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Geological Setting of Gold Mineralization, Snow Lake, Manitoba

by

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OPEN FILE NOTES: SNOW LAKE PROJECT

Introduction

This open file is a preliminary product of a gold deposit study which is part of the federal contribution under the Canada-Manitoba Mineral Development Agreement (1984-89). The map, which includes the town of Snow Lake, encompasses an area 4500 metres by 3500 metres at the scale of 1:5000. The Snow Lake gold district is situated within the eastern half of the Aphebian Flin Flon volcanic belt. The regional geology has been reviewed by Bailes et al (1987). Extensive reports on the geology of the Snow Lake region include Harrison (1949) and Froese and Moore (1980); specific descriptions of the Nor-Acme deposit include Ebbutt (1944), Harrison (1948), Hogg (1957) and Ziehlke (1983). The base map used for this study was compiled from an unpublished 1:4800 scale geological map prepared by Howe Sound Exploration Ltd in the 1940's, and from recent aerial photographs and a town plan supplied by the Town of Snow Lake

The Snow lake region has a long history of gold, and more recently, base metal exploration. In the 1930's, prospectors discovered numerous gold occurrences, including those currently known as the Bounter Zone, Nor-Acme Mine, Boundary Zone, and Snow Lake Mines Ltd. No 3 Zone. The Nor-Acme Mine, located on the north edge of the town, was the largest gold mine in the Proterozoic portion of the Canadian Shield. Total production between 1948 and 1958 was approximately 500,000 ounces of gold from 5.3 million tons grading 0.15 ounces gold/ton. The old workings are currently being dewatered by High River Resources Ltd. to evaluate remaining reserves. Snow Lake Mines Ltd. recently announced reserves at their No. 3 Zone of 560,000 tons grading 0.28 ounces/ton (Thompson Post, October, 1978).

General Geology

The map area is underlain by Amisk Group metavolcanic and metasedimentary rocks and Missi Group metasedimentary rocks. Both supracrustal groups are intruded by mafic intrusions. All of the rocks in the study area have been affected by lower amphibolite grade metamorphism. The prefix 'meta' will be inferred for the remainder of this report.

The Amisk Group volcanic suite is composed of folded and faulted interlayered sequences of felsic and mafic rocks, with the units on the northeast limbs of the folds facing northeast. The mafic volcanic rocks are divided into two main groups, volcaniclastic and pillowed basalts. Massive to pillowed basalt flows form a sequence, 250 to over 500 metres wide, along the west shore of Birch Lake, and extending west across the northern quarter of the study area. The basalt flows are principally aphyric, with minor plagioclase porphyritic flows. The rocks are fine- to medium-grained, with their massive portions locally subophitic. Pillows are poorly exposed, and average 30 centimetres by 50 centimetres with thin selvages.

Mafic tuff makes up approximately one-third of mafic volcaniclastic rocks. The tuffs are commonly finely layered, and with graded bedding, planar cross-bedding and slump features. These layered tuff units are commonly one to ten metres thick, except along the base of the pillowed basalt sequence, where a layered tuff unit is up to 50 metres thick. The remaining portion of the mafic volcaniclastic rocks are interlayered lapilli tuff and tuff breccia, which, along with the tuff units, form a series of coarsely-graded debris flow sequences. The coarser volcaniclastic rocks have abundant phenoclasts of plagioclase and hornblende porphyroblasts up to one centimetre in length. Clasts vary in composition and morphology from angular fragments of purple feldspar-phyric felsic tuff, particularly near the contacts between mafic and felsic units, to more rounded fragments of aphyric, feldspar-porphyritic and scoriaceous basalt.

The felsic volcanic rocks in the area are predominantly fragmental, with a wide variation in clast size and mineral assemblage. Massive felsic rocks are most commonly fine-grained aphyric to feldspar-quartz phyric tuff. In general, the felsic tuff is massive, with few observed outcrop-scale primary structures. One of the few finely bedded sequences is near the Manitoba Hydro station, where one to two metre thick sequences of tuff are interlayered with coarse breccia. The tuff varies from aphyric to feldspar and feldspar-quartz phyric, but is primarily feldspar-quartz phyric. The latter consists of a very fine-grained matrix of feldspar, quartz and biotite, with millimetre-scale bands rich in biotite and garnet. Garnets are usually one millimetre or less in size. Phenoclasts of plagioclase and quartz are commonly one to two millimetres, with the plagioclase commonly larger than the quartz. Within the sequence of felsic rocks that strikes through the town of Snow Lake, tuffs have a maximum thickness of 300 metres, but are thin westward towards the town.

Occurrences of felsic lapilli tuff and lapillistone are generally difficult to trace for any distance, and have not been subdivided into discrete units. These rocks commonly have a biotite-garnet rich matrix containing quartz and feldspar-quartz porphyritic fragments that are rounded to sub-angular, and up to six millimetres in diameter.

Felsic tuff-breccia and breccia form discrete units up to 200 metres thick that are thickest near the townsite and thinner to the west. Fragment size averages 25 centimetres with some fragments up to one metre in diameter. Along the north end of town, the fragments and matrix of these coarse-grained rocks are dominantly plagioclase porphyritic. In units further west the breccia clasts become dominantly quartz porphyritic, with quartz phenocrysts up to three millimetres. In some cases the fragments have chilled margins. Although contacts with lapillistone are generally gradational, those between breccia and tuff are sharp.

The Amisk Group volcaniclastic rocks are intruded by numerous gabbroic and pyroxenitic dykes and sills, with the pyroxenite metamorphosed to hornblendite. Gabbroic rocks include melagabbro, containing abundant hornblende porphyroblasts, to equigranular gabbro and minor leucogabbro. Primary layering is present in several of the bodies. These mafic intrusions are numerous and compose up to 40% of the pillowed basalt sequence west and northwest of Birch Lake.

The Amisk Group volcanic rocks are bordered to the south and west by a thick sequence of fine-grained immature sedimentary rocks which have been metamorphosed to biotite-garnet and staurolite-biotite-garnet schists. Studies in the File Lake region of the Flin Flon Belt by Bailes (1980), indicate that these immature metasedimentary rocks stratigraphically overlie the volcanic rocks. The metamorphic minerals are locally coarse-grained, with staurolite porphyroblasts up to five centimetres long. Kyanite is present at one location on the north shore of Snow Lake. Layering is defined by 20 to 100 centimetre-wide beds of argillite and greywacke. No dykes or sills have been observed to intrude this sedimentary sequence.

The Amisk Group is stratigraphically overlain by the Missi Group, a subaerially deposited sequence of arenite, with minor interbeds of pebble conglomerate. The fine-grained sedimentary rocks are characterized by abundant trough cross-bedding. The sedimentary sequence is intruded by numerous gabbro and feldspar porphyritic diorite sills, with lit-par-lit injection evident at several localities.

Structure and Metamorphism

The area contains several large-scale structures, most of which were recognized by Harrison (1949) and Russell (1957). There is evidence within the volcanic sequence for two major fold events. The first event (F1) is indicated by isoclinal folding of both the Amisk and Missi Group rocks, resulting in the formation of a strong penetrative axial planar schistosity (S1), defined by biotite and hornblende orientation, that dips 55° to 70° to the north and east. Within the plane of this foliation, volcanic fragments are flattened and stretched to an average ratio of 1:3, with the stretch direction defining a strong lineation plunging moderately to the northeast. An example of an F1 fold is the Nor-Acme anticline, first defined by Harrison (1949). The trace of this fold axis is indicated on the map just north of the Nor-Acme deposit, with two more structures of similar scale to the northeast.

The volcanic sequence is bordered to the west and south by the McLeod Road Fault, which has attenuated and truncated the limbs of some F1 folds. Drilling by Hudson's Bay Exploration and Development Co. along the southern trace of the fault indicates that the fault plane dips 45° to 60° to the north and east, paralleling the S1 foliation. West of town, the fault is marked by a zone of schist in the volcanic rocks up to 120 metres wide. The McLeod Road Fault is interpreted as being a reverse fault, overthrusting the Amisk Group volcanic rocks westward onto the Amisk Group sedimentary rocks.

The volcanic rocks are bounded to the east by the Birch Lake Fault, (named during this study), which forms the contact between the volcanic rocks and the Missi Group sedimentary rocks This fault contact was established by Harrison (1949), with the present work providing a more precise location for the fault trace. As the fault trace is approached from the west, the S1 foliation shallows to less that 40° and increases in intensity. East of the fault trace, the S1 foliation and bedding within the Missi Group arenites remains at this shallow angle.

A second phase of deformation (F2) involved folding of the rocks into broad NNE trending structures. This event is indicated by the large scale warping of the litho-stratigraphic units as well as the formation of a second axial planar cleavage (S2), overprinting S1, and defined by biotite alignment and staurolite growth within the S2 foliation plane.

During this second phase of folding, the McLeod Road and Birch Lake faults were reactivated. The reactivation of the McLeod Road Fault is evidenced by the realignment of staurolite porphyroblasts which have been rotated into the fault plane from an original orientation along the S2 foliation. Also post-dating D1 deformation was the formation of a series of north to northeast, moderately dipping faults in the hangingwall to the McLeod Road Fault. These faults cross the strata at an acute angle in the east half of the map sheet, and in the west half transect F1 fold structures at right angles. The fault containing the Nor-Acme deposit offsets the McLeod Road Fault. From underground mapping at the Nor-Acme Mine, Hogg (1957) estimated that there is 120 metres of oblique left lateral displacement along this fault. The movement is parallel to the strong northeast trending, moderately plunging stretch lineation observed along the fault trace. In proximity to these hangingwall faults, the stretch lineation intensifies with fragments attaining aspect ratios of 6:1 to 10:1. The McLeod Road Fault and the hangingwall faults all show kinematic evidence of oblique sinistral movement. This includes a strong stretch lineation and parallel slickensides, deformation of the pre-existing F1 foliation and differential deformation of vein arrays associated with the faults. The faults are characterized by a mineral assemblage that overprints the prograde regional metamorphic assemblage. This assemblage is described below. A series of small northerly striking faults with apparent sinistral displacement offset the Nor Acme ore bodies and associated hangingwall fault (Hogg, 1957), and offset portions of the pillowed basalts and associated synvolcanic alteration.

Mineralization

Gold mineralization is associated with the post D1 reverse faults within the Amisk Group volcanic sequence, with the major deposits and occurrences within 500 metres of the surface expression of the McLeod Road Fault. The mineralized shears and fault sets trend 260°-290° and 330°-340°, dipping 40° to 60° to the north and northeast respectively. The principal mineralized faults, which include the Nor Acme, No. 3, Boundary and Bounter zones, trend 260°-290°. These faults, with the exception of the Bounter zone, cross-cut the F1 axial planar foliation at a high angle, at or near the contact between units of contrasting competency. A 030°-040° mineralized shear, northeast of the No. 3 Zone, contains auriferous altered rocks similar in composition to those in the major gold zones, and may reoresent a conjugate to the principal 260°-290° faults. Mineralized shears along the 330°-340° trend are parallel to the F1 axial plane foliation. The gold zones within all of these faults and shears plunge moderately to the northeast, parallel to the regional stretch lineation. The Nor-Acme deposit is characteristic of the study area, consisting of zones of fault breccia up to 30 metres wide, composed of carbonatized fragments of wall rock in a matrix of quartz, albite and ferroan dolomite. The margins of the breccia zones are strongly foliated, and contain abundant purple biotite. This is an oxy-biotite, reddish-brown in thin section, as opposed to the dark brown to green biotite common in the felsic volcanic rocks. At the margin of the breccia zone, the fragments are attenuated to form a layered rock. The biotite-rich wallrocks and the breccia fragments contain 1-2% pyrite and pyrrhotite, and up to 3% fine-grained needle-like aggregates of arsenopyrite. The gold content in the zone is directly proportional to the abundance of arsenopyrite needles.

Alteration

The volcanic rocks in the study area have been affected by pre- and syn-metamorphic alteration . The mafic volcanic rocks have been affected by synvolcanic alteration commonly associated with the emplacement of volcanogenic massive sulphide deposits in this region (Skirrow, 1987). Within the mafic volcaniclastic rocks there are patchy occurrences of iron-magnesium alteration, characterized by a biotite-garnet-cummingtonite-anthophyllite mineral assemblage. In the pillowed basalts, synvolcanic alteration is restricted to a stratabound zone which is parallel to folded strata from the west shore of Birch Lake, northwest across the top of the map sheet to the faulted-off western limit of this sequence of pillowed basalt. Within this zone of stratabound alteration there are zones of bleached pillowed basalt containing sercite-quartz-biotite-feldspar, and zones of coarse-grained cummingtonite-hornblende-biotite-garnet.

The syn-metamorphic phase of alteration is centered on the post D1 faults and shears within the volcanic rocks, along the McLeod Road Fault and along the trace of the D1 fold structure in the north-central part of the map area. The alteration is characterized by intense iron carbonate-biotite-chlorite alteration along the main lineaments, a mineral assemblage that overprints the prograde metamorphic assemblage. Within the smaller S2 faults and shears, the overprinting assemblage is similar, becoming more complex along auriferous portions of these lineaments. Within the mafic rocks, this assemblage includes actinolite, ferro-dolomite, biotite, albite, quartz, sericite, tourmaline, pyrrhotite, pyrite, arsenopyrite and gold. In felsic rocks, the ferro-magnesian minerals are less abundant, and albite and quartz are more abundant. Concentrated around these gold-rich alteration zones, are veins up to 50 centimetres wide and several metres long that parallel and are perpendicular to the shear zones. Within 50 metres of the altered shears, the veins consist of quartz-carbonate-clinozoisite-albite-tourmaline and, from 50 to 80 metres from the zones they consist of quartz-carbonate-albite-tourmaline. Also associated with the auriferous alteration zones are undeformed fractures containing hematite-carbonate-epidote. These latter fractures clearly formed late in the tectonic history of the area, and their relationship to gold-associated alteration is unclear.

Conclusions

Gold mineralization in the Snow Lake area is controlled by a series of sinistral oblique slip reverse faults within Amisk Group volcanic rocks in the hangingwall of the McLeod Road Fault. The faults formed late in the F2 folding event. The gold mineralization is characterized by carbonatization of the host rocks surrounding a quartz-albite-iron carbonate fault breccia with strongly biotitized and sheared margins. The carbonate-rich alteration assemblage overprints the prograde regional metamorphic mineral assemblage. The principal sulphide mineral associated with gold mineralization is arsenopyrite. The gold zones plunge parallel to the regional stretch lineation within the moderately dipping reverse faults. The relationship of gold mineralization to the F2 faults and shears, and the association of gold to a retrograde metamorphic alteration assemblage would indicate that the gold was emplaced late in the deformational and metamorphic history of the belt.

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