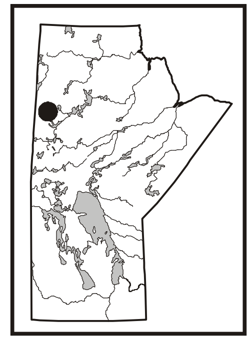
GS-11 PRELIMINARY STRUCTURAL ANALYSIS OF THE AGASSIZ METALLOTECT NEAR THE MACLELLAN AND DOT LAKE GOLD DEPOSITS, LYNN LAKE GREENSTONE BELT (PARTS OF NTS 64C/14, /15)



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SUMMARY

Preliminary field mapping and detailed structural analysis in the western portion of the Agassiz Metallotect have identified five generations of structural fabrics formed by discrete deformational events. Fabrics dominate the major layout of the rocks in the area. The area around the Dot and MacLellan gold deposits is dominated by tight to isoclinal, steeply east-plunging F_2 folds with a pronounced S_2 axial-plane foliation that strikes west-northwest and dips steeply to the north. The earlier S_1 fabric, which is now layer-parallel, is folded by these later folds; isoclinal F_1 folds are rare but locally preserved on the limbs of F_2 folds. The S_2 foliation was overprinted by S_3 fabrics, which are related to dextral kink folds. Open F_4 structures with a penetrative spaced cleavage are oriented perpendicular to the regional S_2 fabric. Late brittle deformation in the form of pseudotachylite breccia crosscuts all other deformational fabrics.

The stratabound gold mineralization occurs in both metavolcanic and metasedimentary rocks of the metallotect. The associated hydrothermal alteration is characterized by calcic amphibolitization, biotitization, muscovitization, silicification, carbonatization, chloritization and serpentinization of the host high-Mg-Ni-Cr basalt (picrite) and fine-grained sedimentary rocks. Gold mineralization seems to be principally associated with the S_2 fabric, as high assays are coincident with carbonate-quartz-sulphide veins crosscutting the sulphidic metasiltstone, and persistent low-grade gold mineralization also occurs in silicified picrite.

INTRODUCTION

The Agassiz Metallotect is an economically important zone of rocks that host significant gold deposits within the Paleoproterozoic Lynn Lake greenstone belt of northern Manitoba. This federal-provincial research project was initiated to complement and expand on earlier regional geological mapping, lithogeochemical sampling and gold deposit studies in the region. Due to our evolving understanding of the genesis of gold deposits in greenstone belts in general, there are presently conflicting genetic theories regarding the origin of the gold deposits, including those in the Lynn Lake region. Therefore, this mapping project in the northern part of the Lynn Lake greenstone belt was initiated to enhance understanding of its stratigraphic and structural evolution, with particular emphasis on the genetic relationship to gold mineralization in the region. This study also complements the detailed structural analysis begun in the southern part of the belt (Johnson Shear Zone; Beaumont-Smith, GS-10, -12, this volume; Beaumont-Smith and Edwards, GS-13, this volume; Jones et al., GS-14, this volume; Beaumont-Smith et al., GS-15, this volume).

The MacLellan and Dot Lake gold deposits are located about 7 km northeast of the town of Lynn Lake within the Paleoproterozoic Lynn Lake greenstone belt. Gold mineralization is hosted by a unique stratigraphic succession know as the Agassiz Metallotect (Fedikow and Gale, 1982), a subdivision of the metavolcanic and metavolcaniclastic Wasekwan Group. The Agassiz Metallotect has long been recognized as host to some important gold deposits, including MacLellan, Dot Lake, Farley and a number of other smaller occurrences (Fedikow, 1986). It has been the target of gold exploration since the 1950s and the focus of research on its geology, geochemistry and the relationship between these and gold mineralization (Fox and Johnson, 1981; Fedikow and Gale, 1982; Fedikow, 1983, 1986, 1992; Fedikow et al., 1986, 1991; Samson and Gagnon, 1995; Ferreira and Baldwin, 1997; Samson et al., 1999). However, the relationship between gold mineralization and deformation is poorly understood. This work is part of a program of detailed structural analysis of the Lynn Lake greenstone belt and the metallogeny of the gold deposits in the area. The purpose is to provide insight into the process involved in the formation of gold mineralization in the Lynn Lake area and provide new information to guide further exploration for gold deposits. Fieldwork during the 2000 field season included detailed 1:5000 geological mapping near the MacLellan and Dot Lake gold deposits, geochemical sampling, and the logging and sampling of a dozen diamond-drill holes from the area.

GEOLOGICAL SETTING AND STRATIGRAPHY

The Lynn Lake greenstone belt is subdivided into northern and southern supracrustal belts, with intervening intrusive complexes. The supracrustal rocks are composed mainly of Paleoproterozoic metamorphosed volcanic, volcaniclastic and sedimentary rocks that make up the Wasekwan Group (Bateman, 1945). These rocks have been intruded by plutonic rocks of the Pool Lake suite (Gilbert et al., 1980). The Agassiz Metallotect is included in Division D of the Wasekwan Group (Fedikow, 1986) and is characterized by a unique and well defined lithological assemblage, although facies changes are apparent (Fedikow, 1986). The metallotect is generally defined by an interlayered (intercalated) sequence of high-Mg-Ni-Cr basalt (picrite), sulphidic siltstone and iron-formation. This stratigraphic sequence has a strike length of over 65 km, and hosts the MacLellan and Dot Lake gold deposits in the western portion of the metallotect and the Farley Lake gold deposit in the eastern portion (Fedikow, 1983; Fedikow et al., 1986, 1991). In the vicinity of the MacLellan and the Dot Lake gold deposits, the stratigraphy comprises three units: hanging-wall mafic volcanic and volcaniclastic rocks, Agassiz Metallotect, and footwall mafic volcanic and volcaniclastic rocks (Fig. GS-11-1). The hanging-wall and footwall mafic rocks are texturally and geochemically very similar (Fedikow, 1986). Metamorphism within the northern part of the Lynn Lake greenstone belt is characterized by lower to middle amphibolite facies assemblages. The peak of metamorphism postdates the main deformation events and emplacement of the mineralization and associated alteration.

The hanging-wall mafic volcanic sequence comprises amygdaloidal and aphyric to plagioclase porphyritic basalt, autoclastic and heterolithic breccia, and thin mafic epiclastic units. The abundant mafic breccia within the hanging-wall sequence consists of matrix-supported clasts of dark green plagioclase porphyritic basalt, amygdaloidal basalt, aphyric basalt and quartz porphyritic rhyolite in a matrix of variable composition. The basaltic clasts (<40 cm) are rounded, elongated and locally strongly epidotized, whereas the rhyolite clasts are usually rounded and slightly elongated (Fig. GS-11-2). The breccia matrix ranges from fine-grained hornblende and plagioclase, very similar in composition and appearance to the clasts, to a very fine grained, silty matrix. The local preservation of primary depositional features, most notably bedding, together with the heterolithic nature of the breccia in the immediate MacLellan deposit area, suggests that this unit probably

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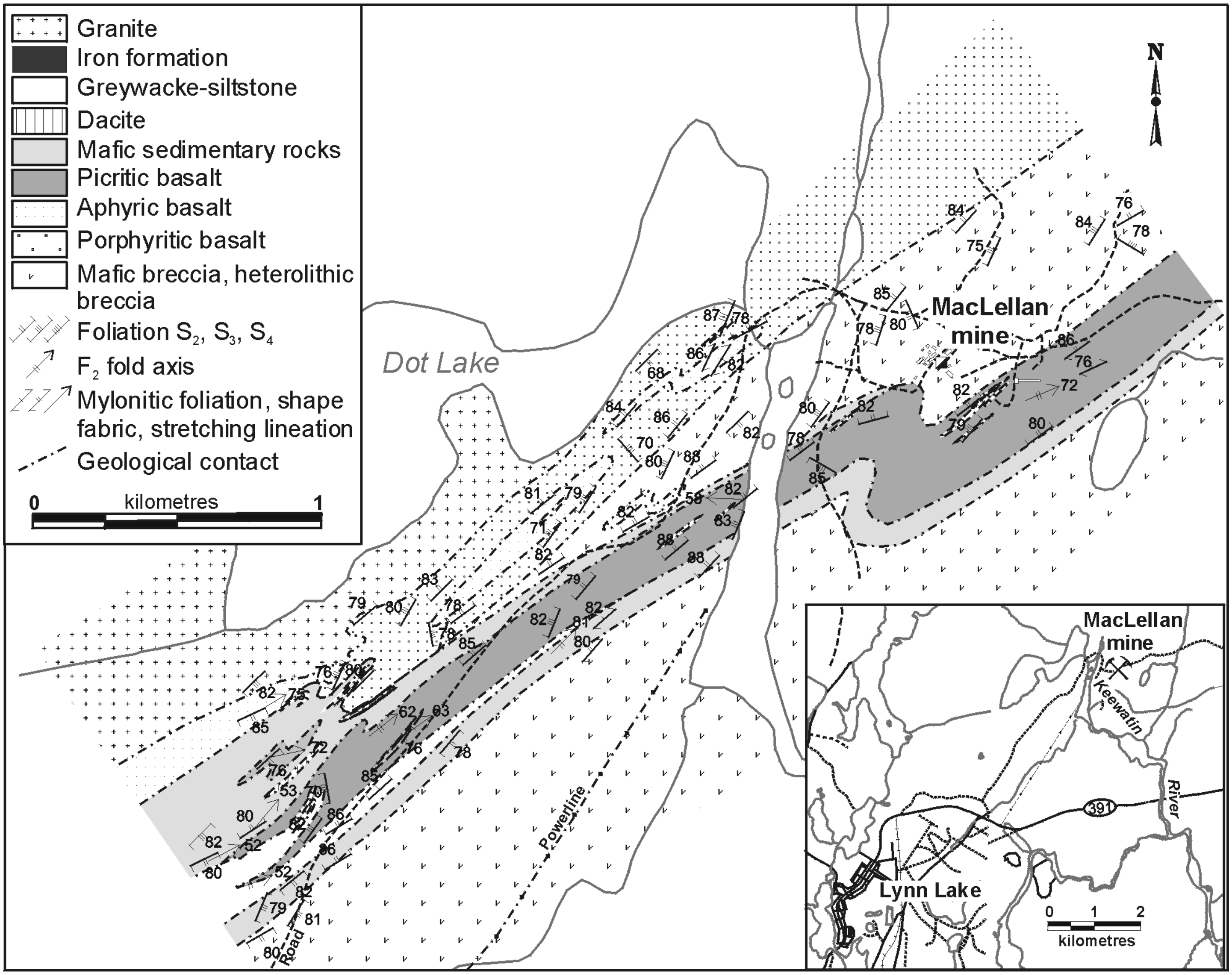

Figure GS-11-1: Geological map of the Dot Lake and MacLellan gold deposits area.

Figure GS-11-2: Basaltic epiclastic layer within heterolithic mafic breccia. S_2, which is defined by the stretched clasts, is crosscut by refracting S_4.

represents a debris flow. The coarse breccia north of the MacLellan headframe grades laterally (west) into finer grained breccia and finely laminated mafic epiclastic sedimentary rocks, consistent with more distal facies of this volcaniclastic unit.

This lateral facies change is mirrored by a change in the nature of the basalt in the stratigraphy. The hanging-wall porphyritic basalt in the MacLellan deposit area contains plagioclase phenocrysts, about 3 mm in size, that typically constitute approximately 20% of the rock. To the west of the deposit, the basalt becomes increasingly aphyric as the proportion of breccia decreases. To the north of the deposit, the phenocrysts are less abundant and smaller, with the basalt eventually becoming aphyric in the northern part of the study area.

The Agassiz Metallotect in the MacLellan–Dot Lake area consists of high Mg-Ni-Cr basalt (picrite), dark green (mafic) sedimentary rocks, greywacke, and minor dacite and oxide-facies iron-formation. The Agassiz Metallotect stratigraphy in the MacLellan–Dot Lake area is dominated by picrite in the immediate MacLellan mine area and by sedimentary rocks to the west.

The picrite has a highly variable mineralogical and textural nature, reflecting alteration and deformational changes throughout the study area. Picrite is recognized by its bright forest-green colour and very soft outcrop surface. Unaltered picrite is composed of coarse-grained actinolite (up to 5 mm) and lesser dark green hornblende in a fine- to coarse-grained chloritic groundmass. The picrite is generally strongly foliated, with the main foliation defined by the preferred orientation of amphibole. Rarely preserved pillows with well defined selvages and porphyritic cores indicate a submarine volcanic-flow setting (Fig. GS-11-3).

Mineralized and altered picrite is characterized by increasing degrees of biotitization, silicification and carbonatization. The mineralized zones exposed at the MacLellan and Dot Lake deposits are very highly strained, making an assessment of the nature of alteration and mineralization difficult. These zones generally comprise intercalated, lens-shaped domains of coarse-grained actinolite-chlorite (unaltered picrite), biotite-actinolite-talc-quartz and biotite-actinolite/hornblende-plagioclase-quartz with minor amounts of finely disseminated sulphide minerals (dominantly pyrite; cf. Gagnon, 1991). It is uncertain at this stage of the investigation whether the latter two constituents represent boudinaged and transposed, originally interbedded stratigraphic units (now altered) or transposed zones of varying degrees of alteration. The altered, biotite-rich domains are significantly more siliceous than the unaltered picrite, and contain a very penetrative fabric defined by the preferred orientation of biotite and amphibole.

Intercalated with the picrite are layers of well laminated biotitic greywacke, composed of quartz, plagioclase, biotite, and minor amphibole and disseminated sulphide minerals. Siltstone clasts are also present but are rare. Low-grade gold mineralization is associated with sulphide minerals, which locally approach 60% of the rock. Possible mafic sedimentary rocks associated with this unit have a bedded (laminated) texture and are dominated by metamorphic fine-grained amphibole and plagioclase, although these units may represent highly deformed mafic volcanic rocks.

Oxide-facies iron-formation, the second diagnostic rock type characterizing the Agassiz Metallotect, occurs as 10 to 30 cm thick units of magnetite-chert exhalative sedimentary rocks locally interbedded with the clastic sedimentary sequence. The finely laminated magnetite and chert layers clearly show the original bedding (Fig. GS-11-4). The competent chert layers were folded and boudinaged into discontinuous layers during deformation.

Minor units of grey to white dacite are found intermittently throughout the metallotect stratigraphy. These units are composed of fine-grained quartz and plagioclase. The nature of these units is not well understood and the contact relationships with surrounding rock types are unclear. These rocks locally appear conformable with sharp contacts, whereas, in other areas, they are characterized by diffuse contacts that appear discordant. The uncertainty regarding this unit revolves around the possibility that it may represent either felsic dykes with local alteration of their host, or transposed silicic alteration.

The footwall mafic volcanic rocks only outcrop in the southwest corner of the study area. They consist of fragmental basalt very similar in appearance to the hanging-wall sequence. The rock has a clastic texture, although it is typically massive in appearance with minor bedding features preserved. The porphyritic phases contain angular and unsorted plagioclase phenocrysts. There are cases where this fragmental basalt unit contains some smaller clasts of aphyric or porphyritic basalt.

STRUCTURAL ANALYSIS

Detailed structural analysis was conducted around the MacLellan and Dot Lake gold deposits in order to understand the postdepositional deformational history and its role in controlling the gold mineralization. Detailed mapping has identified five generations of deformational fabrics.

The preservation of early S_1 fabrics is rare due to the intensity of S_2. In siltstone, S_1 was observed as relict isoclinal folds on the limbs of F_2 folds, with its axial plane folded by F_2 folds. The F_2 event folds an older bedding-parallel tectonic fabric (S_1), which is locally preserved in S_2 crenulation cleavage microlithons.

The most penetrative fabric developed in rocks of the Agassiz

Figure GS-11-3: Pillowed porphyritic picrite. The pillow cores contain coarse-grained amphibole (after pyroxene), whereas the margin is composed of fine-grained chlorite.

Figure GS-11-4: Banded chert-magnetite iron-formation. Note boudinage of more competent chert layers. Back-rotation of chert boudins indicates dextral transcurrent shearing.

Metallotect is S_2, which generally forms a finely spaced to differentiated, steeply northwest-dipping foliation in the picrite and sedimentary rocks. It is defined in the coarse volcaniclastic rocks as a preferred orientation of the flattened clasts. The lack of S_1 preservation results from its widespread transposition to form an S_2 composite fabric. Zones of S_2 crenulation cleavage are generally restricted to F_2 hinge areas, reflecting the lower strains associated with the fold hinges. The S_2 fabric is axial planar to tight to isoclinal F_2 folds that plunge moderately to steeply to the east-northeast (Fig. GS-11-5). The F_2 folds represent the primary control on the distribution of units within the metallotect. The overall geometry of these folds is Z-asymmetrical.

The possible deformational control on the mineralization and alteration of the gold deposits hosted by the metallotect is suggested by the close association between distribution and timing of the introduction of mineralization and the development of D_2 high-strain (shear zone) fabrics. This association is evident at both the MacLellan and Dot Lake (K zones) deposits. In both cases, fabric development is characterized by the development of pre–peak metamorphic dextral shear fabrics, including dextral transcurrent S-C fabrics and shear-band cleavages (Fig. GS-11-6). Where the picrite is strongly altered, quartz and carbonate ribbons and veins define S_2, producing ribbon mylonite (phyllonite). Silicification and carbonatization of the picrite begins as syn-shear veins that become progressively transposed; this is a cyclical process that results in the wholesale silicification and carbonatization of the host. The transcurrent shear fabrics are accompanied by the development of steeply plunging to down-dip stretching lineation. These kinematics are consistent with those characterizing the Johnson Shear Zone (Beaumont-Smith and Rogge, 1999; Beaumont-Smith, GS-12, this volume), further supporting the possibility of the regional development of D_2 shear zones elsewhere in the Lynn Lake greenstone belt.

The field observations suggesting a link between D_2 fabric development and mineralization are reinforced by examination of drill core. Logging and sampling of a dozen diamond-drill holes shows that the mineralization is controlled by both lithology and hydrothermal alteration related to D_2 shear-related deformation. The higher average gold mineralization is associated with sulphidic greywacke and silicified picrite. No mineralization has been documented in the hanging-wall or footwall mafic volcanic rocks. Almost all the picrite-hosted gold mineralization is associated with quartz-carbonate-sulphide veins and the associated alteration. In the Dot Lake K_2 zone, gold mineralization is closely related to a 4 m wide zone of quartz-sulphide veining accompanied by silicification and intense biotitization, which is subparallel to S_2. The mineralized outcrops also show that the quartz-carbonate-sulphide veinlets and the alteration are subparallel to S_2. Although there are several later generations of quartz, quartz-carbonate and quartz-carbonate-chlorite veins, they do not seem to have sulphide or gold mineralization associated with them. At this point, based on these field-scale observations, it seems that gold mineralization is associated with hydrothermal

Figure GS-11-5: Z-asymmetrical F_2 folds in siltstone.

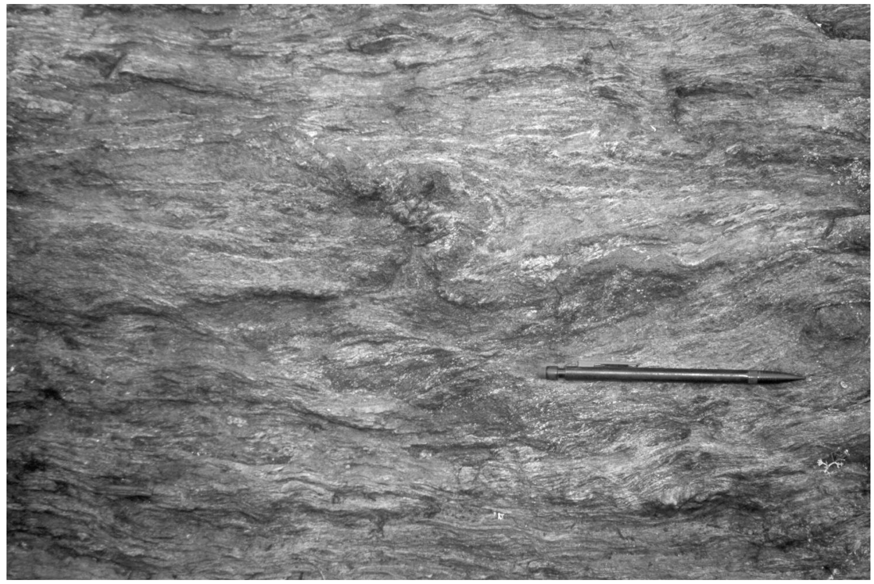

Figure GS-11-6: D_2 dextral S-C fabric and shear-band foliation in picrite.

activity related to late S_2 fabric development and shearing (*see also* Samson et al., 1999). However, it is still uncertain if this zone contained any pre-existing gold mineralization (epithermal style), as was postulated in earlier models (cf. Fedikow, 1986). If this was the case, remobilization of sulphide minerals and gold from pre-existing mineralization by focused fluid flow along this deformation zone may enhance earlier protore mineralization; however, further work is required to ascertain the most appropriate genetic model and discriminate between the two dominant hypotheses. Therefore, microstructural analysis will be done on the outcrop and drill core samples taken this year around the deposits, so as to examine the gold and base-metal mineralization and its relationship to deformation fabrics.

The D_2 fabric elements and the gold mineralization and alteration are overprinted by northeast-trending F_3 folds and axial-planar S_3 crenulation cleavage (Fig. GS-11-7). The F_3 folds are open to close in style and are uniformly Z-asymmetrical. They plunge moderately to the northeast and the associated northeast-trending S_3 crenulation cleavage dips steeply northwest. The crenulation microfolds generally have a chevron geometry, as do the F_3 folds in areas of elevated D_3 strain. Locally, narrow pseudotachylite zones follow S_3, but the exact timing of pseudotachylite development is less clear and may represent exploitation of the S_3 foliation as a pre-existing channelway, as opposed to being the result of D_3 strain.

Development of the D_3 fabric is broadly coincident with the peak of metamorphism. Metamorphic recrystallization overprints D_2 fabrics, whereas D_3 fabric development appears to span the growth of peak metamorphic assemblages (cf. Beaumont-Smith and Rogge, 1999). In picrite, actinolite and biotite porphyroblasts are randomly oriented in some rocks and define S_3 elsewhere, suggesting that the time span of porphyroblast growth reflects variations in local bulk chemistry.

Two post–peak metamorphic deformation events have been identified. A D_4 deformation produced north-trending, open F_4 folds and a weak S_4 foliation comprising crenulation cleavage, fracture cleavage and kink bands. The S_4 foliation commonly forms a conjugate set of kink bands or fracture cleavage. The final deformation produced predominantly east-trending brittle structures. These late structures generally take the form of zones of cataclasite, highlighted by the development of pseudotachylite, which form along the shear structure and are injected into the other intersecting brittle structures (Fig. GS-11-8). The cataclasite zones strike subparallel to the S_2 trend but dip slightly less steeply. The North shear that truncates the MacLellan main zone appears to be a D_5 structure, according to the descriptions of Gagnon (1991) and Samson and Gagnon (1995).

CONCLUSIONS

Preliminary structural analysis of the Agassiz Metallotect has identified

Figure GS-11-7: S_3 crenulation cleavage overprinting S_2 composite foliation in picrite.

Figure GS-11-8: D_5 pseudotachylite (arrow) developed in mylonitic sediments. Note the abundant shear bands in the finely laminated upper portion of the photo.

five generations of ductile and brittle-ductile fabrics. Near the Dot Lake and MacLellan gold deposits, D_2 fabrics are the dominant fabric elements and exercise primary control on the distribution of the stratigraphic units. The deformation associated with D_2 is locally intense and characterized by very high strains, as evidenced by the development of tight to isoclinal folds, the transposition of earlier S_1 foliations producing a composite S_2 foliation, and the local development of S_2 parallel dextral shear zones. It is these zones that are empirically most intimately associated with gold and base-metal mineralization and related hydrothermal alteration. Peak metamorphism is broadly coeval with F_3 folding, based on the presence of amphibole (±plagioclase±phyllosilicate) porphyroblasts along the associated fabrics. The late F_4 open folds and D_5 brittle fabrics do not appear to represent significant deformations in terms of the distribution of units or involvement in the gold-mineralizing event.

As an extension of this work, detailed petrology is planned to complement the geochemical analyses that are presently being obtained. About 200 samples were collected from available drill core and outcrops for polished thin section work, X-ray diffraction analysis, and geochemical analysis. This lab work should provide more clues to the genesis of the MacLellan and Dot Lake gold deposits.

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