor is the fluid resistivity (or conductivity) it is possible to establish a provisional calibration in terms of the brine to freshwater interface. The calibration is based on a series of surface samples of the electrical conductivity (the reciprocal of resistivity) of the fluid in the northern part of the salar across the Rio Rosario delta. As can be seen, the calibration for the 2D inversion particularly is significant, suggesting the main control on bulk AMT resistivity is fluid resistivity.

9.6 Sonic Drilling 2010/11

Boart Longyear was contracted by Allkem to perform the Sonic Drilling program (Figure 9.4) at the Salar de Olaroz for the purpose of obtaining continuous geological and brine sampling. The program (C series) involved the drilling and sampling of 20 holes to a depth of 54 m each using a 4” (100mm) core by 6” (150mm) casing Sonic sampling system, for a total of 1,080 m drilled. The objective of the sampling was multipurpose: to obtain a near undisturbed sonic core and to obtain uncontaminated brine samples.

Sonic technology utilizes high-frequency vibration generated by a highly specialized sonic oscillator, which creates vibration known as “resonance”. The resonance is transferred to the drill pipe, which reduces friction and allows the drill bit at the pipe end to penetrate the formation with minimal disturbance. The rig used was a track mounted 300C ATV Sonic Rig with associated support equipment. Drilling involved:

- Setting up sonic rig at each location;
- Sampling the formation sonically using a 4” (100 mm) core barrel with a polycarbonate (lexan) core barrel liner of 1.5 meter length. The retrieved core barrels were capped and sealed with PVC tape at each end on retrieval at the surface (Figure 9.5):
- At the end of each 1.5 m run 6” (150mm) casing was advanced over the core barrel. No drilling fluids were used for the drilling operation;
- A 2” diameter x 12” long (in an 18” long split spoon - SS) was then pushed ahead of the casing. The SS had a plastic liner in the barrel, and was capped and sealed at the surface (Figure 9.5);
- A “push ahead” brine sampling tool was be advanced on the drill string to allow for sampling of the brine, from the space left by the withdrawal of the SS sample;
- Once in place, brine was bailed out from within the drill rods using a “bailer” or low flow pump until a representative brine sample was obtained. The sample was identified as in-situ, uncontaminated formation fluid as soon as the fluid being extracted came free of Fluorescein biodegradable dye.

Once the 6” casing was at the targeted depth, the hole was be made available to the geophysical contractor to undertake down-hole geophysical logging.

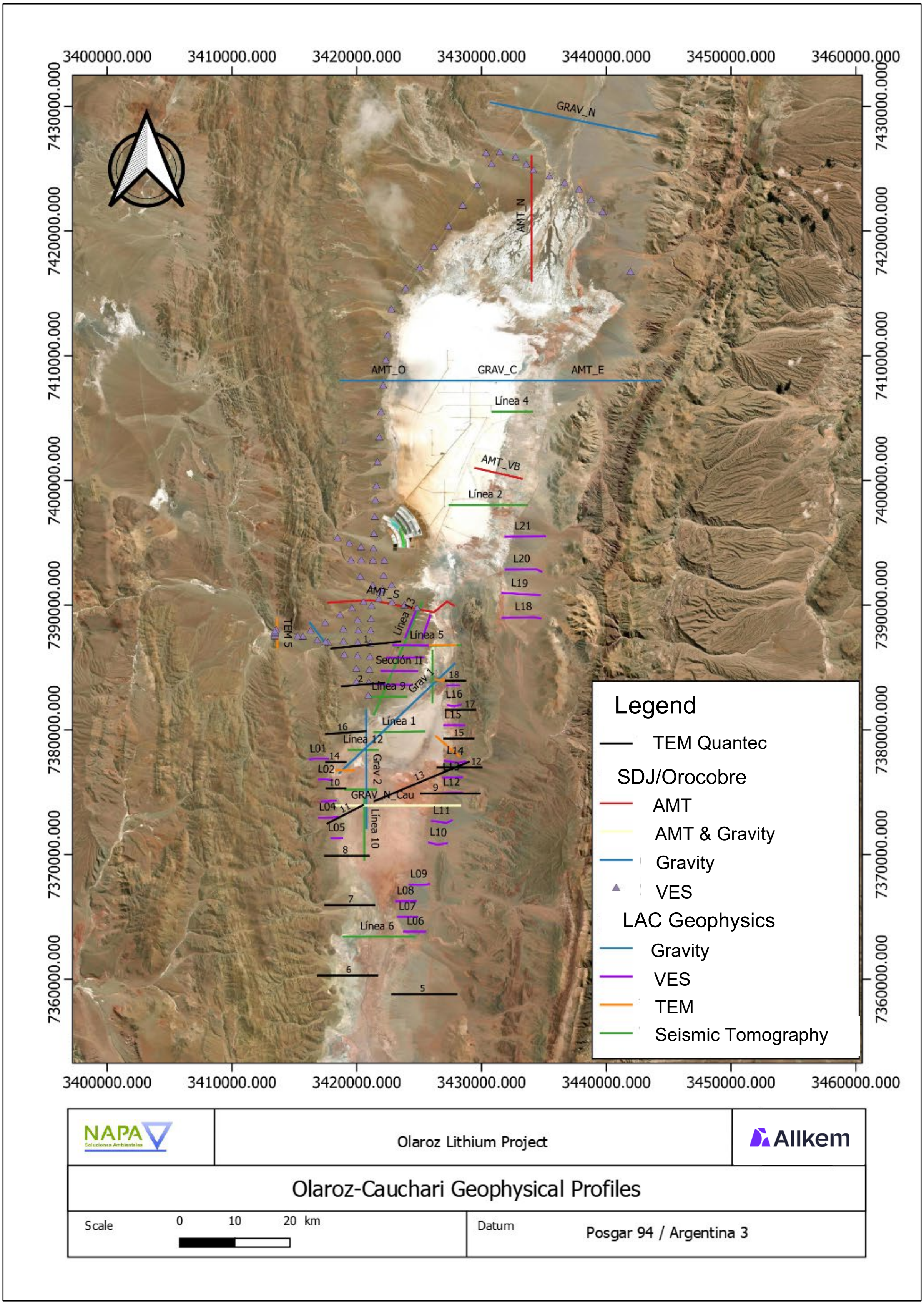


Figure 9.1: Location of the gravity, AMT and SEV geophysical profiles measured at Olaroz and in Cauchari (after Napa, 2021)

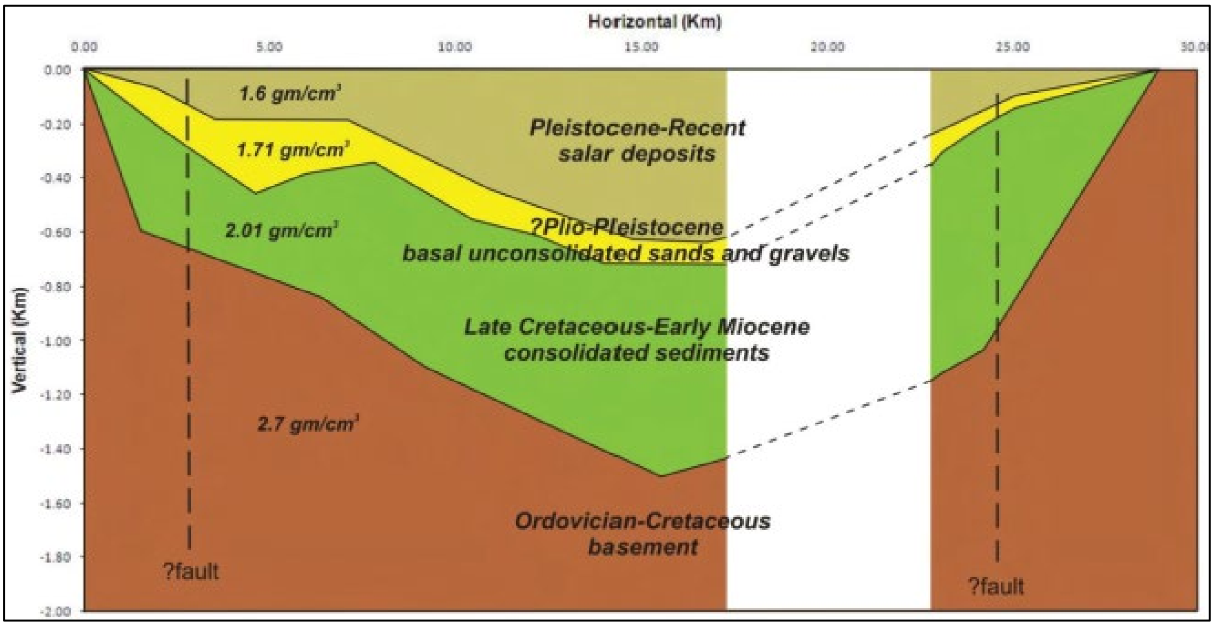


Figure 9.2: Original Olaroz gravity model. Drilling has shown the unconsolidated salar sediments continue to 1.4 km deep, so the green unit is a continuation of these

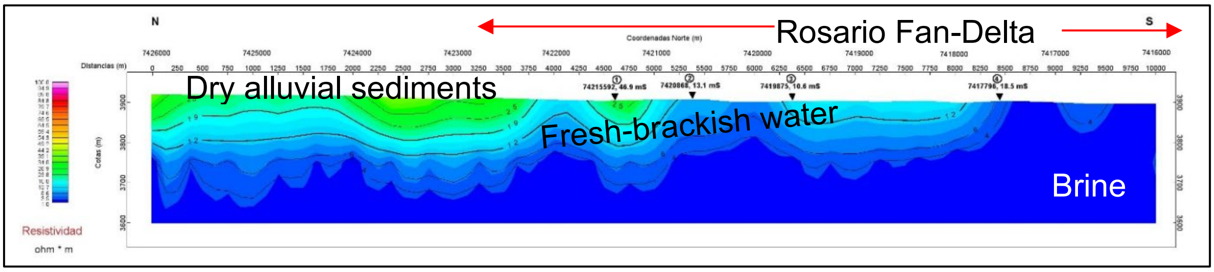


Figure 9.3: AMT line north south through the Rosario Delta area, looking to the east (salar to the right)

Figure 9.4: Sonic drilling rig operating at Olaroz in 2010

9.7 Diamond Drilling 2010/11

Major Drilling was contracted to drill the deep CD series wells. The objectives were the same as for the C series wells; to obtain undisturbed samples of formation and fluid. Drilling was with a Major-50 diamond drill rig with triple tube coring capacity. Drilling was usually accomplished using only the fluid encountered in the well during drilling. However, some drill fluid additive was used. This drill fluid was based on brine taken from a pit dug immediately adjacent to the well at the surface. Since this may introduce sampling issues for the in-situ formation fluid, extra care was taken with the addition of fluorescein biodegradable dye to all drill fluid used. In addition, core samples taken were spun in a centrifuge at the BGS research laboratories in order to extract the pore fluid, which was subsequently analyzed and checked against the in-situ samples.

A total of six wells were drilled using this method to an average 200.7 m depth, for a total of 1,204 m drilled. Depths for individual wells are given in Table 10.1, the total depth for the purposes of resource evaluation. Core recovery was generally poor, due to the poorly consolidated nature of the sediments (Table 9.1).

Figure 9.5: Recovery of the lexan core and split spoon samples on the sonic

Well ID	Drilled (m)	No Recovered meters	%	Recovered meters	%
CD-01	195.5	9.54	4.9	185.96	95.1
CD-02	199.7	35.93	18.0	163.77	82.0
CD-03	200	48.59	24.3	151.41	75.7
CD-04	200	89.65	44.8	110.35	55.2
CD-05	200	11.5	5.8	188.50	94.3
CD-06	199.5	74.67	37.4	124.83	62.6
Average 2011 (6 diamond holes)					77.5%
DDH-02	650	72.52	11.2	564.98	88.6%
DDH-04	537.5	72.88	13.6	452.62	86.1%
DDH-17	650	85.55	13.2	552.45	86.6%
Average 2021 (3 diamond holes)					87.1%

Table 9.1: Recovery for 2021 diamond drill holes and 200 m holes for the 2011 feasibility study

In all sonic and diamond drilled wells, Wellfield Services Ltda were contracted to run wire-line logs from surface to full depth. The logs were run inside temporary steel casing, but this does not present a problem for gamma and other logs that are able to penetrate the casing with their sensors.

The following logs were run: caliper, natural gamma, density and neutron logs. Electronic data is captured on a continuous centimetric basis down the well. Since the logs had to be run inside steel casing because the holes were unstable if not supported, no electrical logs could be run.

The logs are particularly useful to extrapolate lithology and porosity data into the few zones where there was no core recovery. Caliper logs are run to ensure that the drill hole width is constant within the casing so that the other logs may be corrected for drill hole diameter. The caliper log was sufficiently accurate that it was able to identify casing joints throughout the wells.

Natural gamma logs indicate the received gamma ray intensity at the downhole tool. Since gamma rays are emitted by uranium, thorium and potassium minerals in rocks, the log typically responds to clay minerals and volcanic horizons. Evaporitic minerals such as halite and gypsum have a very low radioactive mineral content and can usually be identified by their low count rate. Thus, the gamma is a useful tool for identifying certain types of lithology and for correlating beds across multiple wells.

Density logs emit and receive gamma rays and are thus sometimes known as gamma-gamma tools. This technique measures the bulk density of the rock matrix and pores. Since minerals have characteristic densities, the tool is used for lithological identification when coupled with natural gamma logs. Since it also measures the porosity of the formation it can be used quantitatively to determine total porosity. Since the bulk density depends both on the mineralogy and porosity, any porosity determinations must account for the rock mineralogy. In rapidly changing sequences such as the Salar de Olaroz, it becomes extremely difficult to correct the log for these changes. Thus, its principal use is in the assessment of lithology.

Neutron logs measure the hydrogen ion content of the formation and pores adjacent to the sondes. Two downhole tools are used with different spacings so that penetration is both “near” and “far”, with respect to the well diameter. Since the hydrogen ion content is largely determined by the fluid (water) content of the pores, the log can be calibrated to determine the in-situ total porosity.

9.8 Test Pumping 2011

Three test production wells were drilled using a conventional rotary rig to depths of 50 m (P and O series). In some cases, it was possible to drill using only formation fluid, but in several cases, drill fluid had to be used to advance the well. The test production wells were not used for sampling for the resource estimation. The wells were drilled at 12” diameter and completed with 8” slotted PVC screen with gravel pack to full depth. Immediately after completion the wells were developed by air-lift surging for periods up to 10 days to ensure that all drill fluid and fines were removed from the well.

At test production well site P1, three observation wells were drilled at nominal radial distances of 7 m and 18 m from the pumped wells toward the north and east. These observation wells were drilled at 8” diameter to full depth and completed with 4” slotted PVC casing and gravel pack. At test production well sites P2 and P3, the same configuration was used, except the observation wells were doubled at each locality and drilled to depths of 28 m and 40 m with screens 0-27 m and 29-39 m (P2), and drilled depths of 13 m and 38 m with screens 0-12 m and 15-38 m.

Two deep test production wells, PD1, adjacent to CD01, and PD2, adjacent to CD06 were also completed at a diameter of 8” and depth of 200 m. Wells CD01 and CD06 were completed with slotted plastic piezometers in order to enable their use as observation wells during subsequent pumping tests.

Initially, step discharge tests were undertaken with increasing flow rates in order to determine the well efficiency, which in all cases was above 87%, indicating the development had been effective.

Constant rate tests started on the 25 August 2010 and ran through until 26 January 2011 when they were stopped as a result of surface water flooding throughout the Salar. This represented a period of 154 days, or just over 5 months and provided a high degree of confidence that pumping rates and brine quality can be maintained in the long-term, which has been confirmed by production to date.

9.9 Production Wellfield Installation 2012/13

Two production wellfields were installed between 2012 and 2013 for the initial project development. The northern wellfield comprised 16 wells and the southern field four wells, all drilled to 200 m with rotary drilling and installed as production wells. Five additional monitoring wells were installed within and around the production wellfields, in addition to monitoring wells installed around the edge of the salar.

9.10 Deeper Test Production Wells 2014

In 2014 it was decided to drill a test production well in the southwest of the salar to evaluate the sediments below 200 m. The initial test production well (P301) was highly productive and a deeper, larger diameter well (P302) was subsequently drilled at another site to 323 m, resulting in a flow rate of 30 l/s. These wells were subsequently put into production and the positive results have developed an improved understanding of the salar geology and supported further deeper drilling to supply the expansion. These wells have been in production since 2014 and were drilled with the rotary method. Wells were subject to step tests and constant rate tests prior to entering in production.

9.11 Vertical Electrical Soundings 2016

A campaign of vertical electrical sounding (VES) geophysics was undertaken in 2016 across the Archibarca alluvial fan and around the salar by a geophysical contractor (Figure 9.6), to define the interface between surficial fresh water and underlying brine. This survey defined the interface successfully and allowed confirmation of the estimated volume of freshwater resources in the Archibarca fan area. Definition of the fresh water-brine interface provided important additional information for the groundwater model development, for a better understanding of the salar margins and long term monitoring.

The geoelectric method (Figure 9.7) was used with equipment consisting of simultaneous reading of intensity and potential difference. Two stainless steel current electrodes were used with lengths of 1.20 meters, due to the characteristics of the area. In addition, two copper potential electrodes in a saturated solution of copper sulfate were used to improve the ground connection.

Copper current cables of 1000 meters in length were used with two sources of 270 volts each used as the power source, for a total of 540 volts. The geoelectric prospecting was carried out with the VES (Vertical Electrical Sounding) method, which used a Schlumberger tetrapolar electrode arrangement. The lengths between the centers of the soundings and current electrodes were variable, up to maximum distances of 1000 meters. The separations between the potential electrodes varied between 1 and 200 meters.

The field curve of each VES was plotted on log-log paper where the abscissa corresponds to the OA values and the ordinate to the apparent resistivity values.

The field curves were interpreted by means of specific computer programs RESIST 92 and IPIWIN 2000. The program carried out as many iterations as were necessary in order to fit the computational curve to the field curve. The final result of the geoelectric prospecting was the interpretation of the VESs that, as a whole, determined the geological - hydrogeological environment in depth of each area under investigation. An example curve through the Archibarca area is shown in Figure 9.8.

Figure 9.6: SEV geophysical equipment in use in the Archibarca area

Figure 9.7: The process of converting field resistivity measurements to interpretation of thickness and resistivity

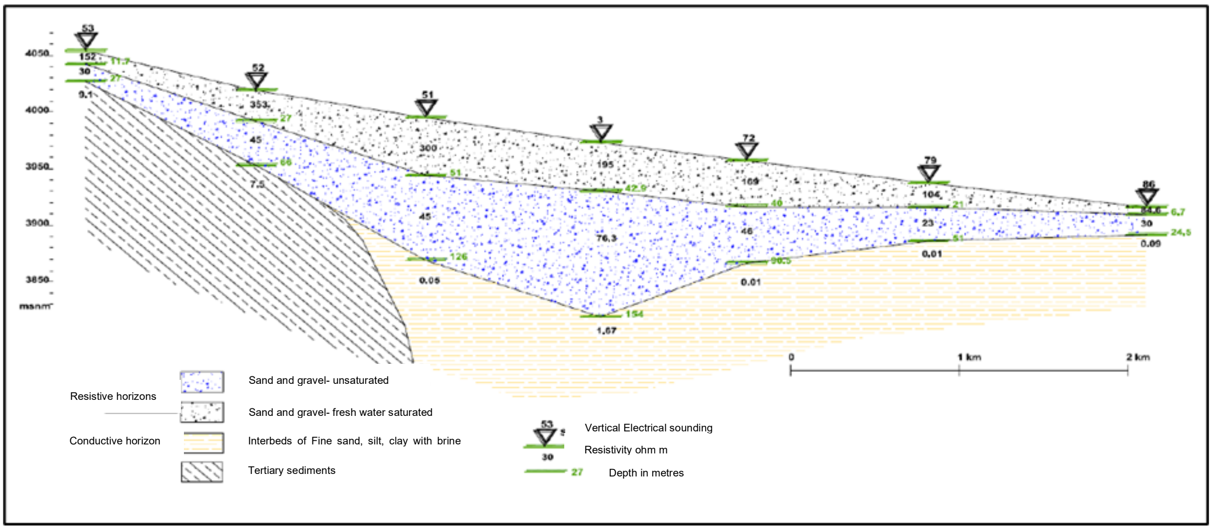


Figure 9.8: West to east profile of vertical electrical soundings through the Archibarca alluvial fan, showing the upper dry sediments over freshwater in sediments, overlying brackish water to brine

9.12 Detailed Gravity and Magnetic Survey 2017

A systematic grid gravity and ground magnetic survey was carried out by personnel from the University of San Juan in 2016-17, to better map the contact of the salar sediments with the underlying bedrock and to better establish the depth to bedrock. This evaluation confirmed that bedrock underlying the salar is over 1 km deep, and deeper on the eastern side of the salar. The survey provided important additional information on the basin geometry. However, no drill holes have intersected the basement rocks underlying the salar and consequently it was not possible to optimize the model with this information.

Measurement campaigns were carried out in the period from November 14 to December 21, 2016, acquiring 6205 gravimetric stations georeferenced with post-process DGPS methodology. In addition, 850 km of linear magnetism were processed in the Salar de Olaroz (Figures 9.9, 9.10).

In the acquisition of the regional gravimetric data three geodetic gravimeters were used. These were subjected to drift controls and calibrated before starting the measurements and during the campaign. Detailed measurements were made with two automatic gravimeters with a precision of 0.010 mGal.

For the magnetic determinations, 4 Overhauser magnetometers with 0.02 nT resolution were used, three of them in rover mode and a base magnetometer to record the diurnal variation of the external magnetic field. The magnetic survey provided useful information on probable faults in the bedrock underlying the salar.

Topographic support was performed by differential GPS positioning (post-process), using 4 GPS receivers (2 Trimble 5700 with Recon controller and 2 Topcon Hiper SR receivers with FC500 controller), one of which operated as GPS base station in the Sales de Jujuy plant.

Equipment for the gravity survey consisted of:

- 1 Automatic Gravimeter, Autograv Scintrex, model CG 5, precision 0.005 mGal;
- 1 Automatic Gravimeter, Autograv Scintrex, model CG 3, precision 0.010 mGal; and
- Thermostated Gravimeter, LaCoste & Romberg, model G, precision 0.030mGal.

Equipment for the magnetic survey consisted of:

- GEM GSM system, model 19GW V7, Overhauser total field magnetometer. Equipped with console and sensors (Gradiometer), which measure in walking mode (in motion continuous recording) with GPS positioning. Sensitivity 0.02 nT; and
- GEM GSM system, model 19 V7, Overhauser total field magnetometer. Equipped with console. One of them registered continuously in base mode. The sensitivity of this equipment is 0.02 nT

Surveying equipment utilized on the Olaroz Project consisted of:

- Two (2) GPS, Trimble 5700, with Recon controller;
- Two (2) GNSS, Topcon Hiper SR, with FC500 controller; and
- Two (2) GPS, Trimble 4400, with TSC1 controller.

Figure 9.9: Team conducting ground magnetic survey, Scintrex CG5 unit and Scintrex CG3 unit

Figure 9.10: Installation of the magnetic base station (left) and the GPS base station (right)

9.13 Shallow Monitoring Well Installation

Shallow monitoring wells were installed around the borders of the salar to provide information on the depth of and variability in the depth to the water table. These monitoring wells (Figure 9.11) were installed to evaluate seasonal variability in the water table relative to possible long-term changes related to pumping.

9.14 Installation of Expansion Wells (2019-2021)

Installation of deeper production wells for Stage 2 commenced in 2019 and has continued through 2021. These wells were installed to 650 metres deep in the east of the salar and 450 metres in the centre and west of the salar. Wells were installed using rotary drilling. Monitoring wells are being installed in diamond drill holes around these new wells. Details are provided in the following section on drilling.

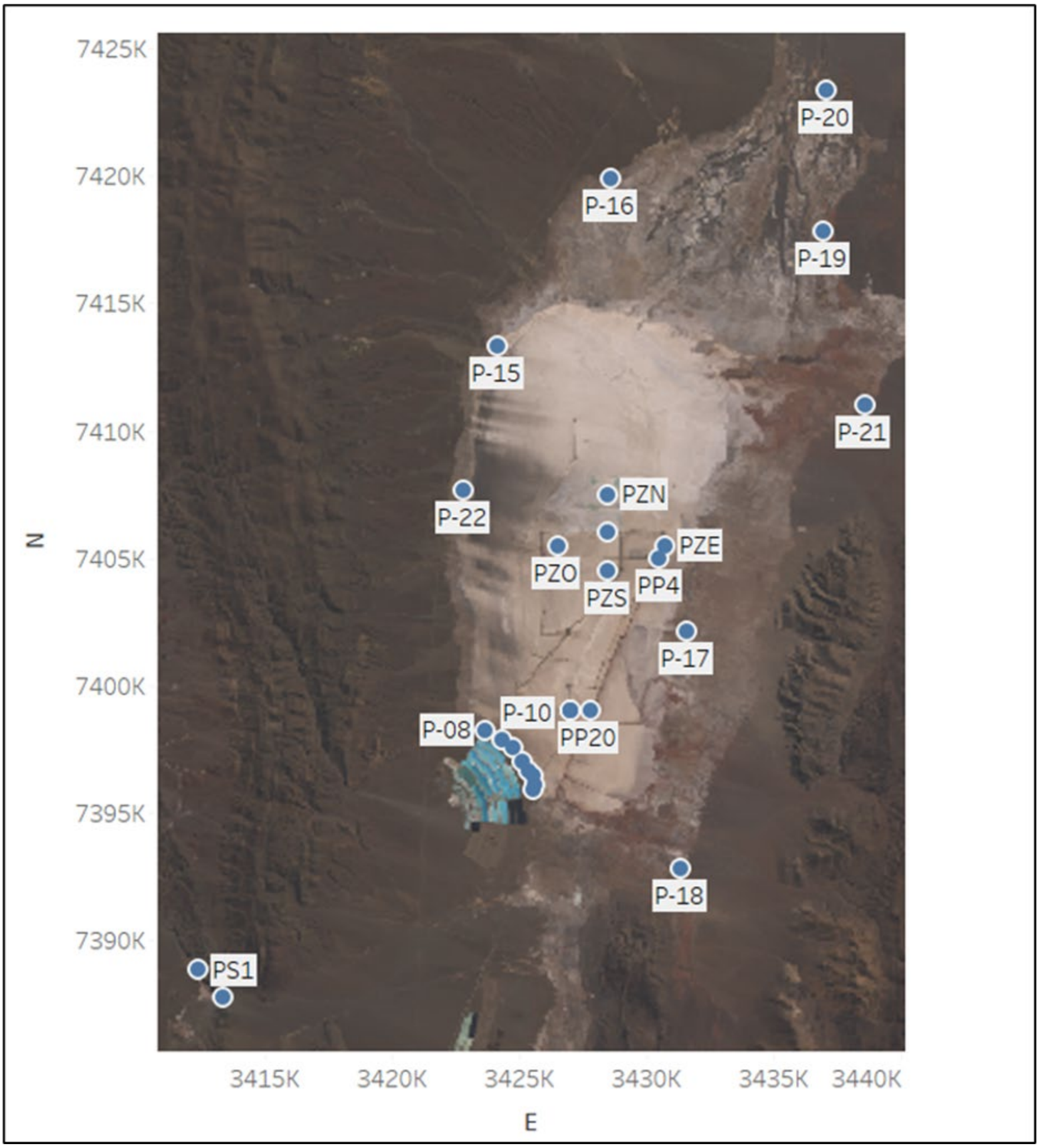


Figure 9.11: Location of monitoring wells across the Olaroz area

10 DRILLING

10.1 Background

Drilling is important to provide representative high-quality samples of the sediments hosting brine, to provide representative samples of the brine itself and to provide samples with a sufficient spacing to support different levels of resource estimation. Obtaining representative porosity and brine samples presents a number of challenges. In order to supplement information from drilling SDJ has a policy of geophysically logging all drill holes, to maximize the amount of information collected. Drilling has been conducted in the Olaroz-Cauchari basin since 2008, with drill holes by SdJ and adjacent property owners (formerly Advantage Lithium) and Lithium Americas Corp/Ganfeng. In the Olaroz-Cauchari area there has been approximately 165 wells or piezometers installed (Figure 10.1). Table 10.1 lists the piezometers and production wells in the Olaroz Project.

Exploration drilling

Three exploration drilling campaigns were previously carried out at Olaroz. Initial drilling consisted of shallow (60 m) diamond drilling in 2008. This was followed by the drilling conducted at Olaroz in 2010/11 of 19 holes with a sonic rig drilling holes to 54 m and six diamond holes drilled to 200 m, as this is generally beyond the capacity of sonic drilling. A third drilling program in 2014 involved the drilling of two rotary holes that were installed as test production wells to a maximum depth of 323 m.

Sonic drilling has the advantage that it is “dry” and does not require drilling lubrication. Other methods of drilling require the use of fluid (in salars brine) for lubrication and to carry drill cuttings to the surface. However, the use of drilling fluid causes difficulties sampling brine and can result in contamination of formation brine during sampling.

Production drilling

Production holes have been drilled with rotary drilling equipment, as this method is well suited to the installation of the larger diameter pipes and screens that are required for production wells, compared to the narrow diameters of diamond drill holes used for exploration and obtaining porosity and brine samples. There have been two major drilling programs installing production wells. The first of these was from 2012-2014, with the installation of production wells to 200 m depth, and several holes to greater than 300 m. This drilling was followed by the extension of several 200 m holes to 350 m depth and drilling of another hole to 450 m depth, all with rotary drilling equipment. This was followed by the ongoing expansion drilling program, commencing in 2019 and continuing, with the installation of production wells up to 650 m deep (Figure 10.2).

The Olaroz expansion program was designed to include both installation of production wells and drilling of diamond drill holes, which would then be installed as monitoring wells. Due to the complication of logistics related to Covid-19 distancing and limited site accommodation the planned number of exploration and monitoring wells has not been completed and the installation of production wells has also been subject to some delays.

The outcome of this situation is that the geological interpretation and sampling has relied on the installation of the new production wells for deeper information.

Traditionally sampling of brine in salt lakes has relied on collecting samples over discrete intervals (typically with a separation from 3 to 12 m) by packer sampling or using a bailer device to purge fluid from the hole prior to sampling, allowing collection of a representative sample of brine due to inflow of formation brine into the well and sampling device. The complication with this methodology is that significant drilling fluid enters the sediments around the hole and during purging it may not be possible to remove all this fluid prior to collecting a representative brine sample. Fluorescein tracer dye can be used with the drilling fluid, so that drilling fluid can be detected by the presence of dye when samples are taken. For the limited diamond drilling completed in the recent diamond drilling Fluorescein has not been used.

The installation of production wells involves widening the initial pilot hole and flushing the hole before the installation of well casing and screens. A gravel pack is added around the well, to minimize the amount of fine material entering the well. The well is then developed by using a jet of high pressure air against the filters, allowing the gravel pack to settle in place and removing fine material from the well. A swab device is also used to clean the hole and gravel pack. Following use of these devices a pump is installed in the well and pumped to clean fine material from the hole. Once the pumped brine is confirmed to be free of suspended sediments the well is allowed to equilibrate before undergoing pumping tests to confirm the hydraulic characteristics of the well. For individual wells and drilling contractors' procedures varied for well development.

Screens are typically installed over long vertical intervals in wells, as outside the high permeability sandy units the sediments constitute a "leaky" package of sediments that liberates brine from the thick sequence of sediments. The brine extracted during pumping comes from different depths in a well is an averaged composition, which is influenced by the permeability of the host sediments, with higher permeability sediments contributing relatively higher flows. Brine extracted from wells has shown minimal variation since the start of pumping on the Olaroz Project in 2012, with the variability on the scale of laboratory uncertainties.

Because of delays with diamond drilling and sampling and the difficulties of collecting brine samples in diamond drill holes to 650 m, assays from the pumped wells to 650 m deep, have been used as part of the resource estimate. Historical diamond drilling to 200 m depth showed the coefficient of variation between lithium in brine samples is low, and consequently use of brine results from production wells is considered reasonable, particularly given the history of pumping and production at the site.

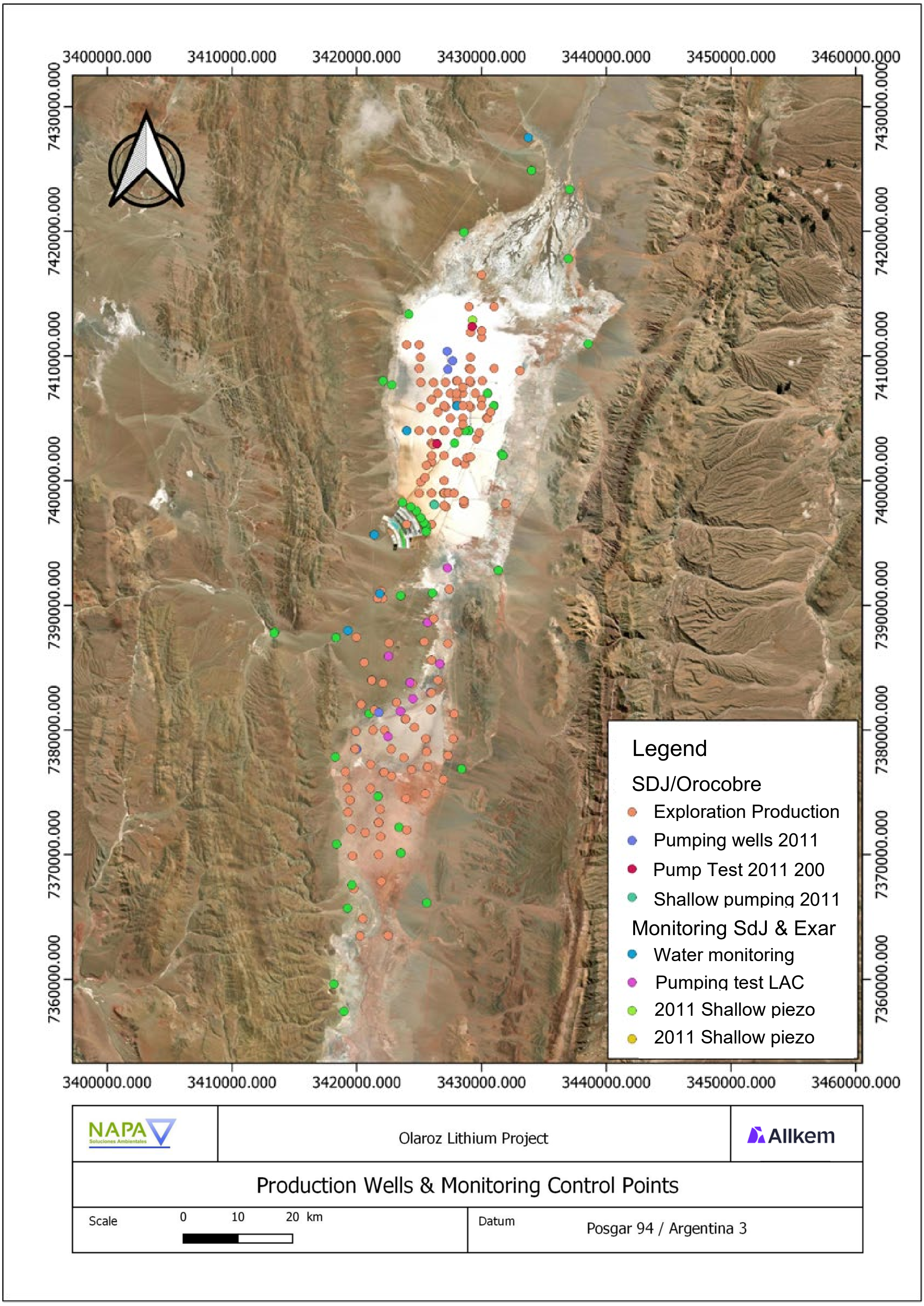


Figure 10.1: Drilling undertaken in Olaroz and Cauchari by SdJ and other companies

10.2 Drilling Density

The original production wellfields have been constructed with a one kilometre spacing between drill holes to 200 m depth. The expansion drill holes are filling in the area between the two wellfields and extending further to the west and south. These wells are installed on a nominal one kilometre spacing, as a continuation of the historical drilling. These holes are drilled at a closer spacing than that recommended by Houston et. al., 2011, with regards to Indicated and Measured hole spacings of five and three kilometres respectively in immature salars.

10.3 Diamond Drilling and Sampling

A limited amount of diamond drilling was completed for this resource update, due to logistical challenges associated with Covid-19 (principally a limitation of on-site accommodation). Three diamond holes were completed along the eastern boundary of the Olaroz properties to a depth of 650 m. Holes were drilled as HQ diameter diamond holes, with HWT size casing accompanying the drilling of the diamond holes, to maintain hole stability and facilitate brine sampling.

Cores were recovered in 1.5 m long lexan polycarbonate tubes, which were pumped from the core barrel with water, to recover the core tube. The lexan tube was capped immediately following recovery of core and stored in core boxes. Samples of core for the laboratory were cut from the base of core runs using a battery powered angle grinder. The laboratory sub-sample was 30 cm long, retained in the polycarbonate tube, and sealed with plastic caps, which were sealed in place with tape, to minimize seepage of brine from the cores. Cores were labelled with the hole name and depth range and sent by courier to the porosity laboratory.

The location of the diamond holes drilled in this program is presented in Figure 10.2, along with the location of production wells. Historical diamond holes are shown on Figure 10.1, with production wells.

Brine samples were collected using a packer system during the drilling of the three diamond holes. The packer device was lowered into place in the sediments and inflated using nitrogen gas to expand the packers against the walls of the hole. The space between the packers and the sampling line to the surface were then purged of brine, with three volumes of the packer and sampling line purged, with increased purging required as sampling progressed to greater depths. Sample parameters were monitored during the purging, to establish when parameters such as total dissolved solids and density stabilized. Samples were taken after different purge times and compared to evaluate how values stabilized.

Once this stage was reached triplicate samples were collected for laboratory analysis and storage. However, despite these procedures it was not possible to reliably purge the packer space sufficiently to allow inflow of uncontaminated brine from the hole walls. Because diamond drilling uses significant volumes of drilling fluid this fluid infiltrates the walls of the hole and when samples are taken returns to the hole. The fluid used for drilling was surficial brine taken from a trench in the north of the salar, noted to consistently have significantly lower lithium concentrations than historical sampling in the vicinity of the three diamond holes. Consequently, brine samples from these three diamond holes were not used in the resource estimate.

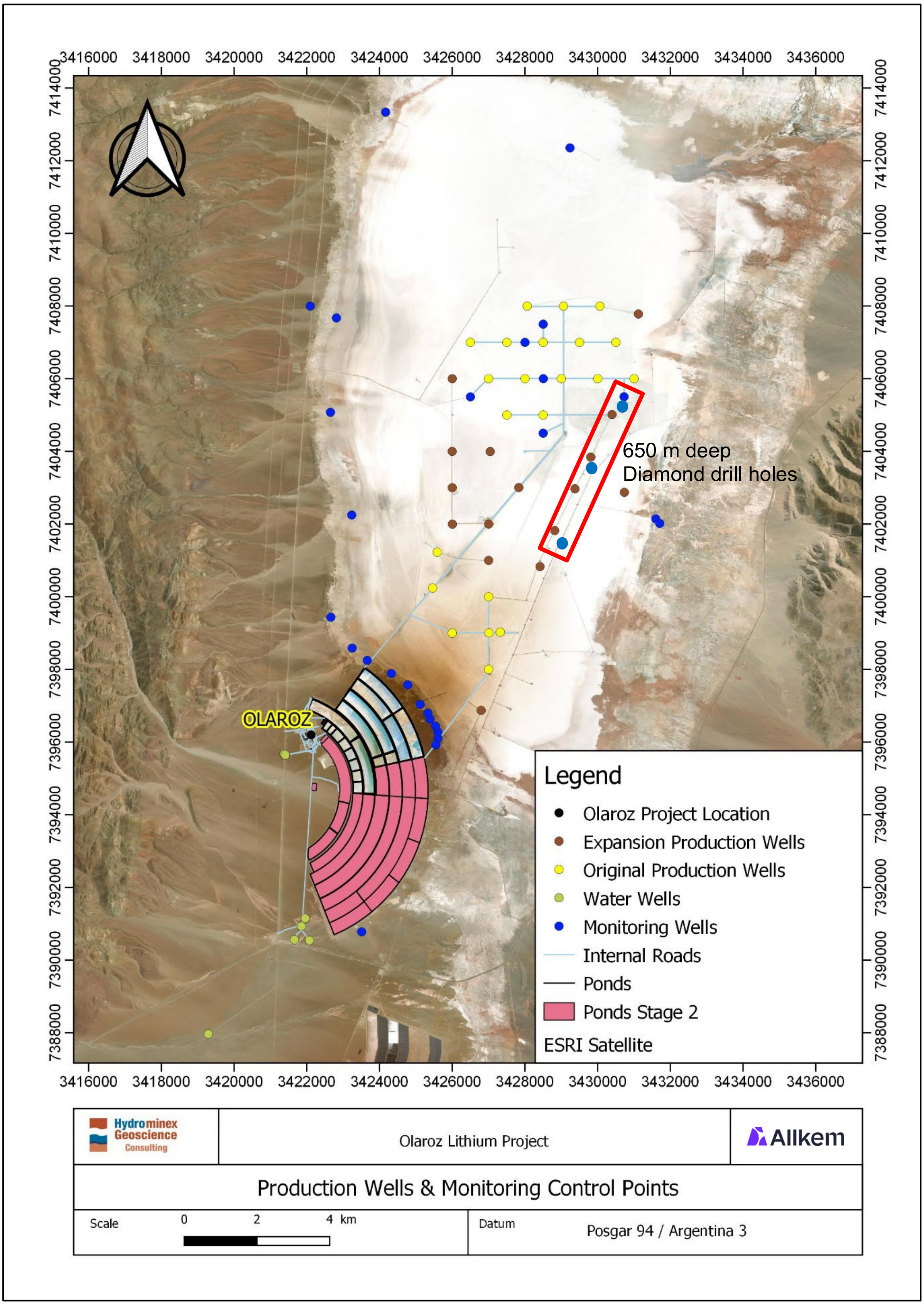


Figure 10.2: Location of Olaroz expansion drill holes and the northern and southern wellfields

Core recovery for the three recent diamond drill holes DDH-02, DDH-04 and DDH-17 was between 86.1 % and 88.6 % (Table 9.1). This is higher than historical diamond drilling, which covered a larger spatial area and is summarised in the historical exploration section.

Well	Easting UTM (POSGAR 94)	Northing UTM (POSGAR 94)	Elevation DEM (msnm)	Type of well	Depth (m)	Well	Easting UTM (POSGAR 94)	Northing UTM (POSGAR 94)	Elevation DEM (msnm)	Type of well	Depth (m)
PP01	3427500	7405000	3901	Production well	350	C17	3427006	7398996	3899	Monitoring well	54
PP02	3428500	7405000	3899	Production well	205	CD03	3427998	7408000	3898	Monitoring well	199.5
PP04	3430500	7405000	3900	Monitoring well	62	CD04-A	3424000	7404000	3901	Monitoring well	200
PP05	3427000	7406000	3901	Production well	204	CD04-B	3424001	7403995	3901	Monitoring well	200
PP06	3428000	7406000	3894	Production well	205	CD04-C	3424004	7403990	3901	Monitoring well	200
PP07	3429000	7406000	3899	Production well	205	CD05-A	3428998	7404004	3898	Monitoring well	200
PP08	3430000	7406000	3899	Production well	205	CD05-B	3428996	7404002	3898	Monitoring well	200
PP10	3427500	7407000	3891	Production well	210	CD06	3426985	7398998	3899	Monitoring well	199.5
PP11	3428500	7407000	3898	Production well	209	CD06-B	3426969	7399001	3899	Monitoring well	205
PP12	3429500	7407000	3900	Production well	351	DWE	3431714	7402014	3900	Monitoring well	200.5
PP13	3430500	7407000	3898	Production well	205	DWN	3434012	7424872	3922	Monitoring well	203
PP14	3426500	7407000	3899	Production well	203	DWO	3422105	7407997	3910	Monitoring well	180
PP15	3428060	7407999	3898	Production well	205	DWS	3423521	7390768	3913	Monitoring well	200.5
PP16	3429060	7407999	3899	Production well	205	P-01	3425607	7396103	3899	Monitoring well	1.225
PP17	3430060	7407999	3899	Production well	205	P-04	3425389	7396634	3899	Monitoring well	1.4
PP18	3427000	7400000	3898	Production well	205	P-06	3425117	7397036	3900	Monitoring well	1.59
PP19	3426000	7399000	3886	Production well	203	P-07	3425548	7395921	3902	Monitoring well	1.225
PP21	3427000	7398000	3898	Production well	205	P-08	3423661	7398247	3900	Monitoring well	1.54
P301	3425585	7401225	3899	Production well	304	P-09	3424777	7397576	3901	Monitoring well	1.42
P302	3425460	7400240	3900	Production well	323	P-10	3424327	7397887	3902	Monitoring well	1.99
PD02	3427009	7399008	3899	Production well	202	P-15	3424168	7413337	3899	Monitoring well	1.2
PD02a	3427009	7399007	3899	Production well	450	P-16	3428589	7419922	3904	Monitoring well	1.59
PD20	3427319	7399025	3899	Production well	450	P-17	3431597	7402141	3900	Monitoring well	2.89
PPA	3428000	7407000	3897	Production well	203	P-18	3431337	7392812	3909	Monitoring well	2.43
P2	3426422	7402947	3899	Test well	37.5	P-19	3436953	7417803	3904	Monitoring well	1.3
P3	3426200	7398062	3900	Test well	50.5	P-20	3437046	7423366	3916	Monitoring well	1.91
PP20	3427784	7399000	3898	Monitoring well	204	P-21	3438549	7410986	3905	Monitoring well	1.98
02-E7-28	3426428	7402948	3899	Monitoring well	28	P-22	3422815	7407672	3895	Monitoring well	2.46
02-E7-38	3426428	7402946	3899	Monitoring well	38	PDWE	3431706	7402017	3900	Monitoring well	17.3
02-N18-26	3426421	7402965	3899	Monitoring well	26	PDWN	3434001	7424883	3922	Monitoring well	13.52
02-N18-57	3426423	7402965	3899	Monitoring well	57	PDWO	3422094	7407999	3910	Monitoring well	17.4
02-N7-26	3426421	7402954	3899	Monitoring well	26	PDWS	3423509	7390778	3913	Monitoring well	23.84
02-N7-36	3426423	7402954	3899	Monitoring well	36.5	PMC01	3428394	7376871	3942	Monitoring well	32
03-E7-13	3426207	7398065	3900	Monitoring well	13	PMC02	3425602	7366116	3946	Monitoring well	96
03-E7-37	3426212	7398065	3900	Monitoring well	37	PMC03	3419256	7365692	3925	Monitoring well	43
03-N18-13	3426197	7398069	3900	Monitoring well	13	PMC04	3418347	7387411	3969	Monitoring well	65
03-N18-38	3426197	7398080	3900	Monitoring well	38	PS01	3421376	7395670	3968	Monitoring well	1.5
03-N7-13	3426200	7398069	3900	Monitoring well	13	PS02	3413375	7387766	4022	Monitoring well	1.5
03-N7-37	3426195	7398080	3900	Monitoring well	37	PZC	3428505	7406002	3899	Monitoring well	205
C06	3429002	7408995	3896	Monitoring well	54	PZE	3430725	7405504	3899	Monitoring well	205
C07	3431000	7408998	3899	Monitoring well	54	PZN	3428500	7407501	3898	Monitoring well	205
C08	3425999	7406495	3897	Monitoring well	54	PZO	3426499	7405501	3898	Monitoring well	205
C09	3428000	7406498	3896	Monitoring well	54	PZS	3428501	7404500	3899	Monitoring well	205
C10	3430000	7406498	3899	Monitoring well	54	WSE01	3433750	7427514	3924	Water well	65
C14	3425999	7401497	3899	Monitoring well	54	WSE03	3422071	7390544	3922	Water well	65
C16	3424999	7398990	3902	Monitoring well	54	WSE05	3421848	7390933	3922	Water well	55
E1	3431120	7407782	~3899	Evaluation well	1200	E14	3427830	7403005	~3899	Production well	582
E2	3431200	7408999	~3899	Aproved, not drilled	650	E15	3429374	7402970	~3899	Production well	650
E3	3426999	7407664	~3899	Aproved, not drilled	450	E17	3426003	7401998	~3899	Production well	410
E4	3426000	7407664	~3899	Aproved, not drilled	450	E18	3427000	7402000	~3899	Production well	434
E5	3429191	7409000	~3899	Aproved, not drilled	650	E19	3428819	7401821	~3899	Production well	636
E6	3426000	7406000	~3899	Production well	450	E21	3427000	7401000	~3899	Production well	450
E7	3426000	7405000	~3899	Aproved, not drilled	450	E22	3428413	7400830	~3899	Production well	650
E8	3430393	7405013	~3899	Production well	558	E23	3428034	7399903	~3899	Aproved, not drilled	650
E9	3425998	7403999	~3899	Production well	450	E24	3426794	7396871	~3899	Production well	594
E10	3427942	7403996	~3899	Production well	390	E25	3426328	7395855	~3899	Aproved, not drilled	450
E11	3428657	7403993	~3899	Aproved, not drilled	650	E26	3425534	7393885	~3899	Aproved, not drilled	450
E12	3429810	7403841	~3899	Production well	644	E27	3424746	7391934	~3899	Aproved, not drilled	450
E13	3426000	7403000	~3899	Production well	450	E28	3423000	7389000	~3899	Aproved, not drilled	450

Table 10.1: Well locations and details

10.4 Rotary Drilling – Expansion Holes

Rotary drilling was conducted with conventional tricone rotary drilling equipment, with pilot holes typically drilled and subsequently reamed out in one or more passes to allow the installation of casing with screens of 10 or 12 inch internal diameter. Holes were typically installed with multiple screen intervals in the upper section of the hole and blank sections to act as chambers for the submersible pump. Drilling was carried out using brine as drilling fluid, to lift cuttings from the holes. Drilling details are outlined below:

- Precollar – typically drilled to 12 m and installed with a diameter of 20 inches;
- Pilot hole – typically 8.5 or 9 7/8 inches
- Reaming of the hole to progressively larger diameter – typically with 12, 14.5 and 17 inch tricone bits
- Installation of casing and screen with a diameter of 10 inches for 650 m deep holes and 12 inches for 450 m deep holes.

Once holes were reamed to the final diameter they were flushed and cleaned, prior to lowering in the casing and screen installation (Figure 10.3). The location of the screens was selected based on the geological observations from the well cuttings and the geophysical logging of holes, identifying areas of higher porosity and permeability. Wells were installed with Johnson wound wire screens, to maximize the screen area and inflows to the well.

For the 450 m deep wells gravel pack was installed from surface. For the deeper 650 m deep wells pre-pack filters were part of the well installation, to simplify the process of well completion. Wells 650 m deep are installed with an upper 12 inch diameter section to a depth of 150 to 200 m, with a reduced diameter below these depths.

Once installed with gravel pack the wells were developed by the use of a swab and jet, to settle the gravel pack and remove fine material from around the gravel pack and in the well over a period of days to weeks. Once cleaning of the well was complete test pumping and surging of the well was undertaken, to complete the process of cleaning the well. Once the well was cleaned it was allowed to equilibrate, before step and constant rate tests were undertaken on the well to determine the hydraulic characteristics and to select the appropriate pump for long term production.

The original northern and southern production wellfields were installed with a single diameter of 10 inches, to a depth of 200 m.

10.5 Geophysical Logging of Holes

Diamond drilling was undertaken with standard diamond drilling equipment. Once drill holes reached their final depth the holes were geophysically logged in the open hole with a number of geophysical tools to maximise the collection of data in each well. Geophysical tools used include natural gamma, and resistivity, useful for distinction of halite and clastic layers, spontaneous potential, conductivity and temperature, ultrasonic caliper (for evaluating washouts in the hole) and borehole magnetic resonance (BMR).

The geophysical tools collect information on a 1 cm to 5 cm spacing, providing extensive information for geological interpretation. The logs provide important information on sections of the hole where core may not be recovered – often the intervals with highest drainable porosity and permeability.

Figure 10.3: Installation of filters in a production well at the Olaroz Project

Gamma rays are emitted by uranium, thorium and potassium minerals in sediments, the log typically responds to clay minerals and volcanic horizons. Evaporitic minerals such as halite and gypsum have a very low radioactive mineral content and can usually be identified by their low count rate. The gamma log is a useful tool for identifying certain types of lithology and for correlating beds across multiple wells. Spectral gamma logs provide greater differentiation, for correlation of units with different mineral content.

The BMR tool was developed by the oil industry for in-situ measurements of porosity and permeability. This technology has been miniaturized for use in diamond drill holes and water wells. The BMR60 tool is a 60 mm diameter tool that was run open hole in the HQ diamond drill holes, along with the other tools. For the larger diameter production wells the 90 mm diameter BMR90 tool was run in the pilot hole, together with the other tools. From these profiles of the holes the BMR tool provides information on the total porosity, drainable porosity (specific yield) and permeability.

Borehole magnetic resonance is a unique measurement that responds to both the volumes of fluids present in a rock, and the geometry of the pores in which this fluid resides. As such, it is a powerful addition to any drillhole geophysical characterization aimed at evaluating the storage and flow capacity of subsurface formations. A modern BMR tool consists of two major components, a set of permanent magnets that create the static magnetic field, and an antenna that creates the transient electromagnetic field.

The echo decay train measured is a function of the volumes of fluids undergoing relaxation at different rates (T2's) within the volume of rock being investigated. The purpose of BMR data processing is to extract this underlying distribution of the volumes of fluid decaying at the various relaxation rates, known as the T2 distribution. The measured echo decay train is treated as resulting from multiple volumes of fluid, each undergoing relaxation at a particular rate, with the measured decay being the sum of these individual decays. Through the tool calibration, these amplitudes are translated directly into pore volumes. The simplest application of the tool is to use a T2 cut-off to separate bound water (in small pore spaces and held by capillary forces and as clay bound water) and free water, which can be drained by pumping.

The BMR tool allows definition of the total porosity of sediments (Pt) the drainable porosity (Sy) and a derivation of permeability derived from the porosity data. There are various models for the derivation of permeability, with the Timur-Coates model the most common.

The Borehole Magnetic Resonance tool was designed and built in Australia to operate in highly saline environments like salars. The tools are factory calibrated in Australia and maintained regularly by the service provider

10.6 Pumping Tests

Variable rate tests

Once wells were installed and cleaned pumping tests were undertaken. These consisted of an initial variable rate (step) test, to assess the capacity of the well over a period of up to nine hours (Figure 10.4). Once this test was completed the rate for the constant rate test was determined. Wells do not directly have observation wells, as they are part of production wellfields. The monitoring well network will be updated to monitor pumping from the new production wells.

Constant rate tests

When the well static water level had recovered the constant rate test was completed for a minimum period of up to 48 hours, pumping. The brine was pumped directly to the initial receiving tanks, with each well connected to the site electrical network.

Pumping test results were analysed with standard pumping test methodologies (Figure 10.5) and the hydraulic conductivity and transmissivity at the well was calculated using Theis, Neumann and Jacob methodologies. Hydraulic conductivity, transmissivity and storativity are summarized in Table 10.2 below.

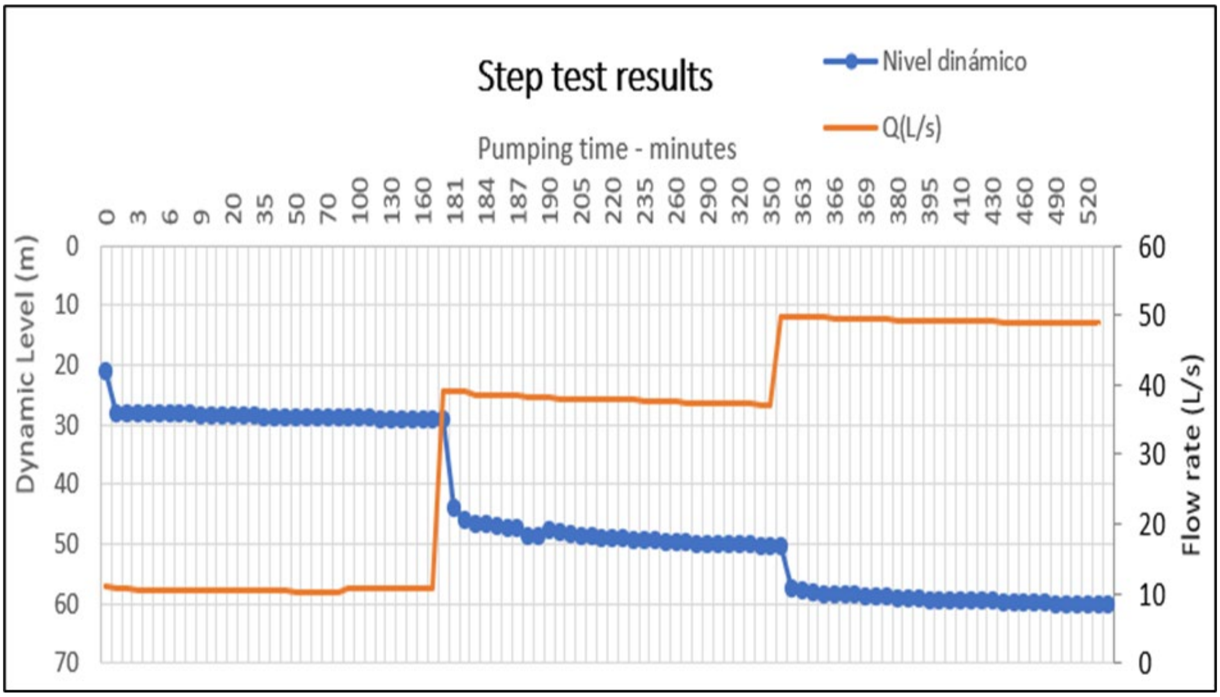


Figure 10.4: Step test for expansion hole E17, showing pumping rate (right) and drawdown (left)

Method	Transmisivity (m^2/day)	Hydraulic Conductivity (m/day)	Storage
Pumping test E10			
Theis	8,04E+00	3,94E-02	1,28E-03
Neumann	8,04E+00	3,94E-02	9,74E-01
Pumping test E17			
Theis	1,46E+02	6,26E-01	1,65E-04
Neuman	2,14E+02	6,26E-01	3,70E-02
Pumping test E19			
Theis	5,98E+01	2,16E-01	2,14 x 10-7
Theis recovery	5,85E+01		
Neuman	5,68E+01	2,05E-01	2,39 x 10-5

Table 10.2: Summary of hydraulic parameters for recently installed wells

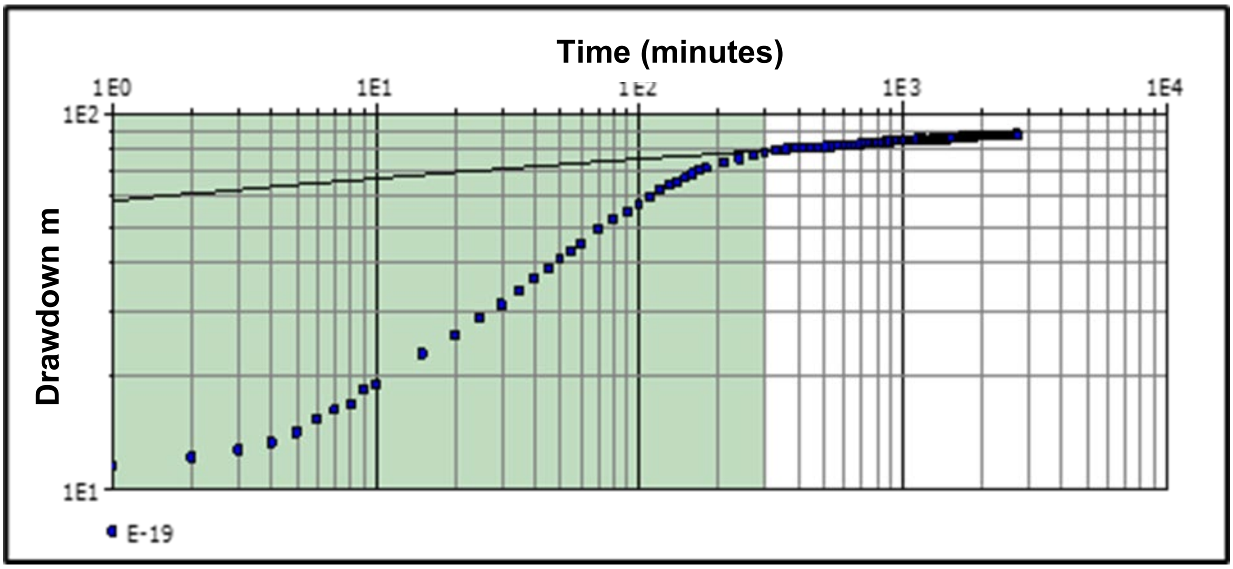


Figure 10.5: Theis analysis of pumping results from production well E19 from constant rate pumping results

11 SAMPLE PREPARATION, ANALYSES AND SECURITY

11.1 Sampling Philosophy

Ensuring that samples taken are truly representative of the subsurface conditions in the salar is a key consideration for sampling. Collecting truly representative samples is challenging and consequently multiple sampling methods have been used over the life of the Olaroz Project in order to compare results and check they are consistent.

11.2 Core Sampling Methods

Core sample collection

Diamond drilling consisted of HQ or NQ size cores, with lexan polycarbonate tubes used as liners inside the core barrel to facilitate core recovery and to preserve samples with minimum disturbance for laboratory porosity analysis. Cores were recovered at surface by pumping the lexan tube from the core barrel using water, with a plug separating tube and water. Upon release from the core barrel tight fitting caps were applied to both ends of the lexan tube. The tube was then cleaned, dried and labelled.

The lower 30 cm of the lexan core was cut from the 1.5 m long core tube using a portable angle grinder. This core sub sample was then capped and tape used to secure the caps in place and minimise any fluid loss during transportation.

Core handling and sampling

The core samples were prepared for drainable porosity testing by the Geosystems Analysis laboratory (GSA) in Tucson, USA, using a 5 cm subsample cut from the base of the core liner that was sent to the lab. All samples were labelled with the hole number and depth interval. Porosity samples were transferred to the site camp and stored, prior to cutting sub samples for laboratory analysis. Prior to sending each sample was wrapped in bubble plastic to prevent disturbance during transportation. A register of samples was compiled at the Olaroz site to control transportation of samples to the laboratory. Samples were sent by courier to the GSA laboratory.

Previous British Geological Survey core testing

Drainable porosity samples were historically (2010/11) tested at the British Geological Survey (BGS) in the UK, with testing of samples at an on-site laboratory in Olaroz for total porosity and testing of duplicates by the BGS. Historically samples from Allkem's Cauchari project were also tested by the BGS in 2011 and more recently in 2017/18 samples were analysed at the GSA laboratory from the extensive drilling program conducted.

The BGS determined drainable porosity using a centrifugation technique where samples are saturated with simulated formation brine and weighed. They are then placed in a low-speed refrigerated centrifuge with swing out rotor cups and centrifuged at 1,200 rpm for two hours and afterwards weighted a second time. The centrifuge speed is selected to produce suction on the samples equivalent to 3.430 mm H_2O, which was previously defined by Lovelock (1972) and Lawrence (1977) as characteristic of gravitational drainage.

GeoSystems Analysis core testing

GSA was selected as the primary laboratory for the drainable porosity (Sy) and other physical parameter analyses conducted on the recent diamond drill cores collected at Olaroz. GSA utilized the Rapid Brine Release method (Yao et al., 2018) to measure drainable porosity and measured the total porosity with a standard gravimetric technique, drying the saturated sample in the oven.

The Rapid Brine Release (RBR) method is based on the moisture retention characteristics (MRC) method for direct measurement of total porosity (Pt, MOSA Part 4 Ch. 2, 2.3.2.1), specific retention (Sr, MOSA Part 4 Ch3, 3.3.3.5), and specific yield (Sy, Cassel and Nielson, 1986). A simplified Tempe cell design (Modified ASTM D6836-16) was used to test the core samples. Brine release was measured at 120 mbar and 330 mbar of pressure for reference (Nwankwor et al., 1984, Cassel and Nielsen, 1986), which is considered to reflect drainage from coarse and fine grained samples respectively.

In addition to drainable porosity, bulk density and specific gravity were determined on core samples. Table 11.1 provides an overview of the test work carried out by GSA and other laboratories where previous samples and check samples were analysed. Table 11.2 shows the porosity results by lithology type from recent and historical porosity measurements at the Olaroz Project and the Cauchari properties owned by Allkem.

Sample numbers and frequency

Sixty-four samples were tested from DDH02, DDH04 and DDH17 diamond cores during the current drilling program, drilling to 650 m deep. Twenty-five of these samples had duplicate core samples analysed in the DB Stephens laboratory in the USA. Historically 543 Olaroz samples were analysed for total porosity (Pt), with 205 specific yield (Sy) analyses at the BGS research laboratories. Sample frequency with depth for those analyses used in the historical resource estimation averaged 2.8 m per sample in the upper 54 m, and 7.1 m per sample in the 54 m to 197 m interval.

In the Allkem Cauchari project 123 samples were analysed by the BGS laboratory for total porosity and specific yield from holes drilled in 2011. A further 292 samples were analysed by GSA in 2017/18 for drainable porosity and other physical parameters. Thirty samples (subsamples from the 2017/18 GSA samples) were analysed as QA/QC analyses by Corelabs in Houston, Texas, in 2018, with a further 26 samples analyzed by the DB Stephens laboratory in Albuquerque, USA. In total 294 drainable porosity samples have been analysed for the Olaroz part of the Olaroz-Cauchari basin and 471 samples from the Cauchari part, for a total of 765 drainable porosity samples.

Figure 11.1 shows the results of the test work by lithology type, comparing the GSA and Stephens laboratories from recent samples. A total of 64 primary samples were analysed by GSA from the three diamond holes drilled to date for the expansion program. Note that the 64 samples were selected for sand, silt and halite materials. Previous testing has shown that clay samples have a drainable porosity (Sy) of 0.02 to 0.03, with a standard deviation of +-/0.02 and this value has been well constrained by testing of Olaroz and Cauchari samples.

Check laboratory testing

Check samples were sent to the DB Stephens laboratory in the USA to determine the drainable porosity (Sy) for core plugs taken adjacent to those analysed by GSA. The Stephens laboratory uses the RBRC test methodology (Stormont et. al., 2011), which was developed by the laboratory. This involves application of a vacuum pressure of -0.25 bars to samples over a period of 24 hours, before the samples are oven dried to determine fluid loss. Quality control using the same method was also carried out on the samples previously analysed on the Cauchari project. In the Cauchari project the Centrifuge Moisture Equivalent of Soils (Centrifuge, ASTM D 6836-16) method was also used by Core Laboratories (Houston, TX) as a check on the primary sample results by GSA.

A total of 25 core plugs were analysed and compared with the adjacent samples analysed by GSA, with results shown in Figure 11.1 and 11.2. It should be noted that salar sediments can show rapid vertical changes in total and drainable porosity, something that is also observed in borehole magnetic profiles of porosity data. The duplicate core plugs, while sampled from as close as possible to the primary sample, also show some natural variation in grain size and hence porosity and are not exactly identical samples to the primary samples.

Some systematic differences are noted between the GSA and Stephens data, with the GSA Sy data measured at 330 mbars showing higher values than the Stephens data on adjacent plugs. Most of the samples tested for Sy fall below the 1:1 line, indicating that GSA measured Sy values are often higher than those for the Stephens lab. The GSA 120 mbar data is more closely correlated with the Stephens data.

The longer time the testing is undertaken at the GSA lab (1 week versus 24 hours at the Stephens lab), together with the slight differences in the pressures used in the tests and the natural variability between adjacent samples is believed to explain the differences in results. The GSA technique is considered to measure brine drainage from easily drained more porous materials (like sands) as well as delayed drainage (as observed in leaky aquifer systems) from finer grained sediments. A statistical comparison of results from the GSA 120 mbar testing and the Stephens RBRC testing is presented in Table 11.3. Note the small number of silt samples is likely to influence the comparison between the sample sets.

11.3 Borehole magnetic resonance data

The BMR tool used for the drilling campaign is purpose built for logging of exploration diameter drill holes. The tools are factory calibrated in Australia and maintained regularly by the service provider. The data acquisition and processing methodology gives information on the total porosity, drainable porosity (specific yield), specific retention and provides a computation of permeability and hydraulic conductivity with a vertical resolution varying from 5-15 cm providing much more information than individual core samples analysed for porosity every 3 m.

Porosity values from the GSA laboratory sampling were compared to the BMR porosity logs. While some differences are noted the general ranges of porosity values for the different hydrostratigraphic values are considered comparable.

Salar sediments often display short range vertical variability (within a metre or over metres to 10’s of metres) due to changes in the depositional environment over time. This results in vertical and lateral changes in drainable porosity. BMR drainable porosity (Specific yield) measurements may be lower than corresponding laboratory measurements as cores may be disturbed during sampling and transportation to the laboratory and not reflect the natural in-situ state.

Salar sediments are subject to compaction as they are buried with compaction generally resulting in a decrease in total and drainable porosity with depth although not all sediments are affected equally by compaction.

Test Type	Sample Type and Number	Test Method	Testing Laboratory	Standard
Physical	64 core samples Olaroz 2021. 292 core samples Cauchari 2017-18	Bulk Density	GSA Laboratory, (Tucson, AZ)	ASTM D2937-17e2
	64 core samples Olaroz 2021 160 core samples Cauchari 2017-18	Specific Gravity of Soils	GSA Laboratory, (Tucson, AZ)	ASTM D854-14
	64 core samples Cauchari 2017-18	Particle Size Distribution with brine wash	GSA Laboratory, (Tucson, AZ)	ASTM D6913-17 / ASTM C136-14
Hydraulic	64 core samples Olaroz 2021, 292 core samples Cauchari 2017-18	Estimated Total Porosity	GSA Laboratory, (Tucson, AZ)	MOSA Part 4 Ch.2, 2.3.21
		Estimated Field Water Capacity		MOSA Part 4 Ch.3, 3.3.3.2
		Rapid Brine Release (RBR as Specific Yield)		Modified ASTM D6836-16 MOSA part 4 Ch.3, 3.3.3.5
	25 core samples Olaroz 2021	Relative Brine Release Capacity (RBRC as Specific Yield)	Daniel B, Stephens & Associates Inc. (Albuquerque, NM)	Stormont et al., 2011
	30 core samples Cauchari 2017-18	Centrifuge Moisture Equivalent of Soils (Specific yield)	Core Laboratories (Houston, TX)	Modified ASTM D425-171
	543 core samples Olaroz 2010/11	Total porosity measurements (every 2.8 m vertical to 54 m and every 7.1 m 54 to 197 m)	British Geological Survey UK	Modified ASTM D425-17
	205 core samples Olaroz 2010/11, 123 samples Cauchari 2011	Centrifuge Moisture Equivalent of Soils for Sy	British Geological Survey UK	Technique based on evalution by Lovelock (1972) and Lawrence (1977)

Table 11.1 Analytical methods and numbers of samples analysed at Olaroz and the Cauchari (Advantage Lithium) Olaroz Project owned by Allkem

Lithology type	Total Porosity Pt	Specific Yield Sy
Olaroz 2021		
Sand variants	0.20+/-0.12	0.09+/-0.08
Silt mixes	0.35+/-0.09	0.06+/-0.05
Halite dominant	0.08+/-0.07	0.04+/-0.02
Olaroz 2011		
Sand dominant	0.31 ±0.06	0.13 ±0.07
Silt and sand-clay mixes	0.37 ±0.08	0.06 ±0.04
Clay dominant	0.42 ±0.07	0.02 ±0.02
Halite dominant	0.27 ±0.14	0.04 ±0.02
Cauchari 2017-18		
Sand dominant		0.19+/-0.06
Sand-clay mixes		0.07+/-0.04
Clay dominant		0.03+/-0.02
Halite dominant		0.04+/-0.03

Table 11.2: Summary of drainable porosity values by sampling program

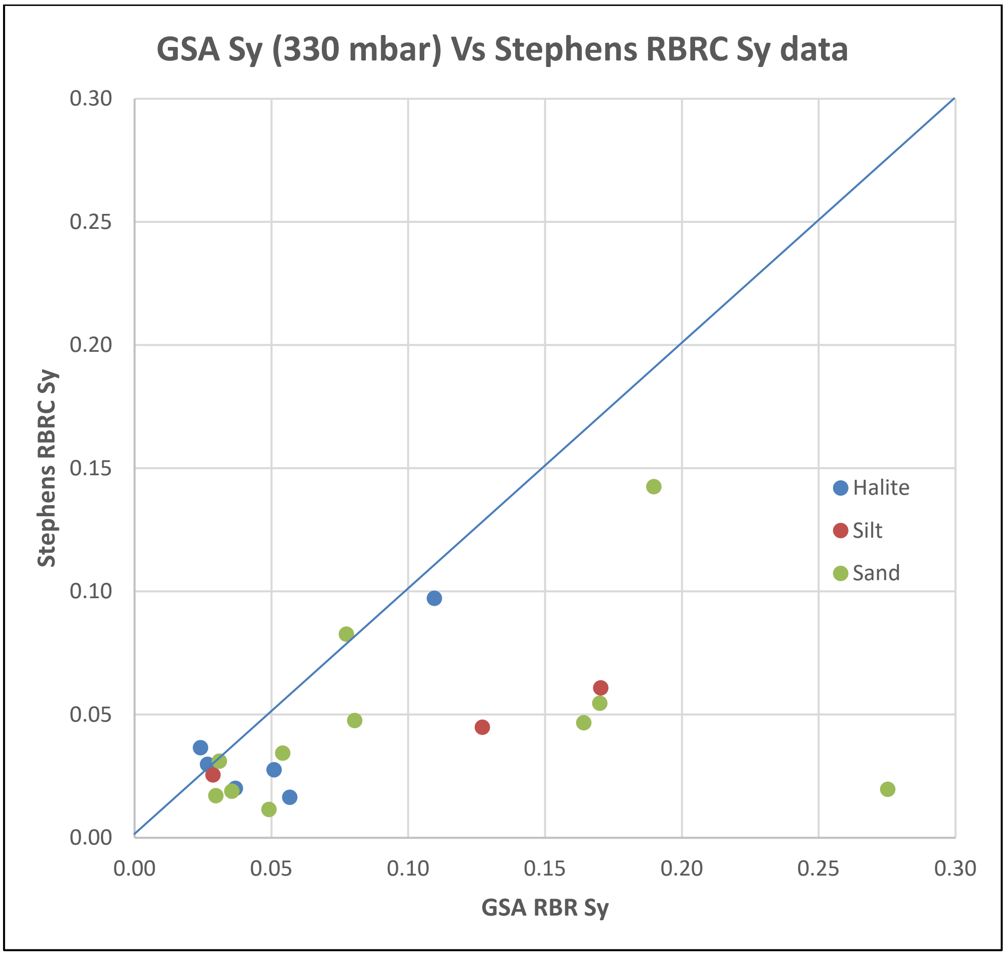


Figure 11.1: Comparison between the GSA and Stephens sample results

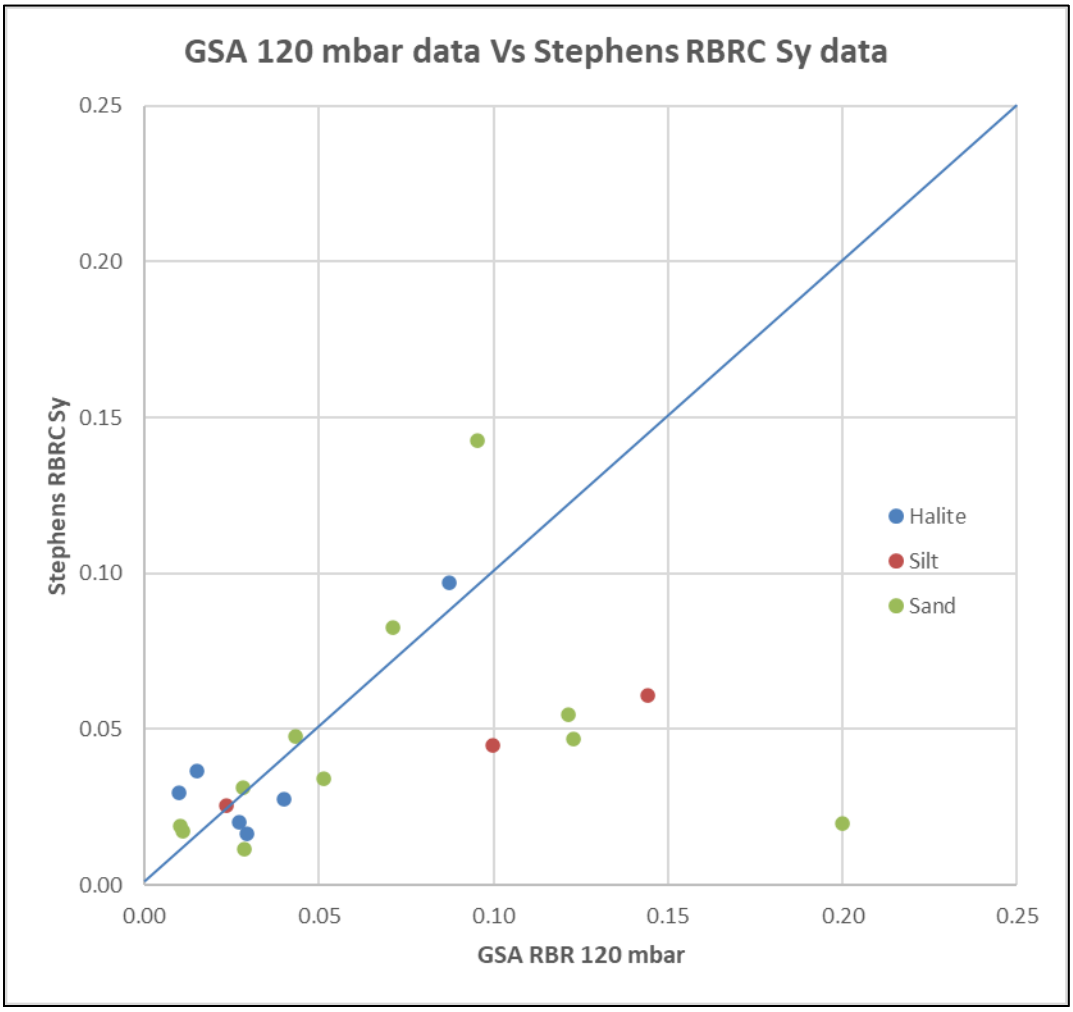


Figure 11.2: Comparison between the GSA 120 mbar results and Stephens sample results

	Sand dominant		Silt & Mixed		Halite	
	GSA	DBS	GSA	DBS	GSA	DBS
Average	0.07	0.05	0.09	0.04	0.03	0.05
SD	0.06	0.04	0.06	0.02	0.03	0.04
RPD %	33		77		29	
Dup samples	6		3		11	

Table 11.3: Comparison of GSA 120 mbar RBR results with Stephens RBRC results

Holes drilled for the original feasibility study were logged with a neutron tool as borehole magnetic resonance technology was not available to the lithium industry in 2011. The neutron tool measures the hydrogen index of the formation (solids and brine). Neutron porosity is the result of applying a simple equation using the neutron measurement and two parameters. For the 2011 Resource neutron log data was compared with laboratory data to develop an algorithm for porosity across the resource area. BMR technology is considered more accurate for porosity definition in the salar environment and has now superseded use of neutron logs.

There are some differences observed between porosity measurements made with the neutron and BMR logs through comparable sediments. The drainable porosity of this updated interim resource is lower than the 2011 Resource, partly due to differences in depth and geological intervals intersected and partly due to a reduction in comparable porosity values.

It is noted the original drilling to 200 m intersected only the upper part of the halite layer. The ongoing drilling for Stage 2 has defined the full thickness of the evaporite/halite unit UH4. This unit has a generally lower porosity than overlying and underlying clastic sedimentary units due to the compaction of halite with depth. Similarly clastic units also undergo some compaction with depth and consequently the overall porosity of the newly estimated resource is lower compared to the original resource in the upper 200 m of the salar.

11.4 Brine Sampling Methods

Diamond drilling

In the Olaroz 2010/11 sampling program, when holes were predominantly to 54 m depth, samples for fluid chemistry analysis were taken every 3 m depth interval in all sonic holes and also in the 200 m deep diamond drilled holes, where possible. With the original sonic drilling a push-ahead well point with double packers was attached to the base of the rods and inserted into the formation ahead of the well casing advance. The packers sit inside the casing and so affect a seal between the well point and the hole above inside the casing.

Sampling of brine from the recently drilled diamond holes consisted of extracting brine using a packer device that sealed over an interval of 1.5 to 6 m. This sampling was conducted approximately every 12 metres. However, it was not always possible to take samples.

Production well sampling

The Olaroz Project has two operating wellfields that were established for Stage 1 of the Olaroz Project. Additional wells have been installed for Stage 2, drilled to between 450 and 650 metres depth. Samples were collected from the operating wellfield holes and the newly installed Stage 2 wells by collecting bottles of brine from the diversion valve located on each wellhead to allow the regular weekly sampling carried out on site. Samples were taken in triplicate and analysed at the on-site laboratory at Olaroz. Duplicate samples were collected and sent to the Alex Stuart laboratory in Jujuy Argentina for analysis.

Samples were also taken during the constant rate pumping tests conducted on Stage 2 wells when the hydraulic parameters were selected before putting the wells into production. These samples analysed at the on-site laboratory showed consistent lithium concentrations. Long term pumping of wells from Stage 1 (over a period of up to 7 years) has confirmed the consistent concentration of brine extracted from individual wells over this period.

Sampling protocol

At the wellhead, prior to filling, the two one litre bottles and their caps were rinsed out with a small amount of sample. The sample was then collected in the two bottles. In each case all air was expelled from the bottle, the caps screwed tight and sealed with tape. Each bottle was labelled using a permanent marker with the drillhole number and the depth of the sample.

Samples were transferred from the drill site to the field camp where they were stored out of direct sunlight. Before being sent to the laboratory the bottles of brine were labelled with a unique sample number. The hole number and date of collection were recorded in a spreadsheet control.

11.5 Brine Analyses QA/QC results

Analytical methods

The primary laboratory used for analyses following the feasibility study completed in 2011 has been the laboratory that is established at the Olaroz Project. The laboratory is run independently by Sales de Jujuy and is used to analyse brine samples from the production wells, evaporation ponds and from the product produced at the plant. The laboratory sends samples to other laboratories as a periodic round robin, to evaluate the performance of analyses. The Olaroz laboratory has been used to analyse all the brine samples from production wells that have been used in the resource estimate. The laboratory also analysed samples from diamond drill holes. Duplicate samples were analysed at the Alex Stuart laboratory in Jujuy.

The Alex Stewart laboratory in Jujuy, Argentina was selected as the secondary laboratory to conduct check assaying of brine samples from wells and diamond drill holes collected for the resource estimate. This laboratory is ISO 9001 accredited and operates according to Alex Stewart Group standards consistent with ISO 17025 methods at other laboratories.

The SGS laboratory in Salta, Argentina (SGS) was used along with the Alex Stuart laboratory as part of the round robin comparison process by the Olaroz laboratory.

Table 11.4 lists the suite of analyses provided by the Olaroz lab and Alex Stuart, the methods used and detection limits. It is noted that there are some differences in the methods between labs and in particular the Olaroz laboratory uses Atomic Absorption for analysis of lithium and potassium.

	Olaroz Laboratory (2014-2021)		Alex Stewart Jujuy (2021)		Alex Stewart Mendoza (2011)	
Analysis	**Methods**	**Detection Limit mg/L**	**Method**	**Detection Limit mg/L**	**Method**	**Detection Limit mg/L**
Conductivity mS/cm	Total Dissolves Solids Dried at 180^0C		LMFQ01 Potentiometer	0.05		
pH	Electrometric Method		0002NLMCI28 Potentiometer	0.1	H gas electronde. IMA-05-Versión 02: SM-4500-H+-B	
Density	Pycnometer		LMFQ19 Pycnometer	0.001	Piconometry. IMA-28-Versión 00	
Boron (B)	ICP-OES	1	LMMT03 ICP-OES	1	ICP-AES USEPA-SW-846 Method 200.7	1
Chlorides (Cl)	Automated titration	1	0002NLMCI01 Volumetric analysis	10	Ag titration IMA-17-Versión 3: SM-4500-Cl-B	5
Sulphates (SO$_4$)	ICP-OES	1	LMCI22 Gravimetric analysis	10	Gravimetric IMA-21-Versión 1: SM-2540-C	10
Sodium (Na)	Atomic Absorption	1	LMMT03 ICP-OES	2	ICP-AES USEPA-SW-846 Method 200.7	
Potassium (K)	ICP-OES	1	LMMT03 ICP-OES	2	ICP-AES USEPA-SW-846 Method 200.7	2
Lithium (Li)	Atomic Absorption	1	LMMT03 ICP-OES	1	ICP-AES USEPA-SW-846 Method 200.7	1
Magnesium (Mg)	ICP-OES	1	LMMT03 ICP-OES	1	ICP-AES USEPA-SW-846 Method 200.7	1
Calcium (Ca)	ICP-OES	1	LMMT03 ICP-OES	2	ICP-AES USEPA-SW-846 Method 200.7	2

Table 11.4: Analytes, analytical methods and detection limits of laboratories

Analytical controls 2010/11 program

A full QA/QC program for monitoring accuracy, precision and potential contamination of the entire brine sampling and analytical process was implemented in this previous program. Accuracy, the closeness of measurements to the “true” or accepted value, was monitored by the insertion of standards, or reference samples, and by check analysis at an independent secondary laboratory (Alex Stuart in Mendoza, Argentina). The details of the quality control program are provided in the NI43-101 report prepared by Houston and Gunn (2011).

Precision of the sampling and analytical program, which is the ability to consistently reproduce a measurement in similar conditions, was monitored by submitting blind field duplicates to the primary laboratory. Contamination, the transference of material from one sample to another, was measured by inserting blank samples into the sample stream at site.

Blanks were barren samples on which the presence of the main elements undergoing analysis has been confirmed to be below the detection limit.

The results of the analyses of the standards are summarized in the NI43-101 report prepared by Houston and Gunn (2011). Results were within one standard deviation of the standard sample, except for Cl and K, which were marginally outside. Lithium values were 1.5 and 0.4% of the standard values for the two standards used.

Analytical controls 2021 program

A total of 55 primary brine samples were analyzed from the three core holes drilled to date as monitoring wells, to a depth of 650 m. These holes are in a spatially localised area, drilled along the eastern property boundary. Considering the limited spread of these holes and difficulties obtaining representative brine samples these drill holes were not used in the resource estimation. Instead, brine samples from the production pumping wells were analysed and utilised in the resource estimate. The PP series production wells and the expansion E series production wells were sampled, where these had been completed. Analytical controls included:

- Analysis of two different standards 2G and 3G as part of the round robin evaluation of standards (Table 11.5 below) and as standards submitted with samples from production wells (Table 11.6 below).
- Duplicates of packer samples from diamond holes analysed by the SdJ laboratory and external laboratory (Alex Stuart Jujuy).
- Duplicates of samples from pumped production wells analysed by the SdJ laboratory and external laboratory (Alex Stuart Jujuy).

Standards

Two standards, 2G and 3G, are prepared and used by the SdJ Olaroz laboratory on a regular basis. These were used for external round robin analysis, where standards are sent to different laboratories to compare results. These standards were sent to the Alex Stuart laboratory in Jujuy, Argentina and the SGS laboratory in Salta, Argentina to check the results of standards. The results of standards from the round robin evaluation between laboratories are presented in Table 11.5 below and in Figures 11.3. Performance of standards is presented in Figure 11.4 and 11.5.

	Chloride mg/L	Boron mg/L	Calcium mg/L	Lithium mg/L	Magnesium* mg/L	Potassium mg/L	Sodium mg/L	Sulphate* mg/L
2G* STANDARD								
STANDARD		**800**	**150**	**650**	**2,000**	**6,000**	**80,000**	**8,600**
SGS	144,627	777	137	609	2,140	5,950	89,900	8,648
SGS	143,279	786	135	604	2,140	5,930	88,900	8,578
Alex Stewart Jujuy	133,344	813	158	660	2,065	5,589	74,696	8,712
Alex Stewart Jujuy	132,312	813	155	656	2,061	5,519	74,981	8,781
SdJ Olaroz lab		836	139	651	2,006	5,944		7,970
SdJ Olaroz lab		835	140	649	2,038	6,102		8,159
SdJ Olaroz lab		848	141	648	2,020	6,207		8,114
3G* STANDARD								
STANDARD		**800**	**80**	**800**	**3,200**	**6,000**	**80,000**	**13,000**
SGS	144,130	728	95	758	3,230	5,700	89,000	13,089
SGS	140,085	732	102	770	3,230	5,680	87,400	13,064
Alex Stewart Jujuy	128,965	794	108	819	3,323	5,619	74,997	13,445
Alex Stewart Jujuy	129,357	786	102	814	3,294	5,574	74,916	13,527
SdJ Olaroz lab		853	90	810	3,256	6,302		13,006
SdJ Olaroz lab		824	95	829	3,271	6,368		13,072
SdJ Olaroz lab		820	92	830	3,204	6,259		13,072

Table 11.5: Olaroz standards analysed in check laboratories

* Standards were prepared with different concentrations of magnesium and sulphate, due to availability of chemicals at this time. Consequently, values are different to later use of these standards.

Standards were also included with batches of samples from production wells that were analysed in the SdJ laboratory on site and the Alex Stuart laboratory in Jujuy. The results of these standards analyses are presented in Table 11.6.

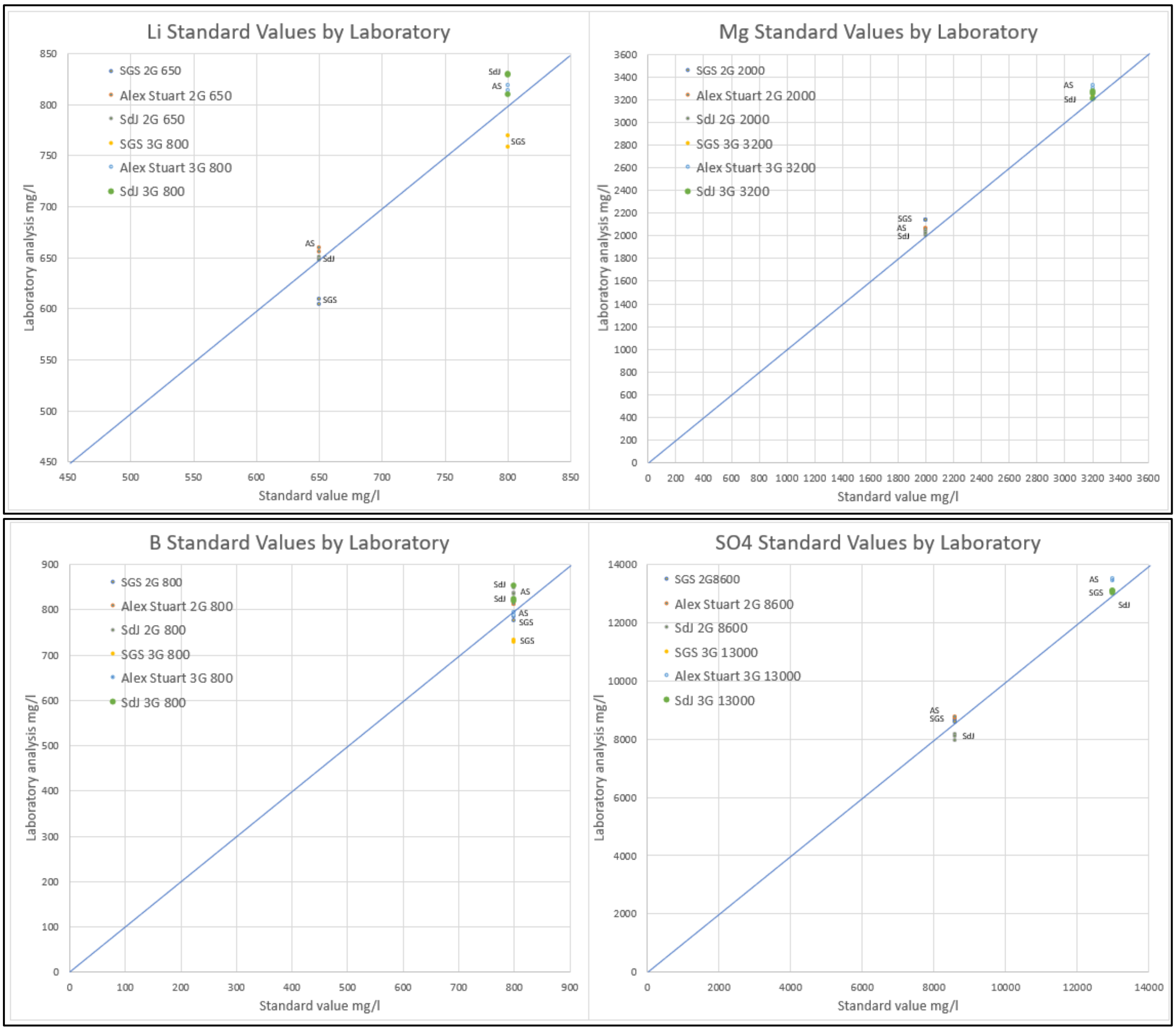


Figure 11.3: Standard results from the round robin analysis of standards at different laboratories

ALEX STUART STANDARD ANALYSES						
Standard	**B**	**Ca**	**Li**	**Mg***	**K**	**SO4***
	mg/L	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
Standard value	**800**	**150**	**650**	**1400**	**6000**	**5529**
2G	756	148	615	1322	5537	5845
2G	755	142	613	1319	5534	5899
2G	747	140	612	1318	5534	5735
2G	753	143	616	1324	5607	5735
2G	764	141	616	1329	5598	5762
2G	749	140	610	1321	5522	5968
Average	*754*	*142*	*614*	*1322*	*5555*	*5824*
Standard value	**800**	**80**	**800**	**2000**	**6000**	**7899**
3G	747	76	746	1866	5502	8492
3G	758	75	758	1887	5624	8438
3G	742	75	749	1866	5541	8438
3G	739	71	745	1861	5503	8396
3G	751	72	753	1883	5598	8204
3G	739	72	747	1848	5497	8383
Average	*746*	*74*	*750*	*1869*	*5544*	*8392*
SDJ STANDARD ANALYSES						
Standard	**B**	**Ca**	**Li**	**Mg***	**K**	**SO4***
	mg/L	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
Standard value	**800**	**150**	**650**	**1400**	**6000**	**5529**
2G	798	139	645	1379	6104	5349
2G	815	140	649	1356	5915	5265
2G	815	143	631	1379	6338	5532
2G	878	158	647	1384	6127	5721
2G	856	152	649	1375	6150	5520
2G	810	133	645	1379	6428	5385
Average	*829*	*144*	*644*	*1375*	*6177*	*5462*
Standard value	**800**	**80**	**800**	**2000**	**6000**	**7899**
3G	803	72	798	2050	6170	7713
3G	785	80	801	1920	6785	7665
3G	816	77	783	1997	6332	7965
3G	871	91	797	1942	6095	8278
3G	866	92	802	1960	6182	7962
3G	798	70	801	1982	6275	7665
Average	*823*	*80*	*797*	*1975*	*6307*	*7875*

Table 11.6: Standard results accompanying production well samples

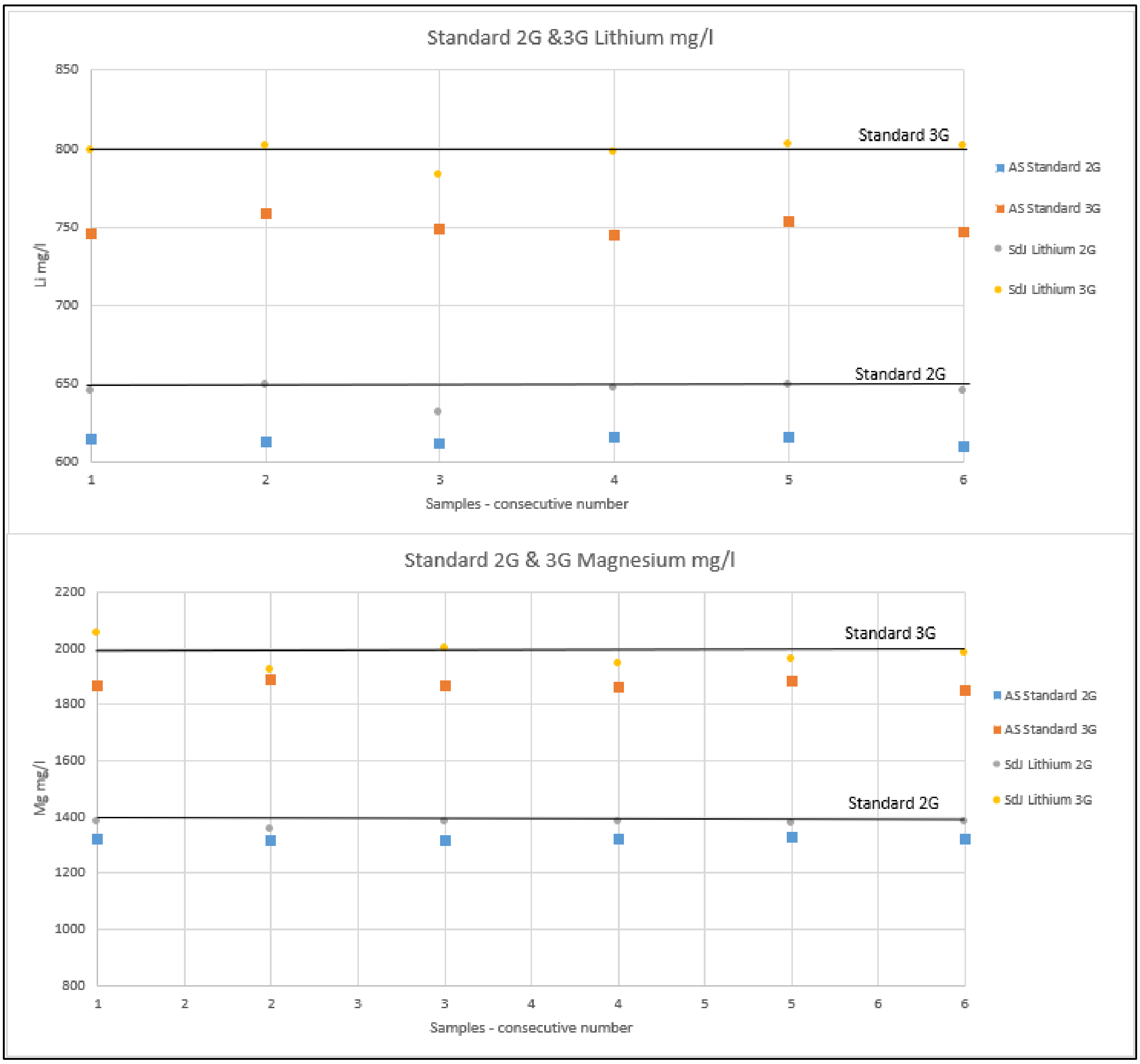


Figure 11.4: Comparison of standards SdJ and Alex Stuart

Duplicates

Sampling of production wells is undertaken on a weekly basis. Duplicate samples were taken during weekly sampling and analysed in the Olaroz laboratory. Duplicate sample results from the Olaroz Projection wells submitted for analysis by the SdJ and Alex Stuart laboratories are presented in Table 11.7. Below.

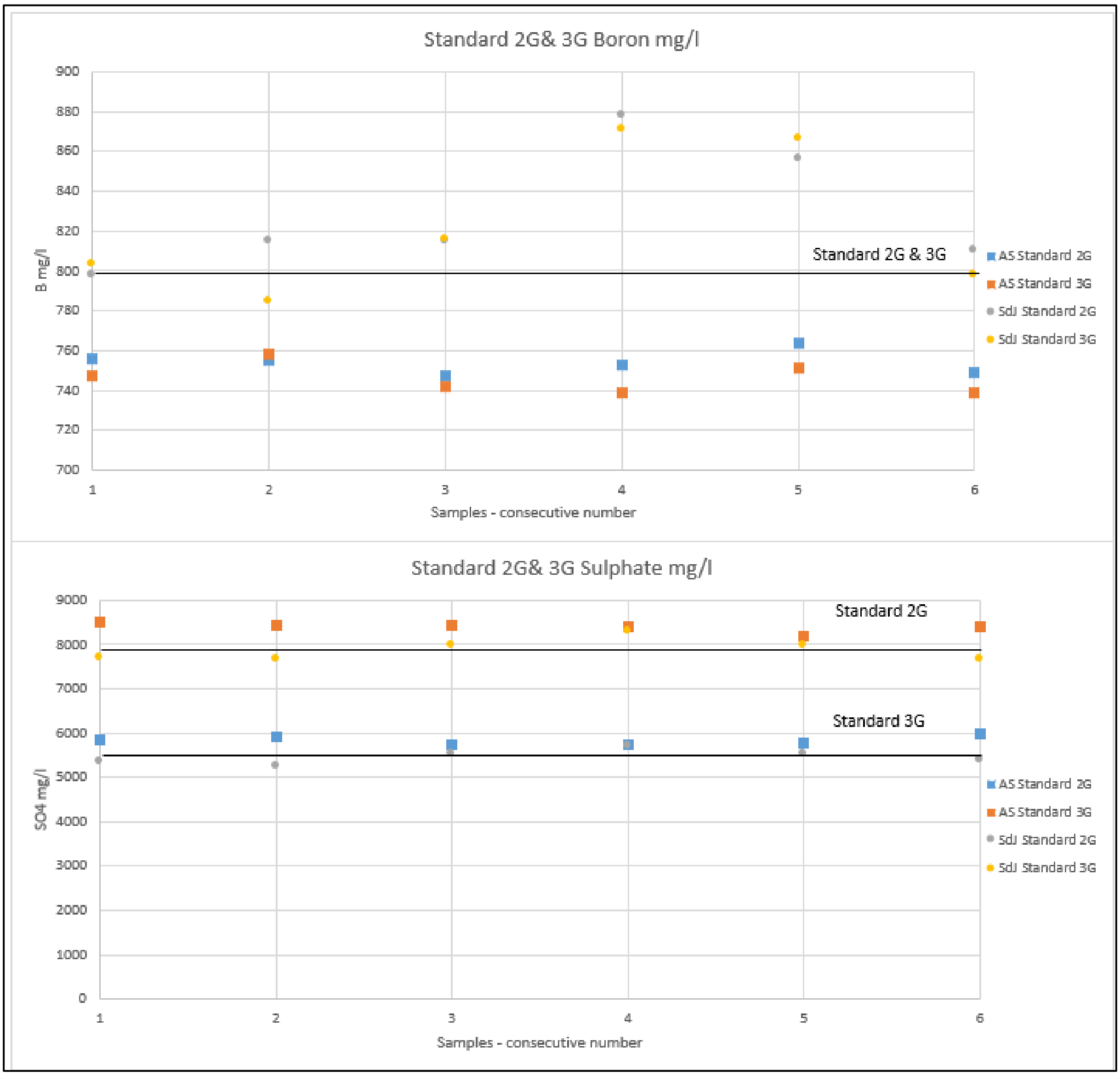


Figure 11.5: Comparison of standards SdJ and Alex Stuart

Interlaboratory duplicates from the production pumping wells are presented in Figure 11.7.

Interlaboratory duplicates

Interlaboratory duplicates from the three diamond drill holes were analysed in the Alex Stuart laboratory in Jujuy in addition to the primary samples analysed in the Olaroz laboratory. The results are presented in the following figures 11.6. These show there is a slight bias between the two laboratories, with higher values for lithium, potassium, magnesium and boron from the Olaroz lab. The Olaroz laboratory used Atomic Absorption spectroscopy for analyses of lithium and potassium, to minimise interference between different elements, whereas the Alex Stuart laboratory uses ICP-OES.

Samples mg/L	Li	K	Mg	Na	B	Ca	Sulphate	Chloride	Conductivity	Densidad	pH
					Duplicates						
PP15_109	496	4112	1100	103889	1116	557	12981	168946	229	1.197	6.7
PP15_108	499	4094	1100	104520	1126	569	13903	166774	227	1.199	6.7
PP15_109A	497	4063	1110	103883	1135	570	12702	168661	229	1.197	6.7
Average	497	4090	1103	104097	1126	565	13195	168127	228	1	7
Standard dev	2	25	6	366	10	7	629	1180	1	0	0
RPD %	**0.60**	**1.20**	**0.91**	**0.61**	**1.69**	**2.30**	**9.10**	**1.29**	**0.88**	**0.17**	**0.00**
E9_98	549	4440	1144	112823	921	486	13733	180950	229	1.214	6.3
E9_99	552	4416	1164	112839	925	488	13678	181556	229	1.214	6.4
RPD %	**0.54**	**0.54**	**1.73**	**0.01**	**0.43**	**0.41**	**0.40**	**0.33**	**0.00**	**0.00**	**1.57**
PP302_112	586	4592	1267	113521	1031	474	13599	178706	232	1.207	6.6
PP302_113	591	4619	1277	110285	1041	479	12364	179312	232	1.206	6.6
RPD %	**0.85**	**0.59**	**0.79**	**2.89**	**0.97**	**1.05**	**9.51**	**0.34**	**0.00**	**0.08**	**0.00**

Table 11.7: Duplicate sample results from a selection of production wells

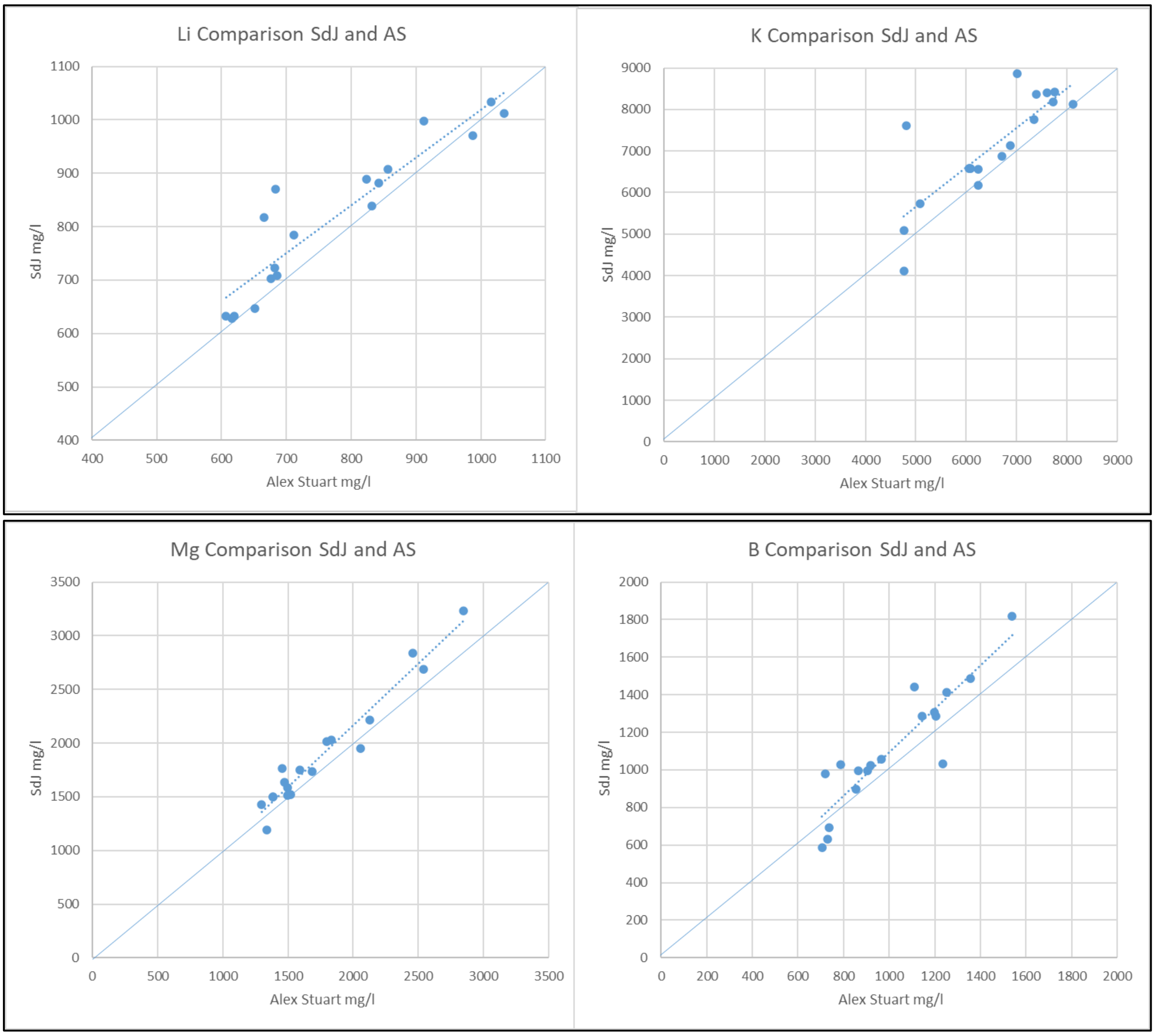


Figure 11.6: Duplicate analyses between the Olaroz and Alex Stuart Jujuy laboratories from recent diamond holes

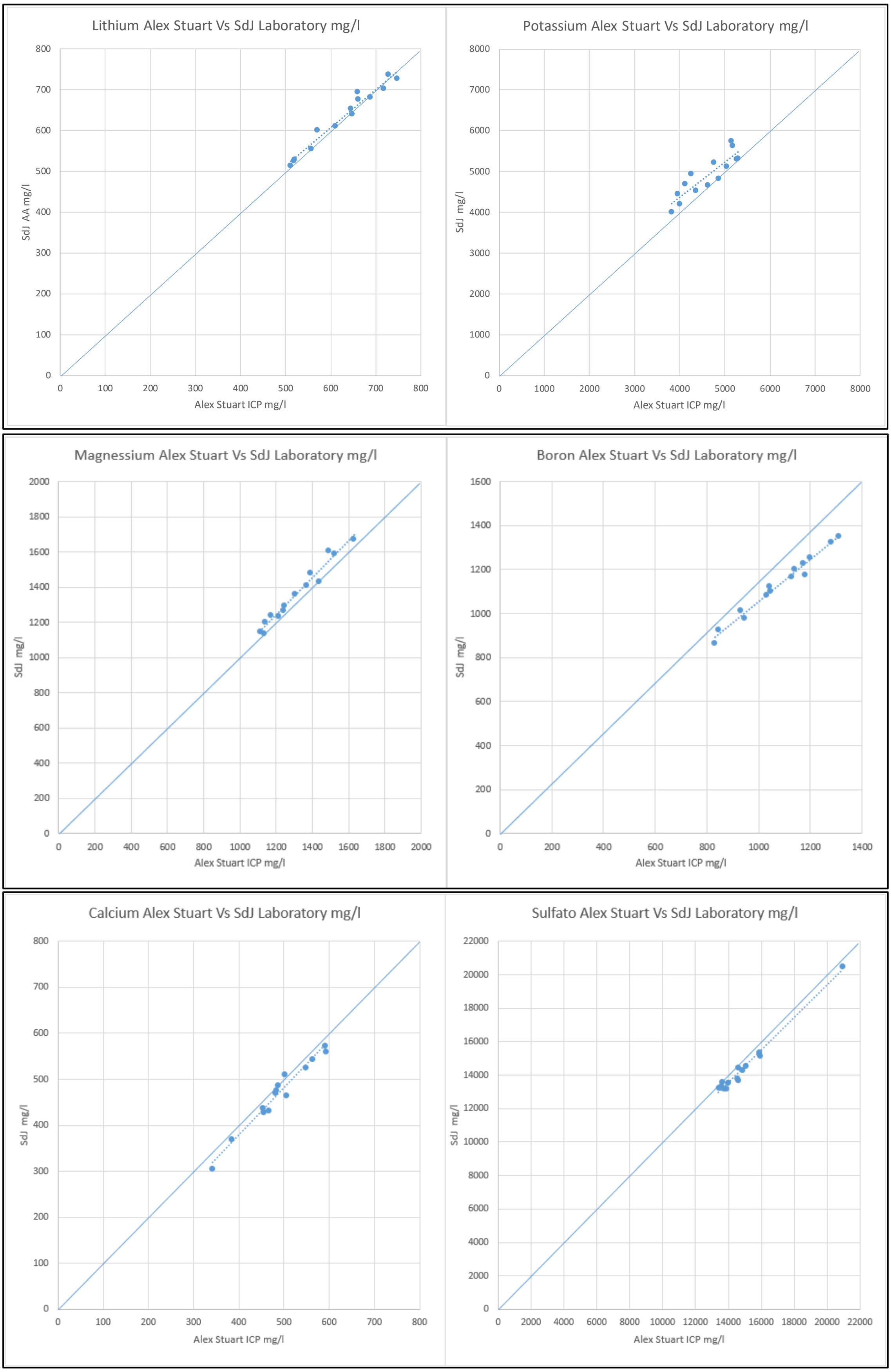


Figure 11.7: Duplicate analyses comparing the Olaroz and Alex Stuart laboratories

Ionic balance

The ionic balance is a measure of the relative imbalance between anions and cations. The ion balance should ideally be as close to zero as possible, although results of less than 5% are generally considered acceptable. Figure 11.8 shows the Olaroz lab ionic balance over the extended period from 2021 to present has almost all samples below 6%.

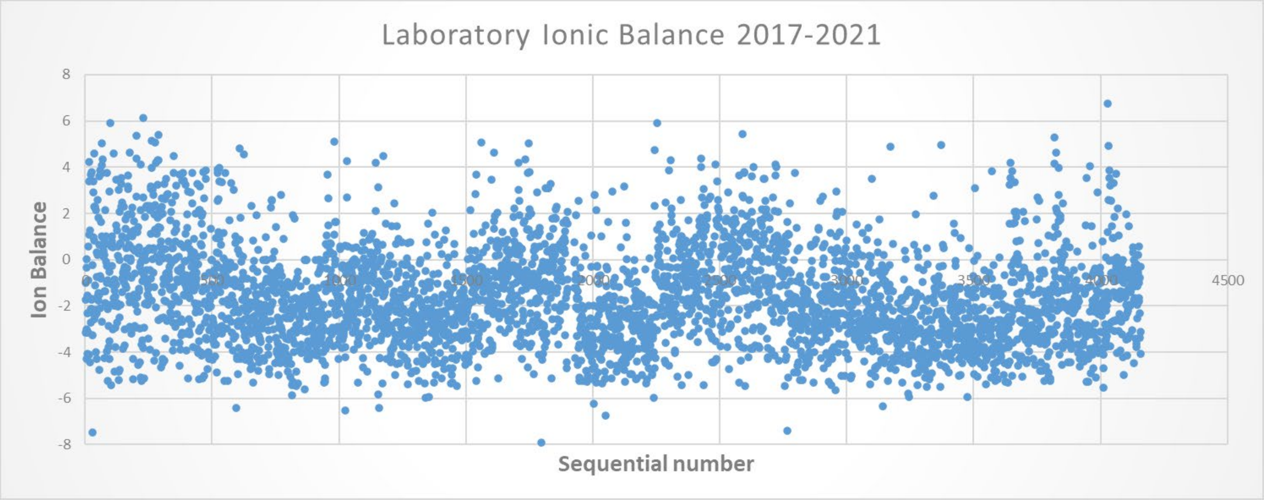


Figure 11.8: Olaroz laboratory ionic balance record

12 DATA VERIFICATION

The principal author has reviewed the protocols for drilling, sampling and testing procedures for the Olaroz expansion drilling program. The author was previously involved in designing the expansion drilling program and has previously spent a significant amount of time at the Olaroz camp working with the SdJ Olaroz Project team during the implementation and execution of drilling, testing, and sampling protocols. Due to Covid limitations the author has not been at the Olaroz Project during 2020 and 2021.

The principal author has reviewed information from the QA/QC programs related to brine sampling and laboratory brine chemistry analysis as well as the laboratory porosity analysis. QA/QC protocols were implemented for the drainable porosity and brine chemistry analysis programs. No significant issues were found with the results of the brine and porosity laboratory analysis. However, the diamond drilling and production well programs were not implemented in the planned time frame, due to constraints imposed by managing Covid-19.

It is the opinion of the principal author the information developed and used for the brine resource estimate is adequate for that purpose.

13 MINERAL PROCESSING AND METALLURGICAL TESTING

13.1 Introduction

The following section is a review of the early testing completed for the purposes of the original Olaroz Project feasibility study. In large part operating results have reflected the findings of this early test work. Very little basic testing has been done since for the obvious reason that full scale operations can be more readily measured and analysed. However, significant information relating to production performance and consequent efficiency improvements have been gained since 2015 by testing and analysis including but not limited to:

- Magnesium precipitation control with lime;
- The mode of Li losses in the pond system;
- Testing of a range of direct extraction techniques for recovery of Li from raw brine, plant feed, and Li recovery from mother liquor;
- Control of sulphate and borate concentrations using calcium chloride;
- Impurity removal in the polishing area; and
- Carbon dioxide recovery from crystallisation reactors in the purification circuit.

13.2 Process Development Overview

The brine resource defined at the Olaroz Project on the Salar de Jujuy contains soluble lithium, potash and boron compounds. The economic value of the lithium as battery grade carbonate is by far the largest and was the focus of early process development work. As market growth for lithium for the Li-ion battery segment has evolved, the objective has been to produce battery grade product.

Initial assessment of the brine chemistry in 2008 indicated that it had a low magnesium to lithium ratio, moderate levels of sulphate and was suitable for application of the 'Silver Peak' method used at the world's first lithium brine treatment operation in Nevada, USA since the mid 1960's. However, the 'Silver Peak' process, although generally applicable to the Olaroz brine chemistry, required modification to suit the differences in brine chemistry and the different climatic conditions at the Olaroz Project. The process route also required some enhancement to produce a lithium product to meet the more demanding prevailing specifications.

The process development program sequentially defined the performance of each stage in the process, resulting in a flow sheet capable of producing battery grade lithium carbonate. Test work has been undertaken at SDJ's facilities at the Olaroz Project site and at commercial and university laboratories.

The process development program resulted in a process route incorporating a number of proprietary innovations. Early work focussed on evaporation rate testing to understand the phase chemistry of the brine during a twelve-month weather cycle, this followed by lime addition test work to remove magnesium. Subsequently, the focus of the Olaroz Project test work moved to the removal of boron by multi-stage solvent extraction processing, and then on to the final stage of lithium carbonate purification.

The lithium is present at concentrations that are economic but are low in comparison to the other salts in the brine. Before final purification the other salts must be selectively rejected, and this is done primarily by evaporation, causing the salt concentrations to increase beyond their solubility limits, and by simple and well-established methods of chemical treatment. Based on test work and phase chemistry, over 70% of the lithium was modelled to be recovered in this process to a high specification product, with the majority of the lithium losses incurred by inclusion of brine in the pores of the solid salts formed during the evaporation process.

By September 2010, Allkem was producing its first pilot scale lithium carbonate and on 8 April 2011, Allkem announced that it had successfully produced battery grade specification lithium carbonate at its process development facilities from Olaroz brines. This was considered to be a prerequisite for completion of a Feasibility Study for the production of 100% of battery grade material. Analysis showed the material to be of greater than 99.5% purity and to exceed specifications of battery grade material sold by existing producers.

Although the primary focus was development of the high specification lithium carbonate production flow sheet, there was a secondary focus on production of potash and boric acid. Test work showed that potash of commercial grade can be produced by froth flotation of mixed halite and potash (sylvite) salts. The deeper 2010 drilling and more detailed testing program revealed significantly higher levels of sulphate in the expanded resource than had been expected based on the shallower 2008 drilling program results. This higher sulphate level had an impact on expected potash recoveries, due to the formation of glaserite ($Na2SO4.3K2SO4$). The process was then expected to produce approximately 0.6 tonnes of potash per tonne of lithium carbonate or 10,000 tonnes per annum in the Feasibility Study production case.

Allkem undertook additional process development work with the aim of reducing the impact of the increased levels of sulphate and increasing potash production to the level of previous estimates, and even potentially higher levels. This work was completed well in advance of the deadline for finalising the design and construction of the final potash circuit.

Some test work was successfully undertaken on the potential to recover boron as boric acid. Further test work and process analysis was planned on the alternative strategy of retaining the boron values in the brine through the evaporation process and recovering the boron to a commercial product.

13.3 Brine Composition Analysis

The Olaroz Project has a very large resource base which has the potential to support a very long Olaroz Project life. The brine composition throughout the deposit is relatively uniform, which is advantageous for process performance, as only minor brine composition changes are expected due to a small decline in grades over time.

For all the experimental work well FD-16B was used which was drilled during the 2008 drilling program. Analysis of the brine chemistry of the 2010 drilling data and 2011 resource estimate show FD-16B brine to be representative of the current resource.

The average brine composition is plotted in the Janecke projection (see Figure 7.11), which indicates the types of salt that can be expected to crystallize during the solar evaporation process. This diagram indicates the relative concentrations of the major ionic species.

Almost all the salt lakes are saturated in sodium chloride, since they are embedded completely in, or contacted partly with, rock salts (halite). The Salar de Olaroz brine is located at the border of the Janecke glaserite (Na2SO4.3K2SO4) field and the ternadite (Na2SO4) fields. Low ambient temperatures at the Salar will cause the crystallization of sulphate as glauber-salt (Na2SO4.10H20) in the evaporation ponds.

The low Mg/Li ratio of the brine makes magnesium removal with slaked lime a feasible process step. The Olaroz brine has a high sulphate content (high SO4/Mg); hence sodium and potassium sulphate salts are likely to crystallize. As it has a SO4/Mg ratio higher than 4, there is also enough sulphate available in the brine to precipitate the calcium liberated during the formation of magnesium hydroxide as gypsum. The only disadvantage of the high sulphate level is that it tends to lock up potassium as glaserite, constraining potential potash yields and at higher concentrations of lithium, causes lithium losses as lithium schoenite.

These brine chemistry characteristics shaped the path of all process testing and development.

13.4 Solar Evaporation Testing

The evaporation of water from the solar evaporation ponds is a critical factor in the processing of the brines. The feasibility study contains extensive climate data and pan evaporation testing data conducted at the Olaroz site, including comparison of data from tests conducted on water and partly saturated brine in standard Pan A equipment, and the data from concentrated brine evaporation in the pilot plant ponds. The solar radiation levels, ambient temperature, local humidity and prevailing wind conditions all impact on evaporation rates. These factors were examined in detail in the Feasibility Study, and a summary is presented below.

The evaporation information was coherent in that the pilot scale pond testing on saturated brine provided an annual rate of 1733mm which is the value used in the original SKM design criteria (Table 13.1). This is conservative in the context of the Pan A test result of 3900mm per year on water and 2600mm per year on unsaturated brine.

The actual ponds area was designed on the basis of 1300mm of annual evaporation [3.6mm/day]. This is a reasonable base line in the context of brine activity factors that range from 75 – 80% depending on saturation levels, and industrial scaling factors of 75% applied to small pond data to predict large pond evaporation rates. This also allows a generous margin to compensate for any unusually high rainfall event.

SKM Design Criteria - Brine Evaporation Rate	
Pilot Pond Data	L/m^2/day (mm/day)
Annual average	4.75
Summer average	5.85
Winter average	3.65

Table 13.1: SKM Design criteria – brine evaporation rate

The most relevant and reliable information was provided by the data gathered from the large number of open evaporation test ponds operating in sequence on the salar. The weather variables needed to be defined to assist with assessing the potential for variance in the pilot plant data.

Evaporation is driven by solar radiation, ambient temperatures, wind impact and humidity, and must take into account the variable rainfall. The average annual temperature at the Olaroz Project site is approximately 7° C, with extremes of 30º C and -15º C. The coldest months with temperatures below zero correspond to May through August. The solar radiation at the Salar de Olaroz is almost as strong as at the Salar de Atacama. The Solar radiation is the most important factor in evaporation.

Rainfall at the Salar is very low and during 2009-2010 no significant rain was registered at the stations. During the summer months (January – March) wind comes frequently from the east with humid air and the rain falls very locally. Summer of 2011 was very wet, and more rain and lower evaporation was registered. At the Salar de Atacama and Salar de Hombre Muerto normally no more than 100 mm/year is registered. Strong winds are frequent in the Puna, reaching speeds of up to 80 km/hr during warm periods of the dry season.

Figure 13.1 below summarises the site evaporation data, comparing other sites and showing the pan test data.

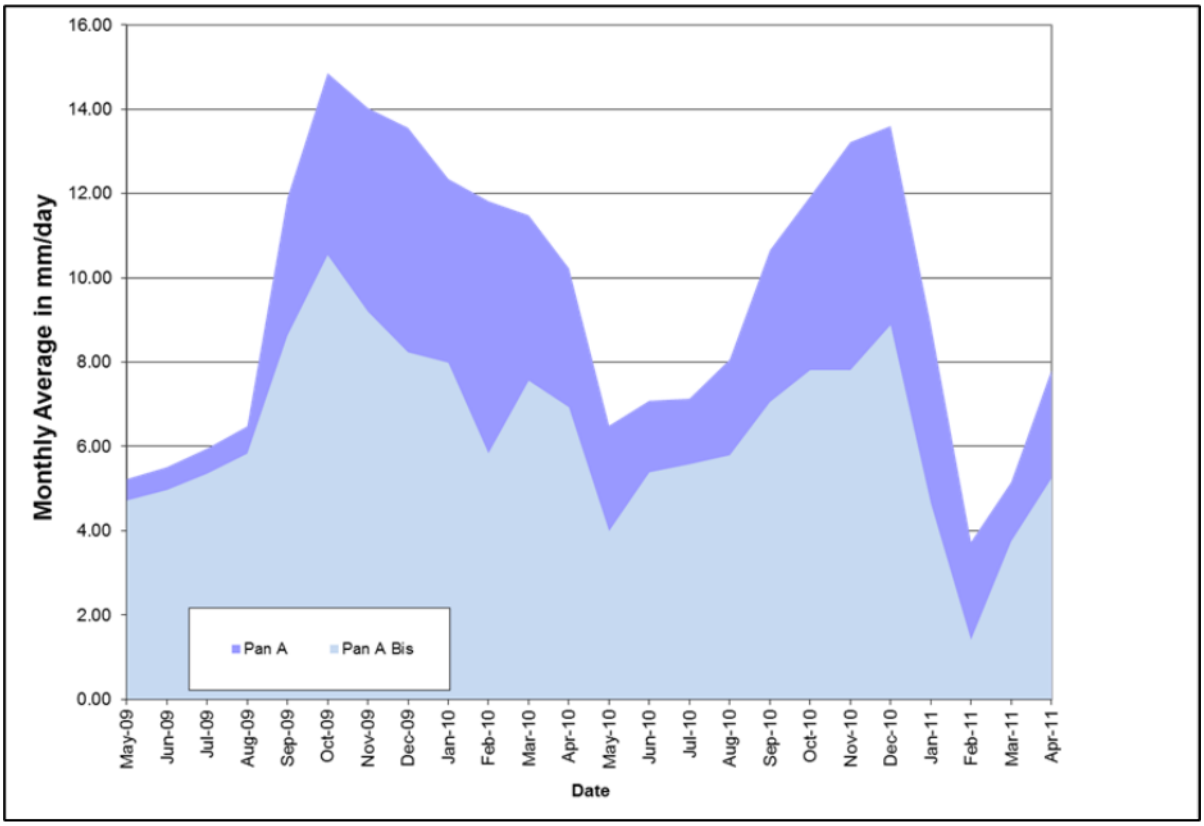


Figure 13.1: Site Net Evaporation Rate Test Data and other sites

The significance of the Pan A bis data is that this was an unsaturated brine test and is compared to Pan A on just water. Pan data is the net evaporation rate, as both precipitation and evaporation are accounted for in the test pan. The rainfall in the operating years 2015 – 2021 was often significantly higher than the early design basis reflects. This contributed to reduced Li concentration in plant feed and so impacted production Olaroz Projections.

Figure 13.2 shows how the brine evaporation rate varies compared to a standard water test as brine concentration increases [represented by Li concentration]. Brine activity is the vapour pressure ratio of brine divided by the vapour pressure of water, and it is a function of brine chemistry independent of ambient conditions. Modelling of pond performance depends on reliable brine activity data and the predictability of climatic conditions.

13.5 Test Work Outcomes

Evaporation Pond Brine Temperatures

Temperatures in the ponds were manually registered at 09:00 and 16:00 every day. Some ponds had continuous temperature registration using data loggers placed in the ponds.

For brine phase chemistry analysis the lowest daily brine temperature is an important parameter as it will indicate which salt will precipitate.

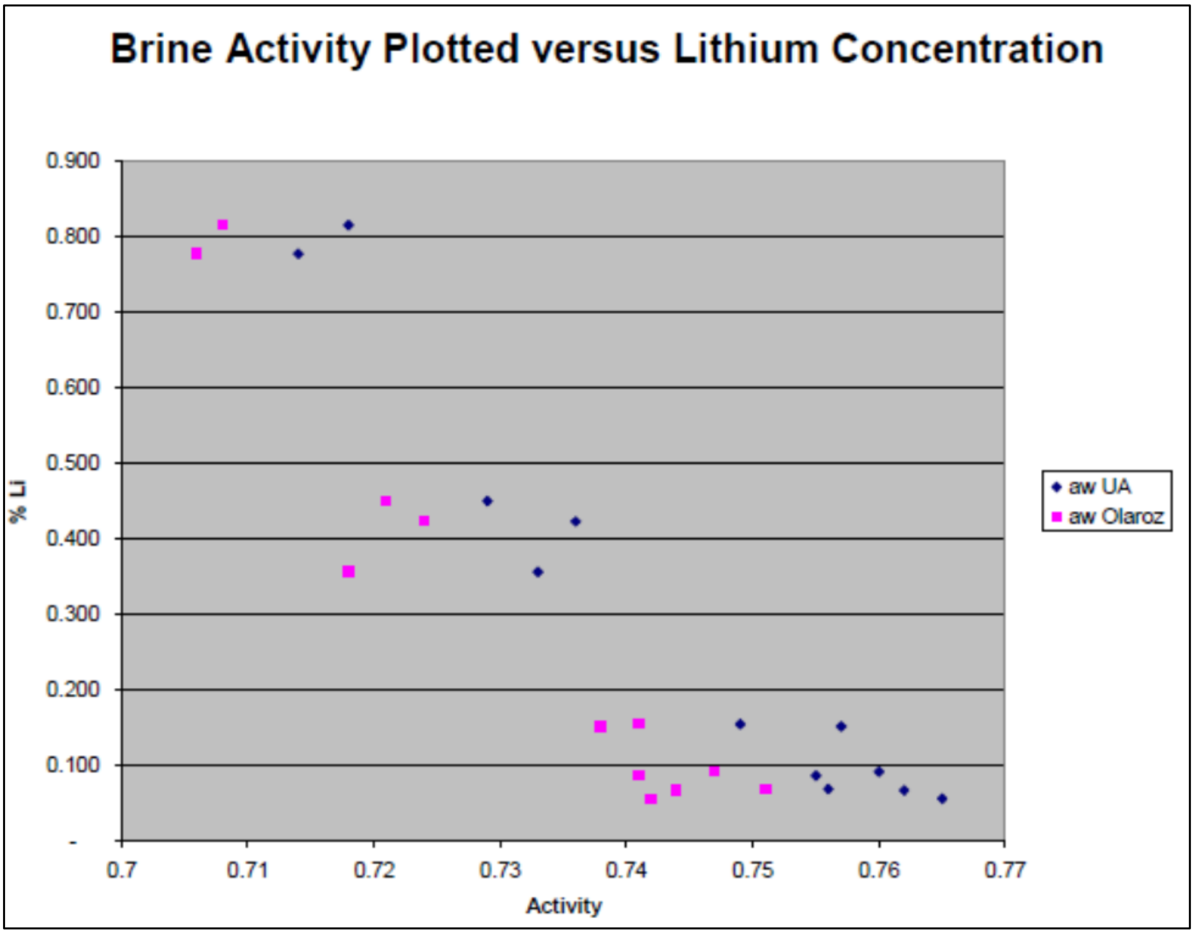


Figure 13.2: Brine activity plotted versus lithium concentration

Figure 13.3: Operational ponds L3 and L4 from the test work phase at Olaroz

Phase Chemistry

The pilot ponds operated under conditions representative of the industrial operation for over one year generating the required phase chemistry data, which defined the amount and types of salts that form as solids in the ponds through the changing ambient temperature, wind and humidity conditions over time. Enough information was collected for the modelling of the behaviour of the evaporation system for the Feasibility Study to enable definition of the brine chemistry in the feed to the lithium carbonate plant, and for detailed engineering of the pond system.

Crystallized Salts

In all the ponds it is mainly sodium chloride (NaCl > 94%) that is crystallized. Other salts that crystallize are glauber salt (Na2SO4.10H20 : 2-6%) and calcium sulphate (CaSO4.2H20 : 1%). In the most concentrated ponds halite and silvite (KCl) crystallise, with minor concentrations of glaserite (Na2SO4.3K2SO4) and borate salts. Under these alkaline conditions the boron is precipitated as sodium and calcium borate [Na2B4O7 and CaB4O7], and to assist in the final lithium purification process this precipitation may be encouraged by addition of calcium chloride.

The optimal lithium concentration for the recovery plant was defined by the loss of lithium at concentrations greater than ~0.7% by precipitation of lithium as schoenite [Li2SO4.K2SO4].

13.6 Liming Test Work

Initially Allkem was using hydrated lime (Ca(OH)2) from a provider located near Jujuy for its experiments. This was replaced by active or burnt lime (CaO) from the same provider, with the advantage of reducing product and transportation costs. The active lime is of a medium grade and contains 83% active CaO. At pilot scale the lime reacted very well and completely fulfilled the process requirements. Higher quality lime from San Juan has also been tested in recent years, however the transport cost is very high, offsetting the advantages of its superior performance.

Magnesium reacts instantaneously with the slaked lime. Subsequently the liberated calcium starts to react with the available sulphate and some boron reacts early with calcium from the liberated lime. Brine at higher levels of concentration could be treated with lime, but the material handling for the concentrated brine becomes more difficult, and lithium losses increase. Data from the pilot scale trial is shown .

Test	Indentification	Date	Mg	Ca	Li	SO_4	B	pH	B Loss	Lime Excess	Mg removal
1	W16	22-Nov	0.137	0.04	0.05	1.17	0.06	11.14	15%	131%	99.4%
	W16-Out		0.001	0.143	0.051	0.578	0.056				
2	W16-Out	22-Nov	0.141	0.042	0.051	1.160	0.059	11.39	3%	135%	99.4%
	W16		0.001	0.144	0.050	0.694	0.049				
3	L1-P1	2-Dec	0.200	0.045	0.078	1.587	0.085	10.60	12%	113%	93.6%
	L1-P1-Out		0.012	0.126	0.079	0.774	0.077				
4	L1-P1	3-Dec	0.178	0.042	0.077	1.659	0.081	10.40	20%	115%	100.0%
	L1-P1-Out		0.000	0.161	0.076	0.721	0.074				
5	L1-P2	4-Dec	0.293	0.028	0.112	2.415	0.118	11.40	11%	115%	99.7%
	L1-P2-Out		0.001	0.109	0.105	0.946	0.104				

Table 13.2: Pond test work results

13.7 Boric Acid Process

To recover the boron, its behaviour in the solar ponds was studied. Several different process options were tested at lab scale to recover the boron. Some tests have been conducted which showed potential for high recovery rates, but this process is still in the preliminary development phase.

Additional testing of solvent extraction has been conducted in recent years, and preliminary tests using calcium chloride to precipitate boron have been conducted.

13.8 Potassium Chloride

Preliminary sylvite froth flotation tests were conducted at the University of Jujuy with salts obtained from the pilot ponds. During the test the most important parameters (collector type and addition, liberation, etc) were defined to obtain an acceptable concentration of silvite salts (KCl). Future test work was planned with some additional bench flotation test followed by pilot scale testing.

13.9 Lithium Carbonate process

The pilot plant was operated successfully from the 3rd Quarter of 2010, producing technical grade lithium carbonate.

At the beginning of 2011 the pilot plant testing process included an alternate purification step to achieve battery grade lithium carbonate. Clients were supplied with samples of this >99.5 % lithium grade product (not including moisture and LOI) for analysis.

Extensive testing was undertaken by Ekato in Europe to optimise reactor mixer design and residence time. Solids thickening and final dewatering by filtration was tested by Outotec to define equipment requirements.

13.10 Analytical Quality Control

The Feasibility Study contains a detailed presentation of the quality control procedures adopted for analysis of the various plant streams emerging from the test work program.

These analyses are complicated since the solutions have a high concentration of ions generating interference in the measurements with the analytical equipment. Only a limited number of laboratories have the experience to analyse brines and those laboratories have been selected to do Allkem´s quality control.

The samples from Salar de Olaroz were analysed by Alex Stewart Assayers [ASA] of Mendoza, Argentina, who have extensive experience analysing lithium bearing brines.

The Alex Stewart laboratory is accredited to ISO 9001 and operates according to Alex Stewart Group (AS) standards consistent with ISO 17025 methods at other laboratories.

Duplicate process samples were sent to:

- University of Antofagasta (UA), Chile; and
- ALS-Environment (ALS) laboratory located in Antofagasta, Chile, which is ISO 17025 and ISO 9001:2000 accredited

Both the University and the ALS laboratory, have a long history in brine analysis, however the university is not certified.

Physical parameters, such as pH, conductivity, density and total dissolved solids are determined directly upon brine subsamples. Determination of lithium, potassium, calcium, sodium and magnesium is achieved by fixed dilution of filtered samples and direct aspiration into atomic absorption or inductively coupled plasma analysis systems.

In summary,

- ASA analyses show acceptable accuracy and precision with an acceptable anion-cation balance.
- Check samples analysed at University of Salta display acceptable accuracy and precision, with a high degree of correlation with ASA analyses for K and Li. Mg is biased lower than corresponding analyses at ASA.
- Check samples analysed at ALS Environment displayed acceptable accuracy and precision, with a high degree of correlation with ASA analyses, but the inorganic analytes (Li, K and Mg) are biased higher than corresponding analyses at ASA.
- Check samples analysed at University of Antofagasta displayed acceptable accuracy and precision, with a high degree of correlation with ASA analyses, but the inorganic analytes (Li, K and Mg) are also biased higher than corresponding analyses at ASA.
- The lower bias observed in the ALS and UA data is most likely due to calibration differences between the ICP and AA instruments used to analyse the samples.

The quality control systems are well designed and under continuous improvement. Data analysis of the QA results produced by the laboratories is considered to have sufficient accuracy for the purposes of process design. The improved performance of the principal laboratory, ASA, as shown by the improvement in ionic balance over time and the reproducibility of the analytical results is noteworthy and shows the benefit of a close working constructive relationship between SDJ and laboratory.

Future refined quality control with newly designed standards has the objective to improve the accuracy of certain elements for the samples related to lithium carbonate production at pilot scale.

14 MINERAL RESOURCE ESTIMATES

Estimation of a brine resource require definition of:

- The aquifer distribution (limits of the brine body);
- The distribution of drainable porosity (specific yield) values;
- The distribution of elements in the brine from drilling and sampling; and
- The external limits (geological or property boundaries) of the resource area.

The resource estimate uses a combination of the aquifer volume, the drainable porosity (portion of the aquifer volume that is filled by brine that can potentially be drained) and the concentration of elements of interest in the brine. Aquifer geometry and the extent of aquifers has been established by drilling, surface and down hole geophysics. Drilling provides samples of sediments for porosity measurements and samples of brine for quantification of the contained content of lithium and other elements. Down hole geophysics provides continuous measurements of drainable porosity.

14.1 Data Types

There are a number of different types of sample data available, which include:

- Spaced down-hole assays, with the assay spacing dependent on depth of the hole. Sonic holes to 54 m deep have assays at 3 m intervals and 200 m deep diamond holes at 6 m intervals. Minimal data is present below 200 m, with assays in recent diamond holes nominally every 12 m (not used in the resource, due to limited geographical distribution);
- Well average assays, with a single homogenised value per hole;
- Laboratory porosity measurements on specific 10 cm intervals of core, at 3 m for sonic and 6 m for diamond drilling above 200 m; and
- Continuous down-hole geophysics, with extensive information per hole, with data at cm intervals;

This mixture of continuous and point data presents some issues when combining the two different data types. For the purposes of estimation, the well average assays were applied to the entire length of the holes, while the porosity interval measurements were assigned a maximum length of six metres in the absence of adjacent samples.

14.2 Resource Model Domain

The aquifer is comprised of salar sediments with different lateral and vertical characteristics. Drilling and geophysics have provided information to develop a geological model for the salar, based on this information. This information now extends to beyond 650 m depth (with the addition of one hole to 1408 m depth) and has greatly added to understanding of the basin since the Feasibility Study in 2011.

- The top of the model corresponds to the phreatic surface, which is generally within one metre of surface;

- The outline of the salar (covering an area of 160 km^2) and the Olaroz Project properties are used to delimit the area of the resource estimate, with minority property owners (Lithium Americas Corp and other owners) in the salar to the east and north of the properties owned by Allkem and SDJ. Where the properties continue beyond the boundary of the salar the resource terminates at the salar boundary. This is entirely due to the concentration of drilling on the salar, with limited drilling in the alluvial fans and delta environments that surround the salt lake.
    - The marginal area around the salar, including the delta area in the north, cover a further 189 km^2, while the Archibarca fan south of the salar covers a further 50 km^2. Neither of these areas is included in the current estimate, as these areas have insufficient drilling to define a resource.
    - The area covered by this resource estimate (113 km^2) is slightly larger than the 2011 Resource (93 km^2). This 2022 Interim Upgraded Resource covers some small properties east of and outside the main body of the properties, that was not included in the 2011 resource. The Sales de Jujuy properties in this estimate cover ~103.3 km^2 on the salar, with the Olaroz lithium properties (Allkem 100%), covering ~9.7 km^2 on the salar, with the majority area of these properties extending into the delta area at the north of Olaroz (these properties were acquired after the completion of the 2011 resource);
    - The brine saturated sediments are known to extend beneath alluvial sediments surrounding the salar. However, to date insufficient drilling has been carried out in these areas (noted above) to support resource estimation there;
    - Within the salar the three dimensional distributions of the different hydrostratigraphic units (UH1 to 5) were defined using Leapfrog software, with these units based on geological and geophysical logging observations. Because the resource is entirely within the salar, there are no locations where brackish or fresh water are overlying brine within the resource area. That relationship is known to exist off the salar;
- The resource estimate (as Inferred Resources) extends to the base of the basin, as defined by gravity geophysics. Inferred resources extend below the 650 m depth of production wells, as the deep hole drilled in the north of the properties confirmed salar sediments continue to at least 1400 m depth in this deepest part of the basin.
    - Measured resources are defined to 200 m, with Indicated resources defined to 450 m depth in the centre and south of the properties, and 350 m in the north of the properties, where drilling is shallower and less extensive.
    - As the Olaroz Project is pumping from production wells to 650 m depth, in similar sediments to those extending below 650 m, the QP considers there is sufficient confidence in pumping extraction from this geological environment to classify the deep area of the basin as Inferred Resources, rather than an exploration target.

- Extraction below 650 m is not planned as part of Stage 2. However, it is likely the classification of this deeper brine could be improved with additional drilling.

As the resource is defined entirely within the salar, there are not areas where fresh to brackish water is overlying brine in the resource.

It is noted hole E14 in the centre south of the resource area extends below the interpreted base of the salar, based on the gravity geophysics survey. This suggests the modelled base of the salar may be conservative and extends below the current interpretation.

SRTM data was used to produce a wireframe of surface topography. Wireframe models developed based on the drilling and representing the lithological units were used for the resource estimation. The lithological wireframes define the base of the salar and internal units. For estimation purposes, the salar sediments were divided into two domains: Domain 1 is the flat upper part of the salar, while Domain 2 is the lower east dipping part of the sequence, where units become progressively deeper to the east. Figure 14.1 shows a cross-section of the various lithological unit wireframes. Domain 1 includes units 1, 2 and 3, while Domain 2 comprises units 4 and 5.

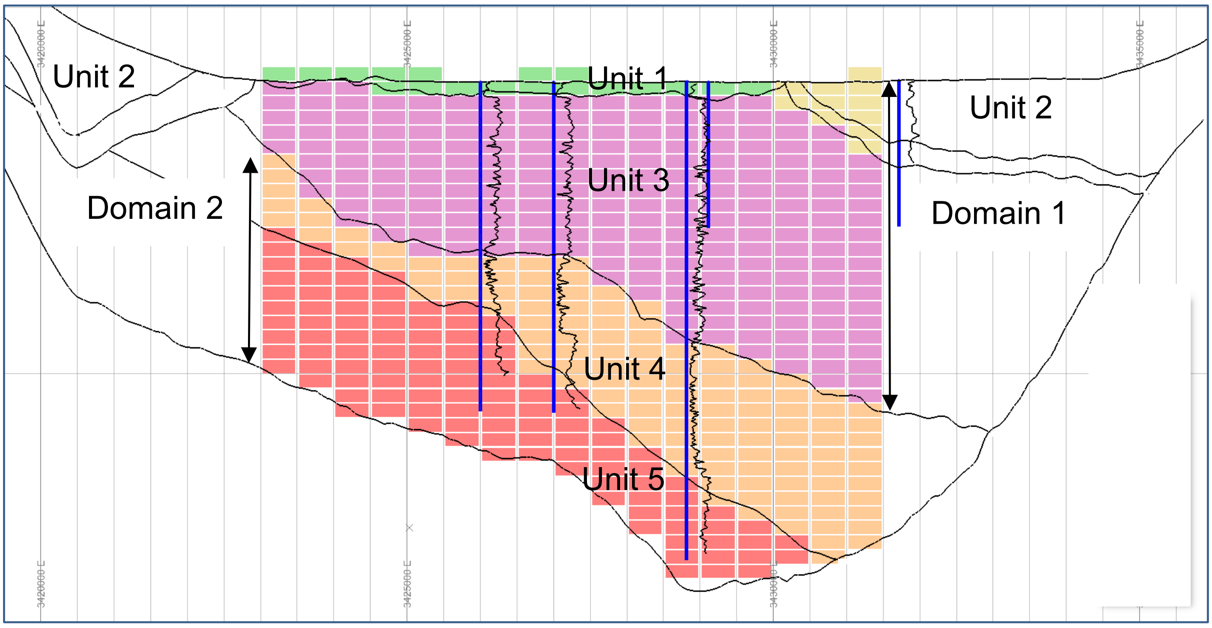


Figure 14.1: Cross section showing lithology units and gamma traces (10x vertical exaggeration, looking North), to the base of the sediments interpreted from the gravity survey. With the block model restricted to the central area of the basin (does not extend off the salar)

14.3 Statistical Analysis

All sample data was composited to nominal 2.0 m intervals for analysis and estimation, and determination of summary statistics. Data includes four elements (Li, K, B, Mg) in concentrations of milligrams per litre (mg/L), as well as total porosity and specific yield (SpecYld) as percentages and gamma response in API units. All attributes have low coefficients of variation (CV=SD/mean), which indicates that ordinary kriging is an appropriate estimation method for these items.

Variograms were generated for these attributes, with some examples presented in Figure 14.2 and variogram parameters provided in Table 14.1 The assays were assumed to be horizontal across the entire salar, while porosity and gamma were divided into the upper and lower domains for both variography and estimation. The lower domain has a shallow dip to the east. Contact plots of different lithologies are shown in Figure 14.3 and 14.4.

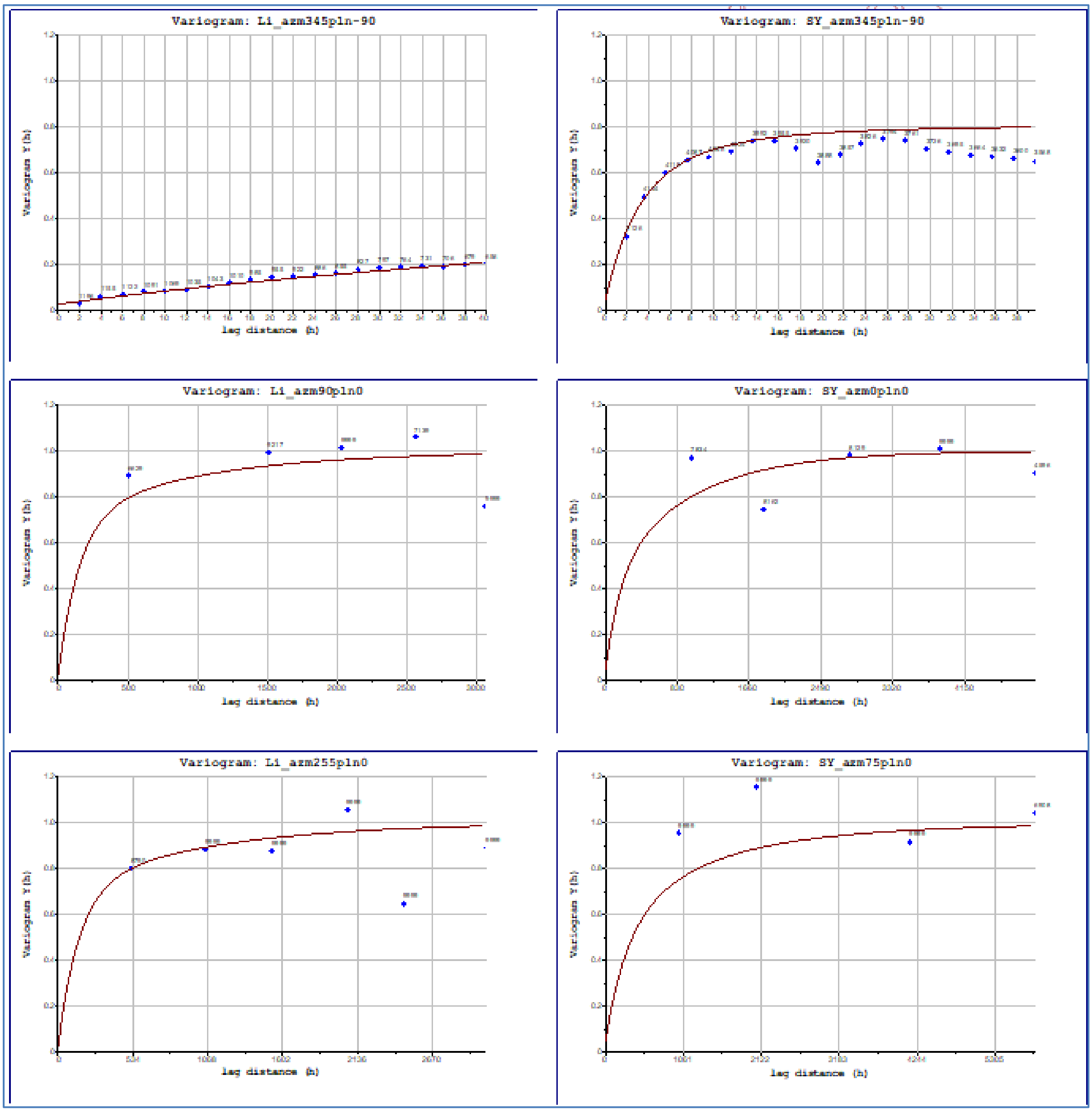


Figure 14.2: Variograms for Li (left) and Specific Yield – Upper Domain (right)

Attribute	Structure	Variance	X Range	Y Range	Z Range
Li	Nugget	0.025	-	-	-
	Exp1	0.035	329	250	40
	Exp2	0.64	452	600	610
	Exp3	0.30	3,110	1,895	933
K	Nugget	0.05	-	-	-
	Exp1	0.32	340	265	260
	Exp2	0.34	800	800	800
	Exp3	0.29	3,500	2,500	1,000
B	Nugget	0.01	-	-	-
	Exp1	0.32	340	265	260
	Exp2	0.33	800	800	800
	Exp3	0.34	3,500	2,500	1,000
Mg	Nugget	0.01	-	-	-
	Exp1	0.32	340	265	99
	Exp2	0.33	800	800	195
	Exp3	0.34	3,500	2,500	1,000
SY Upper	Nugget	0.05	-	-	-
	Exp1	0.39	780	500	8
	Exp2	0.34	2,500	2,800	20
	Exp3	0.22	6,400	2,895	1,200
SY Lower	Nugget	0.26	-	-	-
	Exp1	0.28	900	900	3
	Exp2	0.27	3,995	1,500	69
	Exp3	0.19	6,000	6,000	175
TP Upper	Nugget	0.05	-	-	-
	Exp1	0.39	730	510	8
	Exp2	0.34	2,000	2,000	94
	Exp3	0.22	6,000	6,000	2,000
TP Lower	Nugget	0.22	-	-	-
	Exp1	0.22	800	395	4
	Exp2	0.31	3,495	995	125
	Exp3	0.25	4,505	6,000	170
GR Upper	Nugget	0.10	-	-	-
	Exp1	0.33	925	600	5
	Exp2	0.41	5,940	3,005	97
	Exp3	0.16	10,080	5,300	115
GR Lower	Nugget	0.07	-	-	-
	Exp1	0.15	900	915	4
	Exp2	0.41	8,000	1,500	125
	Exp3	0.37	10,000	10,000	670

Table 14.1: Variogram model parameters

14.4 Specific Yield

Specific yield (drainable porosity) is the key porosity variable that reflects the brine held in pores in the aquifer which can potentially be extracted. This measurement can be made in a number of ways, consisting of both laboratory and in-situ determinations. In Olaroz (and the neighbouring Cauchari Olaroz Project owned by Allkem) a total of 765 laboratory measurements of drainable porosity have been made. This information is primarily available from laboratory sample results in the upper 200 m at Olaroz, where diamond and sonic drilling was conducted. At Cauchari laboratory data is available to depths approaching 600 m. Although this data was not used in the estimation drainable porosity values for different lithologies were compared with BMR geophysical results used in the estimate.

At Olaroz below 200 m there are limited laboratory measurements, restricted to the recent diamond holes on the eastern property boundary. However, production wells for the expansion were geophysically logged with a borehole magnetic resonance tool (as discussed in the drilling section above). This provides continuous measurements of specific yield, showing how the drainable porosity varies on a decimeter scale. The BMR information has been used for the estimation to supplement the limited laboratory porosity data available below 200 m. The porosity data from the BMR geophysics was used to generate a block model across the salar area applying ordinary kriging to smoothed BMR drainable porosity data. The BMR tool was developed in the oil industry for measurement of drainable porosity and is a well-established tool, considered to be much better suited for use in salars than the equipment previously used.

Geophysical logging in the deeper holes has confirmed generally consistent drainable porosity and permeability characteristics throughout the clastic sediments, with higher porosities and permeabilities associated where thicker more sand dominated intervals of unit UH5.

14.5 Brine Concentration

The distribution of lithium and other elements was estimated from point sampling data from the upper 200 m of the model, where samples are typically spaced every 6 m in the 200 m holes and 3 m or less in the 54 m holes. Below the upper 200 m the resource was estimated based on the pumped samples from the production wells, with a single value per hole representing the average pumped value for each hole. There is a systematic variation across the salar and this broadly reflects the pattern presented in the 200 m deep resource drilling results from 2011, when interval samples were obtained.

The QP considers use of the pumped brine samples an acceptable approach in the circumstances, given the level of information available in the Olaroz salar, continuity between drill holes, comparison between historical interval samples and pumped brine concentrations from the same areas of the salar, and the 7 year history of pumping data available. Additional 650 m deep diamond drilling is planned as part of the expansion program which will be used in a further update to the resource once drilling is complete.

14.6 Resource Modelling Methodology

The resource estimate was undertaken by H&S Consulting of Sydney, Australia, under supervision of the QP. Datamine software with variograms was developed for the point samples from the upper 200 m. Estimation was undertaken using ordinary kriging. The ordinary kriging method is the most commonly used kriging method.

- The block model was constructed with 500 by 500 by 20 m blocks, with the proportion of blocks only reported inside of the resource area (salar outline) and any portion of the block outside the salar outline excluded;
- Histograms, probability plots and box plots were undertaken as part of the data analysis;
- Variograms were developed for the three orthogonal directions;
- Kriging criteria were defined; and
- The resource was estimated using the information from the brine and porosity models.

Details of the model are summarised in the table below.

Olaroz	X	Y	Z
Origin	3,421,500	7,390,000	2,680
Maximum	3,441,500	7,426,000	3,960
Block Size	500	500	20
Number of blocks	40	72	64
Length	20,000	36,000	1,280

Table 14.2: Model dimensions

Data analysis

Data analysis of lithium (Li) concentrations involved statistical analysis using histograms, probability plots, contact plots and box plots, and a spatial description using trend analysis. Analysis showed that some variables show significant differences between hydrostratigraphic units, whereas others show little difference. Data analysis was more limited for the deeper units where brine samples are from the pumped wells and porosity data is derived from the BMR geophysics. Gamma ray data was used as a check on the definition of the hydrostratigraphic units which are considered reasonable, based on the available geological and geophysical data. Gamma ray data provides information that allows relative assessment of the halite, clay and sand content.

Ordinary kriging is the most commonly used kriging estimation method. Ordinary kriging re-estimates, at each estimation location, the mean value by only using the data within the search neighborhood.

- A four-pass search strategy was implemented, as outlined in Table 14.3. The first two passes have narrow vertical (Z) radii to reflect the bedded nature of the salar sediments. The second two passes have much larger vertical radii because of the limited amount of data at depth and the need to maintain the lateral trends observed near surface.

- The BMR geophysical data for specific yield was not used for the estimates of the upper 200m of the deposit, where the historical and spatially more distributed laboratory porosity data is available.
- There is a soft boundary between Domains 1 and 2 for brine grades, and a hard boundary between Domains 1 and 2 for specific yield.
- The salar boundaries were defined with a block fraction at 50x50m resolution.
- The model was validated in a number of ways – visual and statistical comparison of block and drill hole grades and examination of grade-tonnage data.
- Visual comparison of block and drill hole grades showed reasonable agreement in all areas examined and no obvious evidence of excessive smearing of higher-grade brine assays.
- A comparison of average sample and block grades presented in Table 14.4 shows that block grades inside the salar boundary are broadly comparable to the samples and differences can be explained in terms of the clustering of drill hole samples in the center of the salar.

Item	Pass 1	Pass 2	Pass 3	Pass 4
X Search	1,200	2,400	8,000	12,000
Y Search	800	1,600	4,000	6,000
Z Search	25	50	800	1,200
Minimum Samples	36	24	12	6
Maximum Samples	48	48	48	24
Number of Octants	8	8	8	4
Max Samples per Octant	6	6	6	6
Max Samples per Hole	12	12	12	12
Min Number of Octants	4	4	0	0

Table 14.3: Estimation search parameters

Attribute	Samples		Blocks		% Diff
	Number	Mean	Number	Mean	
Li	7,223	698	24,170	651	-6.7%
K	6,694	5,230	24,170	4,942	-5.5%
B	3,058	974	24,170	990	1.6%
Mg	3,067	1,332	24,170	1,425	6.9%
Specific Yield	2,806	0.051	24,170	0.055	9.0%
Total Porosity	2,794	0.229	24,170	0.238	4.0%
Gamma	3,299	56.6	24,170	51.7	-8.7%

Table 14.4: Comparison of average Sample and Block Grades

Table 14.5 below shows the area covered by the different property holdings of Sales de Jujuy and Olaroz lithium.

Lease Group	Area (m^2)
Orocobre SdJ JV	103,336,414
Olaroz Lithium	9,649,062
Total	**112,985,476**

Table 14.5: Property area by ownership (numbers are slightly different in other tables due to block sizes and rounding)

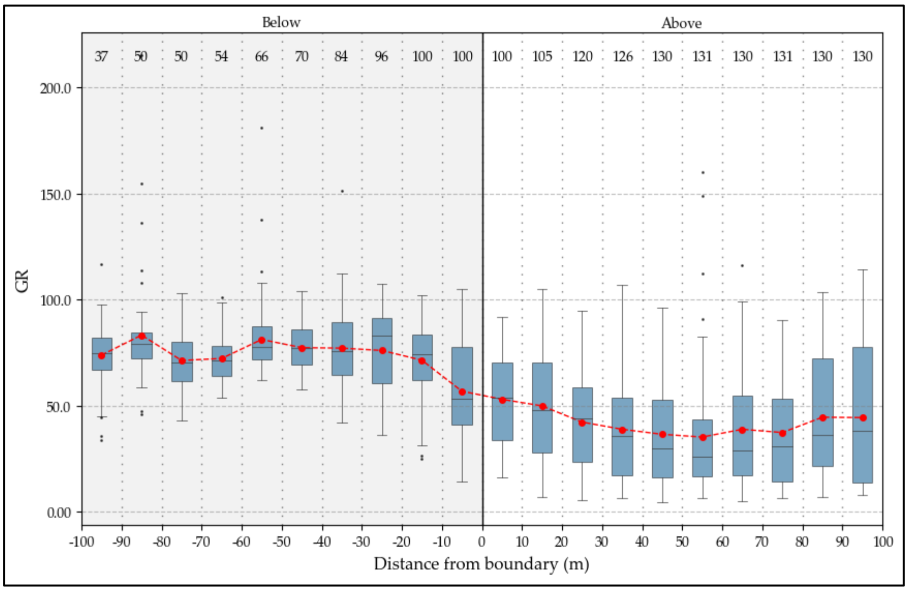


Figure 14.3: Contact plot, showing the change in gamma ray response across the base of UH4/top UH5

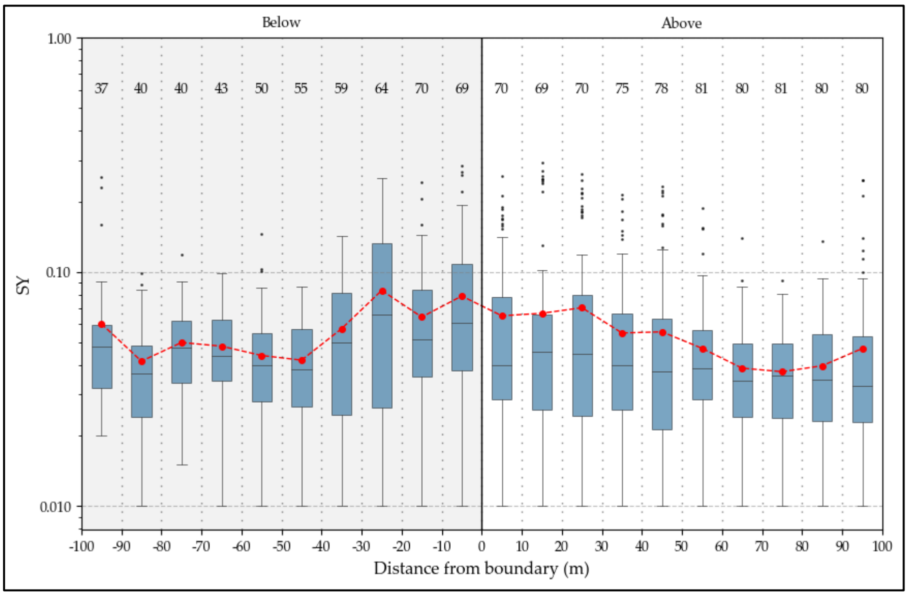


Figure 14.4: Contact plot showing the specific yield across the base of unit UH4/Top UH5

Unit	Blocks	Min	Max	Mean	SD	CV
UH1	4,234	0.017	0.157	0.101	0.028	0.275
UH2b	278	0.049	0.107	0.082	0.011	0.134
UH2c	743	0.010	0.142	0.047	0.020	0.425
UH3	15,840	0.010	0.185	0.071	0.029	0.409
UH4	10,828	0.011	0.189	0.036	0.018	0.501
UH5	17,423	0.014	0.219	0.048	0.025	0.511
Total	**49,346**	**0.010**	**0.219**	**0.057**	**0.031**	**0.545**

Table 14.6: Estimated specific yield by hydrogeological unit

14.7 Grade Tonnage Curve

The grade tonnage curve shows there is essentially no difference in resource tonnage with a cut-off between zero and almost 400 mg/L, due to the large and fairly homogeneous character of the resource. The resource has been stated at a zero mg/L lithium cut-off, as the resource has been restricted to the salar boundary. However, exploration indicates the brine body extends significant distances beyond the salar, for example in drilling by Allkem subsidiary Advantage Lithium south of the Olaroz plant and ponds.

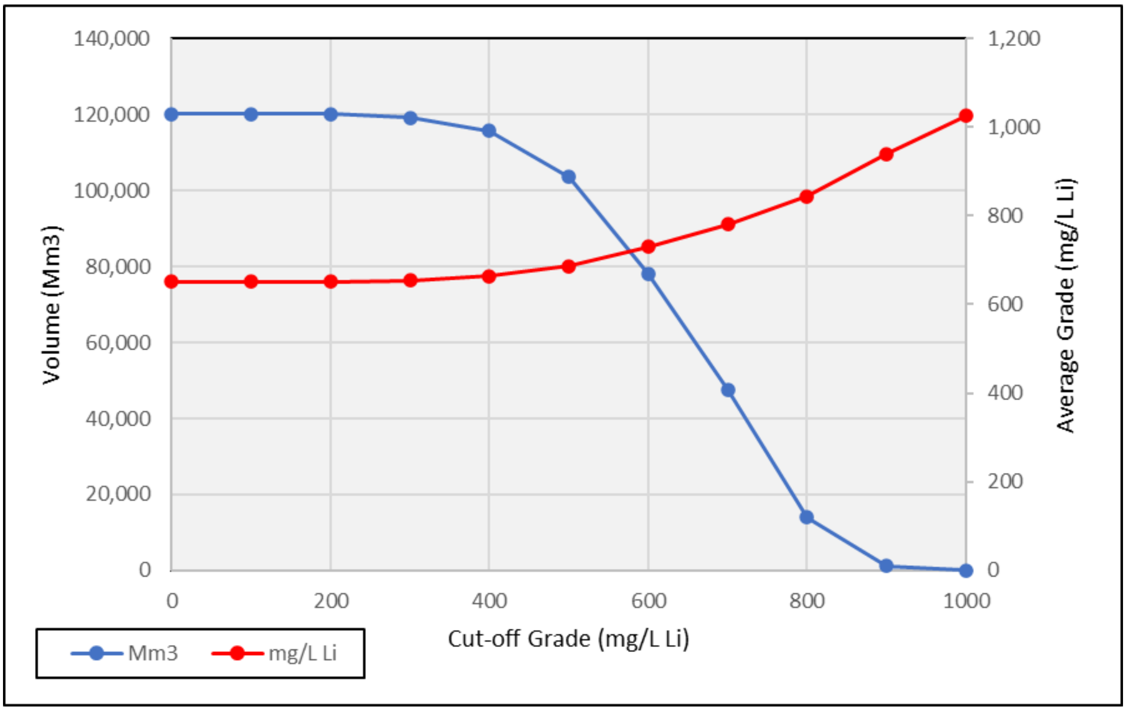


Figure 14.5: Olaroz grade tonnage (sediments) curve – all of the salar

14.8 Resource Classification

The resource was estimated using 4 passes with the search strategy. The results of the first two passes are nominally equated to blocks classified as Measured and Indicated, with the latter two passes equating to blocks classified as Inferred (Figure 14.9).

Measured Mineral Resources

A ‘Measured Mineral Resource’ is that part of a Mineral Resource for which quantity, grade (or quality), densities, shape, and physical characteristics are estimated with confidence sufficient to allow the application of Modifying Factors to support detailed mine planning and final evaluation of the economic viability of the deposit.

Geological evidence is derived from detailed and reliable exploration, sampling and testing gathered through appropriate techniques from locations such as outcrops, trenches, pits, workings and drill holes, and is sufficient to confirm geological and grade (or quality) continuity between points of observation where data and samples are gathered.

A Measured Mineral Resource has a higher level of confidence than that applying to either an Indicated Mineral Resource or an Inferred Mineral Resource. It may be converted to a Proven Ore Reserve or under certain circumstances to a Probable Ore Reserve.

The Measured classification is based on reliable geological correlation between drill holes, which show gradual changes in lithology laterally and with depth. Measured resources were defined to cover the entire salar area to 200 m depth, as exploration drilling was previously conducted across the salar area to 54 m and 200 m depth.

Classification is supported by ongoing extraction by pumping of brine from production wells installed to 200 m for a period in excess of seven years in the central area of the resource, with 1 km spaced production wells and a drilling density of approximately 1 hole per 2 km^2. Since 2013 production wells to 200 m depth have been installed and operated from depths of 200 m, with wells deeper than 300 m producing from 2014 onward. The original exploration included exploration holes and a pumping well (PD01) in the far north of the area on the salar and another (PD02) in the south of the salar.

The drilling spacing is greater than 1 km outside the existing and new wellfields, however geological continuity supports classification as a Measured resource to 200 m. The Measured resources are almost all within 2.5 km from drill holes across the salar, as suggested by Houston et. al., 2011 as an appropriate drilling spacing for Measured resources in clastic salars.

Indicated Mineral Resources

An ‘Indicated Mineral Resource’ is that part of a Mineral Resource for which quantity, grade (or quality), densities, shape and physical characteristics are estimated with sufficient confidence to allow the application of Modifying Factors in sufficient detail to support mine planning and evaluation of the economic viability of the deposit.

Geological evidence is derived from adequately detailed and reliable exploration, sampling and testing gathered through appropriate techniques from locations such as outcrops, trenches, pits, workings and drill holes, and is sufficient to assume geological and grade (or quality) continuity between points of observation where data and samples are gathered.

An Indicated Mineral Resource has a lower level of confidence than that applying to a Measured Mineral Resource and may only be converted to a Probable Ore Reserve.

Geological continuity established by deeper drilling below 200 m, geophysical logging of holes, and gradual changes in lithium concentration provide the basis for classifying the brine between 200 and 350 m below surface in the north of the salar (with lesser drilling density) and 200 and 450 m in the centre and south of the salar as an Indicated resource (greater drilling density). Laboratory porosity samples are relatively limited below 200 m, however similar sediment intervals are present above 200 m at Olaroz, where porosity characteristics have been established from hundreds of laboratory analyses. Extensive porosity samples from similar sediments are also available from the Allkem Cauchari properties. Ongoing extraction by pumping of brine from wells up to 450 m deep since 2014 provides confidence as to the extractability of brine from the resource to this depth.

Additionally, BMR porosity data has been collected below 200 m depth. Future drilling below 200 m provides the opportunity to upgrade Indicated Resources to Measured status.

Inferred Mineral Resources

An ‘Inferred Mineral Resource’ is that part of a Mineral Resource for which quantity and grade (or quality) are estimated on the basis of limited geological evidence and sampling. Geological evidence is sufficient to imply but not verify geological and grade (or quality) continuity. It is based on exploration, sampling and testing information gathered through appropriate techniques from locations such as outcrops, trenches, pits, workings and drill holes.

An Inferred Mineral Resource has a lower level of confidence than that applying to an Indicated Mineral Resource and must not be converted to an Ore Reserve. It is reasonably expected that the majority of Inferred Mineral Resources could be upgraded to Indicated Mineral Resources with continued exploration.

The Inferred Mineral Resource is defined between 350 m and the base of the basin, in the north of the salar and below 450 m in the centre and south of the basin. The base of the basin is defined by the gravity geophysical survey, and is generally deeper than 650 m. There are currently 11 production wells installed below 350 m, with production wells for the Olaroz Expansion Project installed between 400 and 650 m deep between the existing northern and southern wellfields. The deep hole drilled in the north of the salar confirms locally the salar sediments extend to below 1400 m depth. Drilling has not intersected the base of the salar sediments, where the geophysical estimated basement depth has been reached, suggesting the basin may be deeper than estimated from the gravity survey.

Taking account of the distribution of brine grade and porosity to date (as determined by BMR geophysics) there is a sufficient level of confidence to classify the resources extending to the bottom of the basin as Inferred Resources. It is likely that additional drilling could convert these to a higher confidence resource classification.

Reasonable Prospects For Eventual Economic Extraction

There are ‘reasonable prospects for eventual economic extraction’ as extraction activities over a period of more than seven years from the central and southern areas of the salar have resulted in a successful brine extraction operation, with continued lithium processing, production and sales of lithium carbonate product.

14.9 Resource Estimate

The resource estimate is outlined in the following tables presenting the lithium and lithium carbonate tonnages. The resource is broken out by property ownership with the bulk of the resource within the Allkem Sales de Jujuy joint venture. Allkem holds additional 100% owned properties, through Olaroz Lithium, in the north of Olaroz. In the SdJ and Olaroz Lithium properties to the North and south of the Olaroz salar, outside the salar boundary, there are likely to be significant additional volumes of brine that have not yet been explored and quantified.

The resources are reported at a zero mg/L lithium cut-off as the entire Olaroz salar contains brine with an elevated lithium concentration, which based on drilling to date is above the likely minimum concentration for processing of brine. The grade-tonnage distribution of resources is shown in Figure 14.5. Block model grade and porosity data is shown in Figures 14.6, 14.7 and 14.8. Figures 14.9 to 14.11 show the block model with different characteristics. Table 14.7 outlines the resource, with an average of the different property holdings showing an average Measured resource (0-200 m) of 648 mg/L (over the SdJ and Olaroz Lithium properties); an average Indicated resource of 657 mg/L (over the 200-350 m interval in the north and the 200-450 m interval in the central and south over the SdJ and Olaroz Lithium properties) and an average inferred resource of 663 mg/L to the base of the basin, below the Indicated Resource to 450 or 350 m depth.

Classification	Area km^2	Thickness m	Sediments Million m^3	Mean Specific Yield Porosity %	Brine Million m^3	Li mg/L	Tonnes Li	Tonnes LCE
Allkem SdJ JV								
Measured 0-200 m	103.2	200	20,452	6.5%	1,338	646	864,000	4,600,000
Indicated 200-450 m	79.8	250	19,117	5.7%	1,095	667	730,000	3,890,000
Indicated 200-350 m	23.4	150	3,273	4.8%	157	560	88,000	470,000
M&I	103.2	350/450	42,842	6.0%	2,590	650	**1,682,000**	**8,960,000**
Inferred total > 350/450 m	103.2	Variable	29,656	5.3%	1,570	654	**1,030,000**	**5,470,000**
Olaroz Lithium (Allkem 100%)								
Measured 0-200 m	9.6	200	1,913	7.7%	148	673	100,000	530,000
Indicated 200-450 m	6.7	250	723	4.2%	30	830	25,000	130,000
Indicated 200-350 m	2.9	150	925	4.1%	38	631	24,000	130,000
M&I	9.6	350/450	3,562	6.1%	216	687	**149,000**	**790,000**
Inferred total > 350/450 m	9.6	Variable	6,267	4.0%	249	718	**180,000**	**950,000**
M&I TOTAL	112.8						1,831,000	**9,750,000**
Inferred TOTAL	112.8						1,210,000	**6,420,000**
GRAND TOTAL	112.8						3,041,000	**16,170,000**

Table 14.7: Updated interim resource estimate of contained lithium by property and classification

- CIM definitions were followed for mineral resources.
- The Qualified Person for this Mineral Resource estimate is Murray Brooker, MAIG, MAIH.
- No internal cut-off concentration has been applied to the resource estimate, as the estimate is limited to the salar.
- Numbers may not add due to rounding
- Lithium converted to lithium carbonate (Li2CO3) with a conversion factor of 5.32.

This 2022 Interim Resource update supersedes the 2011 Resource completed as part of the Olaroz Feasibility study resource. This 2022 Interim Resource Update does not discount production to date from within the resource.

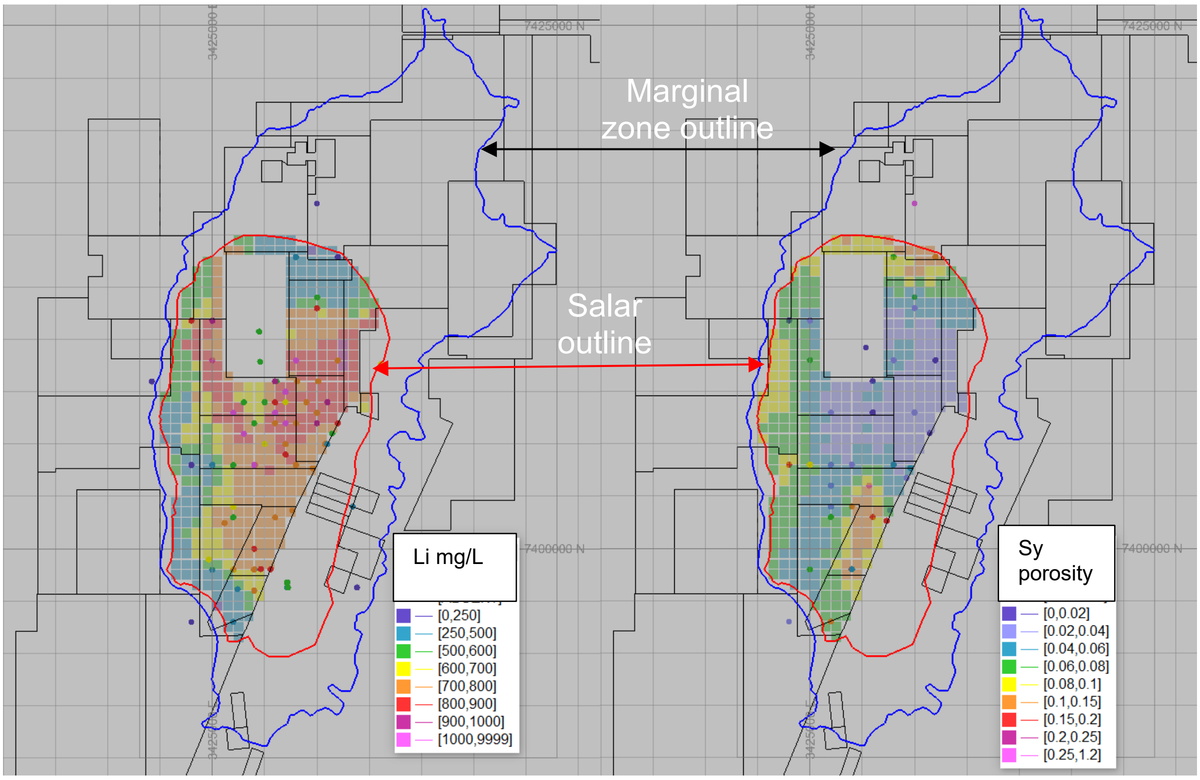


Figure 14.6: Lithium grades (mg/L) and drainable porosity (Sy) at surface at Olaroz

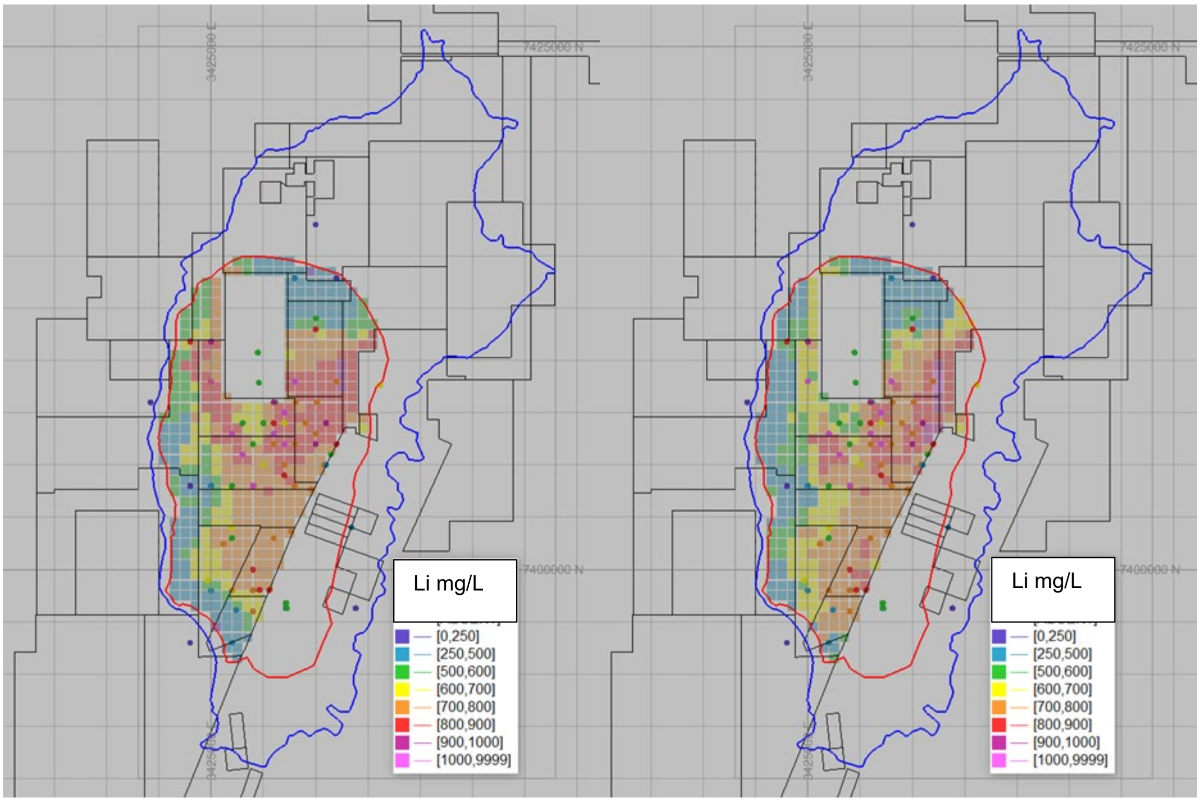


Figure 14.7: Lithium grades (mg/L) at surface (left) and 100 below surface (right)

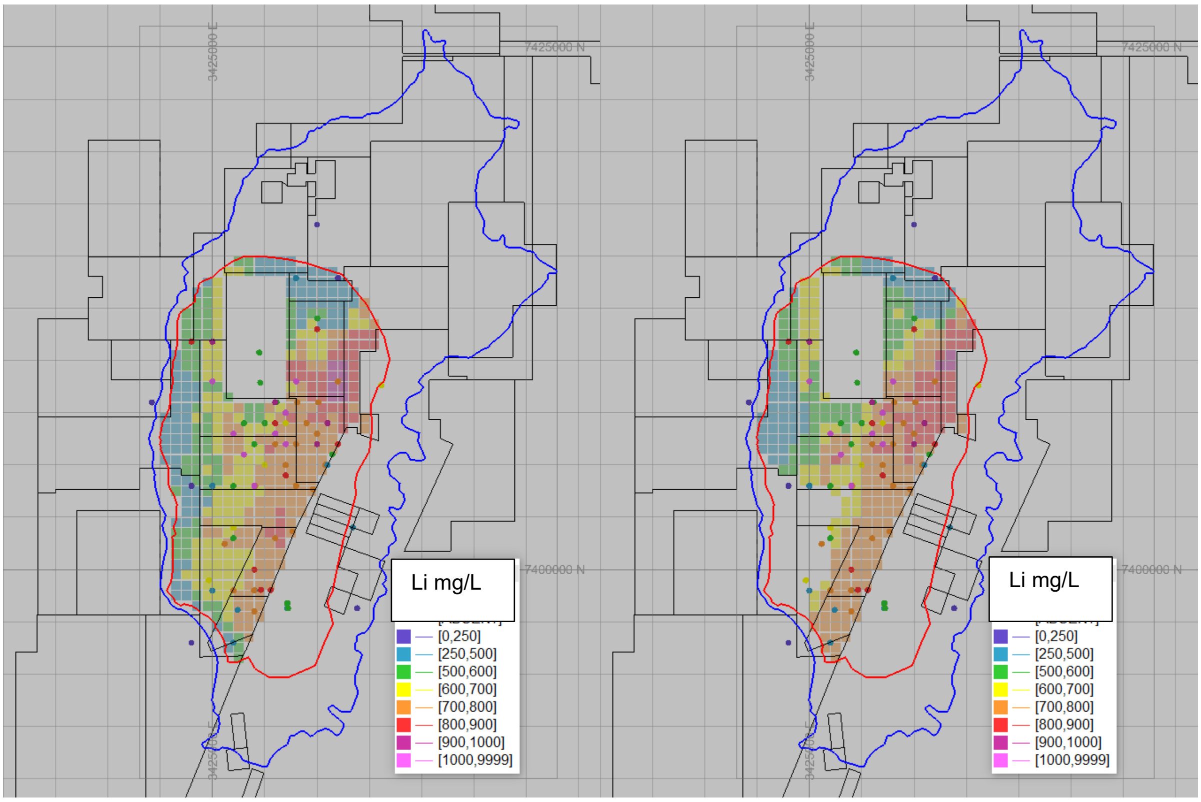


Figure 14.8: Lithium grades (mg/L) at 275 m and 500 m below surface. Note in the SW the basement contact was interpreted by geophysics to be above 500 m, with drilling confirming this is not the case (and hence underestimating the resource in this area – where no resource is defined)

14.10 Further Exploration Potential

The resource is open both laterally to the north and south. Further, the gravity survey, which has been used to define the base of the salar may underestimate the thickness of the salar sediments. One deep hole has been drilled to 1,408m slightly north of the current production wells but to date no drilling in the Olaroz basin has yet intersected the basement bedrock. Gravity surveys also support a model of large areas of similar depths in this part of the basin.

Laterally, the resource area is defined by the salar surface and property boundaries. Previous limited drilling and geophysical surveys indicate the brine body extends south beneath the Archibarca fan to Cauchari (where drilling by Allkem subsidiary Advantage Lithium defined 4.6 Mt of M&I Resources and 1.5 Mt of Inferred resources in 2019). Geophysical surveys conducted by Allkem also suggest the lithium brine body continues north of the resource under the Rio Rosario delta and surrounding alluvial fans.

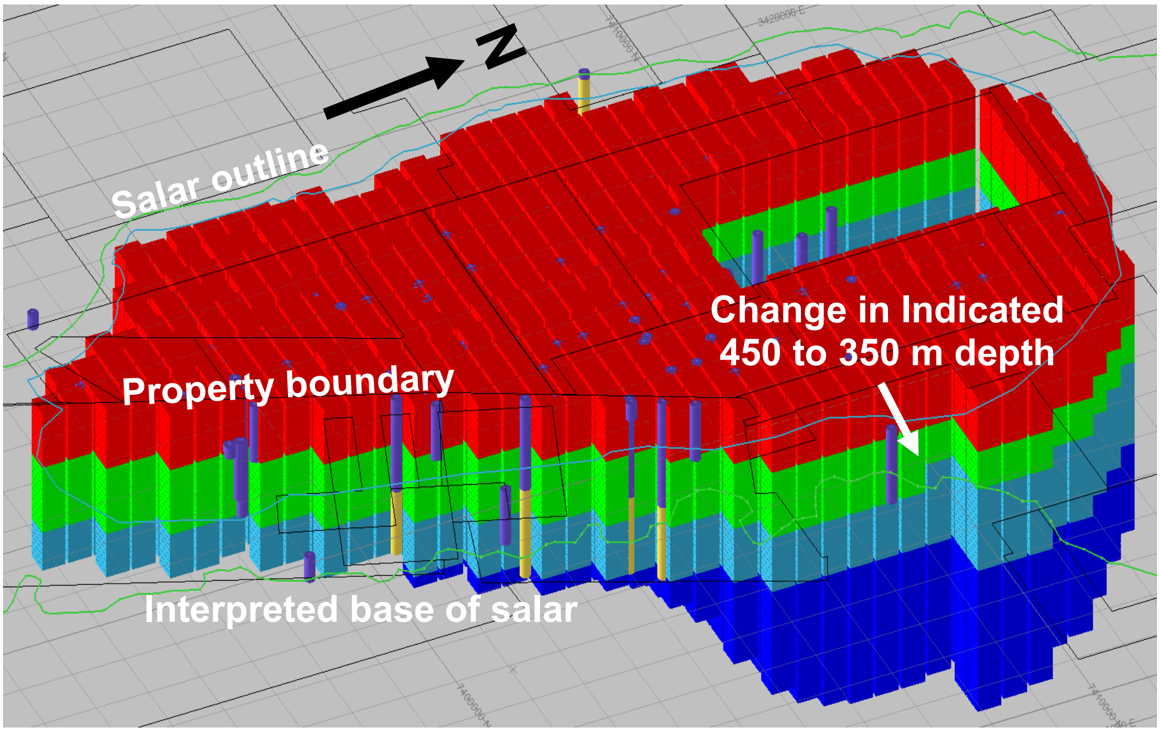


Figure 14.9: Resource classification, with Measured resources to 200 m (red) overlying Indicated Resources to 450 m (south and central) and 350 m (north) in green, underlain by Inferred resources in cyan to 650 m and Inferred resources below 650 m (blue). Block model restricted to the salar. Drill holes shown.

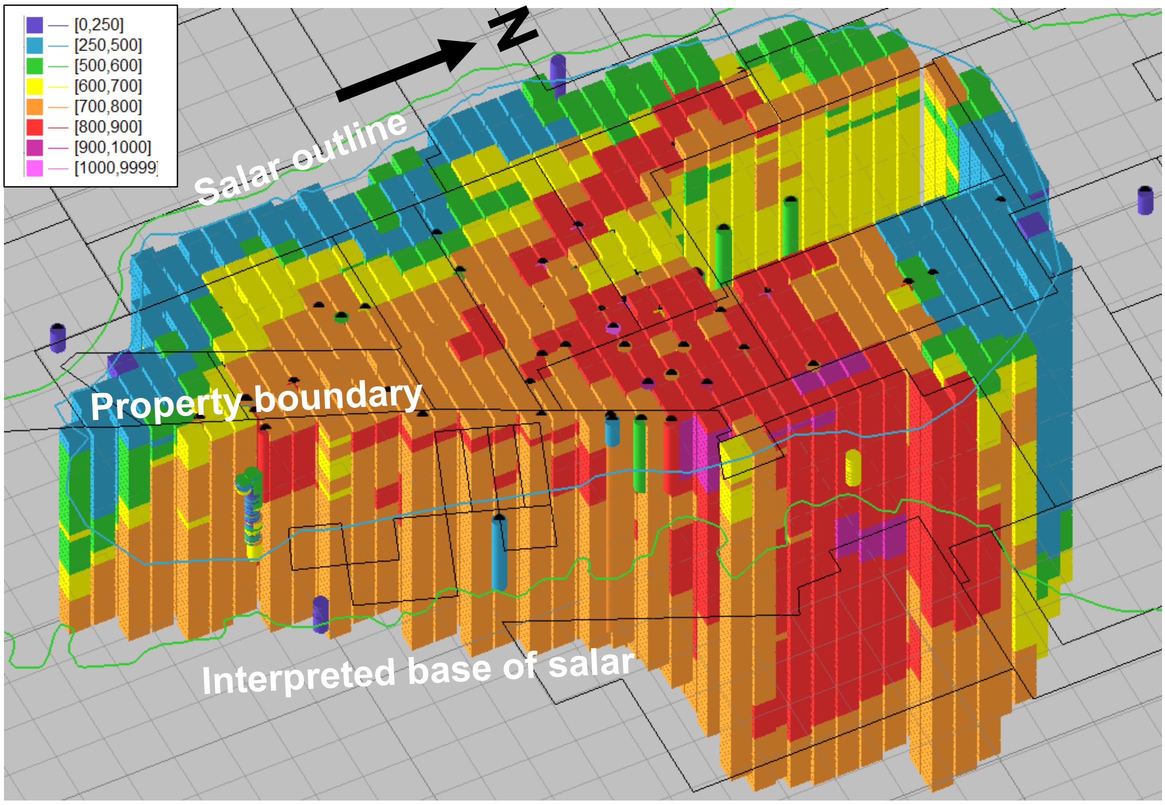


Figure 14.10: Cut away block model, showing lithium grades in mg/L

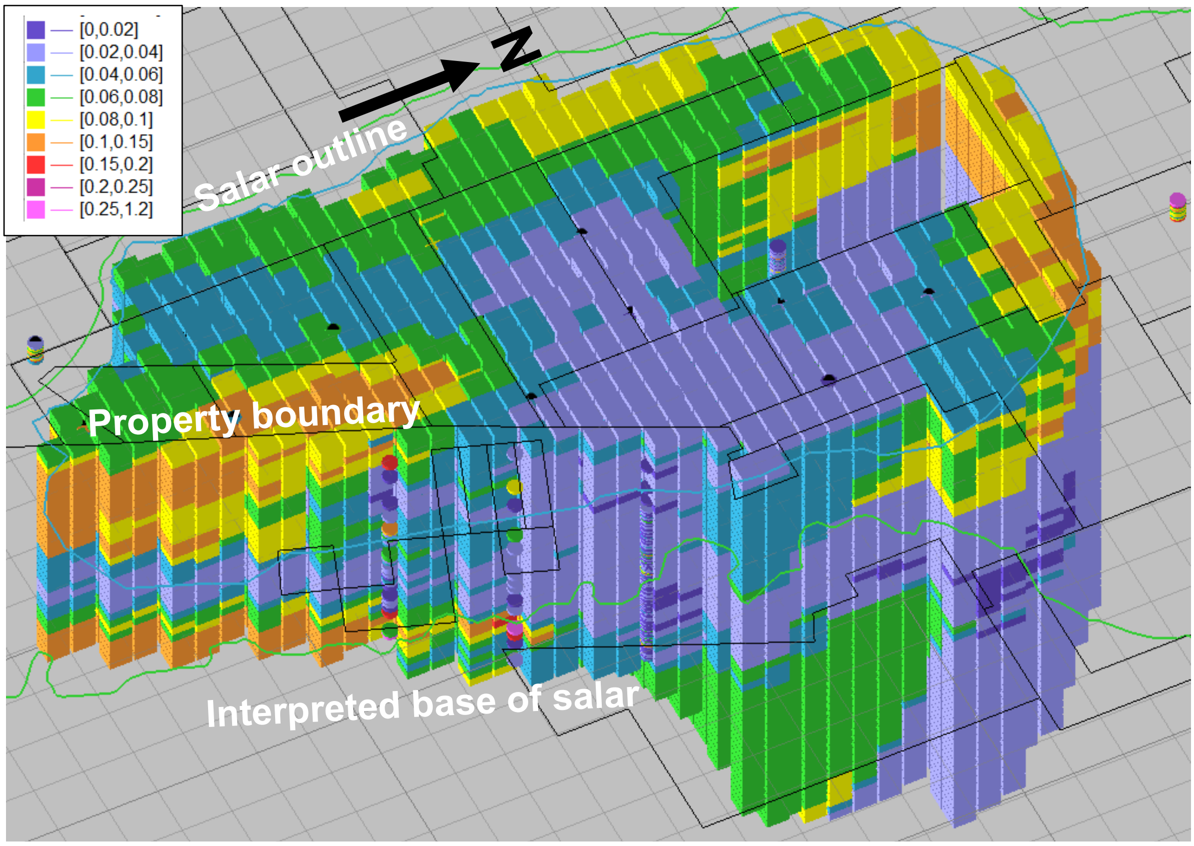


Figure 14.11: Cut away block model, showing specific yield values. Note the higher specific yields towards the north of the basin, around the western and southern margins and at depth

15 MINERAL RESERVE ESTIMATES

No reserve has yet been defined for the Olaroz Project. An updated groundwater model has been developed for the Olaroz Project with the results of drilling to date and this will be used to develop a maiden reserve for the Olaroz Project once the expansion drilling program is complete.

16 MINING METHODS

Lithium bearing brine hosted in pore spaces within sediments in the salar will be extracted by pumping using a series of production wells to pump brine to evaporation ponds for concentration of the brine. The Olaroz Project currently produces brine from two wellfields with wells installed to 200 m depth, with a number of other production wells installed to 350 and 450 metres deep.

Installation of wells for the expansion of the Olaroz Project is currently underway, with a total of 15 production wells planned between depths of 450 and 650 metres, depending on the location in the salar. The expansion wells will fill in the space between the existing northern and southern wellfields in the centre of the salar. Wells consist of stainless steel screen sections and carbon steel casing sections, designed based on geological and geophysical logging to maximise inflow into the wells. Pumps are individually selected for each well, depending on the performance of the well during the variable rate (step) and constant rate tests.

Pipelines for individual wells transport the brine to transfer ponds, from where brine is pumped by high flow pumps through larger pipelines to the evaporation ponds. Overhead electrical power is supplied to each well site to power the submersible pump and controller. The wells are located on elevated platforms, that are connected by elevated roads to the edge of the salar. This ensures that wells operate even when periodic seasonal flooding of the salar takes place in some wet seasons. The ponds for the expansion Olaroz Project are located directly south of the plant and stage 1 ponds on the lower slopes of the Archibarca alluvial fan. The distribution of the operational and planned wells is shown in Figure 16.1.

Wells will be operated 24 hours a day, throughout the year, using submersible pumps with scheduled maintenance periods for wells, allowing wells to be taken out of service periodically for cleaning. The pumping regime for wells is seasonal, with greater pumping during the warmer months of the year, which have higher evaporation and lower pumping rates during the low evaporation winter months. Wells are expected to produce at average flow rates of greater than 15 litres/second, with pumping tests of up to 60 l/s in some wells to date.

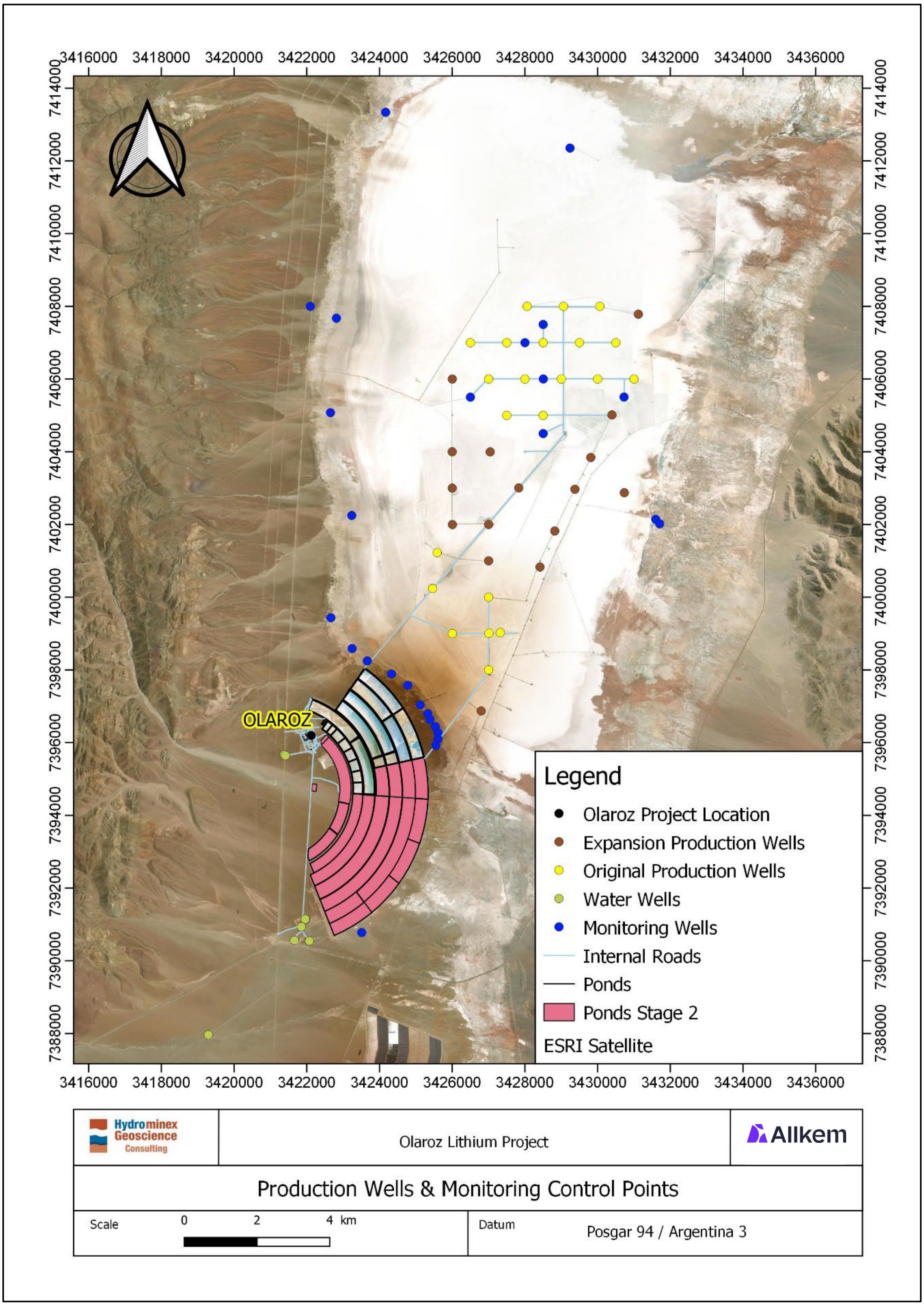


Figure 16.1: Planned expansion production wells in brown, existing wells in yellow

17 RECOVERY METHODS

17.1 Olaroz Process Description

The Olaroz process is illustrated in summary flow sheet form in Figure 17.2. In general terms the process relies upon:

1. Removal of the bulk of the magnesium content by slaked lime addition to the brine;
2. Increasing the Li concentration by evaporation, removing many different salts along the evaporation path by crystallisation;
3. Polishing of the upgraded brine by removal of calcium and magnesium at an intermediate temperature and carbonate concentration; and
4. Precipitation of the lithium carbonate product using high temperature and high carbonate additions.

Wellfields

Each of the northern and southern wellfields distributed over the properties on the salar delivers brine from 200 m or >200m depth into intermediate tanks, which are constructed as deep, compact plastic lined ponds. The brine is pumped from the north and south tanks [with several wells close to the pond area pumping directly] to the liming plant reactors. The total flow for Stage 1 is ~240 L/s at a grade ranging from 650 – 700 mg/L Li.

The brine is rapidly sodium chloride saturated by evaporation with a composition that is primarily sodium chloride and sodium sulphate with smaller concentrations of magnesium chloride, potassium chloride, lithium chloride and sodium borate

Lime Addition

Burnt lime [CaO] is delivered from the Los Tillianes plant at Vulcan, Jujuy, to the Olaroz site by tanker truck which pneumatically discharges burnt lime into silos. The burnt lime is slaked with raw water in a small grinding circuit and the slaked lime stored in an ageing tank. From the ageing tank the slurry is added to the brine in twin reactors in series where magnesium hydroxide and calcium sulphate are rapidly precipitated. Control of calcium [Ca] and magnesium [Mg] concentrations in the brine is critical to the recovery of a quality lithium product as they will co-precipitate.

The precipitates are contained within the first evaporation pond for later reclamation and disposal.

Pond Sequence

The reactors discharge to the first of the eight [8] halite ponds, the brine is transferred by pumping from pond to pond. The ponds (Figure 17.1) are baffled to minimise short circuiting and brine levels are maintained to optimise evaporation rates on a seasonal basis. An extensive chemical and physical data set is collected, and pond performance monitored against a mathematical model. A sequence of salts, primarily halite, Glauber salt [hydrated sodium sulphate] and some complex permutations of the simpler salts, are crystallised according to the change in solubility induced by evaporation. The bulk of the potassium and sodium [K, Na] salts are crystallised out by evaporation as their chloride salts early in the evaporation process and as their sulphate salts later in the evaporation process. The boron is precipitated by the relatively high pH (9 - 11) as tetra-borate [Na2B4O7 and CaB4O7]. This may be enhanced by addition of calcium chloride.

The halite ponds flow into a series of smaller concentration ponds, originally designed to enable recovery of sylvinite salt, a mix of sylvite [KCl] and halite [NaCl]. The flotation separation of sylvite was tested early in the Olaroz Project but has never been economically feasible. At the end of the halite ponds a secondary lime addition is used to control the final magnesium level of the plant feed brine in two [2] intermediate ponds. The brine then flows through the eight [8] pond concentration system to a pair of tanks designed to minimise halite solids, and control plant feed flow.

The volume of plant feed is typically one tenth of the original brine volume with a corresponding increase in Li concentration. This varies seasonally, as does the concentration of the various salts.

Carbonation Plant

The brine feed to the plant is saturated with NaCl, is well below saturation of KCl, and grades 6000 – 8000 mg/L Li depending on the seasonal impact on evaporation rate. The residual calcium in the brine is precipitated with the carbonate from the mother liquor recycle, and trace magnesium as hydroxide is precipitated in the polishing stage at 40 - 45^{o}C. This heating is mainly achieved by recovery from the carbonation reaction mother liquor. The precipitated solids are removed by centrifuge and specialised solution filters.

Flocculant is used to improve the removal of the magnesium hydroxide in the centrifuges and filters. This is the first point of lithium loss as carbonate, with temperature minimised to control the loss. Some gypsum is formed.

$Na_2CO_3 + H_2O \rightarrow HCO_3- + 2NaOH$

$MgCl_2 + CaCl_2 + xNaOH + HCO_3- \rightarrow Mg(OH)_2 + CaCO_3 + xNaCl$

The brine from polishing is heated indirectly with steam to ~85^{o}C, and 28% strength soda ash added to precipitate the lithium as carbonate, which typically grades 99.3% Li2CO3. A small quantity of the boron, sulphates and remaining magnesium are co-precipitated, with some entrapment of sulphates and chlorides in the lithium carbonate crystal and some gypsum. These are the main solids contaminants and the lithium carbonate grades in excess of 99.3%.

Magnetic filters installed in various streams around the plant control iron contamination which has occurred in part due to corroded components, dust ingress and equipment wear.

The plant has a sulphuric acid washing system to break down accretions in tanks and pipework.

Impurities are primarily present as:

- Trace soluble species [chlorides and sulphates] in the washed product cake moisture; and
- Precipitated solids, generally as Ca [some Mg and Sr] salts of borate, sulphate, phosphate and carbonate, which are formed at the higher temperatures and pH in the carbonation reactors.

The underflow of the settler reactors is firstly dewatered to remove mother liquor, then the cake is water washed and dewatered. Both stages are conducted on a single belt filter and the solid filter cake conveyed to the drying plant. The reactor overflow solution and strong filtrate that are not re-used are returned to the ponds, and the weak filtrate from cake washing is used to mix soda ash.

Purification

A proportion of the primary technical grade lithium carbonate is purified to meet battery grade specification. The primary lithium carbonate is reacted with dissolved carbon dioxide at 5°C in absorption reactors to form soluble bicarbonate which enables the removal by filtration of any insoluble solid impurities. Both liquid and gaseous CO2 is utilised and injected at various points in the absorber feed and into the reactors.

$CO_2 + Li_2CO_3 + H_2O \rightarrow 2LiHCO3$

The solution is further purified by removal of the trace Mg, Ca and B in solution by Ion Exchange [IX]. This solution is then heated to 85 – 90°C to re-precipitate Li2CO3, releasing CO2 which is partly recovered and recycled to the absorbers.

The Li2CO3 is separated by cycloning, with cyclone underflow filtered and washed with pure water before being dried and bagged. The cyclone overflow feeds a thickener, from which any settled solids are fed to the product filter.

The strong filtrate and the weak filtrate from the filter cake wash is either recycled to absorption feed as mother water, or used for mixing soda ash, or recycled to the primary reactors depending on process control requirements.

The crystalliser performance achieves the reaction equilibrium levels [dictated by temperature and carbonate concentration] of 2500 – 3500 mg/L of Li as Li2CO3. This causes some losses of Li2CO3 in terms of strong filtrate directed back to the primary carbonation circuit, due to dilution of reactor solution volume.

Drying and Packaging

The lithium carbonate filter cake at ~35% moisture is de-agglomerated and dried to ~0.5% moisture in a gas fired spray drier, and the dried solids are micronized if required by the customer. The dried product is bagged in 1 tonne lots, with extensive quality control sampling and analysis.

Process Controls

A control room remotely monitors the process via a standard SCADA system. This enables remote stop-start, manipulation of variable speed drives on pumps, and contains several P&ID loops, primarily for soda ash addition. Solution filters and the ion exchange system have proprietary PLC controls.

Process Facilities

Soda ash is trucked to site after transferring it to bags from a bulk warehouse in Antofagasta. The bags are stored in a special purpose warehouse at Olaroz from where it is batch mixed by bag breaking over a conveyor feed bin and transfer to the mix tank. This tank is temperature controlled and the batch mix is then transferred to the soda ash dosing tank.

Carbon dioxide is trucked in and transferred into cryogenic bullets on site from where it is distributed via a proprietary regulating system.

Sulphuric acid for process cleaning and hydrochloric acid for ion exchange resin stripping is trucked to site from Chile and stored in special purpose tanks.

Compressed air at appropriate pressure and quality for tools, instruments and valve actuation is provided by duty and standby compressors and an air drier.

Raw water is pumped from five wells in the Archibarca alluvial fan around 3 km to the plant site. This is processed in three reverse osmosis plants to provide clean water mainly for product washing and reagent mixing.

A laboratory for operating control data and QAQC analysis was constructed and is operated with technical links to Japanese and Chilean laboratories that also work with light elements. The facility includes a chemical warehouse and weather station.

Stage 2 and Naraha Supply

The increase in the Olaroz Project brine resource has encouraged planning for a series of production expansions. Stage 2, now nearing completion, builds organically upon the Stage 1 facilities at Olaroz.

A Stage 3 expansion concept will be considered based upon both the acquisition of resources to the SDJ portfolio, the Cauchari resource, further exploration potential for development of new resources, and exploiting some of the emerging higher efficiency technologies.

An additional twenty-two [22] evaporation ponds and eight [8] concentration ponds are completing construction, some of which are in operation at the date of this document. These ponds are for the Stage 2 expansion of the plant which will add 25,000 tonnes lithium carbonate [LCE] annually to the current Stage 1 LCE production.

Allkem 75% and TTC 25% have constructed a plant in Japan to convert lithium carbonate [Li_2CO_3] to lithium hydroxide monohydrate [$LiOH.H_2O$]. This is achieved by reacting LCE with lime [$Ca(OH)_2$], resulting in the formation of LiOH in solutionThe solution is purified by ion exchange, concentrated by evaporation and then crystallised as the monohydrate and dried. The reaction also generates solid calcium carbonate [$CaCO_3$] which is converted back to lime in a kiln and slaking plant.

Stage 2 will supply 9500 tpa LCE for 10,000 tpa lithium hydroxide production.

Stage 2 Plant Design

Stage 2 expansion has been designed primarily based on the experience gained from 5 years of operating development and data analysis from the Stage 1 plant. Some equipment specific testing was also conducted, mostly the new solid liquid separation steps in the polishing area.

The brine wells drilled for the expansion are deeper and better equipped than Stage 1, using a more advanced geophysical profiling strategy and screening technology to optimise flow. They are generally located between the existing northern and southern wellfields. It is anticipated that with the planned 15 new wells a total flow for Stages 1 and 2 of up to 654 L/sec can be sustained at a minimum Li concentration of 650 mg/L. This has been supported by testing of some of the new wells as they became available since early 2020.

The pond design for stage 2 [pond numbers 15 and up shown below] uses flat bottoms to enable salt harvesting and improved control. These ponds are dimensioned to have overall a greater area ratio to brine feed flow than the stage 1 design.

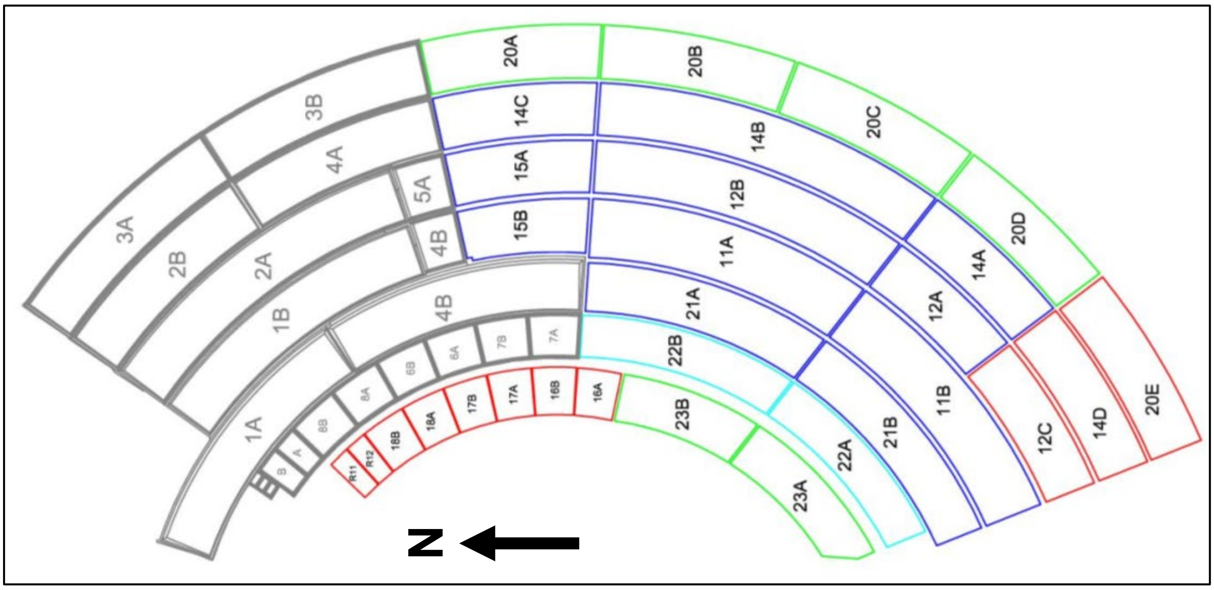


Figure 17.1: Current and expansion pond layout, with the ponds developed on the Archibarca alluvium

The expansion plant is similar in its general process flowsheet and chemistry to the Stage 1 plant, however it has been designed to provide higher quality product and improved recovery.

This is achieved by:

- Washing of solid precipitates in the polishing circuit to minimise Li loss;
- Inclusion of improved ultra-fine filtration technology in the polishing circuit will contribute to product quality;
- Removal of trace Ca and Mg by ion exchange [IX] processing of carbonation reactor feed will contribute to product quality and an anticipated improvement from technical to battery grade;
- Improved control of washing and filtration of final product by the use of air blown plate and frame filters, also contributing to improved quality by minimising entrained impurities in the cake moisture; and
- Improved process control by enhanced instrumentation and increased process buffer storage.

A new soda ash bag storage area and mixing plant with the capability to convert to bulk delivery has been designed.

Additional raw water wells in the Archibarca alluvial field and downstream reverse osmosis plant capacity is provided to meet the increased clean water requirements. Extended water supply rights have been obtained in the northern Rosario river alluvial sediments.

The required increase in power generating capacity is provided by expansion of the stage 1 gas fired generators and additional boiler capacity for solution heating.

A gas fired rotary drying kiln has been used in the expansion drying plant, along with additional micronising capacity.

Olaroz Project Infrastructure

The Olaroz site is managed on a drive-in drive-out basis, with personnel coming from most of the regional centres, primarily Salta and San Salvador de Jujuy. A substantial camp is maintained which undergoes continuous upgrading, including a mess that provides three meals per day and a clinic manned by nurses and a doctor. The Olaroz site is supported with accounting, logistics, HR and supply functions based in an office in Jujuy.

The senior personnel work in an office complex that has been incrementally expanded, and more recently office facilities for the maintenance contractors and the Stage 2 expansion contractors have been constructed.

Access to the site is via highways 9 and 52 from Jujuy, with secondary connections at Salar Grande or Cauchari to Salta via San Antonio de los Cobres. The highway enters Chile via the Paso de Jama and continues as route 27 in Chile to San Pedro de Atacama, Calama and to Antofagasta.

A gas spur line from the north [off the Norte Andino Gasoducto at Tres Cruces] provides all the site energy requirements other than diesel for mobile equipment.

The electrical power for the site is generated on a contract basis in a Secco gas fired generator plant. The gas is also used for drying product and, via boilers, steam heating process solutions as required.

Water supply is from a 5 hole wellfield in the north of the Archibarca alluvial sediments. This is pumped to the plant for process use and purification by three reverse osmosis plants into clean water for product washing and ablutions requirements. Potable water is transported from Jujuy by truck. A new water supply wellfield is being established in the Rosario Delta area north of the salar, to provide greater long term water supply and security.

Warehousing and laydown areas contain a well-maintained inventory of spare parts.

Communications are via satellite with good bandwidth internet and mobile phone coverage. Mobile UHF radios are carried by almost all personnel.

Workshops are capable of all basic electrical and mechanical maintenance functions. More complex machines such as centrifuges are maintained on a rotating basis off site. A number of maintenance and construction contractors have their own facilities on site.

Site access is controlled by a checkpoint and truck weigh station, with regular radio and mobile phone checks on vehicles in transit.

The fuel supply system includes fuel tanks and a vehicle refuelling station.

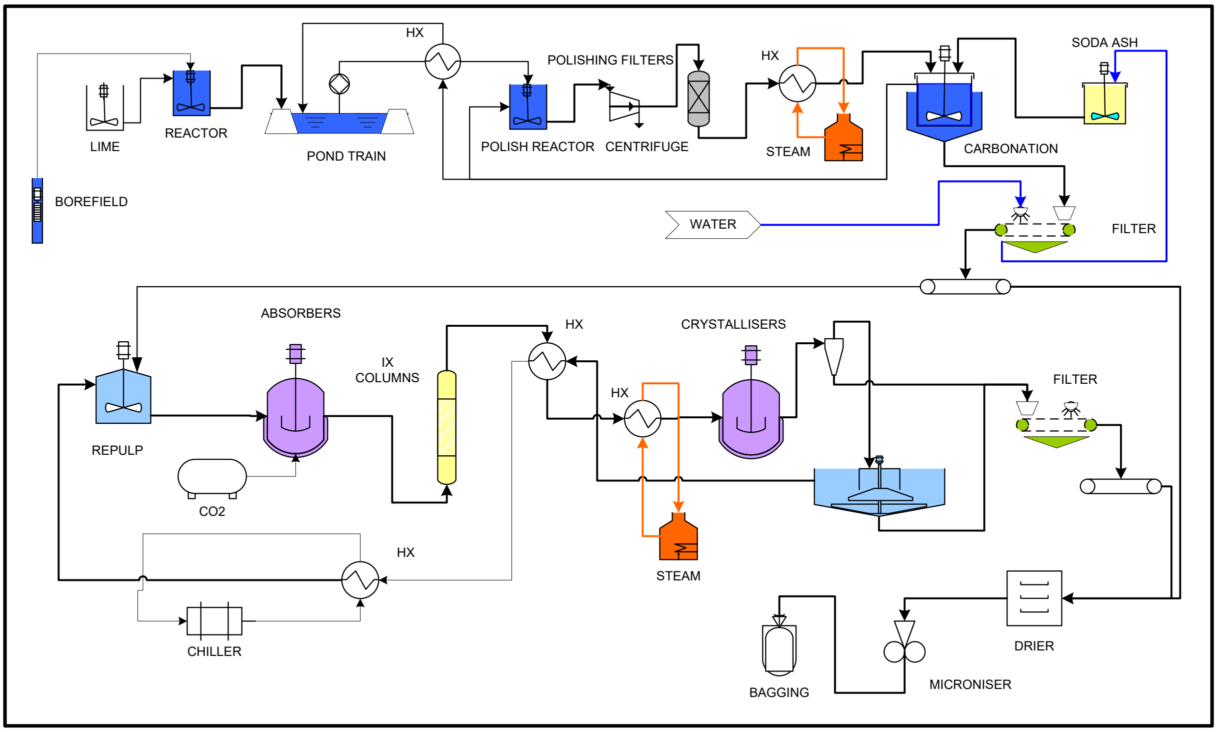


Figure 17.2: Summary Olaroz flow sheet

18 OLAROZ PROJECT INFRASTRUCTURE

18.1 Olaroz Project Access

The Olaroz Project is located in the Puna area of northwest Argentina, within the province of Jujuy (Figure 18.1). The main road access to the Olaroz Project is from the city of San Salvador de Jujuy, along the Ruta Nacional (RN) 9, which heads north-northwest for approximately 60 km, and then meets RN 52 below the town of Purmamarca.

Following Route 52 for 50 km leads to the eastern side of the Salinas Grandes salar. The road crosses this salar before ascending further and after the town of Susques continues south along the eastern margin of the Olaroz salar. It then crosses west where the Olaroz and Cauchari salars meet. Total distance between the city of Jujuy and the Olaroz Project area is approximately 180 km, approximately 4 hours driving. This good quality paved road continues on to the Chilean border at the Jama Pass, and connects to the major mining center of Calama and the ports of Antofagasta and Mejillones in northern Chile. Driving distance to these ports is approximately 500 km and 570 km, respectively. This road is fully paved, from Jujuy to these Chilean ports. The Olaroz process plant and facilities are located north of Route 52, with the access to the Olaroz Project via a gravel road north along the western side of the Olaroz salar.

The Olaroz Project may also be accessed from the provincial capital of Salta by driving 27 km WSW from Salta to Campo Quijano, then continuing north for approximately 120 km along Route 51, through Quebrada del Toro, to the town of San Antonio de los Cobres, at an altitude of 3,750 masl. This route is paved, with the exception of the lower section through Quebrada del Toro and the upper section leading to San Antonio. From San Antonio de los Cobres, Route 51 leads west to the south of the Cauchari salar, with route RP 70 providing access along the western side of the Cauchari salar to reach the international road (RN 52). The distance from San Antonio to the Olaroz Project is approximately 140 km entirely on moderate to well-maintained gravel roads.

Both Jujuy and Salta have regular flights to and from Buenos Aires.

There are a number of local villages within 50 kilometers of the Olaroz Project site. These include the villages of Olaroz Chico, El Toro, Catua, and Sey. The regional administrative center of Susques (population around 2000 people) is one hour’s drive northeast of the Olaroz Project site.

18.2 Olaroz Project Facilities

The Olaroz Project is an established lithium brine evaporation and processing operation. The Olaroz Project has extensive infrastructure and facilities that are being supplemented for the expansion of the Olaroz Project wellfield, evaporation ponds and process plant. The general facilities are shown in Figure 18.2 and include:

- Olaroz Project camp with capacity for the Stage 1 Olaroz Project workforce, currently being expanded for the expansion;
- Construction accommodation;

- Evaporation ponds for Stage 1, currently being expanded to the south for the expansion;
- Liming Plant, with additional liming facilities under construction for the
- Northern and southern brine wellfields, being supplemented by installation of new wells between the existing wellfields;
- Freshwater production wells located southeast of the Olaroz Project area and reverse osmosis plant on site for high quality water production;
- Gas fuelled power generation plant;
- Boiler room for steam generation;
- Lithium processing plant, soda ash storage area, lithium carbonate bagging area and assorted storage areas for reagents and supplies;
- Laboratory, warehouses, refuelling and equipment workshop areas;
- Offices and control facilities;
- Dining rooms and sports and recreation facilities;
- Gate house, weighbridge, transport control and security facility

Wellfields

The original wellfields consist of 22 wells. The expansion Olaroz Project includes a Olaroz Projected addition of 15 wells to the production network in the centre of the salar. Brine will be pumped to the evaporation pond system via intermediate storage ponds where brine flow is consolidated. Wells have dedicated submersible pumps which are powered from aerial power lines. Temporary diesel generators will be used to power new wells before overhead power is installed.

Liming plant

The current liming plant adds lime to the brine in mixed reactors that discharge to the decantation pond in order to precipitate impurities such as magnesium and calcium salts. Additional liming facilities are under construction for Stage 2 expansion.

Decantation pond

The decantation pond retains solids that precipitate in the liming plant reactors.

Evaporation ponds

Evaporation ponds are constructed on the Archibarca alluvial fan, in a semi-circular arrangement, accommodating the curved and sloping topography and minimising required earth movements. These ponds were not originally designed for harvesting; however this will be changed in the medium term by formation of a flat bottom with compacted salt.

The ponds for the expansion are constructed with a flat bottom, in contrast to the original pond construction, and with a higher area to flow ratio. Brine is pumped to the ponds and concentrated by solar evaporation, with the brine transferred between ponds as it progressively becomes more concentrated. When the brine reaches the target concentration it is transferred to the plant via small holding ponds for processing to lithium carbonate.

The final sequence of smaller concentration ponds was designed for harvesting potash salts. This has never proven to be economic.

Pumping stations

Brine is transferred from one evaporation pond to the next through pumping stations. The original pump stations are centrifugal pumps and priming tanks installed on the berm between the ponds, whereas the expansion pumping is by pontoon mounted vertical shaft pumps. The pumps are all powered from an overhead electrical network, and include the facility for pump suction dilution water additions to help keep pipe lines clear of crystallised salt.

Internal roads

Berms constructed between ponds also serve as roads for truck circulation during pond harvesting, and transit for monitoring and maintenance activities. Some berms will be wider and constitute the main service roads for salt harvesting activities. A large network of access roads and platforms for the brine production wells in all the wellfields has been developed.

Lithium Carbonate Process Plant

The Olaroz Project has an operating lithium carbonate process plant built for the original Olaroz Project. A new primary production plant for the production expansion will be located close to the original plant – see Figure 18.2. Facilities associated with the plants include:

- Fuel plant, storage tanks and filling station;
- Storage, preparation and distribution of sulfuric acid, hydrochloric acid, flocculant and caustic soda;
- Compressors room;
- Boiler rooms;
- Water treatment plant [reverse osmosis] and water reticulation plant;
- Storage, preparation and distribution of soda ash;
- Lithium carbonate plant including,
    - Brine polishing by calcium and magnesium removal;
    - Carbonation to industrial/technical grade product;
    - Purification of industrial grade to battery grade product;
    - Product filtration;
    - Drying and micronizing;
    - Packaging;
    - Product storage; and
    - Control rooms inside the industrial buildings.

- Electrical MCC rooms;
- Access control checkpoint: the main entrance to the plant, including admission and control office, weighbridge and vehicle parking area;
- Administration buildings and facilities include the offices required for the plant´s administrative personnel and the various communications systems.

Quality Control Laboratory

The on-site laboratory provides chemical analysis for a large range of brine and solid samples, particle size analysis, moisture analysis and other services to ensure proper operation of the process.

Workshops

Maintenance services for mobile machinery, which will be mostly involved in personnel and consumables transportation, is conducted off site. The workshop facilities include storage areas, mechanical and electrical workshops, waste yards and sludge degreasing treatment.

Waste water treatment plant (WWTP)

This plant treats all sewage and waste water generated in restrooms, bathrooms and camp kitchens.

Industrial waste yards and warehouses are provided for waste separation, destruction and storage, according to its specifications (hazardous and non-hazardous), and a proportion is transported to an authorized disposal center.

Fire protection system

A fire protection system for the Olaroz Project includes industrial water storage tanks feeding the plant´s water network. This system also includes a pump system (electrical and diesel), able to maintain a constant pressure in the network, guaranteeing water supply.

The plant will be surrounded by a perimeter closure, which will be constructed with material obtained from the excavation of the area

Olaroz Project camp

The Olaroz Project's workers camp includes a range of facilities which will be interconnected with pedestrian and vehicular accesses. The main facilities in the camp are:

- Dormitories for the operation and expansion construction phase, with some of the dormitories for the construction being temporary. These bedrooms have a heating system, power supply, ventilation, sanitary installations, networks and fire detection and extinguishing systems.
- The dining room has heating and ventilation systems, as well as sanitary installations and fire detection and extinguishing systems according to existing legal requirements in Argentina.
- There are recreational areas for the personnel that include games and a fitness center.

- A medical clinic is situated inside the camp to provide health care for the personnel for construction and operations. This facility includes a reception room, first aid sector, restrooms, recovery rooms and medical personnel offices, resuscitation equipment and an ambulance.

Electrical supply

The existing operating Olaroz Project has a contractor operated modular gas fuelled electrical power generator complex which will be expanded for the Olaroz Project expansion. The power supply provides the power needs for brine extraction wells, evaporation pond brine transfers, liming plant, lithium carbonate plant and worker´s camp.

Drinking water

Drinking water for the Olaroz Project is obtained from the reverse osmosis [RO] plant and drinking water is also transported to site from nearby cities.

Industrial Water

Industrial or raw water is obtained from production wells installed in the Archibarca alluvial fan area to the south-southeast of the plant. Two new high yield wells have been installed in the Rosario Delta area in addition to the original 5 water wells in the Archibarca area to enable the construction of the expansion ponds and provide the additional process plant demand. This water is used for:

- Moistening of earthwork material for structural fills during construction of ponds and plant platforms (during the construction phase):
- Irrigation and dust control on work fronts during the construction phase;
- Water dilution for transfer pumps used to transfer brine from one pond to another; and
- Feeding the RO plants, and the lithium carbonate and liming plants.

The process plant requires industrial and pure water. Industrial water is used directly from the alluvial production wells, and pure water is obtained from the Reverse Osmosis water treatment plant located near the lithium carbonate plant.

Diesel fuel

Diesel fuel for the Olaroz Project is required for light vehicles, trucks, vans, buses, and heavy equipment required during construction and operations as well as for pond harvesting machinery and trucks when required. Diesel is stored in large double skinned storage tanks with associated dispensers. These will be filled by tanker trucks from the fuel supplier.

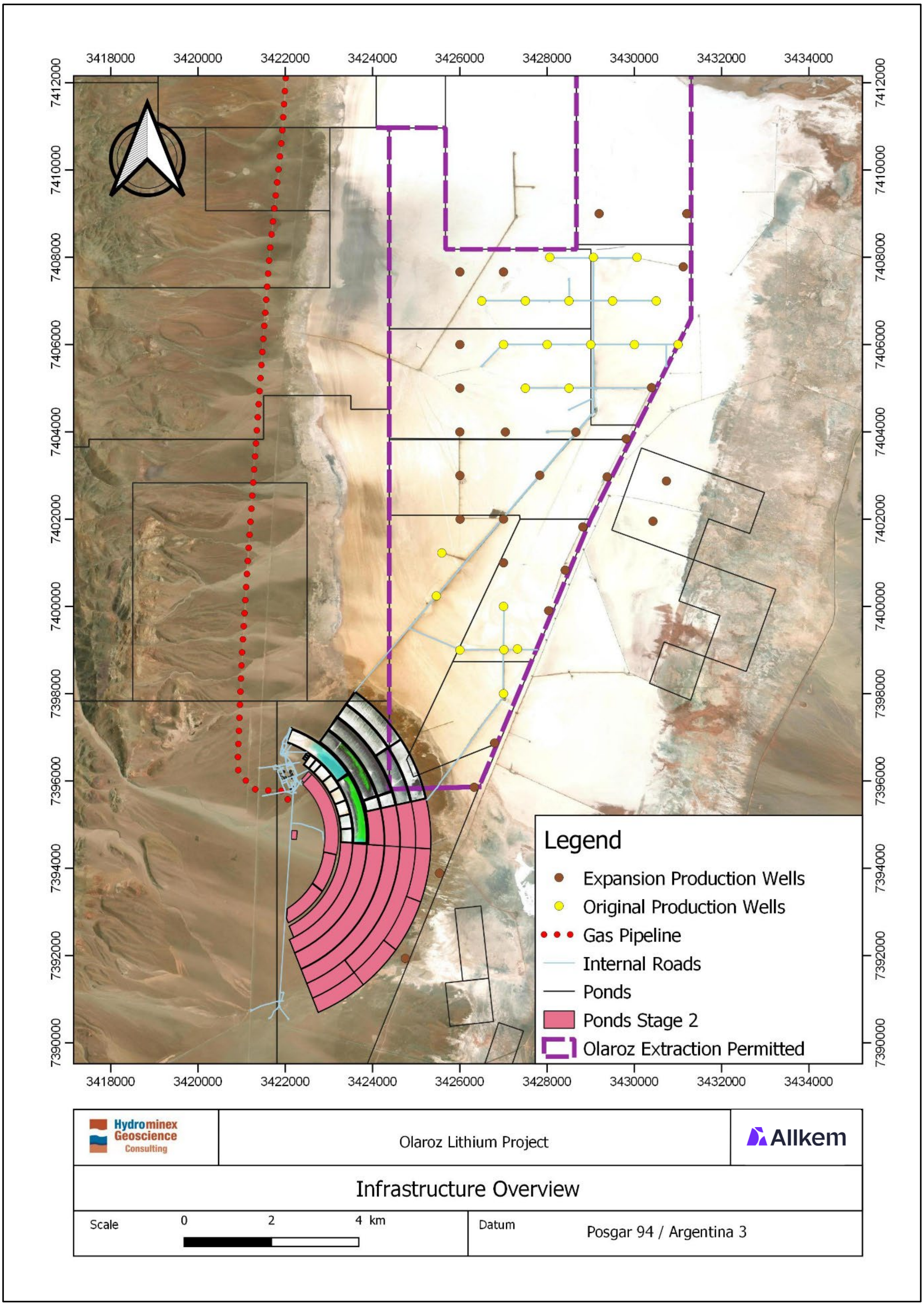


Figure 18.1: Olaroz site infrastructure. Overhead electricity follows roads

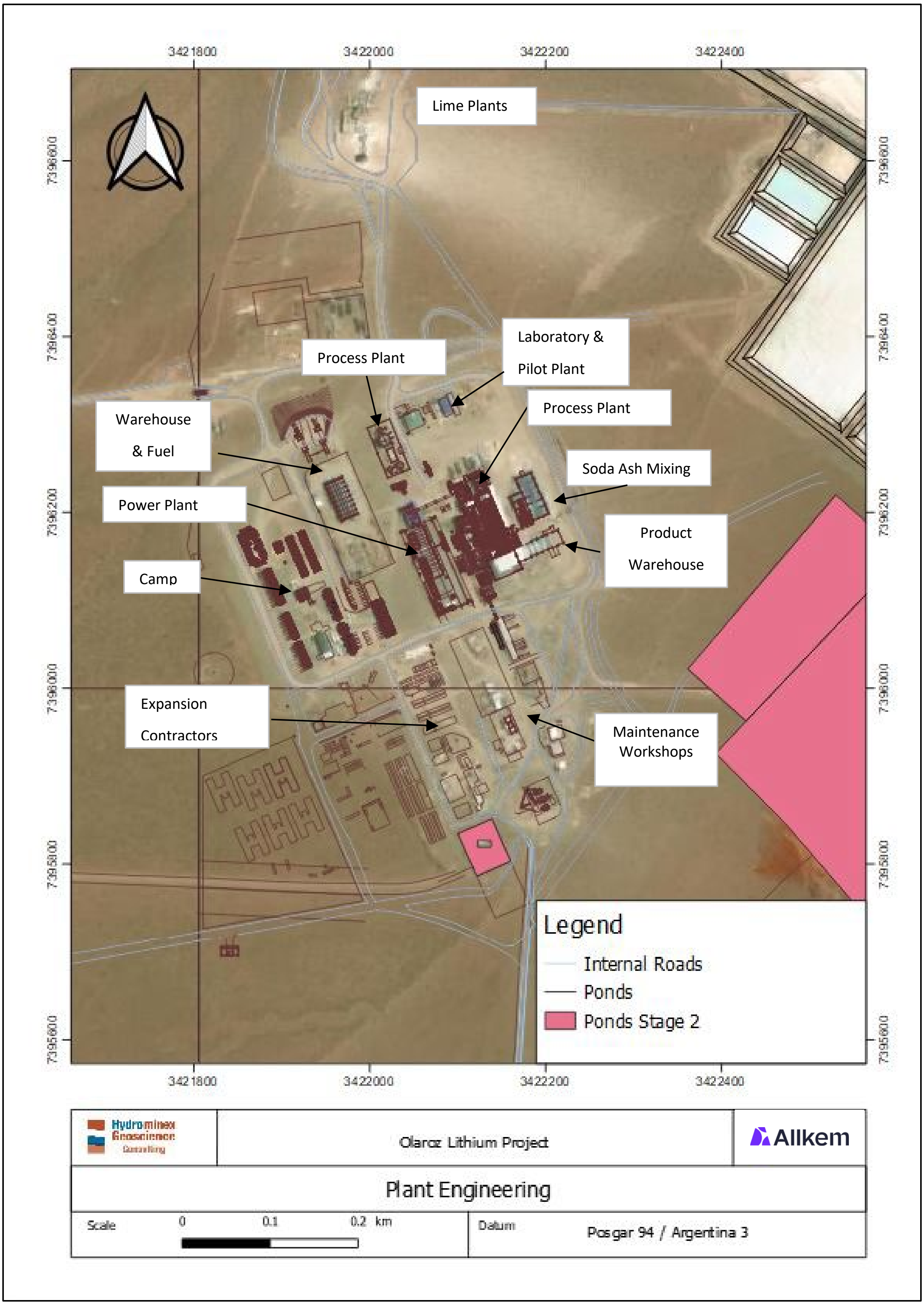


Figure 18.2: Detailed site infrastructure

19 MARKET STUDIES AND CONTRACTS

19.1 Overview of the lithium industry

Lithium is the lightest and least dense solid element in the periodic table with a standard atomic weight of 6.94. In its metallic form, lithium is a soft silvery-grey metal, with good heat and electric conductivity. Although being the least reactive of the alkali metals, lithium reacts readily with air, burning with a white flame at temperatures above 200oC and at room temperature forming a red-purple coating of lithium nitride. In water, metallic lithium reacts to form lithium hydroxide and hydrogen. As a result of its reactive properties, lithium does not occur naturally in its pure elemental metallic form, instead occurring within minerals and salts.

The crustal abundance of lithium is calculated to be 0.002% (20ppm), making it the 32nd most abundant crustal element. Typical values of lithium in the main rock types are 1-35ppm in igneous rocks, 8ppm in carbonate rocks and 70ppm in shales and clays. The concentration of lithium in seawater is significantly less than the crustal abundance, ranging between 0.14ppm and 0.25ppm.

Sources of lithium

There are five naturally occurring sources of lithium, of which the most developed are lithium pegmatites and continental lithium brines. Other sources of lithium include oilfield brines, geothermal brines and clays.

Lithium minerals

There are around 250 identified lithium bearing minerals, although many of these only contain minor amounts of lithium in their composition. The most common sources of mined lithium from mineral sources are:

- Spodumene [$LiAlSi2O6$] is the most commonly mined mineral for lithium, with historical and active deposits exploited in China, Australia, Brazil, the USA and Russia. The high lithium content of spodumene (8% $Li2O$) and well-defined extraction process, along with the fact that spodumene typically occurs in larger pegmatite deposits, makes it an important mineral in the lithium industry.
- Lepidolite [$K(Li,Al)_3(Si,Al)_4O_{10}(OH,F)_2)$]is a monoclinic mica group mineral typically associated with granite pegmatites, containing approximately 7% Li_2O. Historically, lepidolite was the most widely extracted mineral for lithium; however, its significant fluorine content made the mineral unattractive in comparison to other lithium bearing silicates. Lepidolite mineral concentrates are produced largely in China and Portugal, either for direct use in the ceramics industry or conversion to lithium compounds.
- Petalite [$LiAl(Si_4O_{10})$] contains comparatively less lithium than both lepidolite and spodumene, with approximately 4.5% Li_2O. Like the two aforementioned lithium minerals, petalite occurs associated with granite pegmatites and is extracted for processing into downstream lithium products or for direct use in the glass and ceramics industry.

Lithium clays

Lithium clays are formed by the breakdown of lithium-enriched igneous rock which may also be enriched further by hydrothermal/metasomatic alteration. The most significant lithium clays are members of the smectite group, in particular the lithium-magnesium-sodium end member hectorite [Na0.3(Mg,Li)3Si4O10(OH)2]. Hectorite ores typically contain lithium concentrations of 0.24%-0.53% Li and form numerous deposits in the USA and northern Mexico. As well as having the potential to be processed into downstream lithium compounds, hectorite is also used directly in aggregate coatings, vitreous enamels, aerosols, adhesives, emulsion paints and grouts. Other lithium bearing members of the smectite group are salitolite [(Li,Na)Al3(AlSi3O10)(OH5)] and swinefordite [Li(Al,Li,Mg)4((Si,Al)4O10)2(OH,F) 4nH2O].

Lithium brines

Lithium-enriched brines occur in three main environments: evaporative saline lakes and salars, geothermal brines and oilfield brines. Evaporative saline lakes and salars are formed as lithium-bearing lithologies which are weathered by meteoric waters forming a dilute lithium solution. Dilute lithium solutions percolate or flow into lakes and basin environments which can be enclosed or have an outflow. If lakes and basins form in locations where the evaporation rate is greater than the input of water, lithium and other solutes are concentrated in the solution, as water is removed via evaporation. Concentrated solutions (saline brines) can be retained subterraneously within porous sediments and evaporites or in surface lakes, accumulating over time to form large deposits of saline brines.

The chemistry of saline brines is unique to each deposit, with brines even changing dramatically in composition within the same salar. The overall brine composition is crucial in determining a processing method to extract lithium, as other soluble ions such as Mg, Na and K must be removed during processing. Brines with a high lithium concentration and low Li:Mg and Li:K ratios are considered most economical to process. Brines with lower lithium contents can be exploited economically if evaporation costs or impurities are low. Lithium concentrations at the Salar de Atacama in Chile and Salar de Hombre Muerto in Argentina are higher than the majority of other locations, although the Zabuye Salt Lake in China has a more favourable Li:Mg ratio.

Lithium industry supply chain

Figure 19.1 below shows a schematic overview of the flow of material through the lithium industry supply chain in 2021. Raw material sources in blue and brown represent the source of refined production and technical grade mineral products consumed directly in industrial applications. Refined lithium products are distributed into various compounds displayed in green. Refined products may be processed further into specialty lithium products, such as butyllithium or lithium metal displayed in grey. Demand from major end-use applications are shown in orange with the relevant end-use sectors shown in yellow.

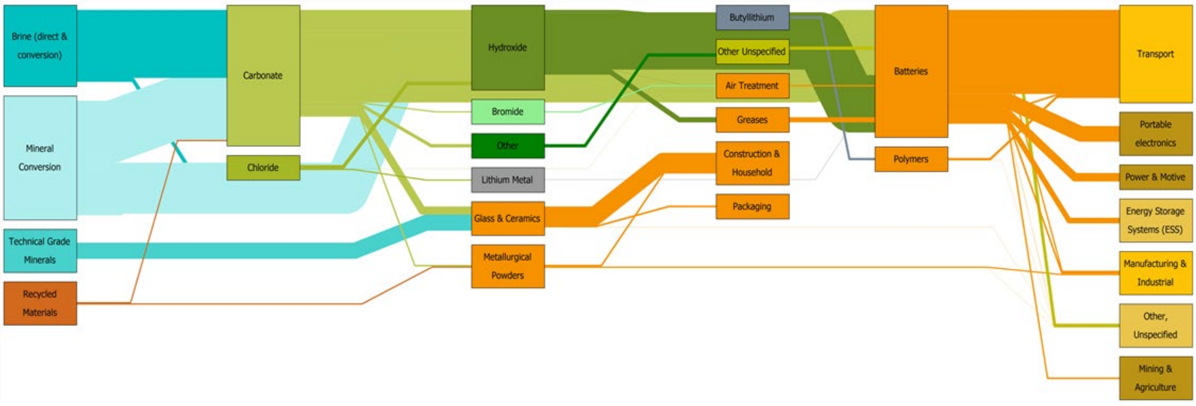


Figure 19.1: Lithium industry flowchart (Wood Mackenzie), 2022

19.2 Global demand for lithium

Lithium demand has historically been driven by macro-economic growth, but the increasing use of rechargeable batteries in electrified vehicles over the last several years has been the key driver of global demand. Global demand between 2015 and 2021 has more than doubled, reaching 498.2kt LCE with a CAGR of 16.8% over the period. Adding to this growth, in 2022 global lithium demand is expected to increase by 21.3% to 604.4 kt LCE as demand for rechargeable batteries grows further. Over the next decade, global demand for lithium is expected to grow at a rate of 17.7% CAGR to 2,199kt in 2032.

Lithium demand by end use

In recent years lithium-ion batteries have become the battery technology of choice for electric vehicles, from hybrid vehicles to full electric vehicles. The lithium-ion battery industry, particularly in its use in automotive applications will be the largest driver of lithium demand for the foreseeable future. Roskill's analysis shows that total vehicle sales continued to increase up until 2017, before the market saw marginal declines in 2018 and 2019. Sales in 2020 saw a sharp decline as the global COVID-19 pandemic set in and restricted movement and production. Demand growth for lithium in rechargeable batteries grew at 26.0% CAGR between 2015 and 2021, forming over 50% of lithium demand since 2017. Unlike most other major end-use applications, demand from rechargeable batteries continued to increase in 2020, despite disruption caused by the COVID-19 pandemic and related lockdowns, with this trend continuing into 2021 with demand reaching 362.0kt LCE.

All other end-uses for lithium have also experienced growth since 2015, albeit at lower rates than the rechargeable battery sector. Non-battery uses of lithium include ceramic glazes and porcelain enamels, glass-ceramics for use in high-temperature applications, lubricating greases and as a catalyst for polymer production. Between 2015 and 2019 growth in demand from ceramics, glass-ceramics, greases and polymers increased on average by between 1.6% pa and 4.4% CAGR, though demand volumes fell notably in 2020 as a result of COVID-19 related lockdowns and reduced industrial output. In 2021, the recovery in industrial production supported a growth in demand once again, with non-battery demand exceeding 2019 levels. In 2022 this growth is expected to continue across all categories.

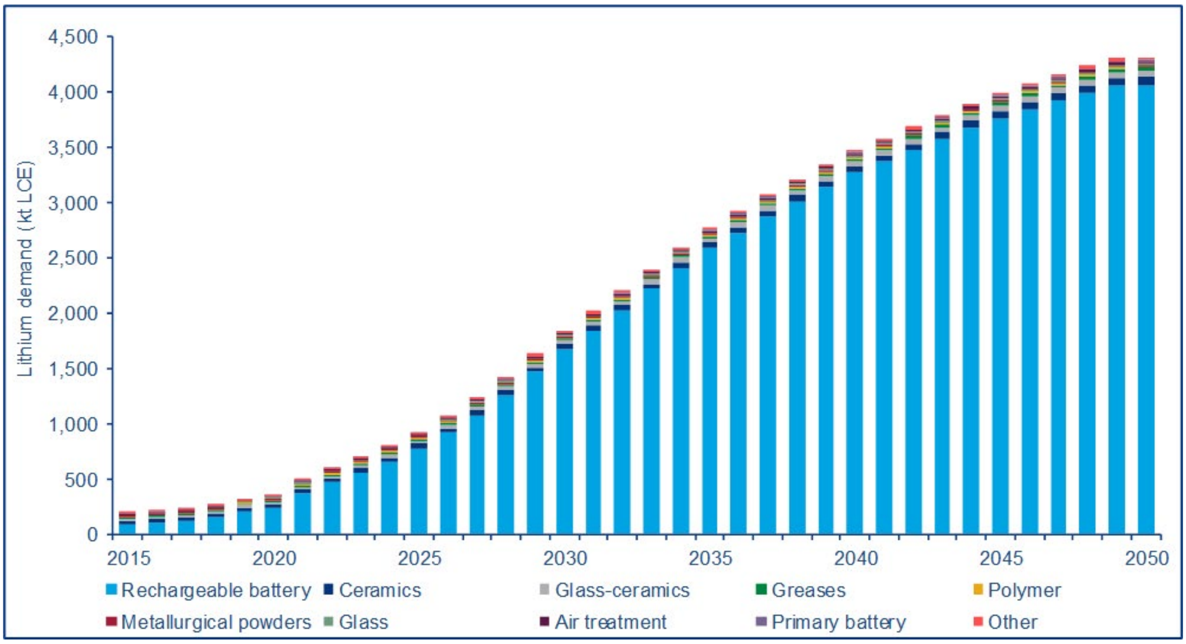


Figure 19.2: Global demand for lithium by end use, 2015 – 2050, in kt LCE (Wood Mackenzie)

Lithium demand is forecast to increase by 13.8% CAGR in the period 2022 to 2032, reaching a total of 2199kt LCE in 2032. Lithium demand is predominantly derived from the expected build-out of battery production, with 3,370GWh capacity required across all end-use applications by 2032. This is primarily driven by growing demand for electric vehicles, government policies facilitating a lower emission future, as well as greater choice for consumers as EV manufacturers bring more models online. The rechargeable battery segment will see a growth of 28% from 2021 to 2022. The largest driver within the rechargeable battery segment is from automotive where growth between 2021 and 2031 is forecast at 19.0% CAGR. Stationary energy storage (ESS) will grow at 18.7% CAGR in the same period. Wood Mackenzie forecast that total lithium demand in rechargeable batteries in 2031 will reach 1,834 kt LCE, up from 362 kt LCE in 2021.

Growth is forecast to slow down in the following two decades as the market matures. From 2030 to 2040, total demand growth of 6.9% CAGR is forecast, followed by 2.2% CAGR from 2040 to 2050. Total demand is forecast to reach 3,262 kt LCE in 2040 and 4061 kt LCE in 2050.

Lithium demand by product

Lithium is produced in a variety of chemical compositions which in turn serve as precursors in the manufacturing of its end use products such as rechargeable batteries, polymers, ceramics and others.

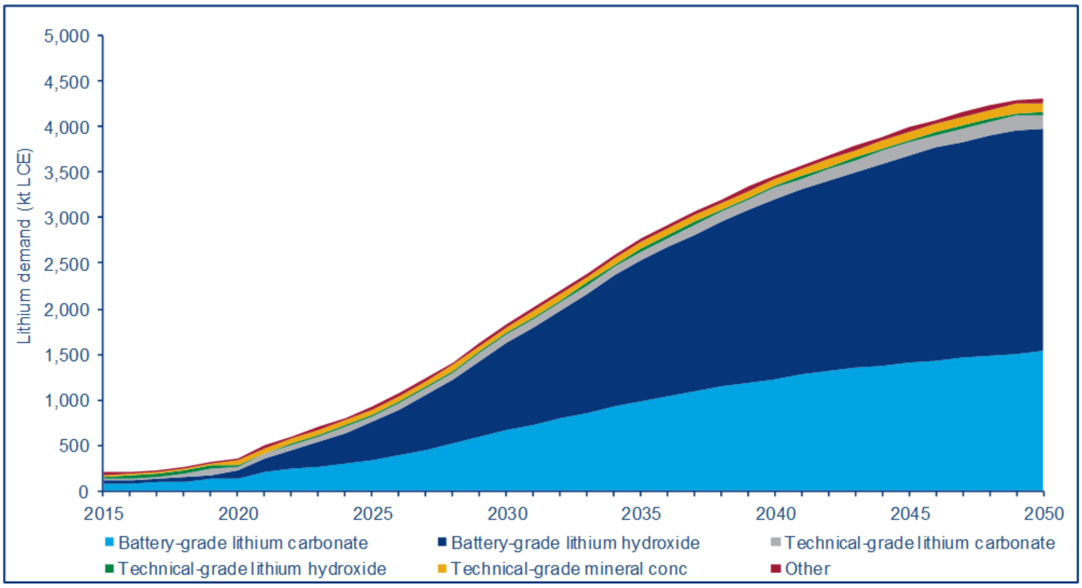


Figure 19.3: Global demand for lithium by product, 2020 – 2050, in kt LCE (Wood Mackenzie)

Lithium in the form of lithium hydroxide and lithium carbonate collectively accounted for 95% of production in 2021 and will continue to be the most important lithium products for the foreseeable future. Lithium hydroxide and lithium carbonate products are classified as 'battery-grade' for use in rechargeable battery applications and 'technical-grade' which is primarily used in industrial applications. Technical grade lithium carbonate can also be processed and upgraded to higher purity carbonate or hydroxide products.

Lithium carbonate is the most widely consumed product, finding application in rechargeable batteries, ceramics, glass-ceramics, glass, metallurgical powders, aluminium and other uses. Demand for battery-grade (BG) and technical-grade (TG) lithium carbonate was 263.0 kt LCE in 2021, with battery-grade now accounting for 42.3% of total refined lithium compound demand and technical-grade 10.5% (Figure 19.3).

BG carbonate demand increased by 19.4% CAGR between 2015 and 2021 and has remained the most widely consumed lithium compound. TG mineral concentrates accounted for a further 10.1% of consumption in 2021 and are used in similar ceramic, glass-ceramic, glass, and metallurgical applications to lithium carbonate. Consumption of mineral concentrates has increased particularly in periods of higher lithium carbonate pricing, as some consumers may switch between the two products in their production process.

TG and BG lithium hydroxide together represented 31.8% of total consumption in 2021, with BG showing the highest growth rate of all lithium products since 2015 at 25.3% CAGR. The use of lithium hydroxide in high-Ni cathode materials for Li-ion batteries is the main factor attributing to the rapid increase in BG lithium hydroxide demand.

BG carbonate and hydroxide together accounted for 70.5% of total demand in 2021 reflecting the share of the rechargeable battery market in the overall lithium market. A small amount of battery-grade metal is used in rechargeable batteries, but its main use is in primary batteries, with all battery uses for lithium at 73.6% of total product consumption. Technical-grade hydroxide is mainly used in greases, butyllithium in polymers and bromide in air treatment.

As a result of the strong growth in demand from rechargeable battery applications, demand growth for battery grade products is forecast to accelerate towards the end of the forecast period. In this context, lithium hydroxide is expected to experience exponential growth due to the introduction of high-nickel Li-ion batteries by the early part of the decade. This type of high-performing batteries was present in the technology roadmaps of most global automakers in 2020 as they could be the key enablers of long-distance driving EV ranges. In the outlook period, however, competition from LFP (Lithium-iron-phosphate) batteries using lithium carbonate, is to be expected in passenger EVs in developing countries and even in the urban vehicles of western auto markets. This will be result of the better economics and the longer cycle life of this battery type, whose cost does not depend on the cobalt and the nickel markets.

In addition to electric vehicle applications, rechargeable batteries will also play an important role in the energy transition. As the world shifts away from fossil-fuel based energy generation to renewable energy sources, growth in energy storage systems used to complement wind and solar generation will contribute to global growth in lithium consumption.

Lithium hydroxide is expected to experience exponential growth due to the introduction of high-nickel Li-ion batteries by the early part of the decade. These include NCM811 precursor material and NCMA and LNMO cathodes. By 2028 battery grade hydroxide is forecast to account to over 50% of chemical demand. Demand for battery grade lithium hydroxide is expected to grow at 19.4% CAGR 2022-2032 to reach 1182.7kt LCE in 2032, up from 140.7kt LCE in 2021. By 2025 demand for battery-grade lithium hydroxide will exceed total demand for all lithium products in 2020. Growth for battery-grade lithium hydroxide will be lower from 2030, with growth of 7.4% CAGR 2030-2040 and 2.1% CAGR 2040-2050, reaching 2437kt LCE in 2050.

The rapidly growing use of LFP chemistries for cathode will result in strong growth for battery-grade lithium carbonate. LFP cathodes are expected to be fastest growing cathode chemistry, increasing its share of the from 30% to 47% by 2050, as the Chinese market continues to expand and LFP cathode increasingly become the material of choice for a large number of EV-makers. This will correlate to a growth in lithium carbonate demand of 11.3% CAGR between 2022 and 2032. Over the forecast period, demand for lithium carbonate is expected to grow at 6.3% CAGR, from 263.0kt LCE in 2022 to 1,695kt LCE by 2050.

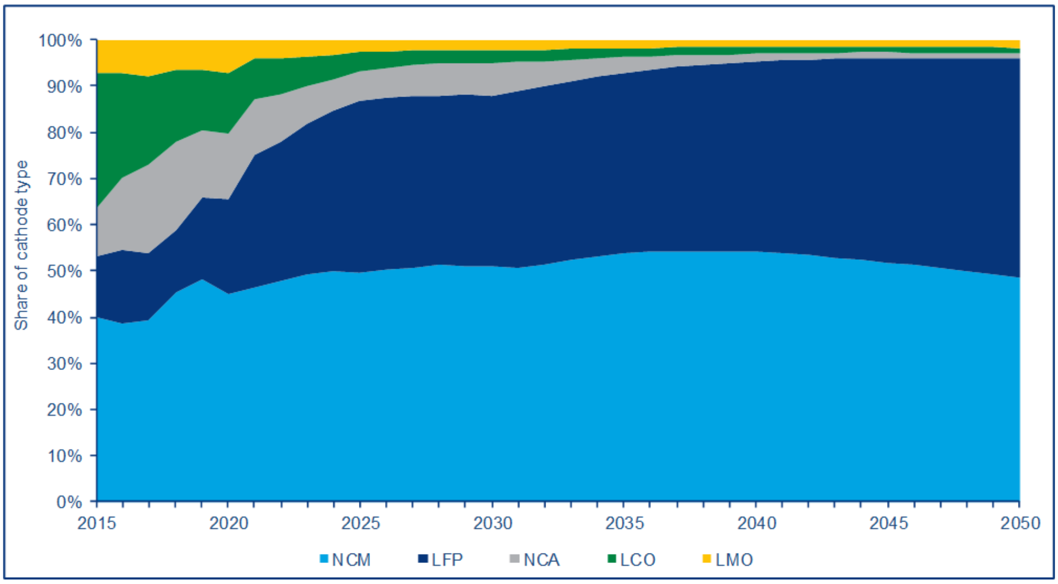


Figure 19.4: Summary cathode chemistry, 2015-2031 (Wood Mackenzie)

Lithium demand by country

In 2021, China was the largest consumer of lithium, accounting for 62.7% of total demand or 324.3kt LCE. Chinese demand has increased by 21.4% CAGR since 2015, largely through rapid expansion of the domestic Li-ion battery sector with supplementary growth in industrial end-use markets. The construction of significant Li-ion battery production capacity since 2018 has seen an acceleration of China's demand for lithium products. The relocation of some production capacity from South Korea and Japan into China has caused further increases in market share. Despite some production capacity being relocated, there has been a rapid build-out of battery production capacity in Japan and South Korea overall during the early to mid-2020s. Japan and South Korea accounted for 8.6% and 8.1% of global lithium demand respectively in 2021, compared with 8.0% and 3.8% in 2015.

European demand has risen significantly in the period since 2015, with the majority of demand growth occurring in the period since 2018 with greater Li-ion battery manufacturing taking place in the region. US demand has displayed growth of 21.4% CAGR from 2015, again driven by greater battery manufacturing capabilities in the region. Both Europe and North America are mature markets for lithium, and while some end-uses for lithium have grown, such as construction, others, like ceramics, glass and aluminium, have fallen, with growth remaining flat since the 2010s. The construction of new battery production hubs in Europe and North America by major battery manufacturers is expected to see these regions increase their overall market share over the coming decade.

India and South East Asia remain relatively small markets, together representing 2.1% of total demand in 2021. The Indian market has increased by 46.7% CAGR since 2015, though from a small base and was only around 7.4kt LCE in 2021, mainly for grease, polymer and ceramic tiles, though with a growing demand from rechargeable batteries. Other countries have also displayed strong growth, especially Southeast Asia where ceramic and primary battery production is growing (e.g. in Indonesia, Thailand and Malaysia) as well as rechargeable battery raw material production (e.g. Taiwan).

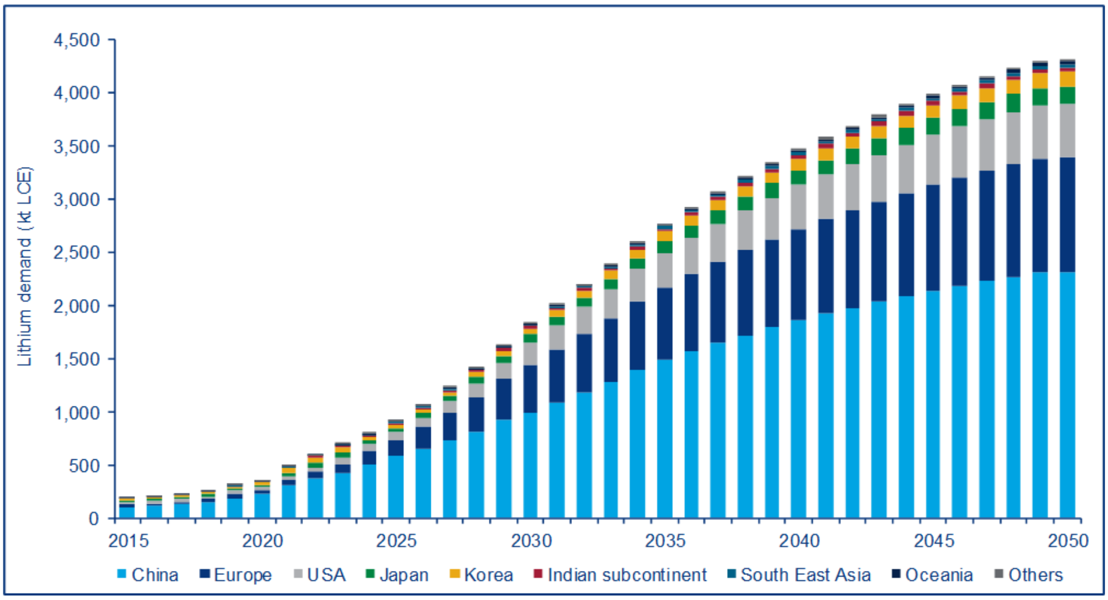


Figure 19.5: Global demand for lithium by country/region, 2015 – 2050, in kt LCE (Wood Mackenzie)

China

Chinese demand has increased by 21.4% CAGR between 2015 and 2021, largely through rapid expansion of the domestic Li-ion battery sector with supplementary growth in industrial end-use markets. The construction of significant Li-ion battery production capacity since 2018 has seen an acceleration of China's demand for lithium products. The relocation of some production capacity from South Korea and Japan into China has caused further increases in market share.

The Chinese lithium market is heavily dependent upon imports of lithium mineral concentrates and lithium compounds produced in the rest of the world. Imports of mineral concentrates from Australia and lithium compounds from South America provide key raw material sources to supplement domestic production and meet demand. Chinese imports of lithium carbonate increased sharply from 29.4kt in 2019 to 81kt in 2021, with imports from Chile (64kt) and Argentina (16kt) forming the majority of imported material.

Japan

Japan has no domestic production of lithium raw materials and is wholly reliant on imports of lithium products to satisfy demand. The Japanese lithium-ion battery industry is a major consumer of battery-grade lithium carbonate and lithium hydroxide.

Chile (both SQM and Albemarle) is the main source of lithium carbonate, accounting for 75-85% of imports in any one year, with most of the balance coming from Argentina and China.

Lithium hydroxide is imported and used as a raw material for production of NCA cathode materials, such as at Panasonic's facilities in Japan, and high nickel content NCM cathode materials at a number of manufacturers such as Tanaka Chemical, SANYO, Hitachi Maxwell and GS Yuasa. Imports from Livent in the USA have fallen sharply in recent years and China is now the main source of supply to the Japanese market.

South Korea

South Korea has no domestic supply of mined lithium materials, though lithium compounds are produced in-country from reprocessing lithium compounds and recycling of lithium-ion batteries sourced domestically and from imports. Strong demand for lithium compounds from the lithium-ion battery and lithium grease industries in South Korea led to imports rising steadily in the 2010s, with the increase in imports accelerating after 2017.

South Korea is the largest market, after China, for lithium carbonate exported from Chile and is by far the biggest market for that country's exports of lithium hydroxide. It is also the principal destination for China's exports of lithium carbonate and lithium hydroxide. The increase in Chinese imports of lithium carbonate in recent years represent growing trade between Ganfeng Lithium and LG Chem.

The increase in imports of lithium hydroxide from about 2019 came as battery cathode manufacturers based in South Korea ramped up production of higher nickel NMC and NCA type cathode materials which require lithium hydroxide as opposed to lithium carbonate. Major global cathode and battery manufactures operate facilities in South Korea, include LG Chemical, Samsung SDI and L&F Corp.

19.3 Global supply of lithium

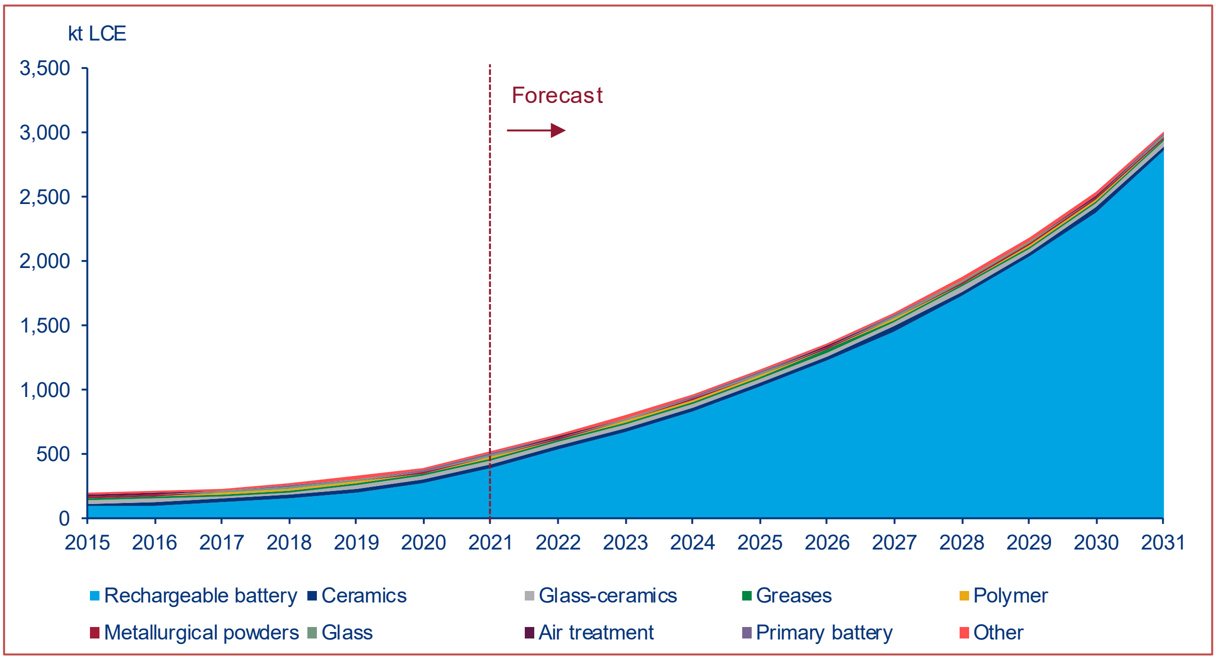


Figure 19.6: Global demand for lithium by end use 2015-2031 (Roskill Wood Mackenzie 2021)

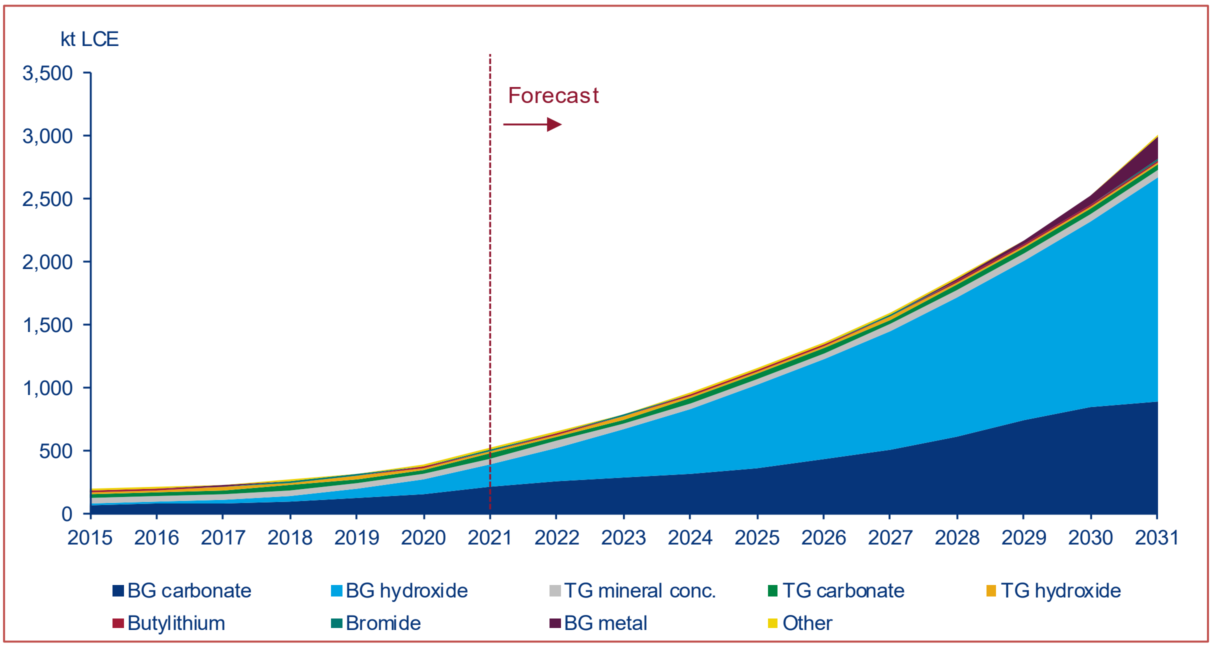


Figure 19.7: Global demand by lithium product 2015-2031 (kt LCE)

Refined supply by source

The world's lithium is supplied by primary production from hard rock mineral mines (spodumene, lepidolite, petalite), continental lithium brines and reprocessing (upgrading) of lithium carbonates. Lithium recycling currently contributes to a very small proportion of global supply (<1%) but as the industry matures and recycling technology develops, supply from recycling will play an ever-increasing role in global supply.

Mineral concentrates are the world's largest source of lithium, and is forecast to continue growing to 1,163kt LCE by 2032 up from an estimated 359kt LCE in 2022. Growth in mineral concentrate supply is forecast to slow down slightly and result in total output of 1,131kt LCE by 2040, decreasing to 1,047kt LCE by 2050. Australia will continue to be the largest supply of mineral concentrate with spodumene ore being the primary source of its lithium.

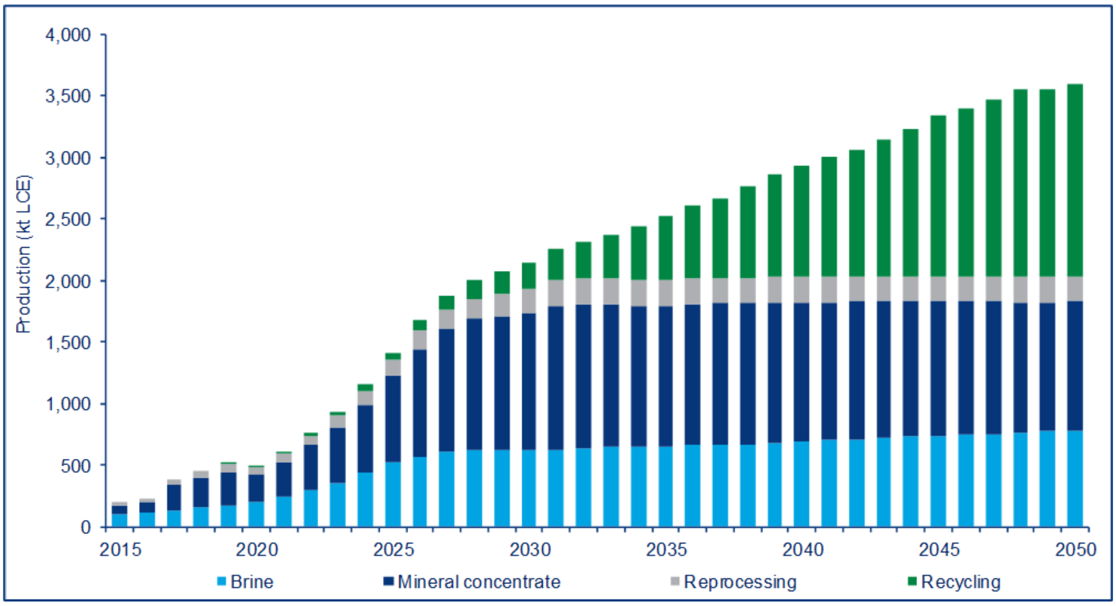


Figure 19.8: Refined lithium production by source, 2015 – 2031, in kt LCE (Wood Mackenzie)

Supply from mineral concentrate will be supplemented by increasing production from brine resources where expansions and new projects in South America will add significant supply to the market. Wood Mackenzie forecast an annual growth rate of supply from brine of 12.5% CAGR 2020-2030 reaching 626 kt LCE by 2030. Growth is forecast to slow down to an annual growth rate of 1.0% CAGR 2030-2040 to reach 693kt LCE by 2040 and 781kt LCE by 2050 at 1.2% CAGR 2040-2050.

Over the next decade, total supply of refined lithium is forecast to increase 17.2% CAGR in the 2022 to 2032 period to reach 2,309 kt LCE by 2032. Global refined lithium supply is forecast for steady growth and will reach 2,927 kt LCE in 2040 and 3,599 kt LCE in 2050.

Wood Mackenzie estimates that battery-grade lithium carbonate accounted for approximately 32% of global lithium supply in 2021, the largest of the lithium chemical products. However by 2023, battery-grade lithium hydroxide is expected to be the largest product in terms of volume supplied to the market. Supply of battery-grade lithium hydroxide, as the final product, will show the strongest growth at 17% over the next decade to reach levels of 920 kt LCE per year by 2032.

Refined supply by country

China has the world's largest lithium refining capacity and is forecast to remain the main supplier of lithium chemicals to the global market. In 2022, around two-thirds of lithium chemicals are expected to be produced in China from domestic sources as well as imported mineral concentrates and lithium compounds (carbonates and chlorides). Chile and Argentina's large brine operations are also significant contributors to global refined lithium, forecast to produce 34% of global supply in 2022. Developing projects in Chile and Argentina are expected to more than double production output over the decade, increasing from 224kt LCE in 2022 to 506kt LCE in 2032.

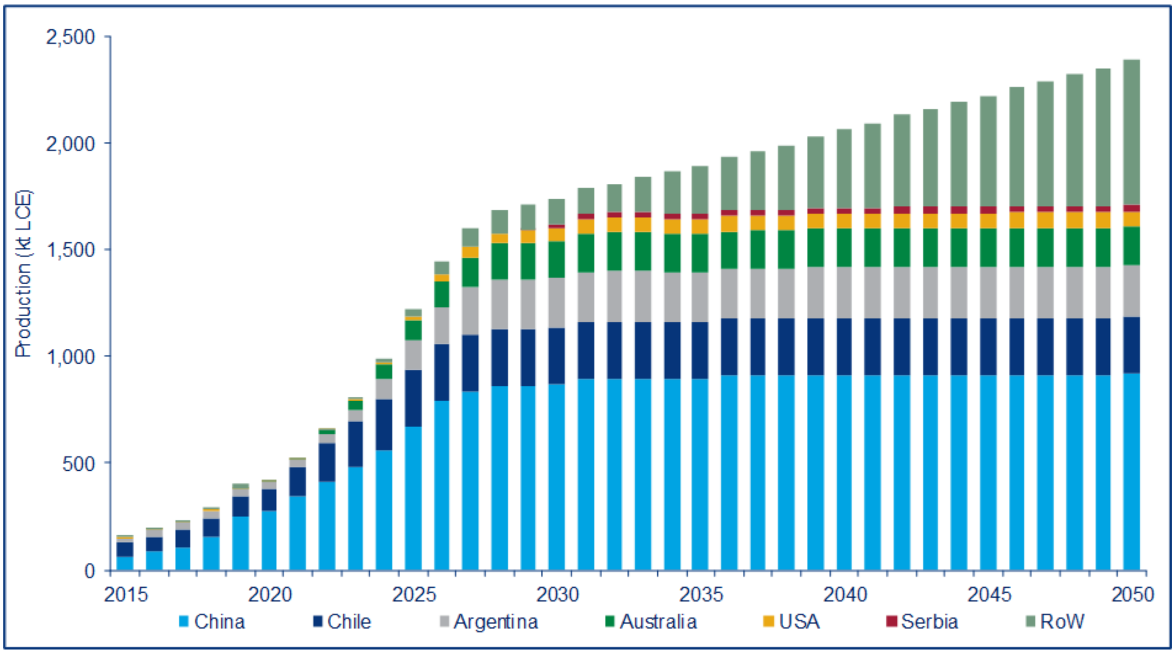


Figure 19.9: Refined lithium production by country, 2015 – 2050, in kt LCE (Wood Mackenzie)

Refined supply by status

Global production of refined lithium, declined to 418kt LCE in 2020, down from 462kt LCE in 2019, primarily driven by supply disruptions in the mineral (hard rock) supply. In 2021, as production began ramping up, global lithium production increased by 25% reaching 521kt LCE.

Following strong growth in the short term, lithium supply from operating assets alone is forecast to plateau at around 700ktpa LCE from 2032 onwards and future supply is expected to come from existing capacity at mines under care and maintenance and new projects

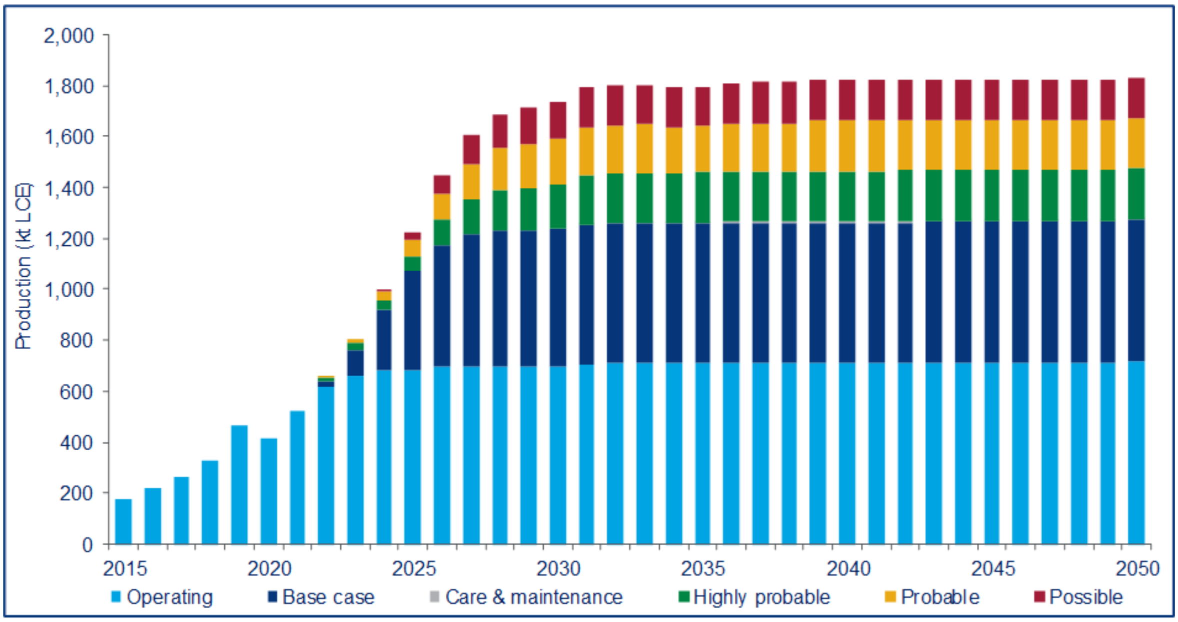


Figure 19.10: Lithium production outlook by status, 2015 – 2050, in kt LCE (Wood Mackenzie)

Including projects classified as base case and assuming operations under care and maintenance will restart production, global supply of lithium is expected to exceed 1 million tonnes (LCE) per year by 2025. With the inclusion of mineral and brine projects rated Highly Probably, Probable and Possible, global supply has the potential to exceed 1.7 Mt per year by the end of the decade.

Refined supply by company

The industry will remain led by a few giant producers with new entrants being added to the list every year. In 2021 there were 46 producing companies of lithium chemicals with the largest five producers accounting for 52% of total output. In 2030 Wood Mackenzie forecast there to be 70 active producers of lithium chemicals with the five largest accounting for 43% of the total output.

Refined lithium production is dominated by integrated producers, with integrated production totaling 386.0kt LCE in 2020 representing 80% of total refined production. Mineral conversion companies have increasingly sought to integrate upstream, in efforts to remove supply-chain risk and additional margin between the mineral concentrate and mineral conversion stages. Despite this, the development of new production capacity reliant upon the free-market or off-take agreements with mineral concentrate producers has outpaced integrated in terms of y-on-y growth between 2014-2021.

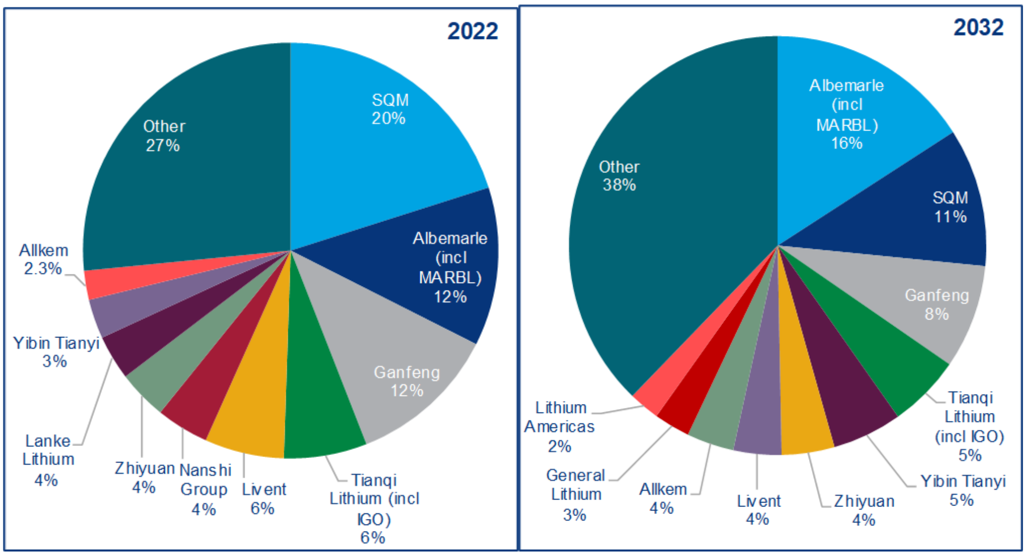


Figure 19.11: Global lithium production by company, 2022; 2032, in % (Wood Mackenzie)

The top five operators in 2022 are forecast to account for 57% of the total refined lithium output. Over the next decade, the share of the top five producers is forecast to decrease to 46% as a new-entrants enter the market. The top five producers will continue to hold an important position in the market as they possess the know-how to produce high-quality products. The large-scale production of these companies will remain attractive to buyers.

In 2022, SQM will claim the crown as the largest lithium producer globally with a forecast output of 147.3 kt or approximately 20% of global output. Wood Mackenzie have assumed that their licence to operate at Salar de Atacama will be renewed beyond 2030 and that expansion will continue to some degree. SQM will have an output of 215 kt LCE by 2030 and will be the world's second largest producer.

Albemarle is the second largest producer in 2022 with a 90 kt LCE output, and will overtake SQM as the largest producer in 2025. Through continued investment in conversion capacity the company is forecast to grow output to over 318 kt LCE by 2030. Production will include output from its brine productions in Chile and USA, and spodumene production from Greenbushes and Wodgina in Western Australia. The spodumene concentrate will feed conversion facilities at Kemerton, Sichuan, Guangxi, Jiangxi and Jiangsu.

Ganfeng's growth in the lithium industry has been remarkable. In 2020 it had an output of 40.4 kt LCE, which will more than double by 2023 and is forecast to reach 160kt LCE by 2030. Their expansions have been through investment in several resource projects around the world and conversion capacity simultaneously. Ganfeng has also actively secured offtake agreements for spodumene concentrate used as raw material in the continued expansion of their conversion assets.

Tianqi Lithium will also remain a top-five producer through the forecast period. Existing assets at Shehong, Zhangjiagang and Tongliang will be supplemented by the production of lithium hydroxide in Kwinana in partnership with IGO. Later the company will add additional lithium carbonate capacity with a new plant at Anju. All facilities will have spodumene sourced from Talison's Greenbushes mine and concentrator.

19.4 Lithium carbonate trade

Lithium carbonate is the most commonly traded lithium compound on the international market. The vast majority of this trade is material flow from Chile and Argentina and there is also a substantial volume of re-export trade.

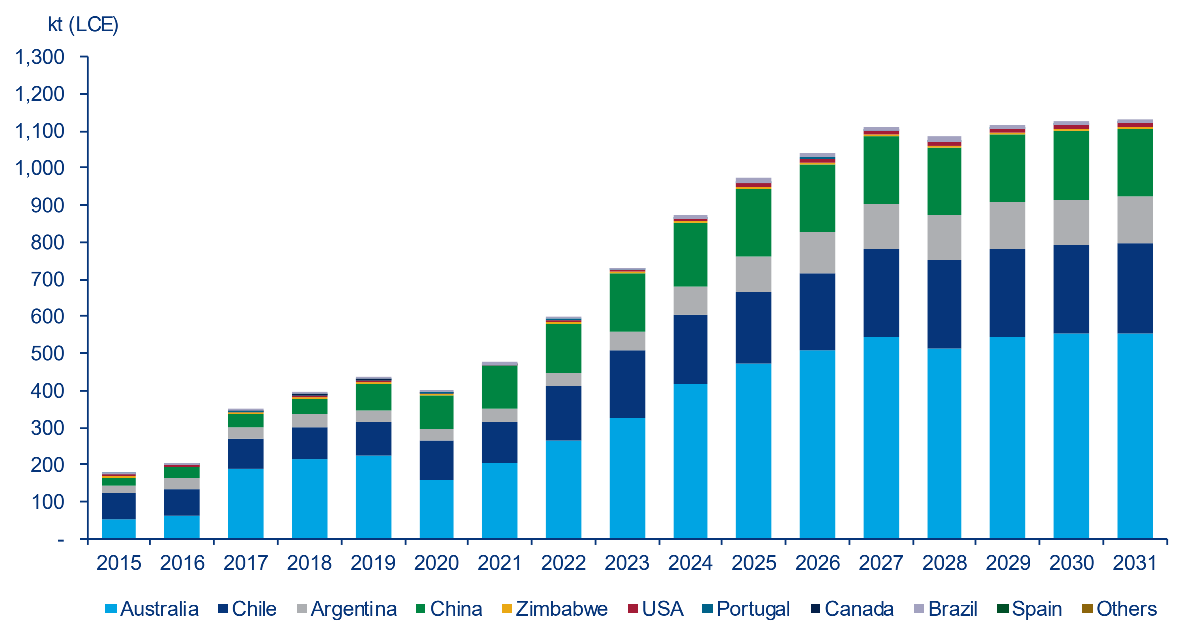


Figure 19.12: Lithium production per country 2015-2031 (kt LCE)

In 2020, approximately 154kt (gross weight) of lithium carbonate were exported, of which about 132kt were exports from the producing countries. Total exports were 5.3% higher than in 2019 (6.0% in the case of the producing countries). Although this growth was lower than had been seen in the two previous years, the fact that there was any increase at all during the worst of the COVID-19 pandemic highlights the rising demand for lithium. Over the period of 2014-2020 total exports of lithium carbonate grew by a CAGR of 9.6%, or 10.8% for the producing countries.

Chile is the largest source of exports, accounting for 73.8% of exports from the producing countries in 2020. Its share of the market since 2014 has varied between 63% and 76.4%. At 97.7kt, exports from Chile in 2020 were almost double the level of 2014.

Argentina is the second-largest exporter of lithium carbonate and accounted for just under 20% of the total from producing countries in 2020. The majority of exports from Argentina are to China and the USA, representing trade ultimately destined for the Asian market or internal trade to USA.

China's exports of lithium carbonate are made largely to the regional market, notably South Korea and Japan. Large volumes of lithium carbonate produced in South America are exported to Belgium and the Netherlands for distribution throughout the European market.

After surging in 2015-2016, the unit value of lithium carbonate exports from China fell back in 2017 and continued to slide through 2020. Overcapacity and oversupply of lithium carbonate within the Chinese market were the main causes for the price decline, which in turn has led many lithium refineries to suspend production temporarily or permanently. The downward trend in lithium carbonate prices continued for all major producing countries in 2019 and 2020, though companies undertaking largely internal trade between the USA and Europe have displayed better price support.

Global imports of lithium carbonate in 2020 were just under 145kt. This figure is higher than for exports from the producing countries as it includes re-export trade, particularly via Belgium and the Netherlands. Despite the COVID-19 pandemic, world imports of lithium carbonate increased by 2.5% in 2020 and remained healthy in 2021, with Q1 imports up 23.6% y-o-y.

China is by far the largest importer and accounted for about 35% of total imports in 2020. Combined, China, South Korea and Japan made up nearly 68% of world imports in 2020. South Korea was the largest single importer in both 2028 and 2019. The prominent position held by these three countries is the result of their being the largest producers of lithium batteries (although US production is similar to that in Japan and South Korea).

The USA, Russia and Germany are the only other major importers. The majority of US imports are for use as feedstock in the production of other lithium compounds. European imports mainly involve redistribution of imports to regional customers. Imports into Russia are understood to represent toll processing of lithium carbonate to lithium hydroxide at Russian facilities for the European market. Imports from China into Russia are believed to also be for conversion to lithium hydroxide for the European market.

19.5 Cost of supply

Figure 19.13 shows the site operating cost curve for lithium brine operations in 2025, it includes currently operating assets, brownfield expansions and several greenfield projects. SQM's and Albemarle's Chilean operations with extraction sites and pond complexes in the Salar de Atacama have the lowest site operating cost of any assets globally, owing to the high-grade brine and favourable dry climatic conditions in the Atacama.

Elsewhere, lower portions of the cost curve tend to be dominated by established operations. In contrast, the upper quartile of the cost curve is populated by a swathe of projects that have the potential to enter production by the midpoint of the decade. Due to the multi-year ramp-up period commonly associated with brine projects, the operating cost of these assets appears artificially high during their early years of production due to the higher proportion of fixed costs, which are spread across a lower volume of production during the ramp-up phase.

In 2025, Olaroz – Stage II is expected to have a site operating cost of US$3,183/t, placing the operation in the 3rd quartile of the cost curve for brine projects. A lithium carbonate price forecast in 2025 ranging between US$15,000 and 17,000 per tonne for technical-grade and battery-grade leaves substantial headroom for margin for the majority of lithium producers.

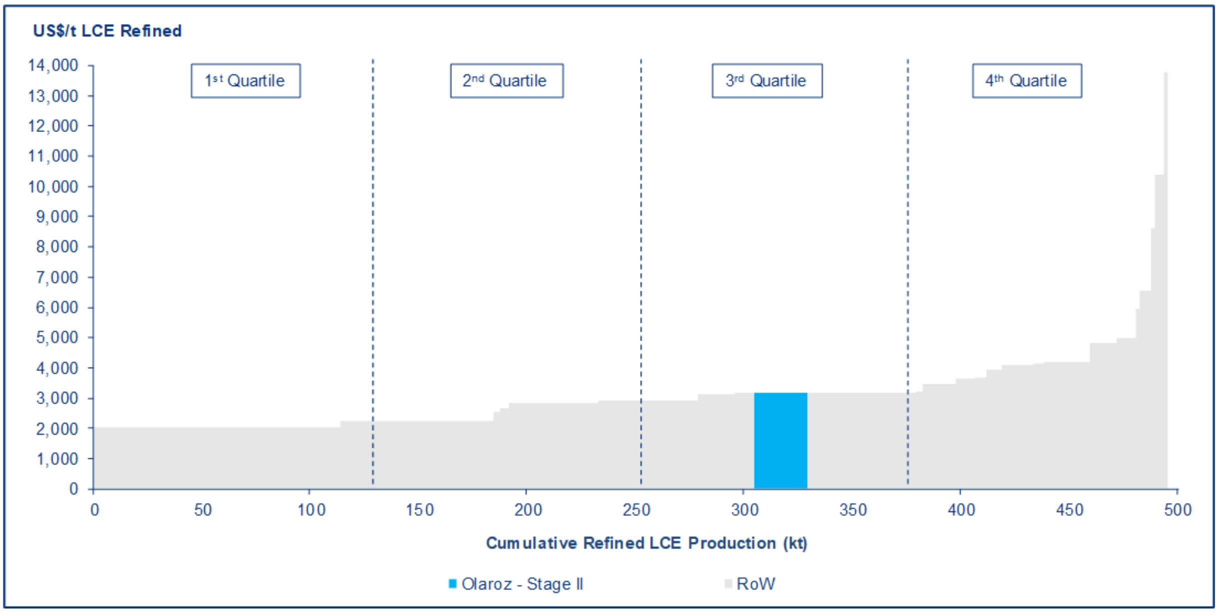


Figure 19.13: Global brine site operating curve, 2025 (Wood Mackenzie)

19.6 Market Balance

The lithium market is forecast to have a supply shortfall in the long term. Supply from current operations and upcoming projects is insufficient to meet the increasing demand. The global interest in the transition towards lower-emission transportation has facilitated many new projects to supply lithium chemicals both from mineral concentrate and brine.

Wood Mackenzie's base case view show that the overall lithium chemical market registered a minor supply deficit in 2021, despite increasing production of lithium chemicals from both brine and minerals. Following a smaller deficit expected in 2022, growing supply is expected to shift the market into surplus from 2023 onwards which will continue to grow to a peak of 230.9kt LCE in 2026. As growth in demand outpaces new supply in the late 2020s, a supply deficit will emerge from 2029. The forecast supply deficit will continue to grow and reach a peak in 2049 at 1,321.0 kt LCE.

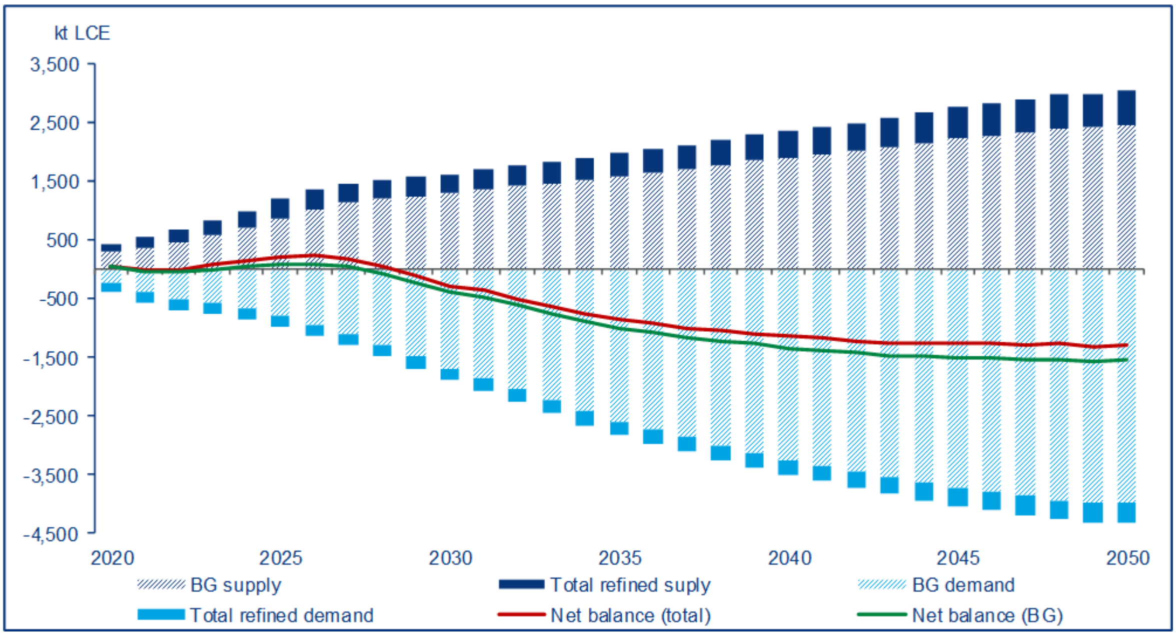


Figure 19.14: Refined lithium market balance, 2020 - 2050 (Wood Mackenzie)

The market balance for battery-grade lithium chemicals in the base case shows a supply deficit in 2022 and a relatively balanced market in 2023. From 2024 to 2027 we forecast a supply surplus across the battery-grade lithium chemical market with a peak in 2026 of 79.8 kt LCE or 8% of demand, shifting to a deficit from 2028 onwards. The deficit will reach 1,573 kt LCE by 2049 as demand for electric vehicles continues to grow despite existing suppliers' expansions, which are mainly targeting the production of battery-grade lithium chemicals. In the late 2040s supply from the recycling of EV batteries will start to have a material impact on the market balance and we expect the deficit to ease. The deficit in our base case is forecast to reach 1,533.9 kt LCE by 2050.

	2020	2021	2022	2023	2024	2025	2030	2035	2040	2045	2050
Total refined supply	428	539	678	821	1,001	1,193	1,620	1,971	2,361	2,767	3,038
BG supply	295	367	467	589	717	872	1,295	1,589	1,902	2,227	2,445
Total refined demand	381	566	688	749	852	978	1,897	2,822	3,509	4,027	4,321
BG demand	236	401	516	586	680	803	1,691	2,586	3,242	3,721	3,979
Net balance (total)	47	-27.2	-10.6	72	150	216	-277	-851	-1,148	-1,260	-1,283
Net balance (BG)	59	-34	-49	3	37	68	-396	-997	-1,340	-1,494	-1,534

Table 19.1:Outlook for refined lithium supply and demand, 2021 - 2050(Wood Mackenzie)

19.7 Lithium prices

Lithium prices continue to outperform expectation in 2022. In 2021, spot prices for lithium carbonate and lithium hydroxide almost quadrupled to reach prices around US$30,000/t, and in the first quarter of 2022, spot prices have breached the US$50,000/t mark for both battery-grade lithium carbonate and battery-grade hydroxide.

While supply has been growing, it has been struggling to keep up with strong demand from the EV sector. In 2021, we saw incentives implemented across Europe that boosted EV sales and spurred stronger lithium demand. At the same time, we saw EV sales in China return to record levels that further boosted demand, especially for battery-grade lithium carbonate used in LFP cathodes.

Despite the short-term imbalance in the market, it is difficult to find justification in the market fundamentals for the price increases we have seen in the spot market. Part of the additional demand is likely created by every link in the supply chain boosting inventories slightly to create a buffer against supply chain delays. The aggregated additional demand for lithium will therefore be substantial and could have contributed to the market sentiment.

Wood Mackenzie believes the elevated lithium spot prices in Q1 2022 are not sustainable in the long term and prices will decrease in the short to medium term to reflect market fundamentals. Spot prices are expected to decline in the second half of 2022. The declining trend is expected to continue as supply catches up with demand and the market moves into surplus in the mid 2020s. Contract prices are expected to follow a similar trend with a delay due to the lag built into price mechanisms in long-term contracts. Prices are expected to trend towards the long term incentive prices by the end of the decade.

Battery-grade lithium carbonate

Demand for battery-grade lithium carbonate is set to exhibit strong growth due to the increasing use of LFP cathode chemistries in LiB batteries. This demand is likely to be met primarily with supply from brine projects. As there are a large number of brine projects entering production in the coming years the longer-term outlook for battery-grade lithium carbonate is more subdued but remains very positive.

During 2022 we forecast a continued increase in contract pricing but as new supply enters the market we forecast a stabilisation of prices followed by declining prices throughout the middle of this decade. By the late 2020s prices are expected to gradually decline to around US$11,000/t. As demand continues to grow, a larger deficit will emerge towards the end of the decade and contract prices will trend towards a long-term contract price of US$16,000/t.

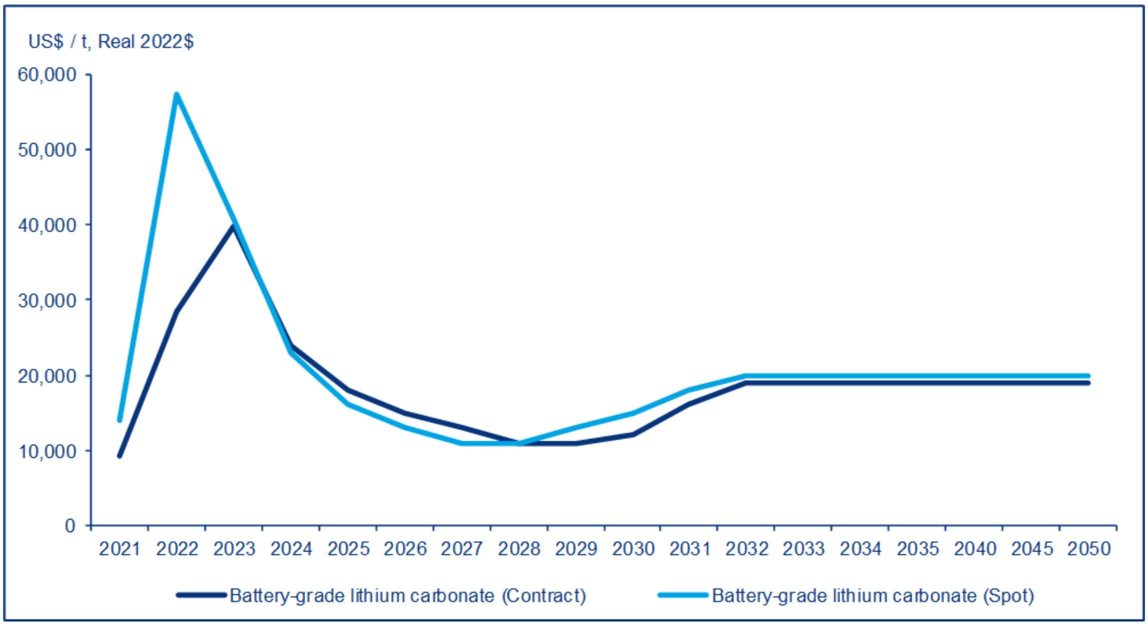


Figure 19.15: Battery-grade lithium carbonate price outlook, 2021 - 2050 (Wood Mackenzie)

	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
CIF Asia (US$/t Real 2022$)											
Contract	9,108	28,336	39,874	23,911	18,000	15,000	13,000	11,000	11,000	12,000	16,000
Spot	13,921	57,375	40,800	22,880	16,000	13,000	11,000	11,000	13,000	15,000	18,000

Table 19.2: Battery-grade lithium carbonate price outlook, 2021 – 2031 (Wood Mackenzie)

Technical-grade lithium carbonate

Demand for technical-grade carbonate from industrial sectors is forecast to grow in line with economic growth, Technical-grade lithium carbonate, however, lends itself very well to be reprocessed into battery-grade lithium chemicals. This is an established process occurring in Chile, US, China and soon in Japan. The ability to re-process the product into battery-grade lithium chemicals will ensure that prices will increase in line with prices of battery-grade lithium chemicals.

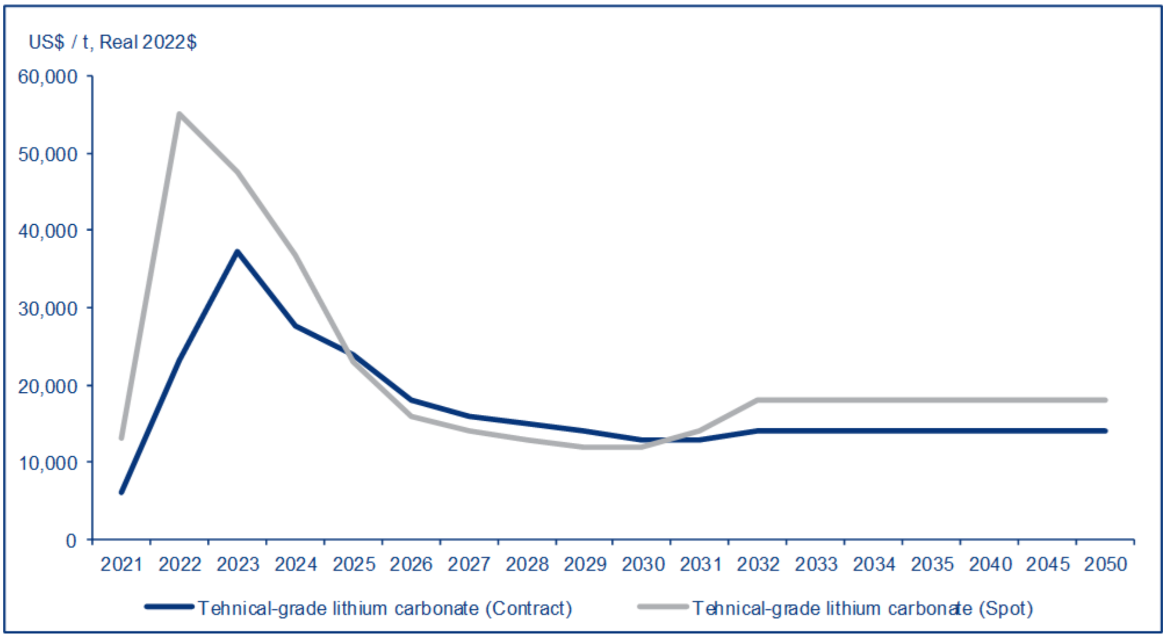


Figure 19.16: Technical-grade lithium carbonate price outlook, 2021 - 2050 (Wood Mackenzie)

	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
CIF Asia (US$/t Real 2022$)											
Contract	6,092	23,246	37,195	27,732	24,000	18,000	16,000	15,000	14,000	13,000	13,000
Spot	13,119	55,136	47,685	36,920	23,000	16,000	14,000	13,000	12,000	12,000	14,000

Table 19.3: Technical-grade lithium carbonate price outlook, 2021 – 2031 (Wood Mackenzie)

19.8 Conclusions

Growth in rechargeable batteries will lead to the growth in lithium demand with 21.9% CAGR between 2020 and 2030, and 6.9% a year in the following decade before slowing down to 2.2% a year between 2040 and 2050 as markets become increasingly saturated. Demand in the Chinese market, and to some extent overseas markets, will drive growth for battery-grade lithium carbonate through increasing demand for LFP cathode chemistry. Demand for battery-grade lithium carbonate is forecast to increase 16.9% CAGR between 2020 and 2030, 6.3% a year from 2030 to 2040 followed by 2.3% a year in the following decade.

Increasing prices are yet again incentivizing investment in supply capacity in brine, mineral concentrate, conversion and in new sources such as clay. Refined lithium production capacity is forecast to grow by 10.8% CAGR in this decade, slowing to 4% between 2030 and 2040 and 2.9% in the following decade.

19.9 Contracts

Allkem has a joint venture with Toyota Tyushu on the Olaroz Project, with Allkem owning 65% of the Olaroz Project, Toyota Tyushu 25% and JEMSE, the provincial government development authority 8.5%. JEMSE

Allkem is a partner with Toyota Tyushu in the Naraha lithium hydroxide plant that is located in the NE of Honshu in Japan. Allkem holds a 75% economic interest in the

10,000 tpa plant. The plant has undergone commissioning and is expected to be operating

Future production is committed to long term contacts with periods of between 2 to 7 years, with most of future sales volumes under contract with customers within the EV battery supply chain. Target consolidated sales volumes from Stage 1 and Stage 2 are expected to be ~80% under long-term contracts. Long term sales contracts have a mixture of pricing sources with adjustments based on market indicators.

20 ENVIRONMENTAL STUDIES, PERMITTING AND SOCIAL OR COMMUNITY IMPACT

20.1 Environmental Studies

Sales de Jujuy has successfully completed various environmental studies required to support exploration and development programs between 2008 and the present. Sales de Jujuy has a multidisciplinary team of qualified and experienced employees, supported by specialist consultants, who have prepared the Olaroz Project Environmental Impact Assessments and undertaken baseline and ongoing monitoring to support Olaroz Project development. This work includes extensive studies of flora, fauna, hydrogeology, hydrology, climate, air quality, noise, limnology, landscape characteristics and ecosystem characterisation. This is supported by social economic and cultural studies, surveys and support programs.

The principal environmental and development approvals for the Olaroz Project consist of:

- Base line for exploration 2009 - Resolution DMyRE N° 026/09 (02/09/2009);
- Base line for exploration 2010 - Resolution DMyRE N° 007/10 (29/12/2010) and expansion in Resolution DMyRE 20/2012 (06/07/2012);
- Updated exploitation stage years 2012 y 2014 - Resolution DMyRE N° 044/2016 (29/12/16);
- Updated exploitation stage 2016 and addendum for Olaroz Project expansion - Resolution DMyRE N° 009/2017 (05/10/17) y Resolution DMyRE N° 012/2017 (07/11/17);
- Updated exploitation stage 2018 – Resolution DMyRE N° 005/2020 (30/01/2020);
- Updated exploitation stage 2020 – Resolution awaited.

The Olaroz Project expansion is permitted under the 2016 and 2018 authorisations, with additional authorisations from March 2021.

20.2 Olaroz Project Permitting

Sales de Jujuy has received the relevant permissions for the Olaroz Project development activities, as described above. SDJ development team includes staff with experience in environmental permitting for lithium Olaroz Projects in NW Argentina, in addition to consultants with extensive experience in preparing environmental studies for lithium development and operating lithium Olaroz Projects.

With regards to operational permits, SDJ is registered with the National Register (Registro Nacional de Bocas de Expendio) with regards to operating diesel fuel tanks at the site and undertakes annual audits of the tank and bowser equipment.

The site laboratory is registered with the relevant authorities for use of chemicals (Registro Nacional de Precursores Químicos (RENPRE)). There is an annual renewal of the certification. SdJ is registered for the use of industrial quantities of the chemical soda ash. SdJ is also registered with respect to disposal of wastes, such as greases (CAPA Peligros y CAPA Patógenos en el marco de la Ley Nacional N° 24.051, Ley Provincial N° 5.063 y Decreto Provincial Reglamentario N° 6.002 y 6.003). These are provincial permissions that are renewed annually. SdJ has also applied for registration in the National Register of dangerous goods (Registro Nacional de Residuos Peligrosos de Ley N°24.051), in relation to these items.

The project is located in the Olaroz Cauchari Fauna and Flora Reserve (La Reserva de Fauna y Flora Olaroz-Cauchari). The reserve was created in 1981, under provincial law 3820. The reserve is a multi-use area that allows for agricultural and mining activities and scientific investigation programs. The operation of the Olaroz project is consistent with the multi-use reserve status

20.3 Social and Community Requirements

SDJ has been very actively involved in community relations since the properties were acquired in 2008. Although there is minimal habitation in the area of the Salar, SdJ has consulted extensively with the local aboriginal communities and employs a significant number of members of these communities in the current operations.

The Olaroz Project permitting process addressed community and socio-economic issues. The Olaroz Project expansion will provide new employment opportunities and investment in the region, which is expected to be positive.

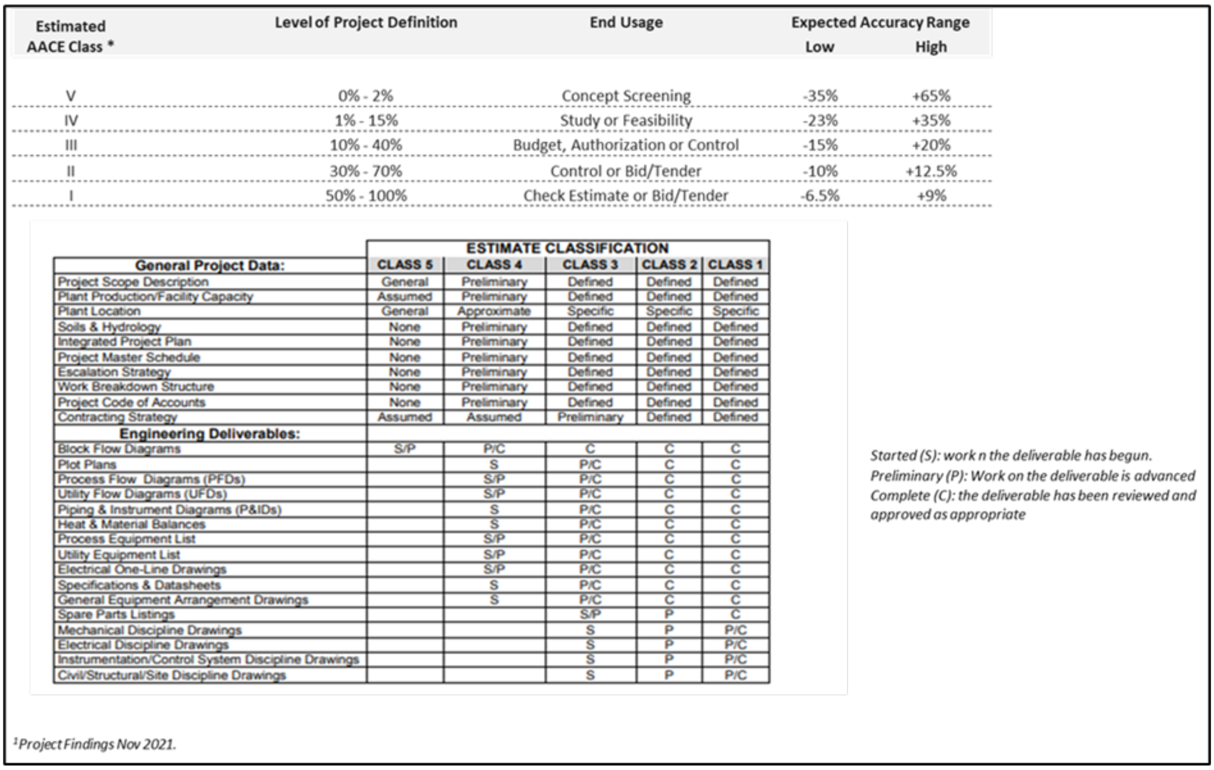
21 CAPITAL AND OPERATING COST

21.1 Introduction

Capital and operating cost estimates were prepared using AACE International guidelines:

- Wellfields, brine distribution, evaporation ponds, waste (wells and ponds): Class 1 -6.5 +9% as these elements are largely completed;
- Process Plant and Non-Process Infrastructure: Class 3 +/-15%, well advanced.

Cost estimates are based on fourth quarter 2021 pricing.



Estimated AACE Class *	Level of Project Definition	End Usage	Expected Accuracy Range Low	Expected Accuracy Range High
V	0% - 2%	Concept Screening	-35%	+65%
IV	1% - 15%	Study or Feasibility	-23%	+35%
III	10% - 40%	Budget, Authorization or Control	-15%	+20%
II	30% - 70%	Control or Bid/Tender	-10%	+12.5%
I	50% - 100%	Check Estimate or Bid/Tender	-6.5%	+9%

	ESTIMATE CLASSIFICATION				
General Project Data:	**CLASS 5**	**CLASS 4**	**CLASS 3**	**CLASS 2**	**CLASS 1**
Project Scope Description	General	Preliminary	Defined	Defined	Defined
Plant Production/Facility Capacity	Assumed	Preliminary	Defined	Defined	Defined
Plant Location	General	Approximate	Specific	Specific	Specific
Soils & Hydrology	None	Preliminary	Defined	Defined	Defined
Integrated Project Plan	None	Preliminary	Defined	Defined	Defined
Project Master Schedule	None	Preliminary	Defined	Defined	Defined
Escalation Strategy	None	Preliminary	Defined	Defined	Defined
Work Breakdown Structure	None	Preliminary	Defined	Defined	Defined
Project Code of Accounts	None	Preliminary	Defined	Defined	Defined
Contracting Strategy	Assumed	Assumed	Preliminary	Defined	Defined
Engineering Deliverables:					
Block Flow Diagrams	S/P	P/C	C	C	C
Plot Plans		S	P/C	C	C
Process Flow Diagrams (PFDs)		S/P	P/C	C	C
Utility Flow Diagrams (UFDs)		S/P	P/C	C	C
Piping & Instrument Diagrams (P&IDs)		S	P/C	C	C
Heat & Material Balances		S	P/C	C	C
Process Equipment List		S/P	P/C	C	C
Utility Equipment List		S/P	P/C	C	C
Electrical One-Line Drawings		S/P	P/C	C	C
Specifications & Datasheets		S	P/C	C	C
General Equipment Arrangement Drawings		S	P/C	C	C
Spare Parts Listings			S/P	P	C
Mechanical Discipline Drawings			S	P	P/C
Electrical Discipline Drawings			S	P	P/C
Instrumentation/Control System Discipline Drawings			S	P	P/C
Civil/Structural/Site Discipline Drawings			S	P	P/C

Started (S): work n the deliverable has begun.
Preliminary (P): Work on the deliverable is advanced
Complete (C): the deliverable has been reviewed and approved as appropriate

[1] *Project Findings Nov 2021.*

Table 21.1: Cost definition levels

21.2 Capital Cost Estimates

The capital cost estimate for Stage 2 of the Olaroz Project was prepared by Worley Argentina S.A. (collectively, Worley) in collaboration with Allkem to include capital cost estimation data developed and provided by Worley, Allkem and other third-party contractors in accordance with individual scope allocations.

Specific cost elements for the estimate that were originally in other currencies were converted to USD (US$).

21.3 Basis of Capital Cost Estimates

The capital cost estimate was broken into direct and indirect costs.

Direct costs

This encompasses costs that can be directly attributed to a specific direct facility, including the costs for labour, equipment, and materials. This includes items such as plant equipment, bulk materials, specialty contractor's all-in costs for labour, contractor direct costs, construction, materials, and labour costs for facility construction or installation.

Indirect costs

Costs that support the purchase and installation of the direct costs, including temporary buildings and infrastructure; temporary roads, manual labour training and testing; soil and other testing; survey, engineering, procurement, construction and project management costs (EPCM); costs associated with insurance, travel, accommodation and overheads, third party consultants, Owner's costs, and contingency.

Quantity Estimation

Quantity development was based on a combination of:

- Detailed engineering (including material take-offs from approved-for-construction drawings, material take-offs from general arrangement drawings, approved-for-construction drawings and engineering modelling that includes earthworks, structural steel and concrete);
- Basic design (engineered conceptual designs);
- Estimates from plot plans, general arrangements or previous experience, and order of magnitude allowances.

Estimate pricing was derived from a combination of:

- Budget pricing that included an extensive budget quotation process for general and bulk commodities;
- Fixed quotations for major equipment, and budget quotations for all other mechanical equipment;
- Historical pricing from the stage 1 project; and
- Estimated or built-up rates and allowances.

The manual base labour hourly costs were based on extensive operating experience at the Olaroz site.

The estimate considers execution under an EPC approach.

The construction working hours are based on 14 consecutive days on, at 9.5 hours per day, and seven days off. Whilst an agreement will need to be reached with the relevant trade unions, this roster cycle is allowed under Argentinian law and has been used for similar projects. Labour at the wellfields, ponds, process plant, and pipelines areas will be housed in construction camps, with camp operation, maintenance, and catering included in the indirect cost estimate. A productivity factor of 1.35 was estimated, considering the Project/site-specific conditions.

Spare parts were estimated at 5% of all mechanical, piping, electrical and instrumentation, and equipment. Sustaining capital is based on the Stage I project sustaining capex and considers some operational improvements such as continuous pond harvesting.

Engineering, management, and Owner's costs were developed from first principles. The Owner's cost estimate includes:

- Home office costs and site staffing,
- Engineering and other sub-consultants,
- Office consumables, equipment,
- Insurance,
- Exploration,
- Pilot plant activities and associated project travel.

The estimate for engineering, management and Owner's costs was based on a preliminary manning schedule for anticipated Project deliverables and Project schedule. Engineering design of the estimate for the home office is based on calculation of required deliverables and manning levels to complete the Project.

21.4 Capital Cost Summary

Table 21.2 summarises the capital cost estimate. The projected growth capital cost estimate is US$376 million. Sustaining capital cost is estimated to be US$ 114 million (approximately US$3 million per year post 2024).

Capex Breakdown		
Direct Capex		
Wells	US$m	27
Brine Handling	US$m	26
Ponds	US$m	111
Liming Plant	US$m	22
LCP & SAS	US$m	122
BOP	US$m	21
Camps	US$m	18
Total Direct	US$m	**347**
Indirect Capex		
Indirects	US$m	11
Contingency	US$m	18
Total Indirect	US$m	**29**
Total Capital Cost Direct + Indirect	US$m	**376**
Capital Intensity	US$/tpa Cap	15,032
Sustaining Capex		
Sustaining Capex	US$m	114
Annual % of LOM Growth Capex	%	1

Table 21.2: Capex breakdown

21.5 Operating Costs

The operating cost estimate for the Stage 2 expansion was prepared by Worley and updated by Orocobre/Allkem management team. The cost estimate excludes indirect costs such as distributed corporate head office costs for corporate management and administration, marketing and sales, exploration, general project and technical developments, and other centralised corporate services. The operating cost does also not include royalties, export taxes and refunds available to the company.

Most of these costs are based on labour and consumables which are in use at Olaroz in the Stage 1 operation.

21.6 Basis of Operating Cost Estimates

Reagent consumption rates were obtained from the plant mass balance. Prices for the main reagent supplies were obtained from costs prevailing for 2021 and were based on delivery to site.

The operations will use the same work rotation as currently practiced at Olaroz, depending on the operational area.

- This consists of a 14 by 14 days rotation: based on fourteen days on-duty and fourteen days off-duty, with 12-hour shifts per workday, applicable for staff at site.
- A 5 by 2-day rotation: based on a Monday-to-Friday schedule, 40 hours per week, and would be applicable only to personnel at the Jujuy city office.

Natural gas is used to generate the on-site power and process heating. Olaroz is connected to the GAS ATACAMA gas pipeline at the Rosario Compressor Station, located between Susques and Paso de Jama (border with Chile). The Atacama pipeline is of Ø 20" and connects Cornejo (Salta) to Mejillones (Chile) with a length of approximately 950 km, of which 520 km is in Argentine territory. The interconnection to the SdJ gas pipeline is at approximately km 470 (Rosario Compressor Station).

Key details of the gas supply are outlined below:

- Transportation Capacity: 240,000 m3/day.
- Current gas transport: 50,000 m3/day
- Gas transport Expansion Project: 150,000 m3/day.
- Total current + Expansion: 200,000 m3/day.

The electrical load was developed by Allkem, using typical mechanical and electrical efficiency factors for each piece of equipment.

A maintenance factor based on industry norms and established practice at Olaroz was applied to each area to calculate the consumables and materials costs.

Pricing for transportation and port costs were based upon existing logistic costs at Olaroz. The estimate includes freight, handling, depot and customs clearance to deliver lithium carbonate either FOB Angamos Chile or Campana in Argentina.

Approximately 75 t of lithium carbonate from the Stage 2 project will be trucked to port each day, equivalent to 3 trucks per day.

Annual general and administrative (G&A) costs include the on-site accommodation camp, miscellaneous office costs and expenditure on corporate social responsibility.

21.7 Operating Cost Summary

Table 21.3 provides a summary of the estimated annual cost by category for a nominal year of operation. No inflation or escalation provisions were included. Subject to the exceptions and exclusions set forth in this Report, the aggregate average annual FOB cash operating costs for the Stage 2 Project is estimated to be approximately US$80.1 million per year.

Reagents represents the largest operating cost category (44.5%), then labour (19.3%) followed by operating consumables (7.7%) and maintenance (7.6%%). A breakdown of the costs is shown in Table 21.3.

LOM Operating Cash Cost		
Costs		
Lime	US$/t LCE	438
Soda Ash	US$/t LCE	989
Electricity	US$/t LCE	169
Natural Gas	US$/t LCE	189
Operating Consumables	US$/t LCE	247
Packaging	US$/t LCE	75
Labour	US$/t LCE	620
Maintenance	US$/t LCE	243
Camp	US$/t LCE	136
Freight & Customs	US$/t LCE	19
G&A	US$/t LCE	80
Total Operating Costs	US$/t LCE	**3,206**
Cost Breakdown		
Variable Costs	US$/t LCE	1,691
Fixed Costs	US$/t LCE	1,514
Total Operating Costs	US$/t LCE	**3,206**

Table 21.3: Estimated Operating Cost by Category

21.8 Comments on Capital and Operating Costs

The total capital cost estimate is US$376 million, consisting of US$347 million in direct capital costs and US$29 million in indirect capital costs. This represents an increase over the US$330M estimated in late 2019. This is attributable to additions to the project scope (camp, roads, and water supply increases) and the lengthy delays incurred due to Covid-19.

Total operating cash costs are estimated at US$3,206/dmt of lithium carbonate produced. This cost represents an improvement on pre-covid estimates due to more favourable consumable unit rates.

22 ECONOMIC ANALYSIS

Certain information and statements contained in this section and in the report are “forward looking” in nature. Actual events and results may differ materially from those described in the forward-looking statements because of a variety of risks, uncertainties and other contingencies including business, economic, political, competitive and social factors.

Forward-looking statements include, but are not limited to, statements with respect to the economic and study parameters of the Project; Brine Resource and Brine Reserve estimates (including, but not limited to, geological interpretation, grades, extraction and mining recovery rates, hydrological and hydrogeological assumptions); the cost and timing of any development of the Project; dilution and extraction recoveries; processing method and rates and production rates; projected metallurgical recovery rates; infrastructure requirements; capital, operating and sustaining cost estimates; the projected life of mine and other expected attributes of the Project; the net present value (NPV) and internal rate of return (IRR) and payback period of capital; capital estimates and operating costs; commodity prices; the timing of the environmental assessment process; changes to the Project configuration that may be requested as a result of stakeholder or government input to the environmental assessment process; government regulations and permitting timelines; estimates of reclamation obligations; requirements for additional capital and environmental risks.

All forward-looking statements in this Report are necessarily based on opinions and estimates made as of the date such statements are made and are subject to important risk factors and uncertainties, many of which cannot be controlled or predicted. Material assumptions regarding forward-looking statements are discussed in this Report, where applicable. In addition to, and subject to, such specific assumptions discussed in more detail elsewhere in this Report, the forward-looking statements in this report are subject to the following general assumptions:

- There being no significant disruptions affecting the timelines for development and operation of the Project;
- The availability of certain consumables and services and the prices for key supplies being consistent with those for existing operations;
- Labour and materials costs being consistent with those for existing operations;
- Permitting and arrangements with stakeholders being consistent with current expectations as outlined in the Report;
- All environmental approvals, required permits, licences and authorizations being obtained from the relevant governments and other relevant stakeholders within the expected timelines indicated in the Report; and
- No material changes in applicable royalties, foreign exchange or tax rates (including tax treatment) applicable to the Project.

22.1 Methodology Used

The financial evaluation is based on a discounted cashflow (DCF) model. The DCF approach involves estimating net annual free cash flows by projecting yearly estimated revenues and subtracting yearly estimated cash outflows such as:

- operating costs, including production costs;
- G&A costs and associated maintenance costs;
- initial and sustaining capital costs; and
- taxes and royalties.

These net cash flows are discounted back to the valuation date using a real, after-tax discount rate of 10%, and then added to determine the net present value (NPV) at the 10% discount rate (NPV10) of the Project. The 10% discount rate reflects Allkem's estimated cost of capital. There are no additional project or country-specific risk factors, or adjustments considered. For the purposes of discounting, the model assumes that all revenues, operating and capital costs, taxes, and resulting free cash flows occur at the end of each month.

The DCF model is constructed on a constant fourth quarter 2021 US$ basis and none of the inputs or variables are escalated or inflated. The primary outputs of the analysis all on a 100% Project basis are:

- NPV10;
- internal rate of return (IRR);
- payback period;
- annual earnings before interest, taxes, depreciation and amortization (EBITDA); and
- annual free cash flow (FCF)

22.2 Financial Model Parameters

Overview

The financial model is based on the following key Project assumptions:

- The production schedule (comprised of annual brine production, pond evaporation rates, process plant production, ramp up schedule), plant recoveries, lithium grades, and the operating, capital and closure costs;
- A 40-year operating life;
- Operating costs from wellfields, evaporation ponds, process plant, waste removal, site-wide maintenance and sustaining costs, environmental costs, onsite infrastructure and service costs and all labour costs including contractors; and
- Product sales are assumed to be FOB South America.

Production Rate

Average annual lithium carbonate production is anticipated to be 25,000 t/year for the expansion part of the project, from an average annual wellfield head grade of 0.067% Lithium.

Process Recoveries

The basis for the process recoveries is included in Section 13, and the process design is outlined in Section 17.

Capital and Operating Costs

The capital and operating cost estimates are detailed in Section 21.

Royalties

Total Life of Mine royalties, export duties, net of incentives, are estimated to be US$492M.

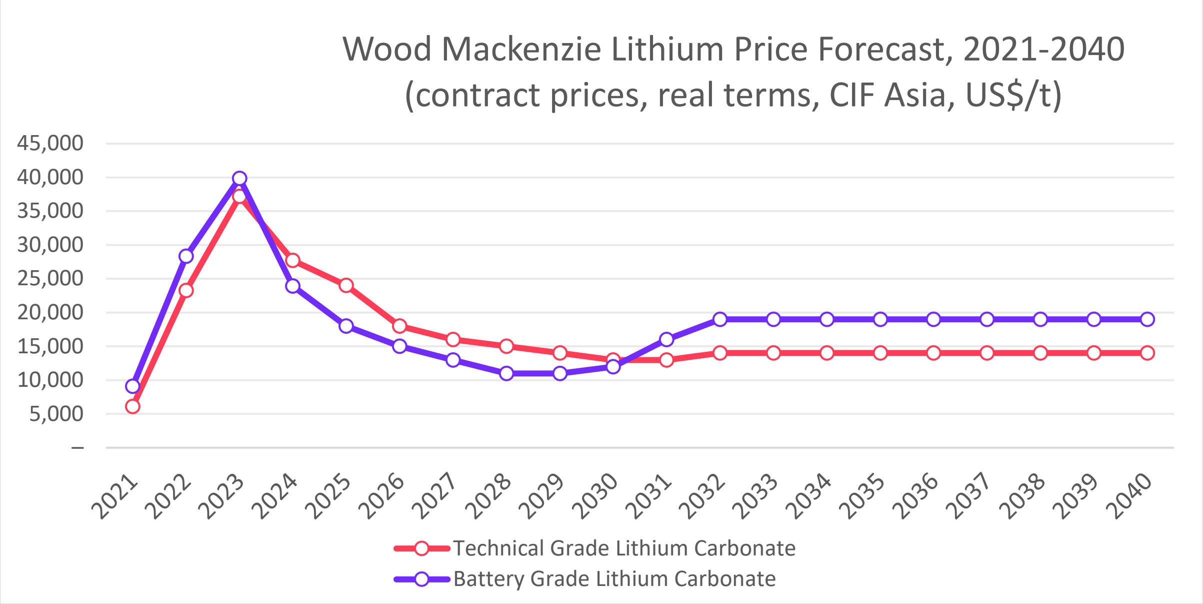


Figure 22.1: Estimated future prices

Taxes

The Corporate Tax Rate is set at 35%.

Closure Costs and Salvage Value

Allkem currently estimates US$28.6 million as the rehabilitation cost for the Project.

Financing

The base case economic analysis assumes 100% equity financing and is reported on a 100% project ownership basis.

Inflation

The base case economic analysis assumes constant prices with no inflationary adjustments.

22.3 Economic Evaluation Results

The key outcomes include:

- The Olaroz Stage 2 Expansion Project is expected to support a production rate of 25,000 t/yr of lithium carbonate for approximately 40 years, producing approximately 960,552 dmt of saleable product
- Saleable product is expected to be technical grade;
- Pre-tax net present value is US$2,674 million at a 10% discount rate;
- Post tax net present value is US$1,704 million at a 10% discount rate; and

- At full production rates, the Project is estimated to generate average annual revenues of US$347 million and operating cash flow before interest and tax of US$155 million.
- The LOM operating cost is estimated at US$3,206/t Li2CO3 produced

The key metrics are summarized in Table 22.1. Summary of LOM annual financial projection.

Summary Economics		
Production		
LOM	yrs	40
First Production	Date	H2 CY22
Ramp Up	months	12-18
Capacity	tpa	25,000
Investment		
Development Capital Costs	US$m	376
Development Capital Intensity	US$/tpa Cap	15,036
Cash Flow		
Operating Costs	US$/t LCE	3,206
Avg Sale Price (TG)	US$/t LCE	14,440
Wood Mackenzie 1Q 2022		
Financial Metrics		
NPV @ 10% (Pre-Tax)	US$m	2,674
NPV @ 10% (Post-Tax)	US$m	1,704
NPV @ 8% (Post-Tax)	US$m	2,051
IRR (Pre-Tax)	%	192%
IRR (Post-Tax)	%	137%
Payback from production start	yrs	1.7
Tax Rate	%	35%

Table 22.1: Summary Economics

A sensitivity analysis was performed on commodity price, production, capital costs and operating costs to illustrate the impact on the project's NPV and IRR.

Table 22.2 shows the impact of changes in key variables on the Project's post-tax NPV10.

Sensitivity analysis indicates that the project is economically viable even under very unfavourable market (regarding price, costs, and investment) and production conditions.

The combined effect of changes in key variables has not been modelled.

Comments on Economic Analysis

Under the assumptions described in this report, the project shows positive economics.

Project Unlevered NPV, 10% Real discount rate sensitivity							
Driver variable	**Base Data**		**Project NPV (US$ M)**				
			-25%	**-10%**	**Base**	**+10%**	**+25%**
Price	US$/Tonne	$14,440	1,118	1,470	1,704	1,939	2,291
Production	Tonne/Year	25,000	1,181	1,495	1,704	1,913	2,227
Capex	US$ M	$376	1,739	1,718	1,704	1,690	1,669
Opex	US$/Tonne	$3,206	1,826	1,753	1,704	1,656	1,583

Table 22.2: Project unleveraged NPV

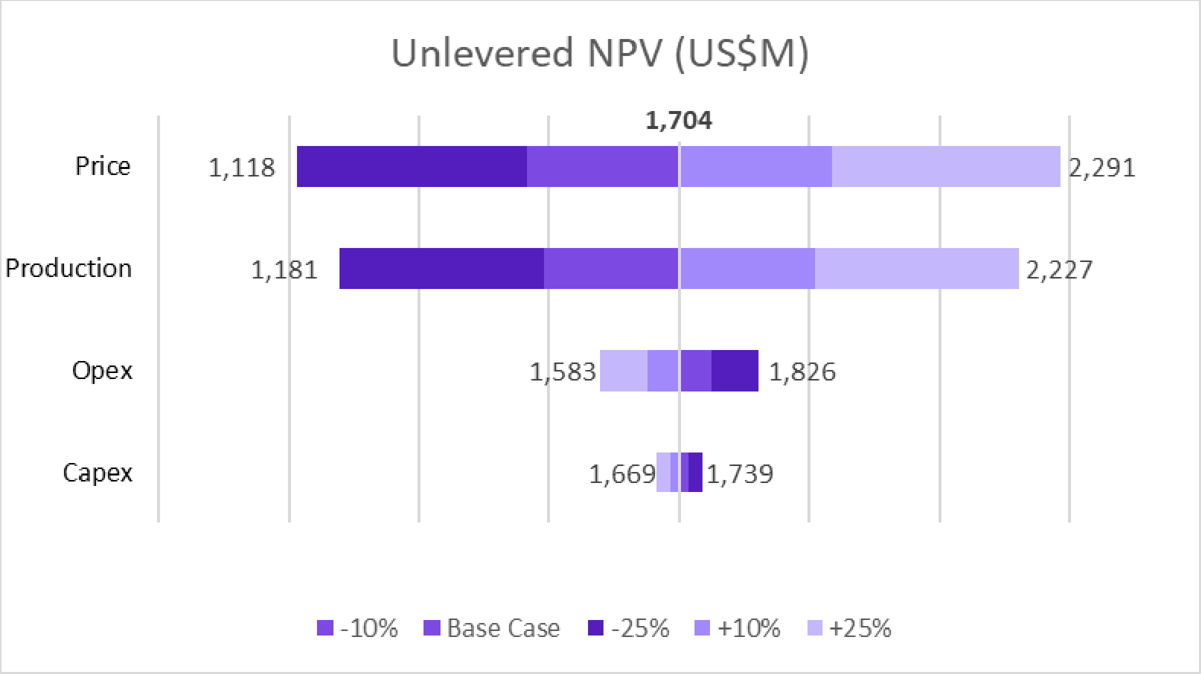


Figure 22.2: Sensitivity chart

Project After-tax IRR 10% Real discount rate sensitivity							
Driver variable	**Base Data**		**Project IRR**				
			-25%	**-10%**	**Base**	**+10%**	**+25%**
Price	US$/ Tonne	$14,440	100.9%	122.8%	136.8%	150.5%	170.7%
Production	Tonne/ Year	25,000	103.7%	123.8%	136.8%	149.5%	168.3%
Capex	US$ M	$376	173.1%	149.2%	136.8%	126.3%	113.3%
Opex	US$/ Tonne	$3,206	142.3%	139.0%	136.8%	134.5%	131.2%

Table 22.3: Shows the impact of changes in key variables on the Project's IRR

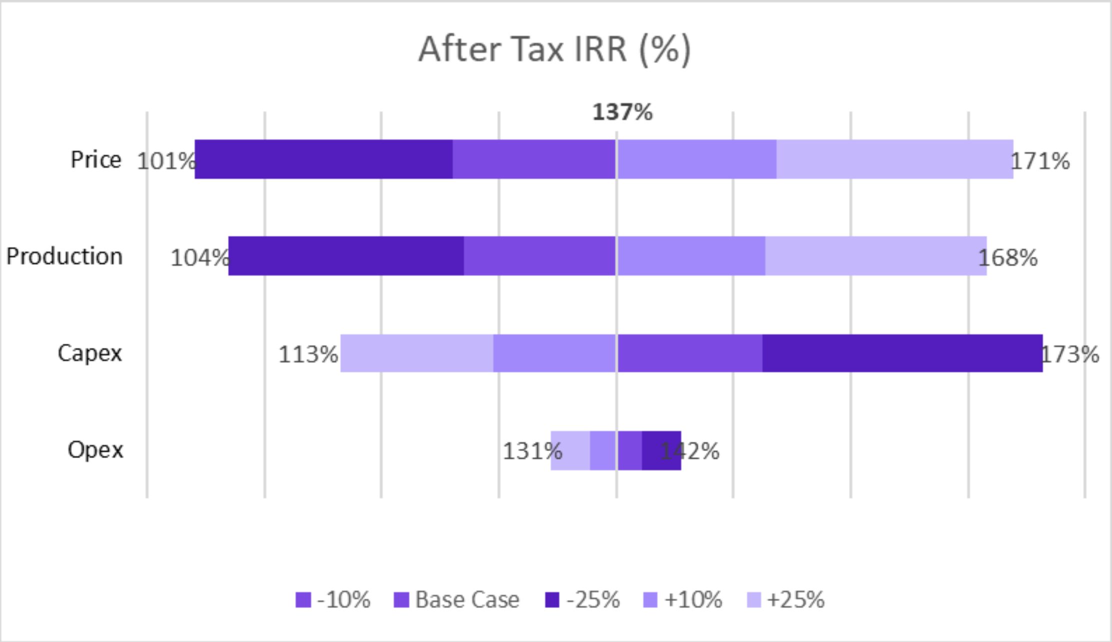


Figure 22.3: Sensitivity chart

23 ADJACENT PROPERTIES

23.1 General Comments

The Olaroz Project is located directly adjacent to two other lithium Olaroz Projects, the Cauchari lithium Project (100% owned by Allkem) is located to the south. The Cauchari-Olaroz development Project owned by Lithium Americas Corp., in joint venture with major Chinese lithium producer Ganfeng, is located to the east and south of SdJ properties.

23.2 Advantage Lithium

The Cauchari Project was explored by Advantage Lithium (Advantage), a Canadian listed company. Advantage undertook an extensive drilling program on the Cauchari properties in joint venture with Orocobre (now Allkem). Exploration included drilling 29 mostly HQ diamond holes, with the installation of 5 test production wells and additional monitoring wells, to further evaluate sub-surface conditions and undertake pumping tests to determine the hydraulic parameters of the aquifers in the Cauchari Project. Electrical geophysics was undertaken around the margins of the Cauchari salar to define the interface between brine and fresh to brackish water in alluvial fans.

Pumping tests were undertaken in the five test production wells, establishing the likely extraction rates in different areas of the salar.

A resource estimate was undertaken for the Olaroz Project, which assessed that the Cauchari Project contains 4.8 Mt of lithium carbonate as Measured and Indicated resources and 1.5 Mt of lithium carbonate as Inferred resources. These resources are included in the western and eastern properties directly south of Olaroz.

A reserve was subsequently defined for the Cauchari Project, following the development of a groundwater model. This was calibrated in steady state mode and in transient mode, using data from the pumping tests conducted in different areas of the salar. The reserve is 1 Mt of lithium carbonate, to be extracted over a 31 year mine life from the Western and Eastern properties in Cauchari. The reserve does not account for losses in evaporation ponds and in the production plant.

	Measured (M)	Indicated (I)	M+I	Inferred
Lithium Carbonate (LCE) kt	1,850	2,950	4,800	1,500
Potash (KCl) kt	5,400	9,600	14,900	4,600

Table 23.1: Allkem Cauchari (Advantage lithium) Project Mineral Resources expressed as LCE and potash (kt). Reported on November 29, 2019, in the NI 43-101 report Prefeasibility study of the Cauchari JV Lithium Project.

- QP Frits Reidel of Flow Solutions Chile (now Atacama Water)
- Lithium is converted to lithium carbonate (Li_2CO_3) with a conversion factor of 5.32.
- Potassium is converted to potash with a conversion factor of 1.91.
- Numbers may not add due to rounding.

Category	Years	Brine Vol (Mm^3)	Average Li concentration (mg/L)	Li metal (kt)	LCE (kt)
Proven	1 - 7	75	560	42	223
Probable	8 - 31	317	470	149	793
Total	**1 - 31**	**392**	**480**	**191**	**1,016**

Table 23.2: Allkem Cauchari reserves (Advantage lithium) Project Mineral Resources expressed as LCE and potash (kt). Reported on November 29, 2019, in the NI 43-101 report Prefeasibility study of the Cauchari JV Lithium Project.

- The QP for this Reserve Estimate is Frits Reidel, CPG
- The effective date of the Reserve Estimate is 15 September 2019.
- The Lithium Reserve Estimate represents the lithium contained in the brine produced by the wellfields as input to the evaporation ponds. Brine production initiates in Year 1 from wells located in the NW Sector. In year 9, brine production switches across to the SE Sector of the Project.
- The PFS wellfield configuration maintains LOM Li concentrations from all pumping wells above 350 mg/L, which is considered a practical cut-off grade for the lithium reserve estimate.
- Approximately 21 percent of M+I Resources are converted to Total Reserves.
- Potential environmental effects of pumping have not been comprehensively analysed at the PFS stage. Additional evaluation of potential environmental effects will be done as part of the next stage of evaluation.
- Mineral Reserves are derived from and included within the M&I resources. Incidental brine pumped from Inferred Resources is not included as reserves.
- Additional Indicated Resources of 168.000 tons of Li metal contained in the West Fan Unit are not included in the Reserve Estimate nor the PFS LCE production profile.
- There is a reasonable prospect that through additional hydrogeological test work Inferred Resources in the Lower Sand unit can be converted to M+I Resources.

23.3 Lithium Americas- Ganfeng

Lithium Americas Corp (LAC) owns mineral properties immediately adjacent to the Cauchari mineral properties held by Allkem. In 2018 LAC announced a strategic investment and increased ownership by Ganfeng to advance its Cauchari-Olaroz Project. Ganfeng and LAC currently have ownership in the Cauchari-Olaroz Project of 44.8% LAC, and 46.7% Ganfeng Lithium, with 8.5% held by JEMSE (the Jujuy provincial mining agency).

Development work is underway to construct the Cauchari-Olaroz Project with initial planned production and ramp up to production of 40,000 tpa of LCE to commence in mid-2022. In March 2019 LAC announced an expansion of Measured and Indicated Resources to 16.3 Mt (LCE), with an additional 4.7 Mt (LCE) of Inferred resource. Probable and Proven Reserves are estimated at approximately 1.95 Mt of LCE, taking account of a processing efficiency of 53.7%.

Category	Average Lithium Grade (mg/l)	Brine (m^3)	Lithium Metal (Tonnes)	LCE (Tonnes)
Measured	591	1.1×10^9	667,800	3,554,700
Indicated	592	5.2×10^9	3,061,900	16,298,000
Measured & Indicated	**592**	**6.3×10^9**	**3,729,700**	**19,852,700**
Inferred	592	1.5×10^9	887,300	4,772,700

Table 23.3: Lithium Americas/Ganfeng Cauchari resources

Notes

1. The Mineral Resource Estimate has an effective date of May 7, 2019 and is expressed relative to the Resource Evaluation Area and a lithium grade cut-off greater than or equal to 300 mg/l.
2. LCE is calculated using mass of LCE = 5.322785 multiplied by the mass of Lithium Metal.
3. Calculated brine volumes only include Measured, Indicated and Inferred Mineral Resource volumes above cut-off grade.
4. The Mineral Resource Estimate has been classified in accordance w ith CIM Mineral Resource definitions and best practice guidelines.
5. Comparisons of values may not add due to rounding of numbers and the differences caused by use of averaging methods.

					Without Process Efficiency	Assuming 53% Processing Efiiciency	
Category	Years	Average Lithium Grade (mg/l)	Brine (m^3)	Lithium Metal (Tonnes)	LCE (Tonnes)	Lithium Metal (Tonnes)	LCE (Tonnes)
Proven	1 - 5	616	1.6×10^7	96,650	514,450	51,900	276,250
Probable	6 - 40	606	9.6×10^8	586,270	3,120,590	314,830	1,675,770
Total	**40**	**607**	**1.1×10^9**	**682,920**	**3,635,040**	**366,730**	**1,952,020**

Table 23.4: Lithium Americas/Ganfeng Cauchari reserves

The information above is taken from the company's technical report entitled "Updated Feasability Study and Mineral Reserve Estimation to Support 40,000 tpa Lithium Carbonate Production at the Cauchari-Olaroz Salars, Jujuy Province, Argentina" dated effective September 30, 2020 and filed on SEDAR on October 19, 2020

As noted above, the SdJ Olaroz properties adjoin properties owned by LAC/Ganfeng in the west of Olaroz and in Cauchari, with additional properties in Cauchari also owned by Allkem. The mineral resources and reserves to be exploited are in brine, which is mobile and reacts to pumping from the host sediments. It is highly likely that wells located near the borders of properties will extract brine across these borders. This creates the potential for legal disagreements between the companies, which share the mineral resources contained in the continuous aquifer beneath the Olaroz and Cauchari salars.

The challenge of adjoining mineral properties with mobile resources beneath them often occurs in oil and gas production, where it is solved via “unitization agreements” among the area concessionaries. Unitization agreements are widespread in the oil and gas industry, including in Argentina. As part of the exploitation of lithium brine in the Olaroz-Cauchari salars it may become necessary for the companies involved to establish an agreement of this type to manage extraction.

24 OTHER RELEVANT DATA AND INFORMATION

No relevant information

24.1 INTERPRETATION AND CONCLUSIONS

Basin Geology

Deeper drilling to support the Stage 2 Olaroz Project expansion has been to depths between 450 and 650 metres, depending on location within the basin. This deeper drilling has confirmed that deposition of coarser grained higher porosity and permeability sediments has been principally from the western side of the basin.

The deeper drilling has confirmed the Olaroz Basin extends to greater than 1400 m in the deeper part of the basin. Drilling to date has not intersected the underlying basement rocks in the basin, confirming the extensive volume of brine saturated sediments present.

Drilling has confirmed that a simplified five unit hydrostratigraphic model is sufficient to represent the sediments in the salar to the depths currently explored. The lower unit contains a higher sandy content and supports high flow rates, which have been confirmed by pumping since 2016 and in more recent deeper wells. There are no significant changes in brine chemistry identified in the deeper drilling, with similar lithium and other element concentrations and key chemical ratios.

An extensive area north of the current day salt lake surface, beneath alluvial sediments around the side of the basin and the Rosario Delta sediments, is highly prospective for the definition of additional brine resources. However, no drilling (beyond several 54 m deep sonic holes) has been drilled in this area, which will be a future focus of exploration.

Resources

Despite the limited diamond drilling and brine interval sampling below 200 m depth, pumping wells installed to depths up to 450 m and pumping since 2016 confirm the brine quality and flow rates in the deeper parts of the salar. Drilling for the Stage 2 expansion has been between 450 and 650 m depth. These holes were geologically and geophysically logged and a robust stratigraphy has been established for the basin.

The resource was estimated based on a combination of the interval sampling in the upper 200 m and the pumping well data below this depth.

The Qualified Persons consider the salar geometry and geology, brine quality and sediment specific yield have been defined sufficiently to support the classification of the resource as Measured, Indicated and Inferred resources.

Reserves

A numerical groundwater flow and transport model has been developed for the Olaroz Project to simulate the proposed brine production over a 40 year mine life. This will be updated with information from additional drilling for the Stage 2 expansion and used to prepare a lithium reserve estimate.

25 RECOMMENDATIONS

The authors recommend the planned diamond drilling program is completed and monitoring wells are installed across the salar for ongoing monitoring of brine levels and brine concentrations. Subsequent diamond drilling should be conducted in the area of the potential Phase 3 expansion, prior to installation of any production wells in that area.

All drill holes should be geophysically logged to obtain the maximum possible information from drilling and to assist geological correlation. Physical porosity samples should continue to be taken for comparison with BMR geophysical logs.

Monitoring well installation should include installation of wells at different depths, to improve the understanding of the distribution of piezometric heads around the salar.

Once additional exploration drilling and installation of Stage 2 production wells has been completed the geological model should be updated to reflect the improved understanding from this additional drilling. The Olaroz Project resource should also be updated at this point, to reclassify additional resources as Measured and Indicated, based on increased geological confidence.

Additional pumping test wells should be installed in the area of expanded exploration drilling, to provide information on aquifer conditions. Once pumping tests and the resource model are updated the Olaroz Project groundwater model should be re-calibrated with the additional data and used to define a mineral reserve and the Olaroz Project production schedule should be updated.

Regular analyses of groundwater samples should be undertaken in external laboratories, to complement the independent laboratory check sampling carried out by the Olaroz laboratory.

Ongoing water level monitoring should establish the changes, if any, of the commencement and ongoing operation of pumping by the LAC/Ganfeng Cauchari Olaroz Project.

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27 QP STATEMENTS

I, Murray Brooker, M.Sc., Geol., M.Sc. Hydro, do hereby certify that:

1 I am an independent consultant of: 63 Carlotta St, Greenwich, NSW 2065, Australia.

2. I have the following academic and professional qualifications:

Academic:

I. B.Sc. (Honours) in Geology from Victoria University of Wellington, New Zealand in 1988
II. M.Sc. in Geology from James Cook University of North Queensland, Australia, in 1992
III. M.Sc. in Hydrogeology from the University of Technology, Sydney, Australia, in 2002.

Professional:

I. Australian Registered Professional Geoscientist (RPGeo) in the fields of mineral exploration and hydrogeology
II. Member of the Australian Institute of Geoscientists (MAIG)
III. Member of the International Association of Hydrogeologists (MIAH)

3. I have practiced my profession for thirty years.

4. I have read the definition of “qualified person” set out in National Instrument 43-101 (“NI 43-101”) and certify that by reason of my education, past relevant work experience, and affiliation with a professional association (as defined in NI 43-101) I fulfil the requirements to be a “qualified person” for the purposes of NI 43-101. This report is based on my personal review of information provided by the Issuer and on discussions with the Issuer’s representatives. My relevant experience for the purpose of this report is:

- 2010-Present Principal Hydrominex Geoscience Consultants
- 2006-2010 Principal Geoscientist – Global Ore Discovery – Mining Industry Consultants
- 2004-2006 Acting Manager Hydrogeology – Parsons Brinckerhoff.
- 2003-2004 Hydrogeologist, Otek Environmental
- 2002-2003 Hydrogeologist, Parsons Brinckerhoff
- 1991-2000 Exploration Geologist and Exploration Manager, North Limited, Argentina, Chile, Mexico, Australia

I have previously been involved in the following brine resource Olaroz Projects:

- Olaroz for Orocobre, Argentina (2010 to present);
- Cauchari for Advantage Lithium and Orocobre from 2016-2019;
- Salar Salinas Grandes for Orocobre, Argentina (2010-2013);
- Salar de Centenario (2011, 2016-2021) for Lacus Minerals and Lithium Power International;
- Salar de Pocitos (2011, 2016) for Lacus Minerals and Argosy Minerals;
- Salar de Maricunga for Lithium Power International, Argentina (2016-2021);
- Salar de Hombre Muerto (various parties (2018-2021);
- Lake Mackay, Western Australia for Agrimin (2015-2016); and
- Numerous other salt lake Olaroz Project due diligence and consulting assessments in Argentina, Chile and Australia.

5. I am responsible for the technical report entitled “Technical Report Olaroz resource update, Jujuy Province, Argentina” (the “Technical Report”) prepared for Allkem and dated effective 4 April, 2022.

6. I am independent of Orocobre. I have previously visited the Olaroz Project area many times but due to Covid travel restrictions have not visited the site as part of the preparation of this report.

7. As of the date of this certificate, to the best of my knowledge, information and belief, the Technical Report contains all scientific and technical information that is required to be disclosed to make the Technical Report not misleading.

8. I have read NI 43-101 and Form 43-101F1 (the “Form”), and the Technical Report has been prepared in compliance with NI 43-101 and the Form. I have no personal knowledge, as of the date of this certificate, of any material fact or material change which is not reflected in this Technical Report

Effective Date: 4 April 2022
Date of Signing: 4 April 2022

M R. Brooker

Original signed and sealed
(Signed) “Murray Brooker”

REGISTERED PROFESSIONAL GEOSCIENTIST
AUSTRALIAN INSTITUTE OF GEOSCIENTISTS
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NI 43-101 Technical Report.

I, Michael J. Gunn, am an independent consultant based in Brisbane, Queensland, Australia, and am a registered Fellow of the Australasian Institute for Mining and Metallurgy, member number 101634.

This certificate applies to the technical report titled “OLAROZ RESOURCE UPDATE APRIL 2022, NI 43- 101 Technical Report” with an effective date of April 4th, 2022 (the “technical report”).

I graduated from the University of New South Wales with a Bachelor degree in Applied Science (Metallurgy) in 1975, and I have practiced my profession for 46 years. I have been directly involved in the testwork, design, commissioning, operation and management of numerous process plants, including plants for the extraction of lithium from salar brines, and the technical review of many lithium and potash projects.

As a result of my experience and qualifications, I am a Qualified Person as defined in National Instrument 43-101 *Standards of Disclosure for Mineral Projects* (NI 43-101) for those sections of the technical report that I am responsible for preparing.

I have been involved with the Olaroz project during the period 2011 to present. I have not visited the Olaroz project area since 2020, due to the Covid restrictions introduced by the Australian and Argentinean governments.

I am responsible for sections 1, 2 and 3 (in part with other authors), 13, 17, 18, 19, 21, 22, and 25, 26 and 27 (in part with other authors) of the technical report.

I am independent of Allkem and Galaxy Lithium as independence is described in Section 1.5 of NI 43-101. I have read NI 43-101 and the sections of the technical report for which I am responsible have been prepared in compliance with that instrument, and certify that by reason of my education and past relevant work experience, I fulfill the requirements to be a Qualified Person for the purposes of NI 43-101.

As of the effective date of the technical report, to the best of my knowledge and the information provided, the sections of the technical report for which I am responsible disclose sufficient scientific and technical information that the technical report is not misleading.

Dated the 4th day of April 2022.

Michael Gunn

Michael J. Gunn

B.App.Sc.(Metallurgy), FAusIMM.

28 APPENDICES

No Appendices included