GS-4 Metallogenic and metamorphic study of selected deposits from the Snow Lake area and the southern flank of the Kisseynew Domain, Manitoba (NTS 63K16 and 63N2)

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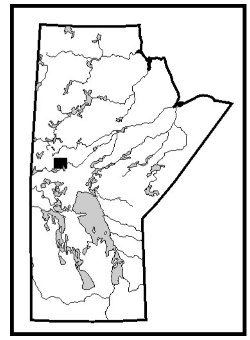

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Summary

During the 2006 field season, four gold-bearing mineral deposits (Chisel North, Squall Lake, Nokomis Lake and Puffy Lake) were investigated in the Snow Lake greenstone belt and overlying Kisseynew Domain margin. Work carried out at each site included detailed mapping of surface outcrops and trenches, underground mapping, sampling of ore and hostrocks, and relogging and sampling of drill core. The purpose of this field campaign was to collect a set of representative samples from each deposit for detailed textural and chemical analysis, as well as to gain a good understanding of the geological context of the mineralization.

Introduction

This project, which is supported by the Manitoba Geological Survey and the Geological Survey of Canada, aims to investigate the effects of metamorphism on sulphide-gold mineralization. It is part of a larger scope regional gold metallogenic study of the Snow Lake greenstone belt. The 2006 field season permitted the continuation of the project started in 2005 and completion of the sample collection. The sulphide-gold mineralization of the various deposits (Chisel North mine, Squall Lake, Puffy Lake mine and Nokomis Lake; Figure GS-4-1) is hosted by rocks displaying a spectrum of metamorphic conditions from lower to upper amphibolite facies. Each deposit will be studied in a two-fold manner. First, a comparison study will examine the variation in chemistry and mineralogy between the unaltered hostrock, the altered wallrock and the ore to better understand the nature of the mineralization. The conditions and timing of peak metamorphism will be established as accurately as possible for each location. The role of metamorphism in the evolution of the mineralization to its current state

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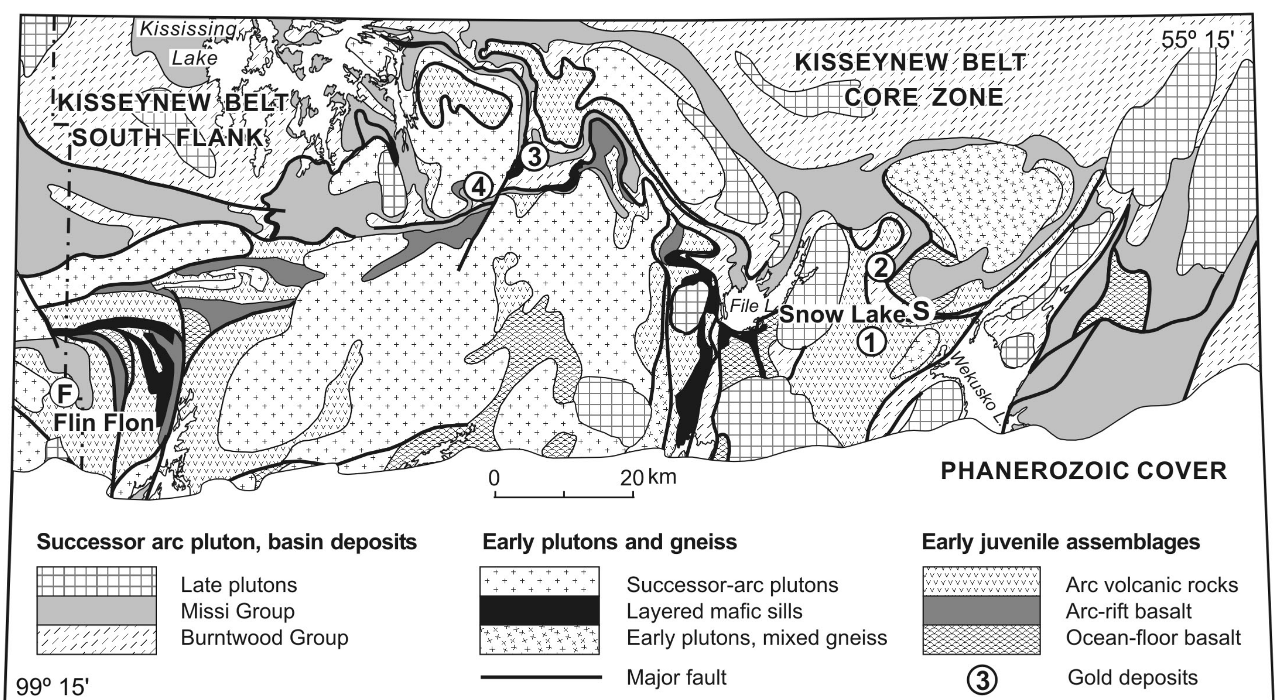

Figure GS-4-1: *Generalized geology of the Snow Lake area, showing the location of the selected gold deposits: 1) Chisel North mine, 2) Squall Lake, 3) Nokomis Lake, and 4) Puffy Lake mine.*

will also be investigated in detail. The results from all the deposits studied will be synthesized to enable a better understanding of the possible effects of increasing P-T conditions on the evolution of sulphide-gold mineralization.

Chisel North mine

The Chisel North mine, owned by Hudbay Minerals Inc., is located about 12 km south of the community of Snow Lake. In 1987, deep step-out exploratory drilling intersected sulphide lenses occurring near the same stratigraphic level as the main Chisel mine orebody but 300 m down plunge. Mining started in 2000. Chisel North is a proximal volcanogenic massive sulphide (VMS) deposit (Galley et al., 1993) with sulphide mineralization occurring mainly as semimassive to massive sphalerite-pyrite. The hangingwall of the deposit, which is enriched in Au, Ag, Cu and Pb, is of interest to this study.

Previous work

The area around Chisel North has been the site of regional mapping by the Manitoba Geological Survey (MGS; Bailes et al., 1996). Work by Galley et al. (1993) examined in detail the alteration and mineralization of the Chisel and Chisel North orebodies.

Regional geology

The Chisel North deposit is hosted by evolved subaqueous volcanic rocks from the mature portion of the 1.8 to 1.9 Ga Snow Lake arc assemblage (Bailes and Galley, 1999). The northwest-trending synclinal fold interference structure locally known as the Chisel basin is host to the Chisel North orebody, as well as the past-producing Chisel, Photo Lake, Ghost Lake and Lost Lake mines. The Chisel basin is an ~5 km thick arc assemblage comprising mainly mafic wacke, mafic breccia, pillowed basalt and synvolcanic gabbro intrusions. Menard and Gordon (1995) carried out thermobarometric calculations for the Photo Lake mine, located ~2 km northeast of the Chisel North mine. Results suggest that peak P-T conditions reached nearly 535°C at approximately 5 kbar.

Mineralization

The ore typically consists of up to 20 m of silicate-dolomite-rich, semimassive, sphalerite-rich ore with thin interlayers of massive sulphides, and is underlain by discordant zones of disseminated and vein sulphides. Sphalerite and pyrite are the main sulphide phases, although massive pyrrhotite occurs near the hangingwall. The underlying dacite consists of recrystallized, hydrothermally altered rocks now consisting of sericite and chlorite, with common kyanite, biotite, staurolite and garnet porphyroblasts (Galley et al., 1993). The orebody is stratigraphically underlain by a broad, hydrothermal alteration zone hosting sericite- and chlorite-rich lenses containing Zn, Fe, Pb, Cu, As, Au and Ag. Throughout the Chisel basin, the ore horizon is typically overlain by a thick package of mafic wacke. In the no. 4 lens of the Chisel North deposit, the hangingwall of the zinc-rich sulphides is an altered basalt or gabbro body that is locally enriched in Au, Ag, As, Cu and Pb. The nature of this Au-Ag-As-Cu-Pb mineralized zone is still ambiguous.

2006 results

Four days were spent underground mapping and sampling the hangingwall of the no. 4 lens and paying special attention to the nature and intensity of alteration in the hostrock, as well as the presence of sulphide veinlets. The hangingwall of this zone contains highly anomalous values of Cu, Pb, Au, Ag and As, which contrasts with the typical sphalerite-pyrrhotite dominated zinc-rich ore of the mine. Efforts were also dedicated to establishing possible structural controls on the geometry of the mineralized zone.

Squall Lake

The Squall Lake property, owned by Garson Resources Ltd. and located 8 km north of the community of Snow Lake, hosts several lenses of gold mineralization. Exploration on the property started in the mid-1940s. More than 500 exploration holes have been drilled throughout the property and 11 mineralized zones have been identified. Drilling has outlined inferred mineral resources for the Margaret Extension gold occurrence of 100 000 t grading 4.85 g/t Au in the lower silicified zone and 337 000 t grading 5.40 g/t Au in the upper silicified zone (Cavey, 2002). Three bulk samples have also been processed from the Moon-Gertie and Margaret zones.

Previous work

Previous work on the Squall Lake property included mapping by MGS (Ostry, 1990; Schledewitz, 1998). Exploration companies also carried out detailed mapping, trenching, channel sampling and drilling in the area (Cavey, 2002). The most recent drilling was carried out in 2003 by MBMI Resources Inc. (now Garson Resources Ltd.). No detailed study, however, has investigated the nature of the mineralization and its associated alteration.

Regional geology

In the Squall Lake area, the main lithological units are 1) Missi metamorphic suite arkose; underlain by 2) southeast-dipping (25–30°) garnet-staurolite Burntwood metamorphic suite metapelite; and 3) a relatively thick metadiorite sill, now metamorphosed to amphibolite, intruded at the base of the Missi near the contact with the Burntwood metasedimentary rocks. The Squall Lake gold deposit occurs along the northwest limb of the McLeod synform, an F_2 structure. The mineralization host, the diorite sill, is affected by the McLeod fold structure. An east-west regional sillimanite isograd runs across the McLeod syncline but does not show any disturbance from the F_2 fold, suggesting that the peak of metamorphism postdated folding of the mineralized rocks. Thermobarometric calculations for the Squall Lake area were carried out by Kraus and Menard (1997) on Burntwood metamorphic suite metapelite in the vicinity of the deposit. The sample closest to the deposit yielded peak P-T conditions of 605°C and 5.6 kbar (sample #D156-P1; Kraus and Menard, 1997).

Mineralization

The gold mineralization is found in three main zones of subparallel lenses located near the hangingwall contact of the diorite sill (Richardson and Ostry, 1996). The mineralized lenses are found over a stratigraphic thickness of 60 m above the diorite sill. The uppermost zone is hosted within arkosic metasedimentary rocks of the Missi Group and consists mainly of quartz-carbonate stockwork. The middle zone is located at the contact between the diorite sill and the arkosic metasedimentary rocks of the Missi Group. The mineralization occurs as lenses within silicified and slightly carbonatized diorite. The lowermost zone occurs as an ~2 m thick horizon within silicified and carbonatized diorite. Arsenopyrite is the most common sulphide, but highest Au values generally occur in association with chlorite-bearing quartz veins (Richardson and Ostry, 1996).

2006 results

At Squall Lake, large stripped outcrop areas were mapped in detail with special attention being given to the different quartz-vein orientations. Core from six holes drilled in 2003 through the Margaret extension mineralized zone were relogged and sampled. Logging of core enabled the identification of zones of silicification and carbonatization in the dioritic hostrock. Locally, there is a significant increase in biotite abundance in the diorite, suggesting possible potassium enrichment. Reconnaissance mapping was carried on around the nose of the McLeod synclinal structure to collect gabbro and quartz-vein samples and compare their chemistry around the fold nose.

Nokomis Lake

The Nokomis Lake deposit is located along the east shore of Nokomis Lake, 55 km northwest of the town of Snow Lake and 8 km northeast of the Puffy Lake deposit. The property, owned by Pioneer Metals Corporation, is the site of a shear-related intrusive-hosted (tonalite) lode-gold mineralization system associated with quartz veining in a ferrotonalite sill. More than 100 holes, totalling more than 6000 m, have been drilled on the property since exploration began in the 1940s. The most recent drilling was carried out by Claude Resources Inc. in the winter of 2005.

Previous work

The Nokomis Lake area was the subject of detailed mapping during the NATMAP Shield Margin Project (Zwanzig, 1994, 1999). Detailed mapping and drilling were also carried out by exploration companies (Buhlmann, 1997). No study, however, has examined in detail the nature of the mineralization and alteration, and the effect of metamorphism.

Regional geology

The Nokomis Lake property is situated in the Kisseynew Gneiss Belt. Zwanzig (1994) interpreted the amphibolite horizon to be metamorphosed basalt intruded by differentiated gabbro sills that vary in composition from gabbro to ferrotonalite. Zwanzig (1994) indicated that the gold mineralization is hosted in a ferrotonalite horizon. At the Nokomis Lake deposit, a thick sequence of ~190 m of layered amphibolite is structurally overlain by the Burntwood metamorphic suite and underlain by arkosic gneiss of the Missi Group (Zwanzig, 1984).

Mineralization

The gold mineralization is hosted by an ~20 m thick, discontinuous, quartz-bearing tonalite horizon within the amphibolite sequence. The gold is associated with arsenopyrite, although pyrite and pyrrhotite are the main sulphides found in the mineralized horizon. Sulphide veinlets are found toward the base of the mineralized zones. Peloquin et al. (1985) observed that the mineralized zones are subparallel to the gneissic layering. Amphibolite from the Nokomis Lake deposit is traceable over a distance of 8 km (Zwanzig, 1984).

2005–2006 results

At Nokomis, ten holes drilled by Pioneer Metals Corporation in 1997 and 2000 were relogged and sampled, and a dozen old trenches were also visited. Several traverses were carried out across the mineralized horizon to provide samples for P-T work and to get a more general idea of the geological context. Old trenches were visited and mineralized samples collected. In 2005, core samples from older drillholes were also collected for thin section purposes. Preliminary microscope and electron-microprobe work has focused mainly on the sulphide-gold assemblage. Further work will examine textural relationships between sulphide, oxide and silicate minerals. A thermobarometry study of the ore assemblage and the hostrock is also planned.

Preliminary electron-microprobe results have shown that the arsenopyrite (FeAsS) associated with the Au mineralization commonly displays a core of löllingite ($FeAs_2$; Figure GS-4-2). This relationship suggests that the arsenopyrite was late and replaced löllingite, possibly during retrograde metamorphism when sulphur-bearing hydrothermal fluid may have been circulating through the hostrock. Microprobe analyses showed systematic outward increase of the sulphur content in zoned arsenopyrite crystals. Even the löllingite core presented a sulphur-rich rim. Gold was typically found as small (10–300 µm) inclusions within the arsenopyrite grains rather than as free gold in the matrix. Also, most gold inclusions occur at or near the contact between the löllingite core and the arsenopyrite (Figure GS-4-3). Further work will investigate the reaction history of the sulphide minerals and attempt to establish with confidence the evolution of gold.

Puffy Lake mine

The Puffy Lake gold deposit is located within the southern flank of the Kisseynew Domain. The deposit is located about 75 km northeast of Flin Flon and 80 km west of the community of Snow Lake. Hostrocks to the gold mineralization are gneissic supracrustal rocks of medium to high metamorphic grade (Ostry and Halden, 1995). The deposit was first identified by the Hudson Bay Exploration and Development Co. Ltd. in 1960, and was developed by Pioneer Metals Corporation. The mine was in production from December 1987 to March 1989, during which period it produced 991 kg of gold.

Previous work

Zwanzig (1994) carried on detailed mapping in the vicinity of the Puffy Lake mine. Ostry and Halden (1995) studied the gold mineralization underground and recognized two main settings for the gold. Dyck (1997) completed an M.Sc. thesis that addressed the structural complexities and deformation history of the Puffy Lake area.

Regional geology

Within the Puffy Lake area, the Kisseynew Domain comprises the following units: 1) Amisk Group fine-grained amphibolite; 2) greywacke-derived gneiss and migmatite of the Burntwood metamorphic suite; 3) Missi Group fine-grained sedimentary (subgreywacke-arkose) gneiss and, near the base of the unit, intermediate amphibolitic gneiss; and, 4) lineated tonalitic

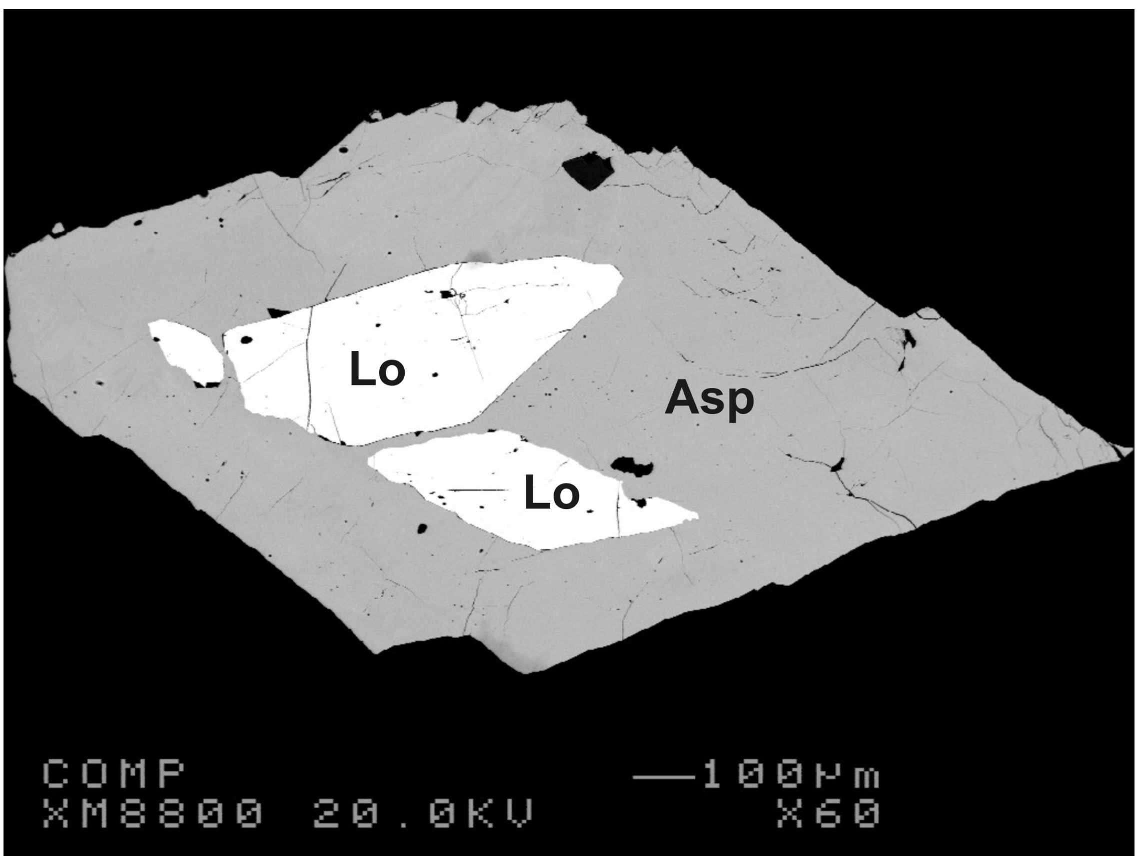

Figure GS-4-2: *Back-scattered electron-microprobe image showing a löllingite (Lo) core in an arsenopyrite (Asp) crystal.*

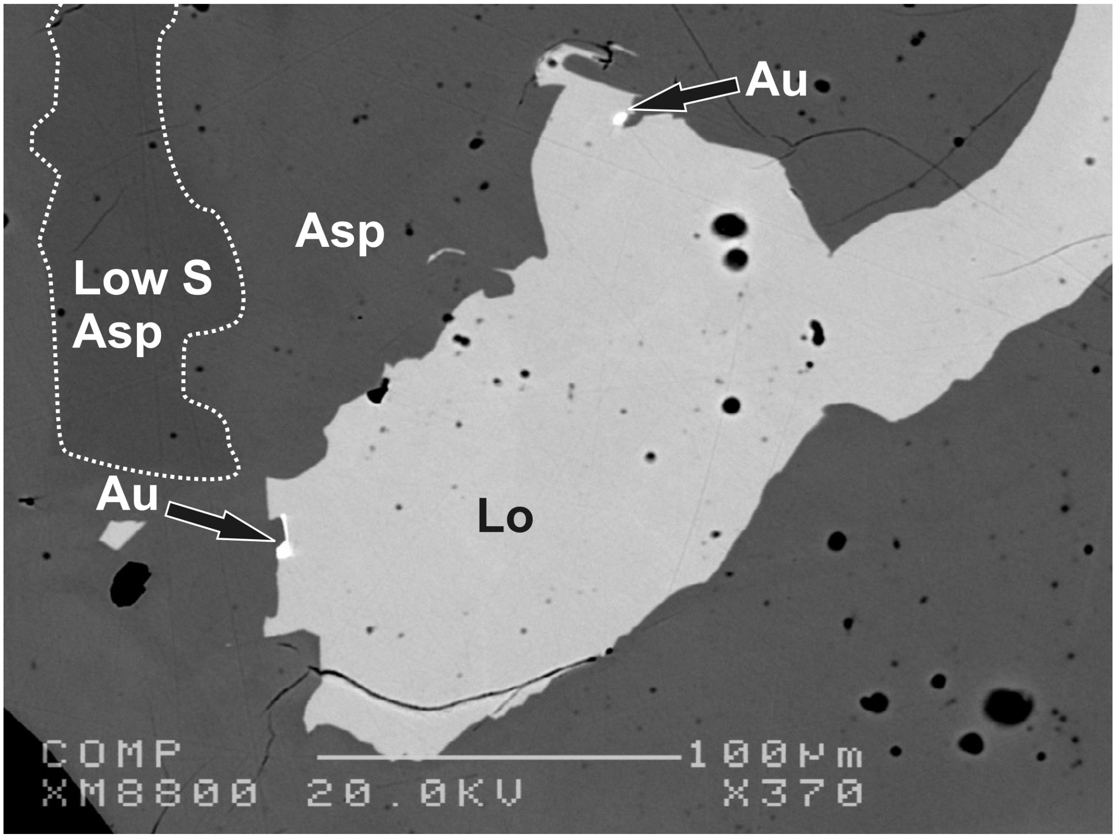

***Figure GS-4-3:** Back-scattered electron-microprobe image showing a löllingite (Lo) core in an arsenopyrite (Asp) crystal. Arrow points to a gold (Au) inclusion sitting at the boundary between the löllingite and the arsenopyrite. Note also the presence of the low-sulphur zone in arsenopyrite.*

gneiss and granitic intrusions. The deposit is located within the core of an anticline folding Burntwood and Missi metasedimentary rocks, and gneissic metavolcanic rocks of the Amisk Group (Zwanzig, 1994). The rocks generally strike north to northwest with a moderate dip (25–40°) and commonly display mineral lineations. The Amisk intermediate to mafic gneiss is interleaved with Burntwood Suite paragneiss. Missi quartzofeldspathic gneiss disconformably overlies the Amisk and Burntwood gneiss. In the Puffy Lake area, peak metamorphic conditions were estimated to have reached 650 to 700°C and 3.5 to 6.5 kbar, based on the presence of the mineral assemblage biotite-garnet-sillimanite-quartz-plagioclase-muscovite south of Puffy Lake and the reaction isograd muscovite + plagioclase + quartz ↔ sillimanite + liquid (melt) in the vicinity of Puffy Lake (Dyck, 1997).

Mineralization

The gold-arsenopyrite-pyrrhotite mineralization with minor chalcopyrite-galena-sphalerite is associated with biotite±hornblende intermediate gneiss layers (Ostry and Halden, 1995). Ostry and Halden (1995) recognized two main settings for the gold mineralization: 1) the 201 type (number referring to the stope where the mineralization was described), which consists of a 1 to 2 m thick mineralized horizon of biotite-rich amphibolite containing abundant disseminated lineated arsenopyrite (up to 20% locally), with minor pyrrhotite and gold; and 2) the 214 type, consisting of a network of anastomosed veins of diopside-biotite-feldspar±quartz containing arsenopyrite, pyrrhotite, pyrite and gold, with traces of chalcopyrite, galena and sphalerite. Crosscutting relationships and the absence of preferred orientation of the sulphide minerals in the 214 type indicate that it is younger than the 201 type. Ostry and Halden (1995) also interpreted the 214-type mineralization to be the result of remobilization of 201-type gold and arsenopyrite during or after the D_3 event. The strong lineation of 201-type arsenopyrite and the presence of a mineral assemblage indicative of a metamorphosed alteration (e.g., assemblage of coarse-grained diopside, Ca-amphibole and calcite associated with sulphide mineralization) strongly suggest a pre–peak metamorphism origin for the deposit (Ostry and Halden, 1995).

2005–2006 results

Reconnaissance mapping of the Puffy Lake property during the summer of 2006 allowed the evaluation of a few trenches; however, no good mineralized exposure could be found. Structural data and unmineralized samples of various rock types were collected in the vicinity of the minesite for future metamorphic and thermobarometric study. Mineralized samples were also collected from drillcore left on-site, as well as from the ore pile. Samples with a sulphide and silicate mineral assemblage similar to that described by Ostry and Halden (1995) were collected. Oriented samples from underground, provided by G. Ostry, will be used to further investigate the mineralization evolution during metamorphism and deformation. During 2005, core samples from the Puffy Lake mine were collected at the MGS core facility in The Pas.

Preliminary microscope and electron-microprobe work on samples collected in 2005 focussed on the sulphide assemblage. Investigation of Puffy Lake samples showed a sulphide relationship similar to that seen in the Nokomis material. At Puffy, the arsenopyrite is also typically cored by löllingite and gold is commonly found as inclusions located near or at the boundary between the two arsenic-bearing phases. Gold inclusions are generally composed of relatively pure Au (90–95%) in solution with Ag content varying from 5 to 9%. No measurable amounts of Hg, Sb, or Bi were obtained during electron-microprobe analysis of gold inclusions.

Economic considerations

Investigation of sulphide-gold mineralization will provide new constraints on the timing of mineralization and the P-T-t history of the deposit. If the pre–peak metamorphism origin of the mineralization is confirmed, the careful petrographic study of the ore will help provide a better understanding of the mineralogical and compositional consequences of mid-amphibolite-facies metamorphism and migmatization of sulphide-dominated ore. The study will also increase knowledge of sulphide-silicate interaction during prograde metamorphism. Finally, the combination of all these data will allow a better understanding of the evolution of the gold mineralization through prograde metamorphic conditions and clarification of the role of the associated sulphide assemblage. This information will, in turn, provide useful guidelines to help explorationists in the selection of exploration targets in medium- to high-grade metamorphic terranes.

Acknowledgments

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