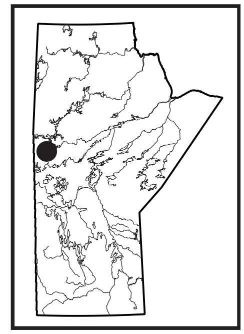
GS-10 Geological scoping study of the Sherridon structure, northern margin of the Flin Flon domain, western Manitoba (parts of NTS 63N2, 3)

by C.G. Couëslan and T. Martins



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Summary

Ten days of geological investigations were conducted in the Sherridon structure in July and August of 2014, to assess the accessibility and quality of outcrop, in advance of a possible detailed mapping project in areas affected by a 2008 forest fire. Exposures outside of the burned areas are typically poor due to heavy lichen and moss cover, whereas those within the burn are typically clean and highly suitable for detailed geological studies. Vegetation growth in the six years since the fire is thick in areas of overburden, and local accumulations of deadfall can make access to outcrops difficult. However, outcrop ridges remain relatively clear of vegetation and afford excellent exposures and ease of mobility. Mapping at a scale of 1:10 000 within the burned area would provide additional detail to existing maps and could possibly aid in future exploration for volcanogenic massive-sulphide (VMS) deposits in this historic base-metal camp. Hence, a detailed mapping program is being considered for inclusion in the 2015 Manitoba Geological Survey work plan.

Introduction

Base-metal mineralization was first discovered in the Sherridon area in 1922, and the Sherridon mine, operated by Sherritt Gordon Mines Ltd. from 1931 to 1951, produced 7.7 Mt of Cu-Zn sulphide ore (Zwanzig and Bailes, 2010). During that period, and in the time that has followed, several other deposits have been discovered within the Sherridon structure. Although originally thought to be hosted by metasedimentary rocks (Bateman and Harrison, 1945; Robertson 1953; Froese and Goetz, 1981), more recent studies suggest that the mineralization is hosted by volcanic rocks that were hydrothermally altered and mineralized prior to being overprinted by intense deformation and high-grade metamorphism (Ashton and Froese, 1988; Tinkham and Karlapalem, 2008; Zwanzig and Bailes, 2010).

In 2008, approximately 105 km^2 of forest was burned to the south and east of Sherridon–Cold Lake, Manitoba. In July and August of 2014, geological investigations were conducted in the Sherridon structure with a goal to evaluate the accessibility, abundance and quality of outcrop in areas affected by the burn.

Geological background

The Sherridon structure is part of a large composite gneiss dome along the northern margin of the Flin Flon domain (Figure GS-10-1). It is defined by the Sherridon gneiss, consisting of felsic to intermediate gneiss and amphibolite thought to be derived from predominantly juvenile volcanic-arc rocks of the Sherridon–Meat Lake assemblage (Zwanzig and Bailes, 2010). Although previously considered to be part of the Kisseynew domain, these rocks are now considered to be high metamorphic-grade equivalents of the Flin Flon domain (Zwanzig and Bailes, 2010). These rocks occur along strike with, and share similar attributes to, rocks in the Snow Lake subdomain of the Flin Flon domain, suggesting a similar tectonic and metallogenic history (Zwanzig and Bailes, 2010). However, a recent U-Pb zircon age of ca. 1855–1850 Ma for metavolcanic rocks of the Sherridon gneiss suggests they are much younger than the volcanic rocks hosting base-metal deposits (>1886 Ma) in the rest of the Flin Flon domain (Zwanzig and Bailes, 2010). The Sherridon structure is interpreted to be a window into a regional-scale nappe or sheath fold, cored by rocks of the Sherridon–Meat Lake assemblage and referred to here as the Sherridon gneiss.

The Sherridon gneiss suite is dominated by variably garnetiferous, biotite quartzofeldspathic gneiss derived from rhyolite, dacite, and related intrusions (Figure GS-10-2a; Tinkham and Karlapalem, 2008; Zwanzig and Bailes, 2010; D.K. Tinkham, J.D. Krebes and B. Barclay, unpublished report, 2013). The quartz-rich nature, along with the widespread presence of garnet and local sillimanite, led to their earlier misidentification as metasedimentary rocks (Figure GS-10-2b; Bateman and Harrison, 1945; Robertson, 1953; Froese and Goetz, 1981); however, the high silica content is similar to examples of silicified rhyolite from the main part of the Flin Flon domain (Zwanzig and Bailes, 2010). The garnet and sillimanite is attributed to weak, regional, premetamorphic hydrothermal chloritic alteration (Zwanzig and Bailes, 2010). Biotite gneiss with mineral assemblages common to metapelite (e.g., garnet–cordierite–sillimanite±gedrite±hercynite) are interpreted as zones of focused premetamorphic hydrothermal alteration (Figure GS-10-2c); however, a sedimentary origin cannot be ruled out in all cases (Tinkham and Karlapalem, 2008; Zwanzig and Bailes, 2010; D.K. Tinkham, J.D. Krebes and B. Barclay, unpublished report, 2013). The quartzofeldspathic gneiss is intercalated with calc-silicate and carbonate-silicate gneiss derived from felsic and mafic protoliths, and amphibolite units derived

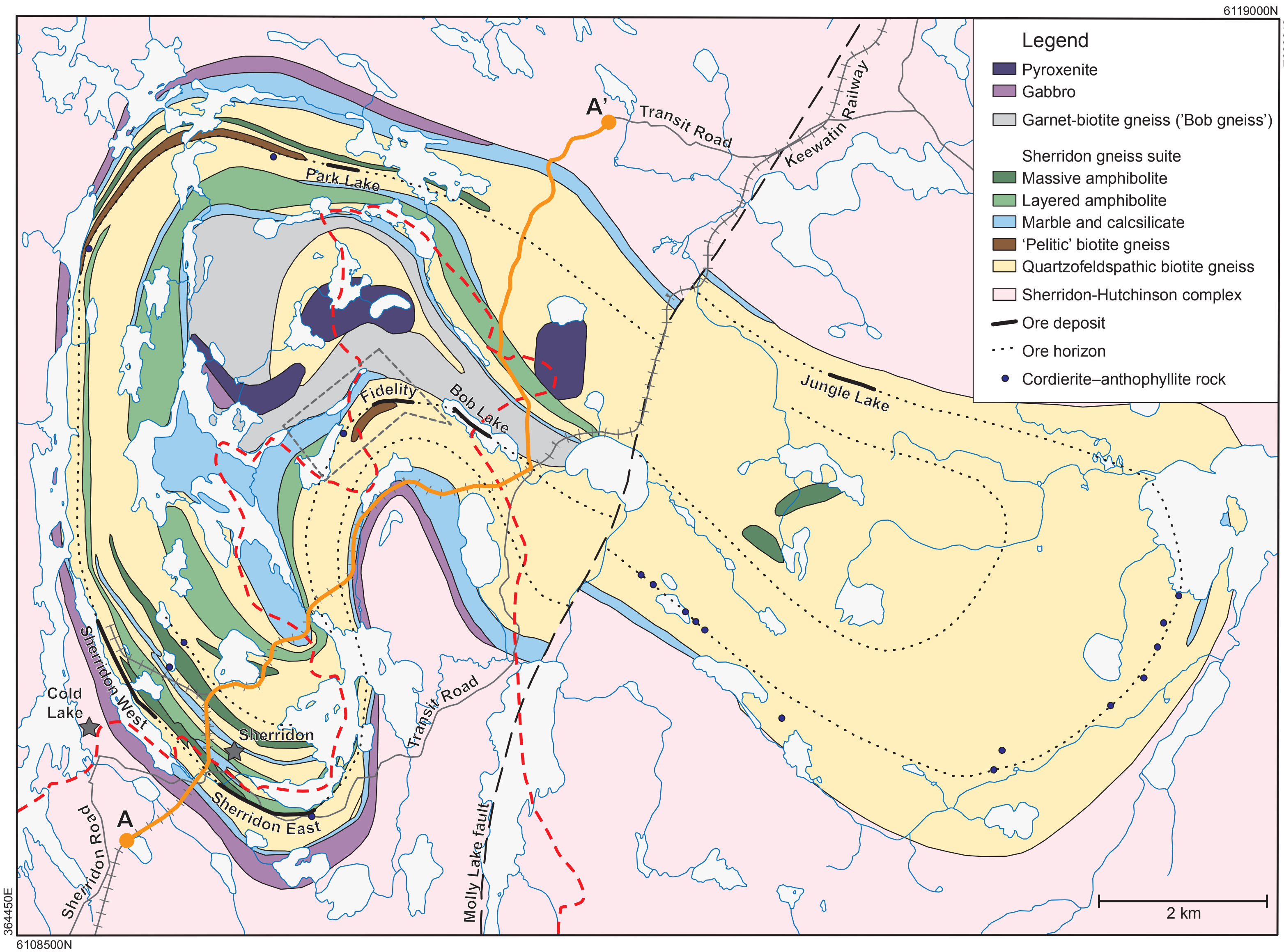

Figure GS-10-1: *Simplified geology of the Sherridon structure (Froese and Goetz, 1981). The red dashed line indicates the extent of the 2008 burn, the dashed grey line represents the map area of Tinkham and Karlapalem (2008), the orange line A–A' indicates the location of the transect across the structure, and stars indicate the locations of the communities of Cold Lake and Sherridon.*

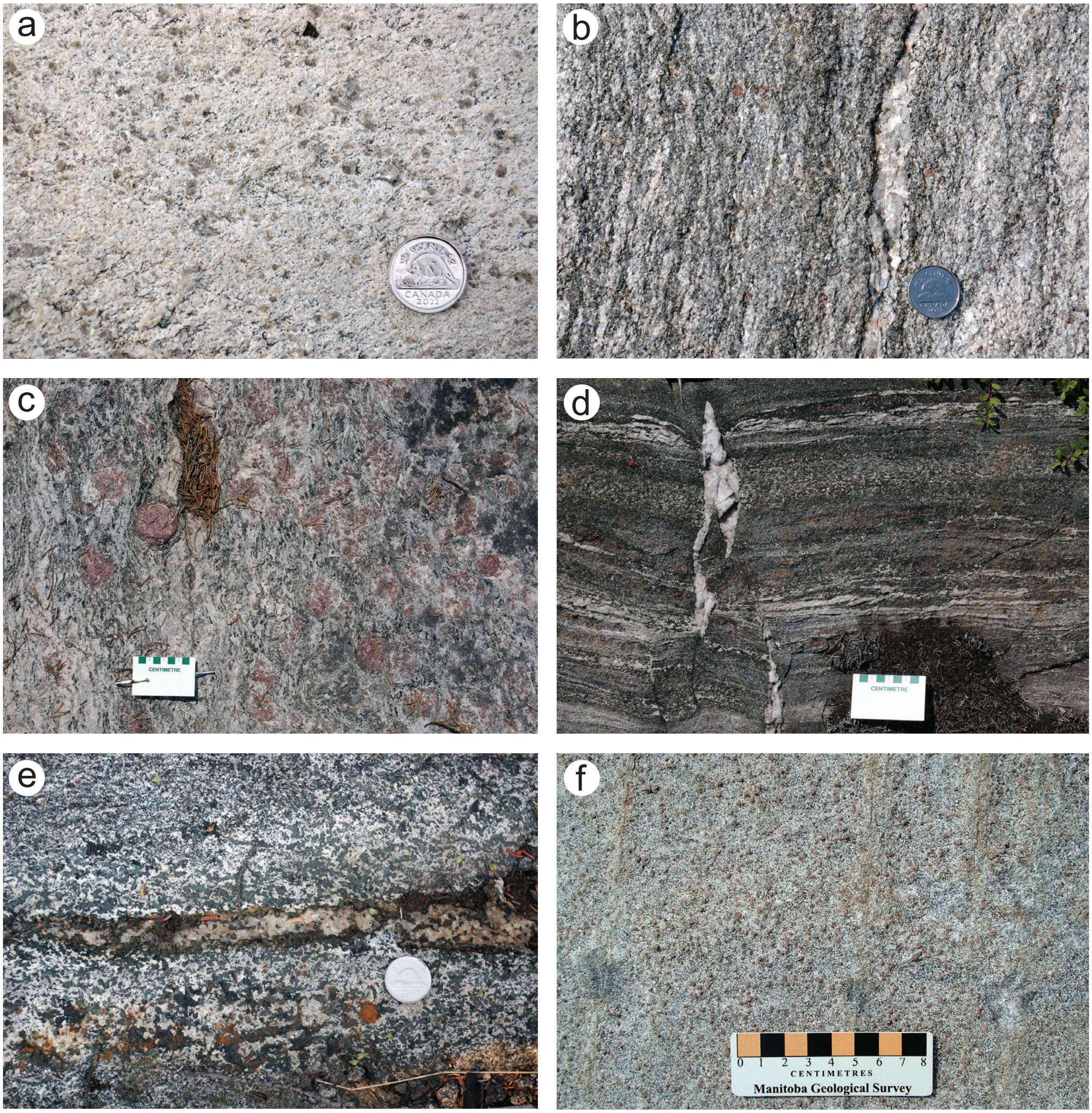

Figure GS-10-2: *Images of outcrops from the Sherridon structure:* ***a)*** *biotite quartzofeldspathic gneiss, quartz eyes may represent relict quartz phenocrysts in a relatively unaltered example of metarhyolite or metadacite;* ***b)*** *garnet-bearing biotite gneiss more representative of the quartzofeldspathic gneiss in the Sherridon area and interpreted as regionally, hydrothermally altered rhyolite or dacite;* ***c)*** *'pelitic' biotite gneiss from the Fidelity zone containing groundmass cordierite and local gedrite, the rock is interpreted as focused, hydrothermally altered rhyolite;* ***d)*** *banded, garnet-bearing amphibolite, interpreted as variably altered mafic volcanic rocks;* ***e)*** *mafic calcsilicate rock with narrow band of marble (above coin), the calcareous rocks are interpreted as variably carbonatized mafic flows or intrusions;* ***f)*** *garnet-biotite gneiss (the 'Bob gneiss'), which could be correlative to the Burntwood group of the adjacent Kisseynew Domain.*

from mafic volcanic and intrusive rocks (Figure GS-10-2d; Tinkham and Karlapalem, 2008; Zwanzig and Bailes, 2010; D.K. Tinkham, J.D. Krebes and B. Barclay, unpublished report, 2013). The presence of mafic rocks suggests a bimodal volcanic assemblage (Zwanzig and Bailes, 2010; D.K. Tinkham, J.D. Krebes and B. Barclay, unpublished report, 2013). Several VMS deposits are hosted by the Sherridon gneiss suite. The VMS-hosting horizon is classified as bimodal-felsic with felsic volcanic rocks more abundant than mafic volcanic or sedimentary rocks (D.K. Tinkham, J.D. Krebes and B. Barclay, unpublished report, 2013). Relatively mafic calcsilicate rock, impure marble, and amphibolite occur toward the core of the Sherridon structure and are interpreted as highly carbonatized mafic volcanic or layered intrusive rocks (Figure GS-10-2e; Froese and Goetz, 1981; Zwanzig and Bailes, 2010).

Relatively homogeneous garnet-biotite gneiss (Figure GS-10-2f) in the core of the Sherridon structure (locally known as the 'Bob gneiss') is compositionally similar to greywacke, and is at least partially sedimentary, based on unpublished detrital zircon data (Tinkham and Karlapalem, 2008; N. Rayner and D.K. Tinkham, pers. comm., 2009, as cited by Zwanzig and Bailes, 2010; Zwanzig and Bailes, 2010). This unit could be correlative to greywacke-mudstone turbidites of the Burntwood group, perhaps representing a more proximal submarine fan setting (Zwanzig and Bailes, 2010). The garnet-biotite gneiss is cut by gabbro and pyroxenite intrusions (Froese and Goetz, 1981; Tinkham and Karlapalem, 2008). Small bodies of weakly foliated granodiorite and masses of granitic pegmatite are found throughout the area (Froese and Goetz, 1981; Tinkham and Karlapalem, 2008).

The Sherridon structure is surrounded by the Sherridon–Hutchinson Lake complex, a northwestern extension of the Gants Lake batholith (Tinkham and Karlapalem, 2008; Zwanzig and Bailes, 2010). The complex includes ca. 1874–1860 Ma foliated granite and tonalite gneiss as highly flattened and folded, nested plutons (Machado et al., 1999; Zwanzig and Bailes, 2010). The Sherridon–Meat Lake assemblage of the Sherridon structure is separated from the Sherridon–Hutchinson Lake complex by a high-strain zone that contains local slivers of greywacke thought to be correlative to the Burntwood group (Zwanzig and Bailes, 2010). Portions of the high-strain zone with high graphite and Fe-sulphide contents may be the expression of a fault that surrounds the Sherridon structure (Zwanzig and Bailes, 2010).

Structure and metamorphism

The regional structural evolution involved a period of stacking of recumbent nappes, resulting in complex infolding of Flin Flon domain volcanic and intrusive rocks, and Kisseynew domain sedimentary rocks and intrusions (Tinkham and Karlapalem, 2008; Zwanzig and Bailes, 2010; D.K. Tinkham, J.D. Krebes and B. Barclay, unpublished report, 2013). The Sherridon structure is interpreted as an elongate, shallow-plunging, regional sheath fold (Zwanzig and Bailes, 2010; D.K. Tinkham, J.D. Krebes and B. Barclay, unpublished report, 2013). A possible sequence of deformation events for the Sherridon structure, as outlined by Zwanzig (1999) and D.K. Tinkham, J.D. Krebes and B. Barclay, unpublished report (2013), is as follows:

- D_1: thrusting and F_1 recumbent folding of all sequences
- D_2–D_3: progressive tight to isoclinal, recumbent, F_2–F_3 folding associated with nappe emplacement and synchronous with peak metamorphism
  - F_2 likely involved west-directed overturning of F_1 folds and faults
  - F_3 likely involved southwest-directed refolding and reorientation of F_2 folds and faults, and includes the Sheila Lake fold that appears to refold the Sherridon structure
- D_4: relatively late and minor F_4 upright folding
- D_5: late brittle faulting

The Sherridon structure lies near the transition from amphibolite- to granulite-facies mineral assemblages toward the north. Widespread evidence of partial melting in the quartzofeldspathic gneiss, coupled with the lack of prograde muscovite in rocks containing sillimanite and K-feldspar, and a lack of metamorphic orthopyroxene in metabasite all indicate peak metamorphism at upper-amphibolite–facies conditions (Tinkham and Karlapalem, 2008; D.K. Tinkham, J.D. Krebes and B. Barclay, unpublished report, 2013). Pressure-temperature conditions are estimated to have reached approximately 6 kbar and 690–710°C (Tinkham, 2009; D.K. Tinkham, J.D. Krebes and B. Barclay, unpublished report, 2013). The deformation, metamorphism and anatexis of the felsic gneiss complicate the identification of premetamorphic, hydrothermal alteration systems (Tinkham and Karlapalem, 2008; D.K. Tinkham, J.D. Krebes and B. Barclay, unpublished report, 2013).

Field activities and possible future work

Ten days of field investigations were conducted in the Sherridon area in July and August of 2014. Two days were spent visiting outcrops recently studied by D.K. Tinkham, J.D. Krebes and B. Barclay (unpublished report, 2013) and in the Fidelity zone map area of Tinkham and Karlapalem (2008), in order to become familiarized with the dominant rock units of the area (Figure GS-10-1). This was followed by several days of describing and sampling outcrops along a roughly north-south transect across the Sherridon structure, which included most of the major map units and thus facilitated comparisons to unit descriptions of Froese and Goetz (1981) and Tinkham and Karlapalem (2008). An additional day was spent traversing in the vicinity of the Sherridon East deposit, which was burned in 2008, in order to assess the need for additional detailed mapping.

Outcrops outside of areas affected by the 2008 burn were found to be heavily obscured by moss and lichen, such that it would be very difficult and time consuming to improve upon the 1:20 000 scale mapping of Froese and Goetz (1981). In contrast, outcrop in burned areas is typically free of moss and lichen (Figure GS-10-3). New vegetation growth and deadfall hamper mobility and

Figure GS-10-3: *Outcrop inside the area affected by the 2008 burn.*

visibility, making it difficult to locate and access isolated outcrops, but outcrop ridges remain relatively clear with relatively thin growth and minimal deadfall, allowing for ease of movement and excellent exposures.

From this investigation, the authors conclude that there is little to be gained by remapping the burned area at a scale of 1:20 000; however, the geological map could be improved in detail by targeted remapping at more detailed scales. Any such mapping would have to follow the methods outlined by Tinkham and Karlapalem (2008) for their 1:2500 scale mapping in the Fidelity zone. During the course of this mapping, these workers found it nearly impossible to arrive at an unambiguous interpretation of protolith in the field. Instead, they defined map units based on mineral assemblages and rock associations. The resulting map is thought to partially reflect the primary distribution of protoliths and hydrothermal alteration. Some units have gradational contacts over 10–50 m which may, in part, reflect premetamorphic hydrothermal alteration fronts.

Mapping would also have to be accompanied by fairly intensive sampling for lithogeochemistry and thin section petrography. Work by Tinkham and Karlapalem (2008) and Zwanzig and Bailes (2010) in the Sherridon–Meat Lake assemblage has demonstrated the utility of immobile trace-elements for identifying protoliths in altered and metamorphosed volcanic successions. Alteration indices can also be calculated from major-element geochemistry to constrain the nature of the hydrothermal alteration (Tinkham and Karlapalem, 2008). Additional geochronology would also be required to test the relatively young (ca. 1855–1850 Ma) age for the Sherridon gneiss suite (Zwanzig and Bailes, 2010), and further constrain the regional significance of these rocks. These aspects will be taken into consideration in planning for the 2015 field season.

Economic considerations

The Sherridon structure is an area of economic interest because of the known presence of eight VMS deposits, plus several more Cu-Zn occurrences, all in the vicinity of the community of Sherridon. A recent review of the deposits and resource estimates can be found in Zwanzig and Bailes (2010). In addition, evidence for both regional and focused, premetamorphic hydrothermal alteration is widespread in the area, and the area is considered prospective for the discovery of new deposits (Zwanzig and Bailes, 2010). Zones of focused Fe-Mg alteration (manifest as cordierite- and gedrite-bearing rocks in metamorphic terranes) are known to be spatially associated with VMS mineralization, and recent mapping has revealed the local presence of thin layers of siliceous rock that are thought to represent the silicified carapace above zones of hydrothermal circulation (Zwanzig and Bailes, 2010). Detailed mapping of well-exposed areas could help to identify and define the distribution of the potential products of focused fluid flow and alteration, and thus provide new exploration targets for VMS mineralization.

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