

# THE GEOLOGICAL SETTING OF THE JULIENNE LAKE IRON-ORE DEPOSIT, WESTERN LABRADOR

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## ABSTRACT

*The Julienne Lake iron-ore deposit is located ca. 32 km by road north of the town of Wabush, on a peninsula between Wabush Lake to the west and Julienne Lake to the east. The deposit has been recognized as a major potential iron-ore deposit since the 1950s, and recent exploration by the Provincial Government has outlined a geological resource of 1166 Mt of ore grading at approximately 33% Fe. Recent logging of 11 diamond-drill holes and related fieldwork have been used to document the geology and structural evolution of the Julienne Lake Deposit. The main economic rock unit is coarse-grained, friable quartz-specularite schist, which is variably altered to hematite, goethite and limonite. This quartz-specularite schist is interbedded with thin (generally less than 5 m) layers of white quartzite and Mn-rich iron formation. The quartz-specularite schist conformably overlies a thin unit of strongly altered and brecciated iron formation (lower iron formation), which, in turn, overlies the lean quartzites of the Wishart Formation.*

*Structurally, the Julienne Lake Deposit is complex, recording multiple episodes of folding and faulting. Based on variations in structural complexity, lithology, and alteration, the deposit has been subdivided into a southwestern and northeastern zone. The southwestern zone is interpreted as an overturned syncline having a maximum thickness of iron formation of 320 m. The northeastern zone is more structurally complex, with complicated folding and thrust repetition responsible for thickening of the iron formation to >575 m. This zone is also characterized by more intense alteration and presence of Mn-rich iron formation.*

*Comparisons with other iron deposits in the Labrador City/Wabush region have recognized similarities between the Julienne Lake Deposit and the Scully Mine and the Rose North Deposit (Kamistiatussset project). These deposits may represent a single continuous basin (termed the Wabush Basin), which formed in the same geological environment and underwent a similar metamorphic and post-metamorphic history.*

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## INTRODUCTION

### OVERVIEW

The Labrador Trough is located in western Labrador and northeastern Québec and contains several world-class iron-ore deposits. Several large coarse-grained metamorphosed iron deposits (metataconites) are located in the Labrador City/Wabush area, and have been mined continuously since the 1960s. Current production comes from Carol Lake (Humphrey Main and Luce deposits) and the Scully Mine in Labrador and Mont-Wright and Bloom Lake in adjacent Québec. In addition, exploration in the 1950s and 1960s identified a number of other potential iron-ore deposits in the Labrador Trough that have become the focus of renewed exploration since 2008, in response to high iron-ore prices (>\$100/tonne) and strong demand from the Asian economies.

The Julienne Lake iron-ore deposit, which was first identified by the Newfoundland and Labrador Company (Nalco) in 1953, is one of the largest undeveloped iron-ore deposits in the region. It is located north of Labrador City/Wabush, on a peninsula between Wabush Lake to the west and Julienne Lake to the east (Figure 1). It is situated 32 km by road from the town and mine site of Wabush and 16 km from the nearest point on the Québec North Shore & Labrador (QNS&L) railway. Exploration from the 1950s to the 1970s indicated a historical resource of 508 million tonnes (Mt) at 34.2% Fe, and having low manganese contents. In 1975, the rights to the deposit reverted to the Crown under the Julienne Lake Deposit (Reversion Act) 1975 and the property was made an Exempt Mineral Land (EML). Due to the increased exploration interest in iron ore, the Provincial Government conducted a diamond drilling, ground magnetometer and trenching program and preliminary metallurgical study in 2010, to define the deposit to the

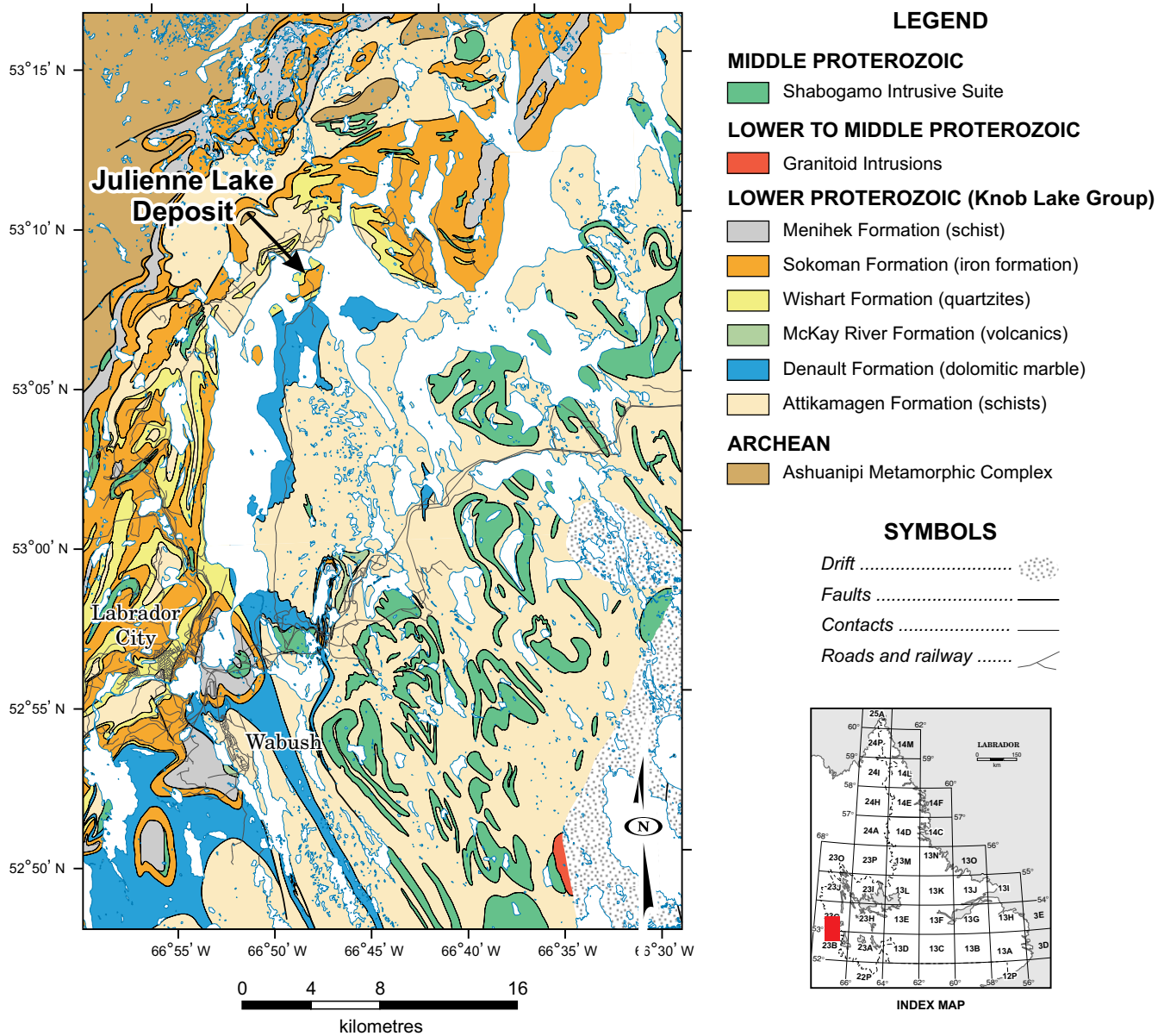


Figure 1. Regional geological map of the area around the Julienne Lake Deposit (after Rivers and Massey, 1985).

level of NI 43-101 compliant indicated and measured resources, establish a reliable 3-D geological model and generate preliminary pit designs. The results of this study were publically released in October 2012, having a geological resource estimate of 1166 Mt grading approximately 33% Fe, including a measured and indicated resource of 867 Mt at 33.7% Fe.

In 2012, the Geological Survey of Newfoundland and Labrador undertook a re-evaluation of all data from the Julienne Lake Deposit. Field work in 2012 focused on the examination of archived drillcore from the 2010 drilling program. In total, 11 diamond-drill holes were re-logged

(cumulative length 2955 m; Table 1) and samples were collected for petrographic and geochemical analysis. Related field work was conducted on the Julienne Lake peninsula, including mapping and sampling of outcrops and exposed trenches. The main goals of these activities were to document the geology, alteration and structural evolution of the Julienne Lake Deposit, and to compare it with other iron-ore deposits in the Labrador City/Wabush area. This contribution provides a progress report, including discussions on the current understanding of the geology and structural evolution of the deposit. Petrography, geochemical and other aspects of research are ongoing, and these should provide further insights into the Julienne Lake Deposit.

**Table 1.** List of 2010 drillholes logged during this project

Drillhole ID	Section	Length (m)	Collar Coordinates UTM Zone 19, NAD 83		Collar Dip	Azimuth
			Easting (m)	Northing (m)		
JL10-01	L1800E	300	648456.886	5889290.13	-90	0
JL10-01A	L1800E	293	648496.4	5889516.65	-50	150
JL10-05+EXT	L1800E	575	648413.64	5889363.825	-90	0
JL10-08	L1800E	302	648341.7	5889493.925	-90	0
JL10-11A+EXT	L1800E	355	648266.39	5889624.635	-90	0
JL10-14	L1350E	185	648017.96	5889136.745	-90	0
JL10-15	L1800E	273	648195.36	5889753.685	-90	0
JL10-16	L1350E	182	648064.01	5889052.835	-90	0
JL10-16A	L1350E	176	648103.35	5889279.4	-50	150
JL10-17B	L1800E	181	648094.81	5889923.925	-90	0
JL10-20	L1800E	133	648055.18	5889998.785	-90	0

## REGIONAL GEOLOGY

The Labrador Trough consists of Paleoproterozoic (2.17 to 1.87 Ga; Rohon *et al.*, 1993; Findlay *et al.*, 1995; Machado *et al.*, 1997) sedimentary and volcanic rocks that extends for more than 1100 km, from the northwest corner of Ungava Bay south to Lake Pletpi (Clark and Wares, 2005). It forms the western part of a larger orogenic belt called the New Québec Orogen, which records the oblique convergence and collision of the Archean Superior Craton to the west and an Archean core zone to the east (Wardle *et al.*, 1990, 2002). The Labrador Trough largely represents a fore-land basin and comprises three sedimentary cycles, which are together referred to as the Kaniapiskau Supergroup (Zajac, 1974; Wardle and Bailey, 1981; Le Gallais and Lavoie, 1982). The lower cycle (Cycle 1) is an immature continental rift system that was deposited approximately 2.17 Ga ago, as a result of rifting on the eastern margin of the Superior Craton. Cycle 2 is a transgressive sequence that shifts from shelf-type rocks (Wishart Formation quartzites and Sokoman Formation iron formation) at the base to deeper water turbidites of the Menihék Formation at the top of Cycle 2. The alkali volcanics of the Nimish Formation are locally contemporaneous with the Wishart and Sokoman formations. In places, Cycle 2 is unconformably overlain by Cycle 3 arkosic rocks, which are interpreted as a synorogenic molasse. During the collision of the Superior Craton with the core zone between 1.82 and 1.77 Ga, these sedimentary rocks were folded and thrust westward over the Archean basement rocks.

The iron-ore deposits in the Labrador Trough are hosted in the Sokoman Formation, a 30–170-m-thick sequence of cherty iron-rich sedimentary rocks that are continuous throughout the Labrador Trough. A syenite cobble from a volcanic agglomerate in the Nimish Formation volcanics yielded a U–Pb age of  $1877.8 \pm 1.3$  Ma, and is interpreted as an approximate age for the coeval Sokoman Formation

(Findlay *et al.*, 1995). Based on geological mapping in the Schefferville area, the Sokoman Formation has been subdivided into three members (Gross, 1968; Zajac, 1974), which can be correlated throughout the Labrador Trough. The lower part of the Sokoman Formation (*lower iron formation*) consists largely of a carbonate–silicate facies with some magnetite. This grades upward into an oxide facies with abundant coarse-grained hematite and/or magnetite and sugary-textured quartz (*middle iron formation*). These Fe-oxide-rich beds are the most important economically, with iron-rich layers and lenses commonly containing more than 50% hematite and magnetite. The upper part of the Sokoman Formation (*upper iron formation*) is a carbonate–silicate facies along with minor oxides.

In the Labrador City/Wabush area, the weakly metamorphosed Sokoman Formation passes into the younger Grenville Province, within which the rocks are folded and metamorphosed. Although the essential stratigraphy of the sedimentary rocks remains discernable in the area, they have been extensively metamorphosed and deformed during the Grenville Orogeny at *ca.* 1.0 Ga (Klein, 1978; Rivers, 1983; van Gool *et al.*, 2008). Metamorphic grade in the Julienne Lake area is in the mid-amphibole facies, with peak metamorphic conditions (calculated from diagnostic mineral assemblages in semipelitic and pelitic rocks) of 570°C and 800 MPa (Rivers, 1983; van Gool *et al.*, 2008). During this metamorphism, the Sokoman Formation was extensively recrystallized to coarse-grained quartz, specular hematite, martite and magnetite, and lesser carbonate, amphibole and pyroxene (Klein, 1978).

## HISTORY OF EXPLORATION

The earliest known reference to the Julienne Lake Deposit dates back to reconnaissance geological mapping in 1953 by the Newfoundland and Labrador Company (Nalco). In conjunction with Canadian Javelin Ltd., a systematic geo-





**Plate 1.** Aerial view of the Julienne Lake Peninsula, looking south. Historic trench (T62-01) exposed on hilltop.

logical and magnetometer study was completed in 1956 and a general resource of about 275 Mt of iron ore was estimated (Gastil, 1956). From 1957 to 1958, a drilling program was completed on the property, with nine drillholes totaling 3477 ft (1060 m). However, core recovery was poor (~35%) and only three drillholes fully penetrated the iron formation (Department of Mines and Energy, 1975). In 1960, Javelin reported 'potential ore reserves' of 387 Mt at 34.2% iron, based on the nine diamond-drill holes, surface geological mapping and magnetometer surveys (Roxburgh, 1960). An area of bedrock extending across the hilltop was mechanically stripped in the summer of 1962 (Trench 62-01) and is still exposed on the property (Plate 1 and Figure 2). In 1963, Canadian Javelin Ltd. revised the resource estimate to 508 Mt grading 34.2% iron with only trace impurities (Knowles, 1963a). In addition, between 1960 and 1963 Canadian Javelin Ltd. evaluated the practicality of mining the Julienne Lake Deposit and building concentrating, pelletizing and smelting facilities. Three bulk samples (totalling ~238 tonnes) were collected and metallurgical testing on these samples indicated recoveries of 76.6% to 79.6%, and produced concentrates of 63.5% to 64.5% Fe, which were suitable for electric smelting and pelletizing iron (Knowles, 1963b).

A warehouse fire in 1966 destroyed all remaining drill-core and no further exploration was undertaken. Despite a prefeasibility study to determine costs to develop both Julienne Lake and the Star-O'Keefe (Mont Wright, QC) deposits, Canadian Javelin Ltd. was unsuccessful in attracting customers or buyers for the deposits. In 1975, the mineral rights to the deposit reverted to the Crown under the Julienne Lake Deposit (Reversion Act) 1975, due to failure by Canadian Javelin Ltd. to meet requirements of the Mining and Mineral Rights Tax Act. The property was made an

Exempt Mineral Land (EML) and has remained under that status.

In 2009, the Provincial Government initiated studies to evaluate the future potential of the Julienne Lake Deposit. Stage 1 of that process, which was completed in February 2010, consisted of a review of previous work and the development of a strategy to improve the historic resources estimates if warranted. Following that report, Stage 2 of the project was commissioned. The terms of reference of Stage 2 aimed to define the deposit to the level of NI 43-101 compliant indicated and measured resources, establish a reliable 3-D geological model to be used to generate resource models at a range of cut-off grades, and generate preliminary pit-design models.

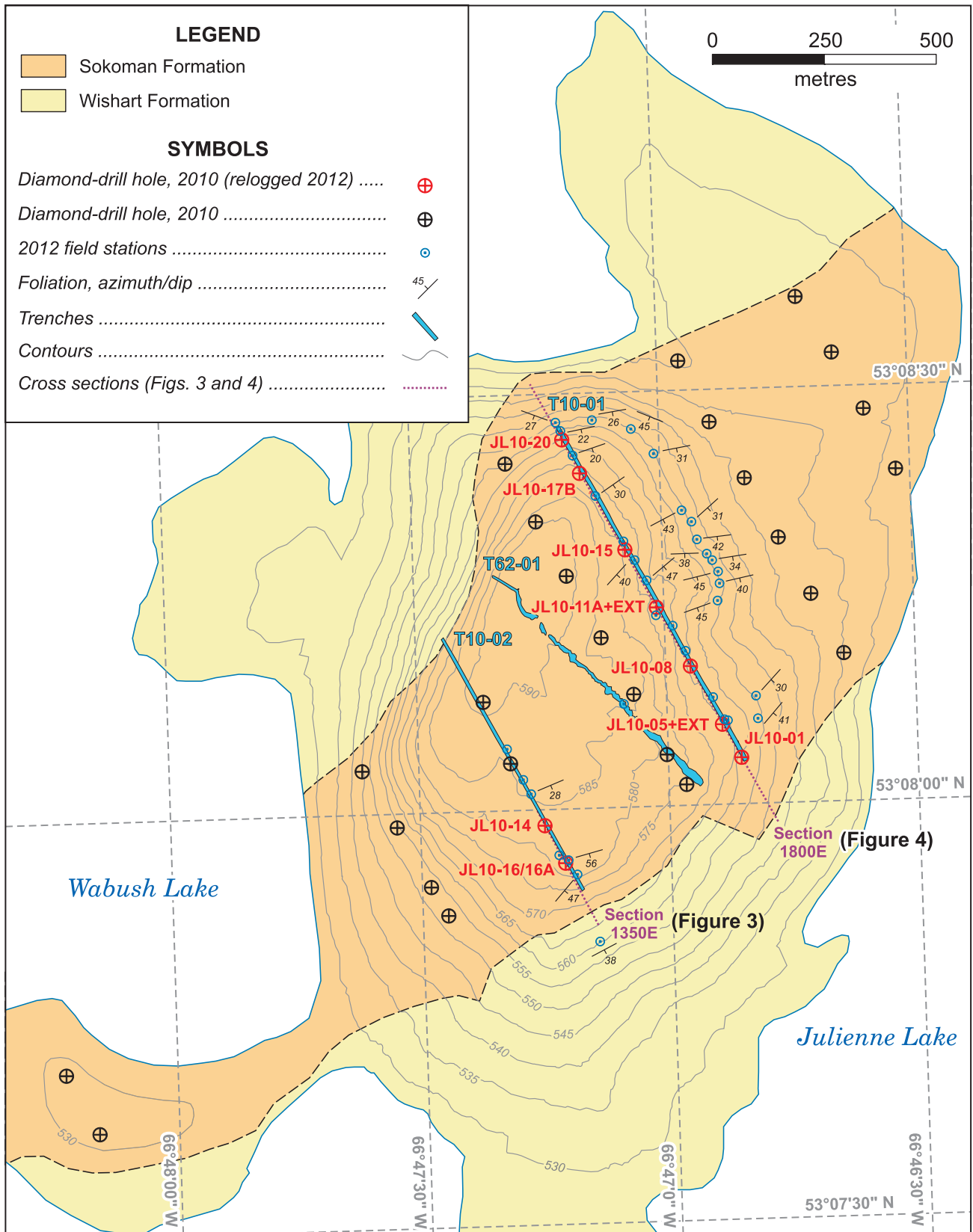
MPH Consulting Ltd. was contracted to conduct the exploration program, which began in July 2010. In total, 42 diamond-drill holes were completed with a cumulative length of 9238.3 m. Approximately 1600 m of mechanical trenching on the property was also completed along two grid-line sections (Trench T10-01 along section 1800E and trench T10-02 along section 1350E; Figure 2). These data showed that the deposit was significantly larger than previously estimated, with a total measured and indicated resource of 867 Mt at 33.7% iron and an inferred resource of 299 Mt at 34.1% iron. This included a conservative open-pit minable resource of 580 Mt grading 34% Fe, with a 100 m buffer to the bounding water bodies. Metallurgical testwork indicate that the iron ore is soft and autogenous or semi-autogenous grinding can produce a concentrate with >66% Fe and <5% silica (Coates, 2012).

In addition to the onshore portion of the Julienne Lake Deposit, airborne magnetometer surveys have shown that the iron formation continues to the east and west underneath the surrounding water bodies. Initial estimates from Canadian Javelin Ltd. estimated that projected extensions of the deposit under Wabush and Julienne lakes (outside of the EML) were 168 and 243 Mt, respectively (Knowles, 1963a). In 2011, Altius Mineral Corporation conducted gravity and Total Field Magnetic (TFM) surveys over the ice that indicate the deposit continues for approximately 1.9 km to the northeast and 900 m to the southwest of the Julienne peninsula. A 2012 winter drilling program conducted by Altius on the northeast extension has confirmed the presence of iron formation (<http://altiusminerals.com/projects/julienne>).

## GEOLOGY OF THE JULIENNE LAKE IRON-ORE DEPOSIT

### MIDDLE IRON FORMATION

The middle iron formation (*see* Regional Geology) is the principal ore-bearing formation at Julienne Lake, and all



**Figure 2.** Surface plan map of the Julienne Lake peninsula, showing main iron formation contacts and location of trenches, 2012 field stations and 2010 diamond-drill holes.

diamond-drill holes collar into the middle iron formation. Based on mineralogy and previous geochemical analysis (Coates, 2012), the middle iron formation can be subdivided into three post-metamorphic lithological units.

### Quartz–Specularite Schist

Quartz-specularite schist is the dominant rock type in the middle iron formation at Julienne Lake, making up >95% of the total thickness of iron formation in the logged drillholes. This unit is highly variable in appearance, ranging from semi-massive to well-banded iron formation and is commonly leached and friable. Previous studies have subdivided this unit into a number of separate rock types: banded semimassive specularite–quartz schist; quartz–specularite schist; quartz–specularite–granular hematite schist; and quartz–granular hematite schist (Coates, 2012). However, field observations and detailed logging of drillcore indicate that these units represent a single rock type, with varying degrees of alteration and recrystallization.

Mineralogically, this unit consists of specularite and quartz, and minor red granular hematite, goethite, limonite, and martite. Semi-massive varieties consist of almost equal proportions of coarse-grained, sugary quartz and medium- to coarse-grained specularite (Plate 2A). Banded quartz–specularite schist consists of alternating quartz-rich and specularite-rich bands (Plate 2B). In places, quartz–specularite schist grades into bands of almost pure hard blue hematite, with up to 65% Fe indicating almost pure hematite. Most such zones are thin (< 3 m) and are associated with vuggy veins of goethite and hematite, which suggests that they are associated with hydrothermal fluid enrichment. Magnetite is generally rare throughout, although several magnetite-rich horizons were identified (magnetic susceptibility measurements up to  $74.5 \times 10^{-3}$  SI). These magnetite-rich units correspond to coarser grained, martite-rich quartz–specularite schist, and most likely represent remnant magnetite remaining after the transformation of magnetite to martite.

Alteration throughout this unit ranges from minor hematization and red staining of the drillcore to intense and pervasive alteration to hematite, goethite and limonite. Zones of intense alteration are distributed through the unit, even at depths beyond 500 m. Alteration is strongest in brecciated zones or along foliations in banded quartz–specularite schist, and is most likely related to late-stage (post metamorphic) fluid flow, secondary leaching and/or deep weathering.

### Mn-rich Iron Formation

Pyrolusite-bearing Mn-rich iron formation accounts for

<2.5% of the total thickness of iron formation in the logged drillholes. This rock type has a characteristic black sooty appearance (Plate 2C), with disseminated specularite, quartz and pyrolusite and numerous pyrolusite-bearing veinlets. Manganese-rich units form thin layers (generally less than 5 m thick) with sharp upper and lower contacts (Plate 2D) and rare pyrolusite veinlets in the overlying and underlying units. Assay data show that these units have Mn contents of over >3%, with values of up to 21.2% recorded (Coates, 2012). It appears that Mn concentration in these beds is associated with hydrothermal fluid flow (supergene or surficial enrichment), and are not recorded at deeper levels (> 300 m).

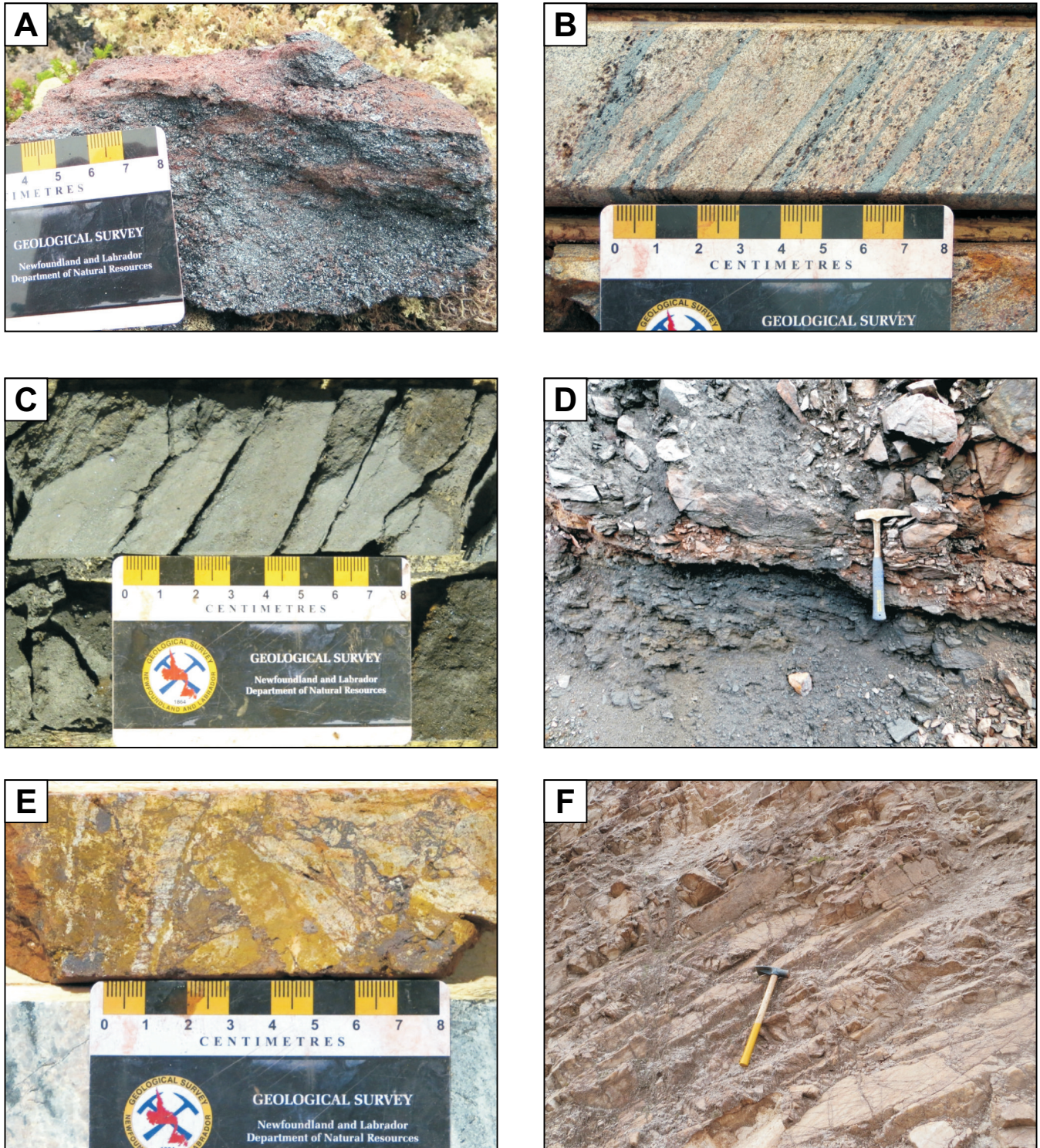
### Lean White Quartzite

Lean white quartzite makes up <3% of the total thickness of iron formation in the logged drillholes. In places, it has sharp upper and lower contacts with the overlying quartz-specularite schist, and in other places, the contact is gradational with an increase of iron content. This ferruginous whitish quartzite generally consists of 60 to 80% medium- to coarse-grained quartz, although some specularite-rich intervals were noted. Specularite is disseminated in the quartzite, or forms metallic, hematite-rich bands. Locally, stockwork-style specularite veins are recorded, which indicate some remobilization of iron, possibly during metamorphism. In places, the quartzite is also altered by late, low-temperature fluids, with abundant goethite, limonite and red hematite. A similar lean white quartzite has been reported from the Scully Deposit at Wabush Mines, where it is used as a marker horizon (Farquharson and Thalenhorst, 2006).

## LOWER IRON FORMATION

The lower iron formation (*see* Regional Geology) has been recorded at the base of the middle iron formation in all eight drillholes that fully penetrated the Sokoman (Iron) Formation. It ranges in thickness from 1.55 to 16.35 m and commonly has faulted upper and/or lower contacts. This unit is commonly strongly altered and brecciated (Plate 2E), and core recovery is generally poor. Therefore, identification of primary mineralogy is generally difficult. The best preserved sections of the lower iron formation (Hole JL10-14) consist of red hematite, quartz, goethite, limonite, and iron silicates, with rare specularite bands. Euhedral garnet pseudomorphs (replaced by hematite and limonite) have also been recorded in the lower iron formation and assay data show that this unit has higher Al contents than the middle iron formation (0.96 to 4.46%  $\text{Al}_2\text{O}_3$ ). The lower iron formation at Julienne Lake has similarities to a narrow layer of Fe-silicate-rich iron formation recorded at the Scully and Kami (North Rose) deposit, which has been referred to as the Basal Iron Silicate Unit at the Wabush Mine (Farquhar-





**Plate 2.** Photographs of representative rock types of the Julienne Lake Deposit. A) Massive, friable QS iron formation (648209E, 5890022W). B) Banded QS iron formation, with quartz-rich layers and bands of pure specularite (from JL10-16). C) Pyrolusite-bearing, Mn-rich iron formation, with typical black sooty appearance (from JL10-17B). D) Gently dipping bed of Mn-rich iron formation, from north end of Trench 10-01 (648078.E, 5889963N). E) Brecciated and strongly altered lower iron formation (from JL10-14). F) Well-bedded Wishart Quartzite in quarry south of the Julienne Lake Deposit (648141E, 5888878N).



son and Thalenhorst, 2006). This unit may also correlate with Ruth Formation in the Schefferville area.

### WISHART FORMATION

The Wishart Formation quartzite defines the footwall contact of the Sokoman (Iron) Formation at Julienne Lake, and is recorded in all drillholes that penetrate the iron formation. The quartzite is well bedded in outcrop (Plate 2F), and is strongly recrystallized to coarse-grained quartz. Thin bands of hematite and hematite staining are recorded close to the upper contact. Core recovery is poor, and the quartzite close to the contact with the iron formation is intensely leached and friable, in places consisting entirely of micaceous sand.

### STRUCTURE OF THE JULIENNE LAKE DEPOSIT

The deformational history of the Labrador City/Wabush area is complex, with multiple phases of folding and faulting. In the Schefferville area, which is unaffected by Grenvillian metamorphism, the Sokoman Formation experienced low-grade (greenschist facies) metamorphism and open- to tight-folding associated with westward thrusting over the basement rocks of the Superior Province (Wardle *et al.*, 1990, 2002). South of the Grenville Front, which is marked by the basal (most northwesterly) thrust fault of Grenvillian age (James, 1997), the sedimentary rocks of the Knob Lake Group are highly metamorphosed (upper greenschist to upper amphibolite facies; Rivers, 1983; van Gool *et al.*, 2008) and complexly folded. Van Gool *et al.* (2008) subdivided the Archean and Proterozoic rocks of the Labrador City/Wabush area in five lithotectonic domains, based on their stratigraphy and Grenvillian structure and metamorphism. The Julienne Lake peninsula is located in Domain IV, which is characterized by large-scale, open to tight, northwest-vergent  $F_2$  folds and thrust repetition (van Gool *et al.*, 2008)

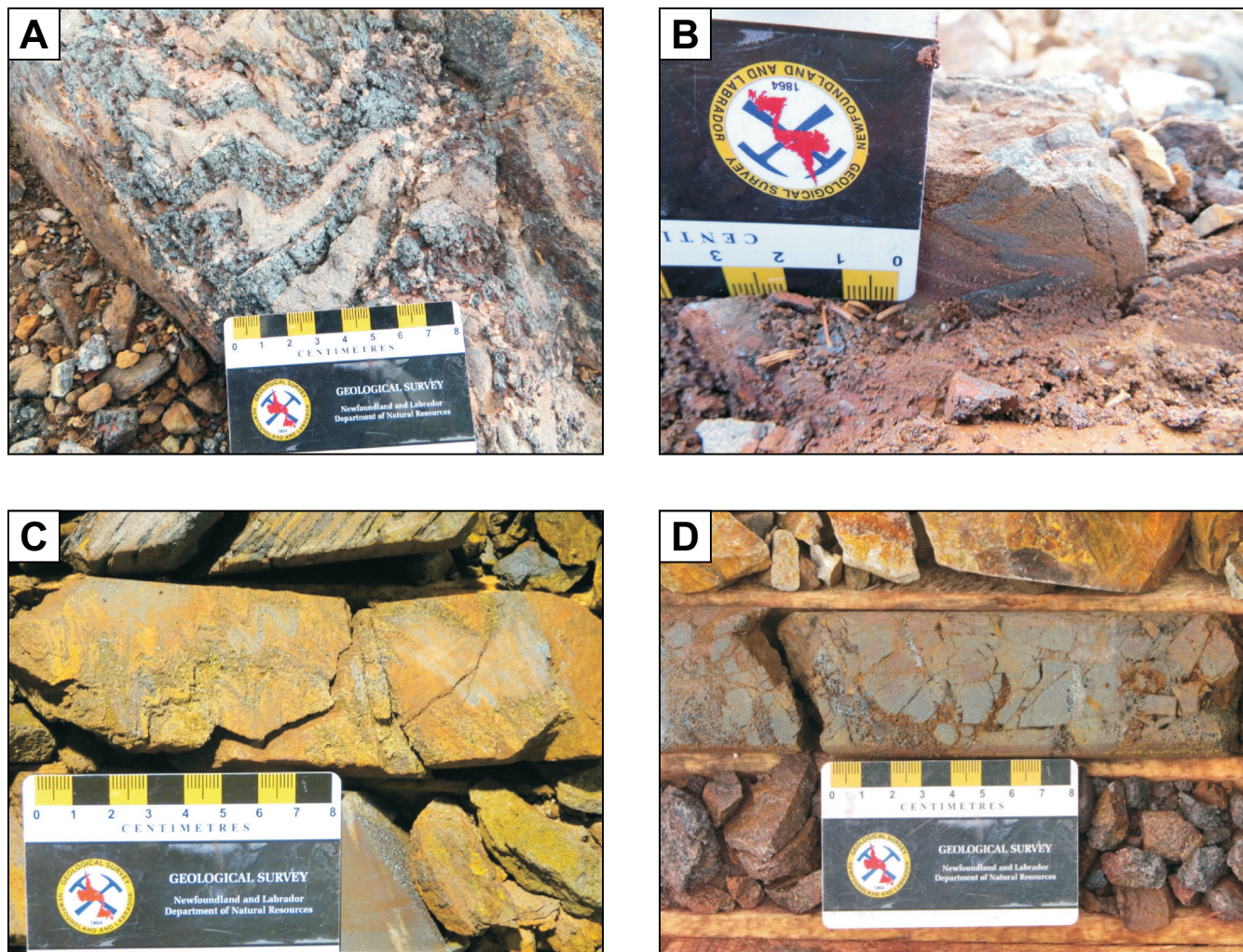
This complex deformational history is reflected in the Julienne Lake Deposit, with previous workers differing greatly in their interpretation of the deposit. Based on exploration in the 1950s and 1960s (trenching and drillcore), Knowles (1967) subdivided the Sokoman Formation on the Julienne Lake peninsula into a series of lithological units that generally plunge to the southeast. These units defined the limbs of a refolded northeast–southwest-trending syncline (Knowles, 1967), which was overprinted by numerous smaller scale isoclinal folds. During the fieldwork and trenching program of 2010 it became apparent that this model needed reinterpretation, particularly in light of the thicker than predicted intersections of the Sokoman (iron) Formation (>575 m). Coates (2012) found no evidence for the postulated hinge zone reported by Knowles (1967) and

the unusual thickness of the Sokoman Formation was attributed to thrust stacking rather than fold repetition (J. Clarke, personal communication, 2012). The lower contact of iron formation with the underlying Wishart Formation was interpreted as a northeasterly striking, gently to moderately southeasterly dipping conformable boundary. The southeastern contact was defined by a steep, northeast-trending fault (Coates, 2012).

During this project, structural data were collected from drillcore and bedrock exposures (including exposed trenches T62-01, T10-01 and T10-02). In all drillholes, the lower contact of the Sokoman Formation is strongly brecciated and commonly faulted, possibly representing a basal thrust. The southern contact of the deposit may represent a high-angle thrust fault, as suggested by Coates (2012). The internal structure of the deposit is very complex, with multiple phases of folding and faulting. Bedding in the iron formation is defined by mineralogical banding, with quartz- and specularite-rich bands, and foliations parallel to compositional banding. As noted by previous workers, most bedding planes and foliations in outcrop are northeast striking (040 to 080°) with dips ranging from 20 to 60° to the southeast. Although there is a wide range of bedding dip across the deposit there is a general trend across the deposit, from relatively shallow dips (<30°) at the northern margin to moderate dips (>50°) at the southern margin. Similarly, bedding dips in drillcore range from 30 to 60° and are generally consistent. However, rare zones where bedding directions rapidly change from 0 to 90° are recorded, which may represent fold axes (*see below*).

Evidence for the major fold axis recorded by Knowles (1967) was observed in two outcrop locations. In the historical trench (T62-01), folded quartz-rich and coarse-grained specularite-rich layers are readily observed where predicted (Plate 3A). In addition, fold structures were also recorded in Trench 10-01, close to the collar of drillhole JL-10-11A and where predicted by the maps of Knowles (1967). These structures include tight isoclinal folding of specularite layers (Plate 3B) and metre-scale fold structures. Due to the poor relief of most outcrops it was difficult to determine the attitude of these folds. No evidence of folding was recorded in Trench 10-02, but the predicted trace of the fold axis passes through an area where bedrock was not exposed. Fold structure was also recorded in drillcore, with zones of small-scale, tight isoclinal folds (Plate 3C) and rapid changes in bedding orientation recorded. Numerous intervals of clay-like fault gouge were also recorded in drillcore, particularly along section 1800E. These faults were either parallel to the bedding, or rarely at high angles to bedding. Brittle deformation was also represented by the formation of breccia zones (Plate 3D), with fragments of quartz-specularite iron formation in a matrix of hard hematite, quartz or goethite.





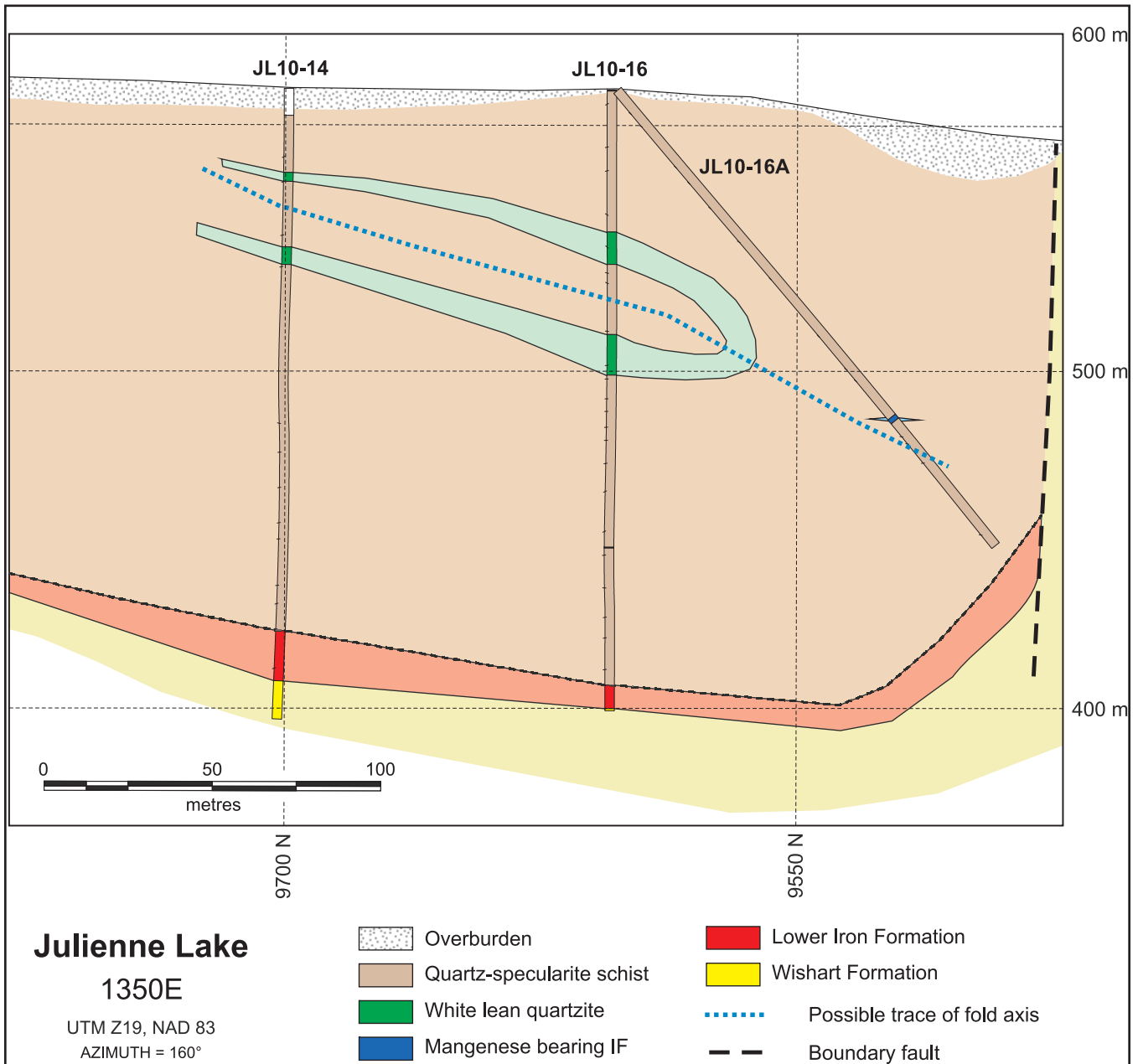
**Plate 3.** Photographs illustrating structural features at the Julienne Lake Deposit. A) Folded bands of coarse-grained specularite from trench T62-01 (648193E, 5889408N). B) Tight isoclinal folding of specularite band from Trench 10-01, close to collar of JL10-11A (648265E, 5889607N). C) M-type folding in possible fold hinge, associated with alteration (from JL10-08). D) Breccia zone with fragments of QS iron formation healed by hematite and goethite (from JL10-16).

Based on the observations outlined above and detailed logging of drillcore, revised cross-sections have been drawn from two sections, 1350E in the east of the deposit (Figure 3) and 1800E in the west of the deposit (Figure 4). The section through 1350E interprets the deposit as a southeasterly plunging, overturned syncline, with repetition of the lean white quartzite horizon and steepening of dips on the overhanging wall. The section through 1800E is more complicated, due to the lack of readily identified marker horizons, differential ductile and brittle deformation of rock types and possible thrust imbrication. However, identification of marker horizons based on trace-element and rare-earth element geochemistry may enable a better understanding on the correlation of units between drillholes.

## DISCUSSION AND SUMMARY

### THE JULIENNE LAKE DEPOSIT

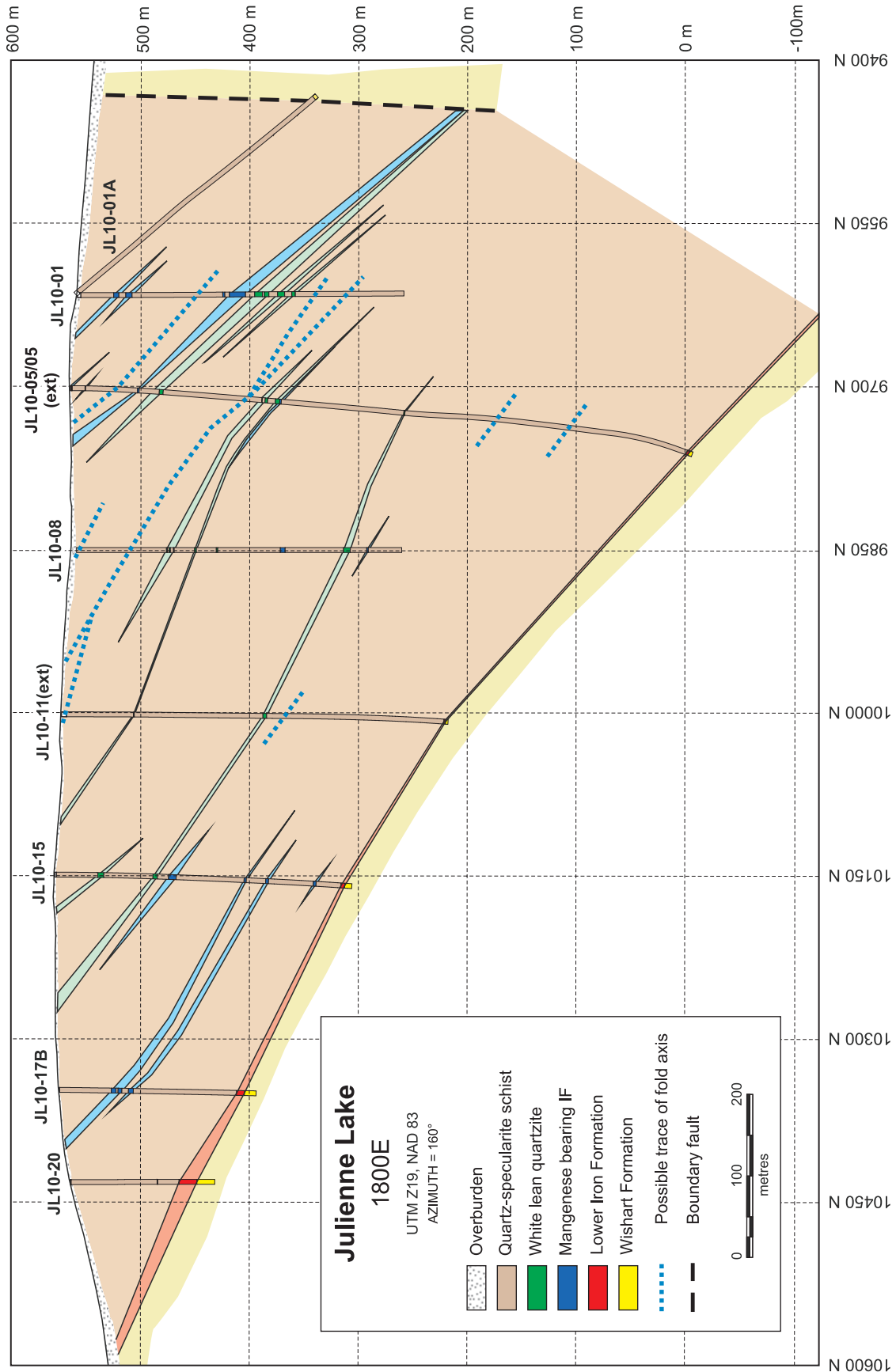
The Julienne Lake Deposit is subdivided into two main zones, based on variations in lithology, structural complexity and alteration (Figure 5). The southwest zone has a maximum thickness of 320 m and is interpreted as a relatively simple overturned syncline having little or no thrust stacking. Alteration is generally weak to moderate, although some zones of more intense alteration are recorded, particularly in the lower iron formation. Manganese-rich iron formation is generally absent from this zone, with thin (<50 cm) beds of Mn-rich iron formation recorded in only two



**Figure 3.** Schematic cross-section along section 1350E, showing overturned syncline and repetition of lean white quartzite horizon. For the location of section 1350E refer to Figure 2.

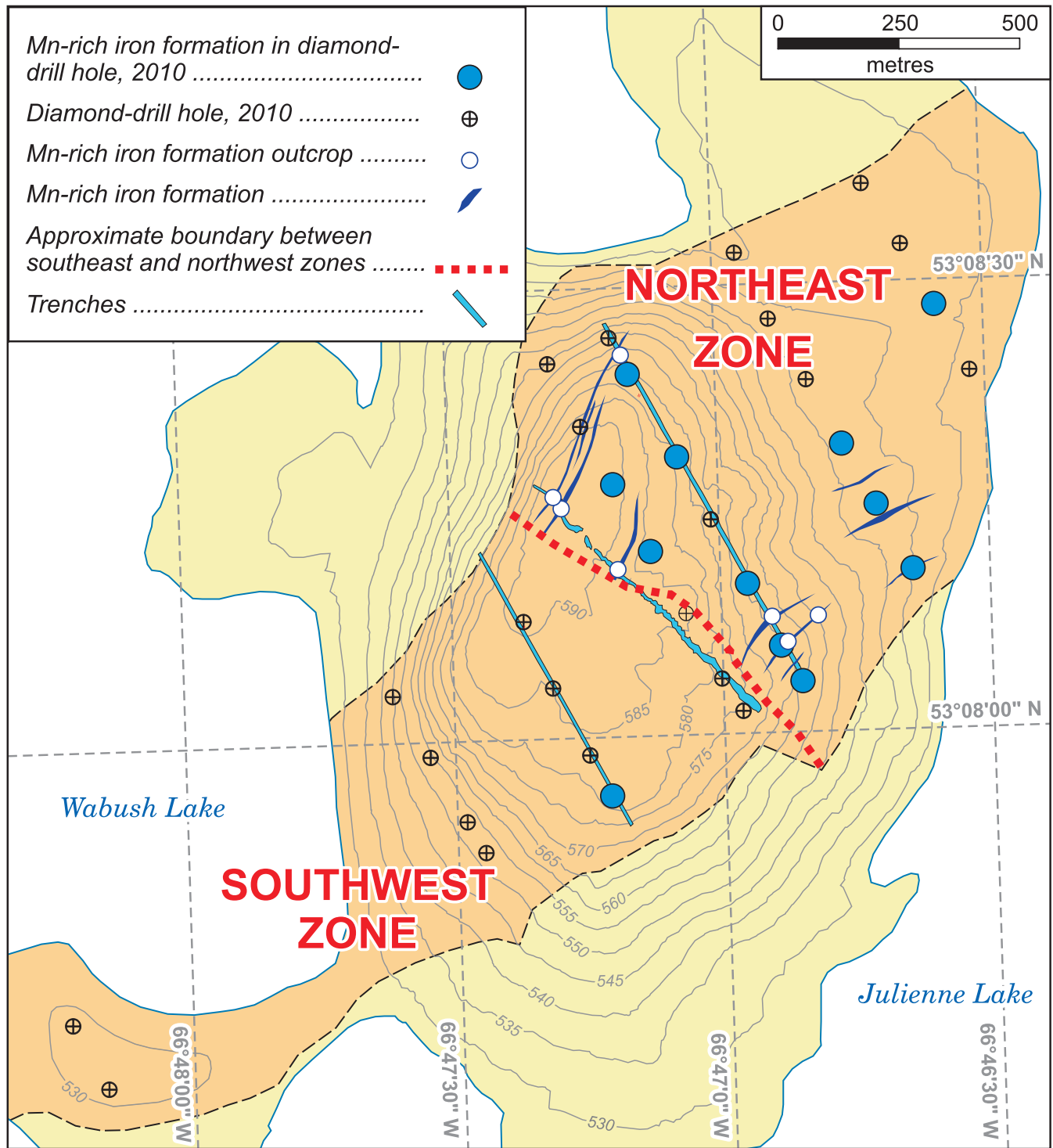
drillholes. Northeast of a line between 1350E and 1500E, the deposit thickens rapidly from a maximum thickness of <300 to >575 m. This boundary may reflect a north-northeast-trending vertical fault with little or no horizontal movement. This fault may have been intersected at the base of drillhole JL-10-06, where 9 m of fault gouge have been recorded. Evidence for the division of the deposit into an eastern and western sector is also provided by the ground magnetometer survey (Figure 6), which show a linear feature close to line 1500E and variations in the magnetic signal either side of this line.

Northeast of this boundary the deposit is much more structurally complex, with abundant minor faults and breccia zones. Preliminary interpretations indicate that complicated folding and thrust repetition is likely responsible for thickening of the iron formation to >575 m. Alteration in this zone is generally more intense than in the southwest zone, and Mn-rich iron formation is common, particularly in shallow levels (>200 m). It is likely that low-temperature, post-metamorphic fluids responsible for alteration and remobilization of Mn into Mn-rich iron formation were able to better penetrate the deposit in this zone due to the abun-



**Figure 4.** Schematic cross-section along section 1800E, showing complex structure (multiple fold axes) and distribution of Mn-rich iron formation. For the location of section 1800E refer to Figure 2.





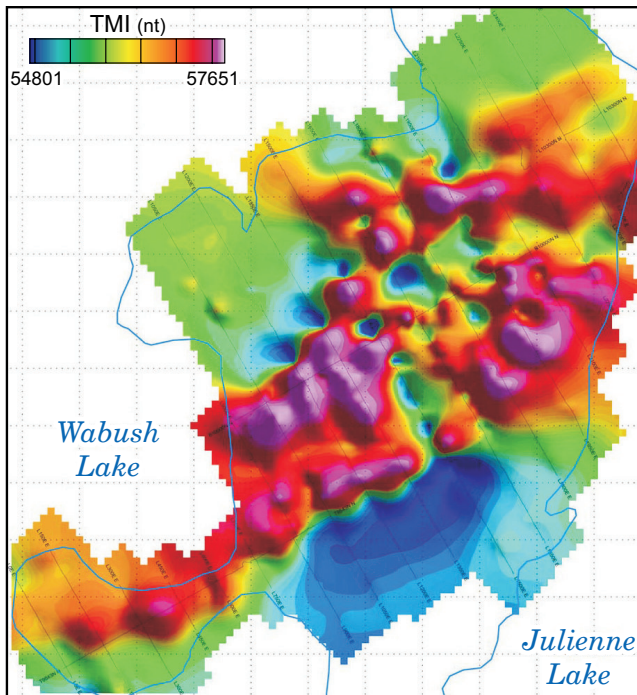
**Figure 5.** Surface plan map of the Julienne Lake peninsula, showing the division into southwest and northeast zones.

dance of low-angle faults, which provided suitable fluid conduits.

**REGIONAL CORRELATIONS**

The iron-ore deposit at Julienne Lake is located close to

a number of other large metataconite-type iron deposits, including operating mines at Carol Lake and the Scully Mine in Labrador City/Wabush (Figure 7) and Mont-Wright and Bloom Lake in adjacent Québec. In addition, there are a number of advanced exploration projects in the Labrador City/Wabush area, including the Kamistiatusset (Kami

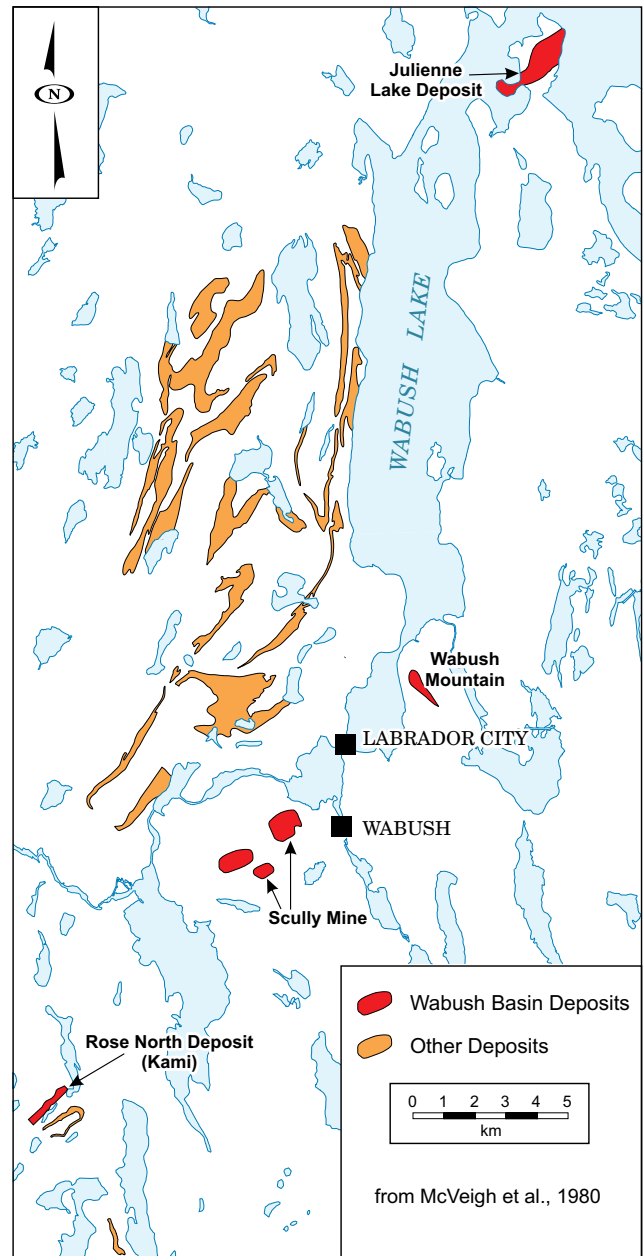


**Figure 6.** Ground magnetic survey data from the Julienne Lake peninsula (Total Magnetic Intensity).

project (10 km southwest of Wabush, Figure 7), which is slated to go into production in 2015. There are significant variations in terms of mineralogy, alteration and stratigraphy of these deposits, which have important implications for development of individual deposits. The Julienne Lake iron-ore deposit shares characteristics with a number of these deposits, particularly the Scully Mine and the Rose North Deposit at Kami. These include:

- the mineralogy of the iron formation (specularite  $\gg$  magnetite),
- the extent of secondary weathering (leading to the development of limonite, goethite and secondary hematite), and
- the presence of Mn-rich intervals and a narrow layer of Fe-silicate-rich iron formation at the base of the Sokoman Formation.

The similarities between these deposits indicate that the Julienne Lake Deposit represents a continuation of a single continuous basin, which has been termed the Wabush Basin (Grandillo *et al.*, 2011). The Wabush Basin extends from the Rose Lake area north-northeast beyond the town of Wabush and along the eastern shore of Wabush Lake to the Julienne Lake Deposit (Figure 7). It is likely that the deposits in the Wabush Basin were deposited in the same geological environment, and underwent a similar metamorphic and post-metamorphic history. In contrast, the deposits at Carol Lake, west of Wabush Lake are geologically distinct, having a higher magnetite content, lower degree of alteration and absence of Mn-rich layers. In addition, the overall stratigra-



**Figure 7.** Location map of iron-ore deposits in the Labrador City/Wabush area (adapted from McVeigh *et al.*, 1980), showing the distribution of deposits grouped together in the 'Wabush Basin'.

phy varies between these two regions, with the Denault Dolomite (at the top of Cycle 1) absent west of Wabush Lake and the Sokoman Formation and Wishart Formation deposited directly onto the Archean basement. A similar geological pattern is seen in the Schefferville area with the iron formations of the Schefferville Zone (which overlie the Denault Dolomite) thrust over the nearshore facies of the Howell's River area, which were deposited directly onto basement rocks (Zajac, 1974).

## FUTURE WORK

Current research on the Julienne Lake Deposit is focused on identification of marker horizons in the Julienne Lake iron-ore deposit, in the hope of gaining a better understanding of the structure of the deposit. Geochemical data from drillcore and outcrop samples may also lead to more confident correlations between drillholes, particularly in the structurally complex northeast zone. In addition, regional studies are aimed at comparing the geological and geochemical features of the Julienne Lake iron-ore deposit with other nearby deposits. These will be used to assess the relative roles of depositional controls and later hydrothermal and metamorphic processes in the formation of these deposits.

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