Geology and geochemistry of the Gem assemblage, Rice Lake greenstone belt

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Thanks to:
P. Kremer, A. Carlson and C. Chamale, University of Manitoba
K. Reid, Brandon University

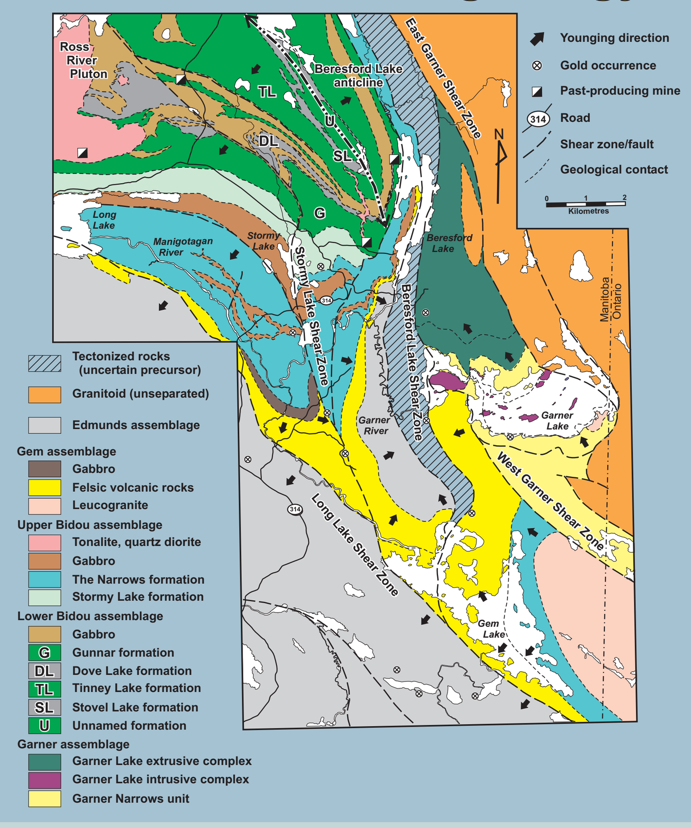
Introduction

In 2002, the Manitoba Geological Survey initiated a program of bedrock mapping, structural analysis, lithogeochemistry, Sm-Nd isotope studies and U-Pb geochronology in the geologically complex and poorly understood Garner Lake - Gem Lake area, which is located 45 km southeast of Bissett, Manitoba, in the southeastern part of the Archean Rice Lake greenstone belt.

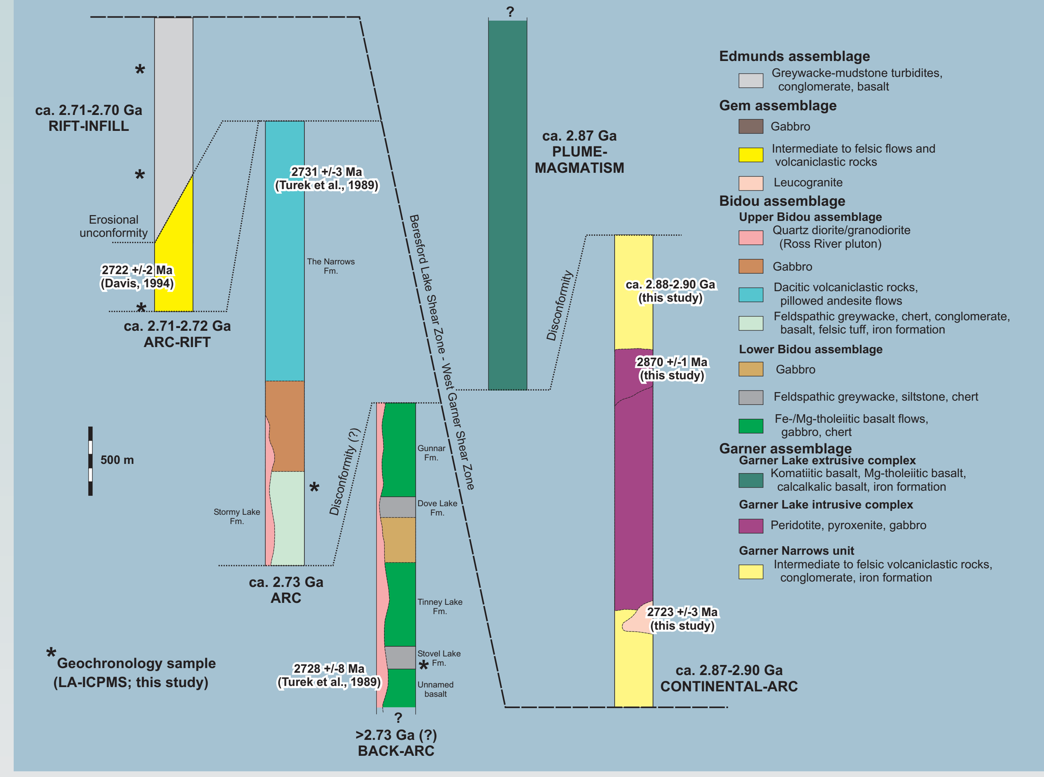
This area contains several significant gold occurrences, as well as key exposures of the principal supracrustal assemblages in the eastern portion of the Rice Lake belt, and thus represents an important area for understanding the tectonostratigraphy, tectonic evolution and metallogeny of the belt as a whole.

This poster summarizes some of the results of 1:20 000 scale bedrock mapping and geoscientific investigations completed since 2002 in the Garner Lake - Gem Lake area, with emphasis on the rock-types, stratigraphy, geochemistry and economic potential of the Neoarchean Gem assemblage, which is interpreted to represent a ca. 2.72 Ga arc-rift succession with potential for volcanic-hosted massive sulphide (VHMS) and orogenic gold deposits.

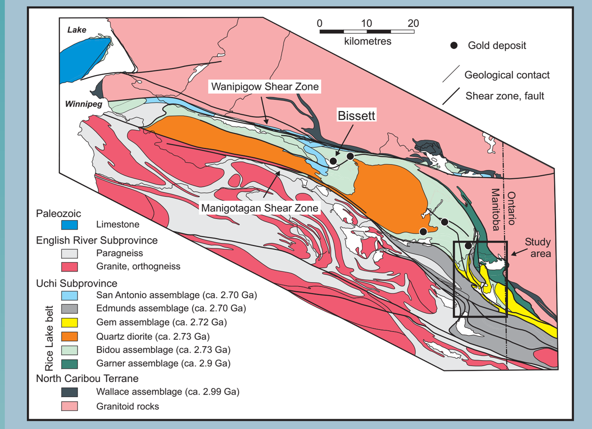
SE Rice Lake belt geology



Stratigraphy



Regional geology



The Rice Lake greenstone belt is situated in the western Uchi Subprovince of the Archean Superior Province, and is flanked to the north by the ca. 3.0 Ga North Caribou continental terrane and to the south by ca. 2.69 Ga paragneiss and granitoid plutons of the English River Subprovince (see map above). The Rice Lake belt consists mainly of Meso- and Neoarchean intermediate volcanic and volcaniclastic rocks, constituting several distinct lithotectonic assemblages.

In the eastern Rice Lake belt, these assemblages include the Mesoarchean Wallace (ca. 2.92-2.99 Ga) and Garner (ca. 2.87-2.90 Ga) assemblages, and the Neoarchean Bidou (ca. 2.73 Ga) and Gem (ca. 2.72 Ga) assemblages (see map and stratigraphic columns to lower left). The Bidou assemblage includes synvolcanic quartz diorite and granodiorite plutons, including the ca. 2.73 Ga Ross River pluton in the central portion of the belt. As indicated by the multi-element diagrams below, volcanic rocks in the Garner, Bidou and Gem assemblages can be distinguished on the basis of geochemical attributes.

Fluvial and alluvial rocks of the ca. 2.70 Ga San Antonio assemblage unconformably overlie the volcanic rocks and likely represent the proximal equivalents to basinal turbidites of the ca. 2.70 Ga Edmunds assemblage, which overlaps the south margin of the Rice Lake belt.

These assemblages provide a punctuated record of magmatism, sedimentation and orogenesis spanning roughly 200 m.y. Broadly comparable assemblages in the Red Lake and Birch-Uchi belts in northwestern Ontario provide a basis for regional-scale tectonostratigraphic correlations.

Mesoscopic overprinting relationships indicate at least six generations of ductile deformation structure in the eastern Rice Lake belt. In the Garner Lake - Gem Lake area, a series of generally northwest-trending, relatively low-strain lithostructural domains are separated by a complex network of ductile and ductile-brittle high-strain zones that record multiple overprinting generations of fabric development. The Beresford Lake Shear Zone (BLSZ) represents the most significant and apparently long-lived structural discontinuity.

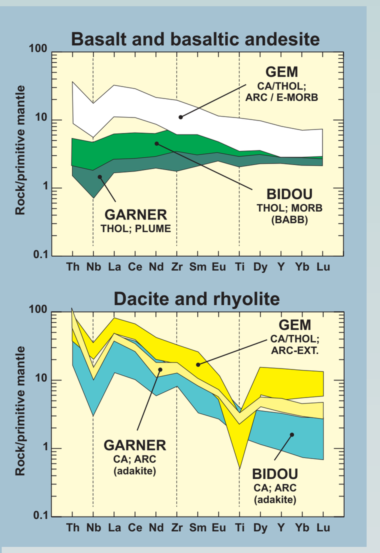
East of the BLSZ, generally north-younging rocks of the Garner assemblage are juxtaposed to the south across the West Garner Shear Zone (WGSZ) with generally west-younging rocks of the Bidou and Gem assemblages. The Garner assemblage is juxtaposed to the east, across the East Garner Shear Zone, with an extensive granitoid domain of uncertain age and affinity. West of the BLSZ, macroscopic map patterns and younging criteria in the Neoarchean succession, comprising the Bidou, Gem and Edmunds assemblages, define the regional-scale Beresford Lake anticline, which is the dominant structural feature in the core of the Rice Lake belt.

At Gem Lake, structures associated with late-stage transcurrent shear deformation, including southeast-trending dextral high-strain zones, mesoscopic and macroscopic z-asymmetric folds, and late brittle faults, overprint and reactivate early high-strain fabrics resulting in very complex map patterns.

Metamorphic mineral assemblages west of the BLSZ and southwest of the WGSZ indicate peak metamorphism in the low- to middle-greenschist facies. South of Garner Lake, the hornblende and garnet isograds coincide with the WGSZ, and indicate an abrupt increase to peak amphibolite-facies metamorphism northeast of the shear zone, consistent with observed northeast-over-southwest kinematic indicators.

Along the south margin of the Rice Lake belt, greenschist-facies supracrustal rocks are tectonically juxtaposed and locally interleaved with ca. 2.69 Ga (Corfu et al., 1995) paragneiss of the English River Subprovince along a series of greenschist-facies high-strain zones, which include the regional-scale Manigotagan Shear Zone and subsidiary structures. The paragneiss records high-temperature, low-pressure regional metamorphism of metasedimentary rocks that are the distal equivalents to the Edmunds assemblage.

The geology of the Garner Lake - Gem Lakes area is shown on Preliminary Map PMAP2006-7 (at right).



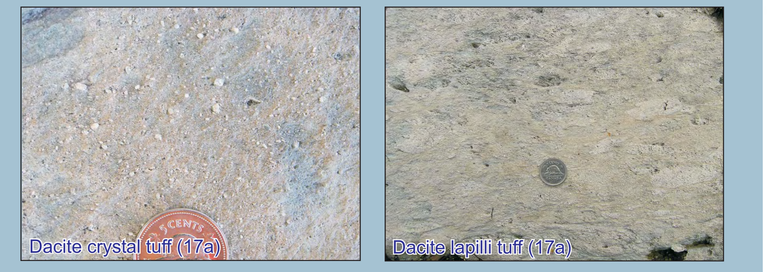
Gem Assemblage - map units and representative rock types

The Neoarchean Gem assemblage overlies the ca. 2.73 Ga Bidou assemblage and consists of a thick succession of primary and variably reworked felsic to mafic volcanic flows and pyroclastic rocks that ranges up to at least 2.0 km thick.

At Gem Lake, the lower portion of the assemblage consists mainly of rhyolitic volcanic, volcaniclastic and intrusive rocks composed of high-silica, FII- and FIIIa-type (Lesher et al., 1986) tholeiitic rhyolite. On the basis of texture and colour, two units are distinguished: buff to white to pink quartz-phyric to aphyric rhyolite (unit 11) and weathering grey to black aphyric rhyolite (unit 12). Leucogranite plutons (unit 10) that intrude the Bidou and Garner assemblages along the eastern margin of the belt are chemically and texturally similar to the overlying unit 11 rhyolite, and are thus tentatively interpreted to be the subvolcanic equivalent. Davis (1994) obtained a U-Pb zircon age of 2722+/-2 Ma from quartz-phyric rhyolite breccia of unit 11 at Gem Lake, which overlaps a ca. 2.72 Ga age obtained from a leucogranite pluton (unit 10) at Garner Lake.

These rocks are overlain by a thick heterogeneous succession of coarse volcaniclastic rocks, with minor occurrences of flow-banded to massive flows composed of buff to grey, sparsely porphyritic, tholeiitic dacite and rhyolite (unit 13). Unit 14 consists of gabbro sills and dikes, which are compositionally and texturally similar to pillowed basalt and basaltic andesite flows and associated coarse volcaniclastic rocks of unit 15. These rocks are intimately interleaved and overlain by discontinuous intervals of bedded heterolithic epiclastic rocks (unit 16). The uppermost portion of the Gem assemblage is locally marked by white to buff to light green-grey dacitic volcaniclastic rocks of calcalkalic affinity (unit 17).

Unit 17

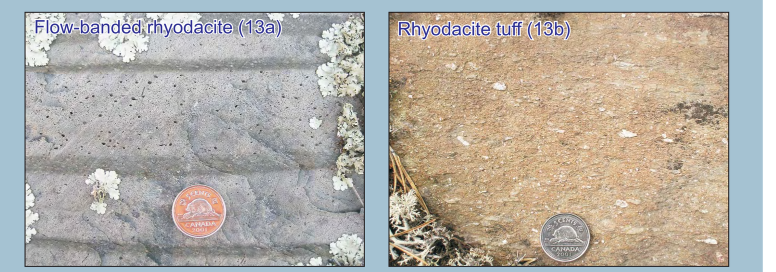


Unit 16

Unit 15

Unit 14

Unit 13



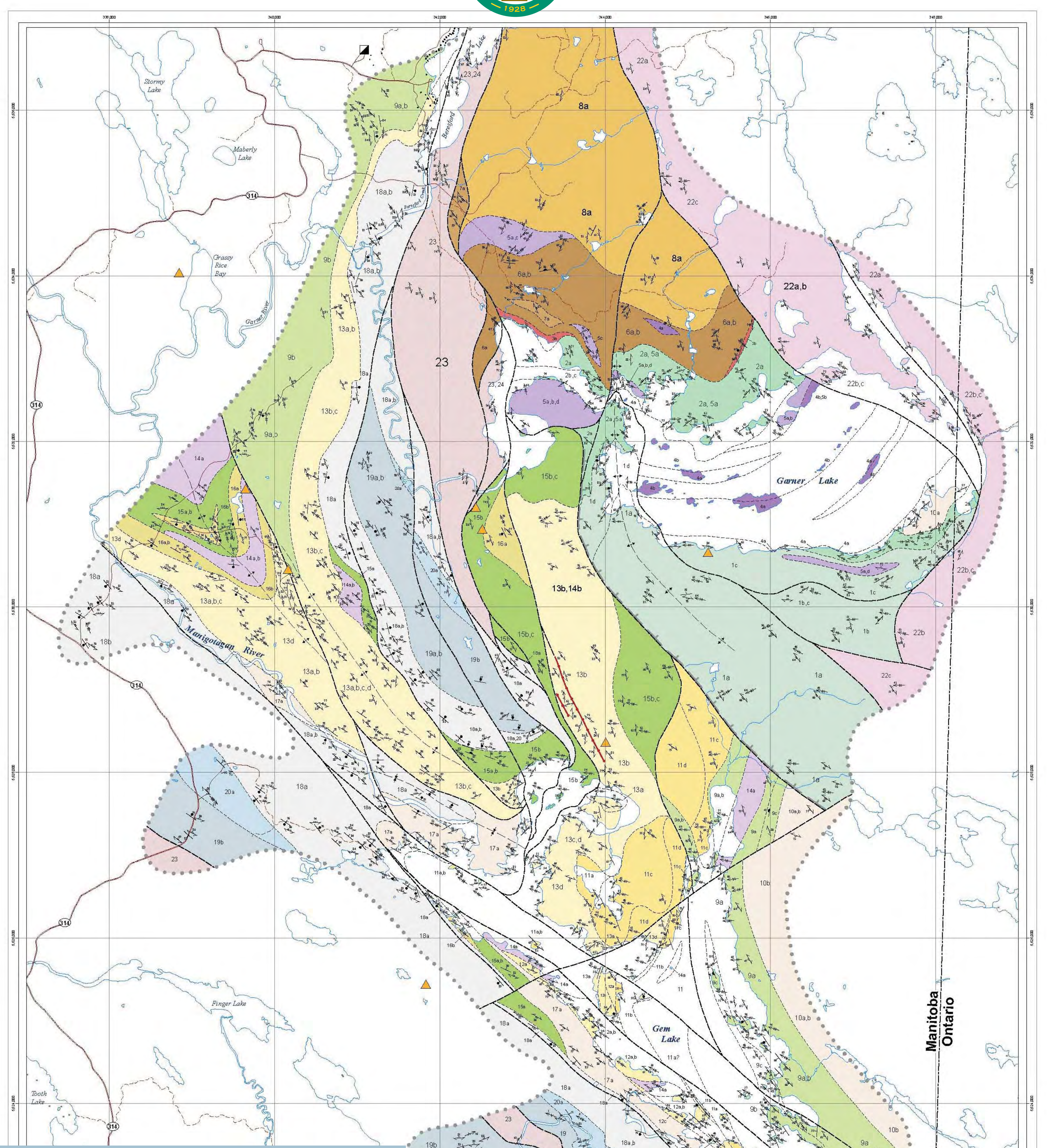
Unit 12

Unit 11

Unit 10

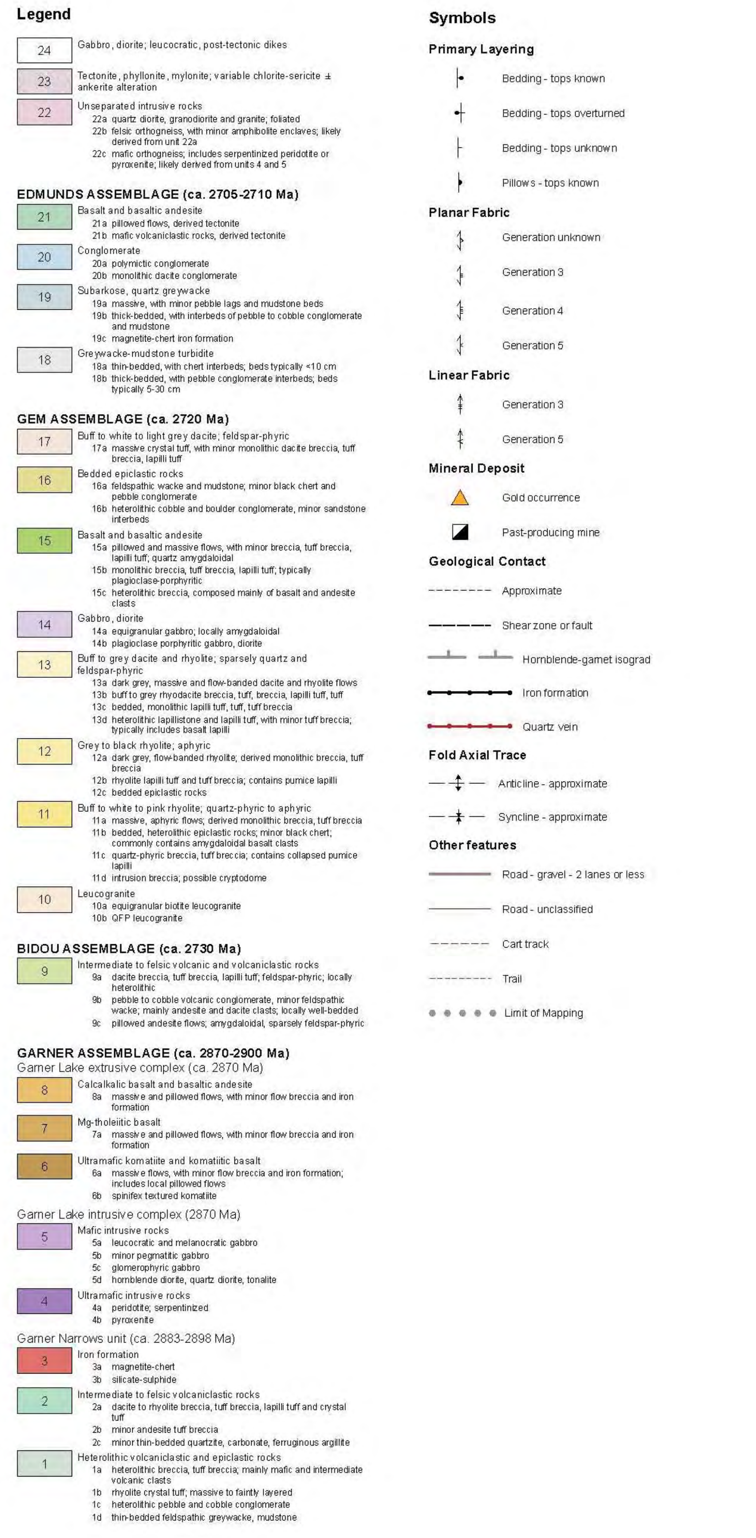
Preliminary Map PMAP2006-7

Geology and structure of the Garner Lake–Gem Lake area, Rice Lake greenstone belt, Manitoba (NTS 52L11 and 14)

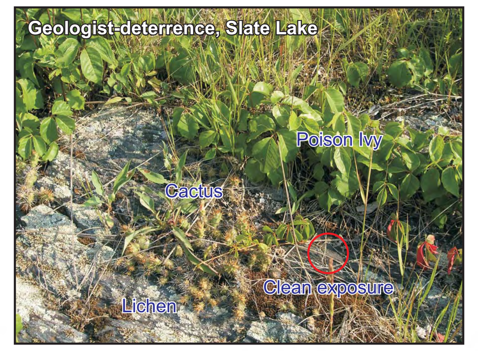


Legend

Symbols



Geologist deference: Slate Lake



Geology by:
S.D. Anderson (2002-2006)

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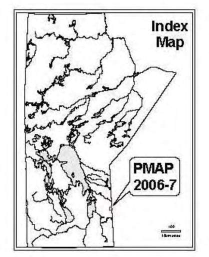
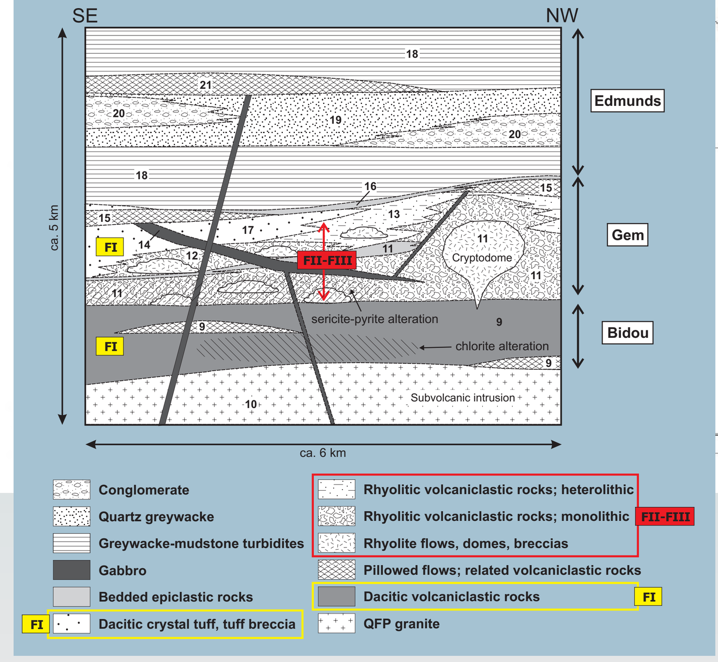
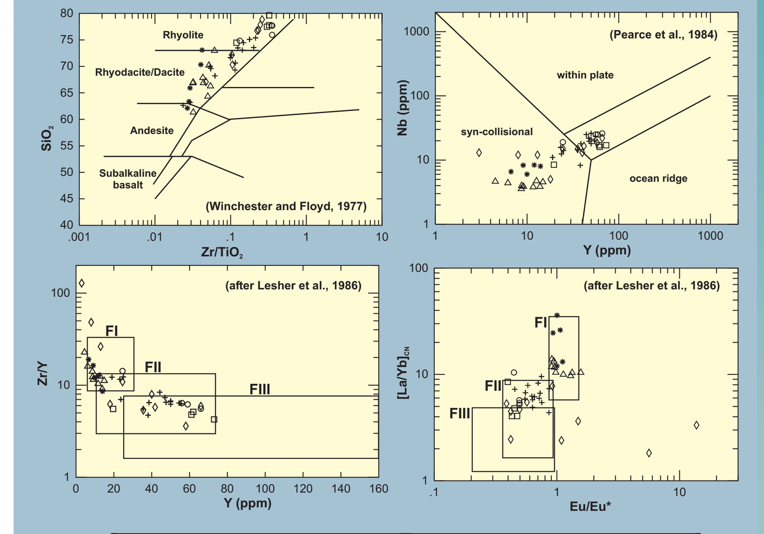


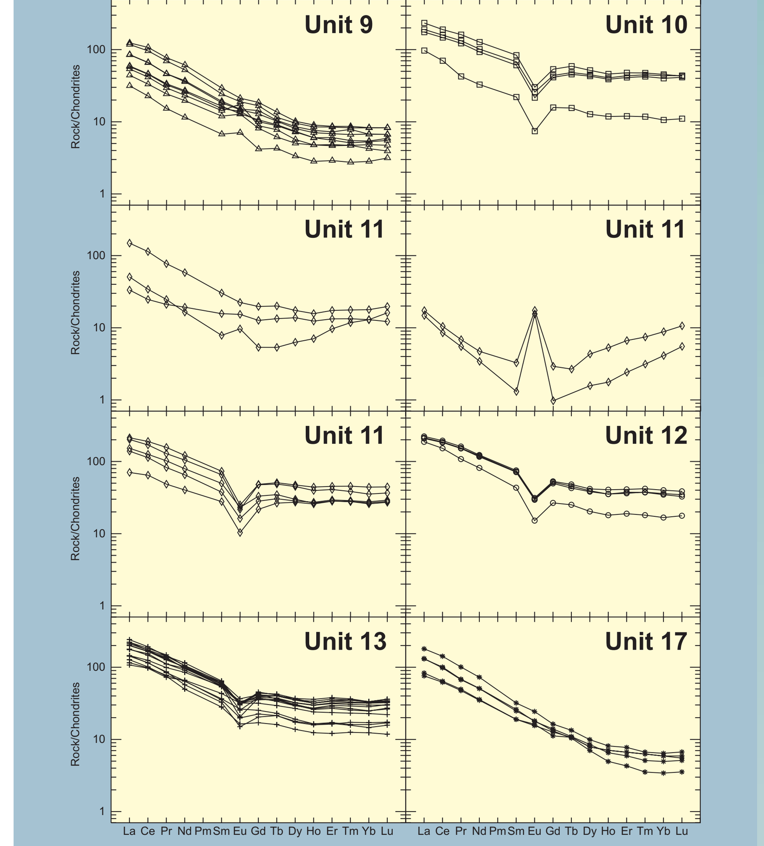
Schematic section



Felsic geochemistry

Felsic volcanic rocks of the Gem assemblage consist mainly of rhyolite and high-silica rhyolite (68-81 wt.% SiO_2, anhydrous), with minor dacite, that exhibit transitional calcalkalic-tholeiitic affinities (Zr/Y 4-30). Chondrite-normalized multi-element profiles exhibit strongly enriched and fractionated LREE, with relatively flat, weakly fractionated HREE and moderate negative Eu anomalies (Eu/Eu* 0.4-2.0). The HFSE signatures indicate an affinity to extension-related, within-plate volcanism. Elevated Y and Yb contents, with correspondingly low Zr/Y and $[La/Yb]_N$ ratios, classify these rocks as FII- and FIIIa-type rhyolites in the scheme of Lesher et al. (1986).

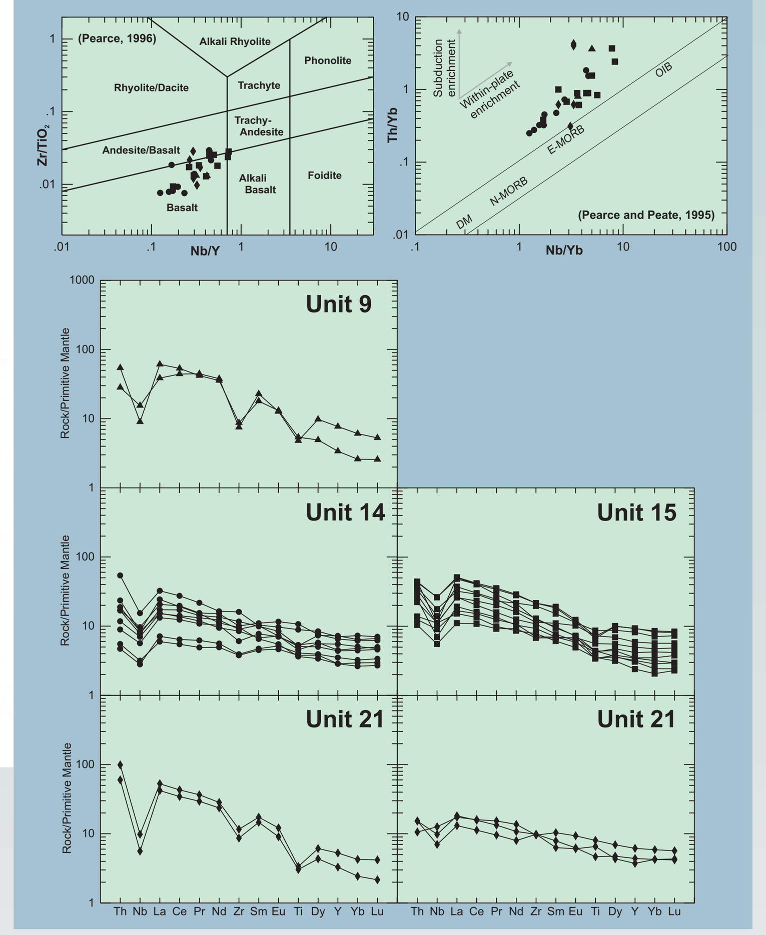




Mafic geochemistry

Mafic and intermediate flows and sills of the Gem assemblage (units 14 and 15) are composed of basalt and basaltic andesite that exhibit transitional calcalkalic-tholeiitic affinities. Primitive-mantle normalized extended-element profiles are characterized by enriched and fractionated LREE, with moderate negative Nb anomalies and weakly fractionated and enriched HREE. These rocks plot between E-MORB and typical arc-tholeiite on basalt discrimination diagrams.

Basalt flows and sills from the Bidou (unit 9) and Edmunds (unit 21) assemblages are shown for comparison.

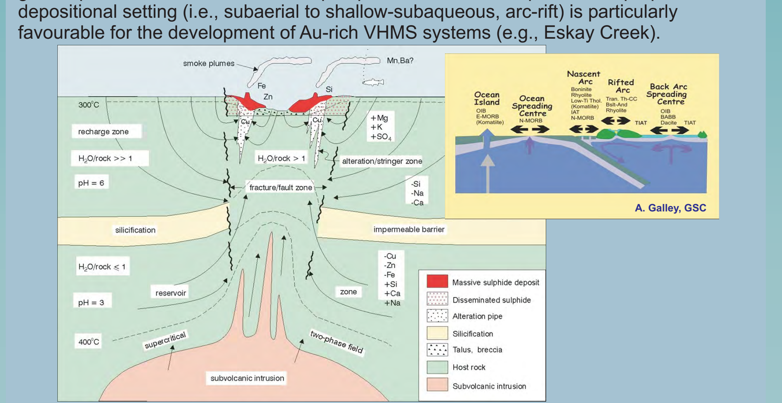


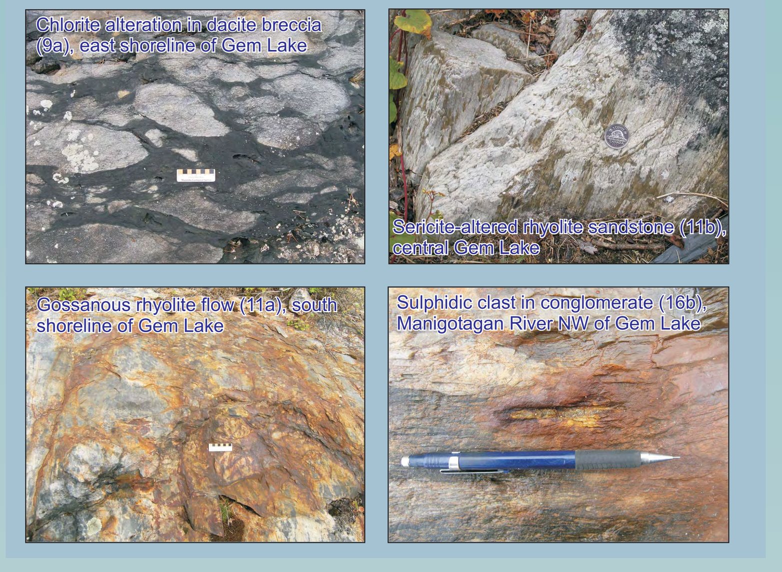
VHMS potential

Felsic flows and vent-proximal fragmental volcanic rocks of the Gem assemblage are composed of FII- and FIIIa-type (Lesher et al., 1986) tholeiitic dacite, rhyolite and high-silica rhyolite, which exhibit HFSE signatures indicative of extension-related, within-plate volcanism. These rocks are provisionally interpreted to record subaerial to shallow subaqueous volcanism associated with the initiation of a ca. 2.72 Ga arc-rift basin within the Bidou volcanic arc. Type FII and FIII rhyolites host several important VHMS deposits in the Superior Province (Lesher et al., 1986), and the association of extension-related volcanism and VHMS deposits has been well documented in the literature.

At Gem Lake, the rhyolitic succession contains semi-concordant zones of sericite-pyrite alteration, with minor intercalations of laminated black chert and sulphidic epiclastic rocks that may represent paleoexhalative horizons. Altered sulphidic clasts (sericite-pyrite) are observed in overlying units of heterolithic volcanic conglomerate, indicating that the sericite-pyrite alteration observed at Gem Lake may be syngenetic. Stringer-style chlorite alteration is also observed, and occurs along the eastern shoreline of Gem Lake in dacitic volcaniclastic rocks of the underlying Bidou assemblage.

These attributes indicate that, in addition to the demonstrated potential for orogenic gold deposits, the Gem Lake area is prospective for VHMS deposits. The proposed depositional setting (i.e., subaerial to shallow-subaqueous, arc-rift) is particularly favourable for the development of Au-rich VHMS systems (e.g., Eskay Creek).





Orogenic gold potential

The Garner Lake -Gem Lake area contains several occurrences of auriferous quartz-carbonate veins, which are hosted by discrete, ductile and brittle-ductile shear zones in close spatial association with the major southeast-trending, domain-bounding, high-strain zones that dominate the map pattern in the area. Hence, proximity to these zones appears to represent an important, property-scale exploration parameter. Detailed prospecting along these zones, with emphasis on potential chemical or structural traps, will prove useful in identifying exploration targets.

As described by numerous authors, lode-gold deposits in greenstone terranes show a distinct spatial association with zones of transition from lower to upper greenschist-facies regional metamorphism, which broadly coincide with the coeval transition from brittle to ductile deformation. In this regard, the West Garner Shear Zone (WGSZ), which coincides with an abrupt, northeastward change from greenschist- to amphibolite-facies metamorphism, may be a particularly attractive exploration target. North of Gem Lake, the footwall of the WGSZ contains several stockwork-breccia quartz-vein systems, one of which is traced along strike for 1.2 km, suggesting that the footwall of the WGSZ was a significant locus for hydrothermal fluid flow.

Elsewhere, gold mineralization in hosted by quartz-ankerite-pyrite veins in strongly altered (ankerite-sericite-pyrite) rocks within shear zones cutting the Garner, Bidou and Gem assemblages, or by quartz-ankerite-arsenopyrite veins in zones of intense ankerite-silica-arsenopyrite alteration associated with shear zones and/or iron-formations in the Edmunds assemblage, or shear zones in the adjacent Gem assemblage.