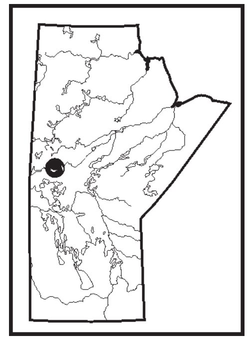
GS-3 Geological investigations of the platinum group element potential of the Chisel Lake mafic-ultramafic intrusion and other targets in the Flin Flon Belt, Manitoba (parts of NTS 63K16)

by P. Theyer and A.E. Stansell[1]



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Summary

Drillcore was examined from two holes that intersected a massive to disseminated, stratabound and stratiform sulphide layer that was at least 300 m long and several metres thick. This layer occurs within the Chisel Lake mafic-ultramafic intrusion, near its contact with sulphide-rich intermediate volcanic, volcaniclastic and sedimentary rocks. It contains substantial concentrations of Cu, Zn and Au, and has the potential to host significant amounts of platinum group elements (PGE) because

- virtually unlimited amounts of sulphur were available on emplacement of the pluton, since it intruded sulphur-enriched volcanic hostrocks and parts of the Chisel Lake massive sulphide deposit;
- samples of the pluton's marginal chill zone yielding Pt+Pd one order of magnitude higher than the expected background concentrations in this type of rock, suggesting that the magma of the Chisel Lake pluton was 'fertile' (i.e., capable of producing immiscible PGE-bearing sulphides); and
- information that the PGE, presumably from the Chisel Lake pluton, were concentrated into accumulations of sulphides in a number of "multi-tonne pockets of disseminated pyrrhotite containing high PGE-enrichment tenors (multiple oz./ton)" within the Chisel Lake deposit was known several decades ago (N. Provins, pers. comm., 2001).

Drillcore of several holes from the Radar Lake Ni-Cu-PGE prospect was investigated. This mineralization, located north of the Reed Lake mafic-ultramafic complex, is of interest because 1) significant concentrations of Ni, Cu and Pt +Pd occur in drillcore from this prospect; 2) the occurrence of mafic-ultramafic breccia (empirically known to be associated with certain PGE-bearing complexes) is repeatedly mentioned in drill logs; and 3) the hostrocks are probably part of the Reed Lake mafic-ultramafic complex, which in places is known to contain significant concentrations of PGE.

Introduction

This report describes part of an investigation focusing on the platinum group element (PGE) potential of the Flin Flon Belt. Discovery of the McBratney PGE-Au occurrence (containing up to 31 g/t Pd and 9 g/t Pt; Fort Knox Gold, press release on company website, 2000) and other PGE occurrences within the Flin Flon Belt (Theyer, 2001; Olivo et al., 2002; Theyer and Heine, 2002). The Flin Flon program was expanded to the Snow Lake area in 2004.

Part of the 2004 season was devoted to investigating the PGE potential of the Chisel Lake pluton, located near the town of Snow Lake. This intrusion has potential to host PGE due to 1) its nature as a differentiated, layered mafic-ultramafic intrusion of significant size (9 km by 1.5 km; Young and Ayres, unpublished report prepared for 1984–1989 Canada-Manitoba Mineral Development Agreement, 1985); and 2) the probability that this pluton assimilated sulphides of the Chisel Lake volcanogenic massive sulphide (VMS) deposit and its hostrocks at the time of emplacement. Intrusion of a hot mafic-ultramafic melt into sulphur-bearing crustal rocks can lead to an interaction of these rocks, causing devolatilization, partial melting and incorporation of sulphides that, if introduced at the right stage in the evolution of the intrusion, may scavenge PGE from the melt and subsequently concentrate them as sulphide disseminations and layers (Keays et al., 1999).

Additional strong support for investigations of the PGE potential of this body came from an observation made by a geologist formerly employed with Hudson Bay Mining and Smelting Co., Limited (HBMS) at the Chisel mine. He recalled that "in the lower parts of the (Chisel Lake) deposit there were a number of odd intersections in the gabbro, spatially very close to the hosting felsic fragmental rocks but not in contact with any massive sulphide areas. These zones or pods were discrete plugs that had minor disseminated chalcopyrite in a fairly uniform mass. Analytical results were variable, but PGE and Au levels were in the oz./t range" (N. Provins, pers. comm., 2001). The existence of pockets of

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high-grade PGE and Au mineralization in the Chisel Lake mine was confirmed by geologists who had worked at the mine some 20 years ago; however, written records of these have not yet been located (K. Gilmore, pers. comm., 2004).

Further interest in this intrusion was raised by unusually high Pt+Pd concentrations (reaching 57 ppb) in samples from the chilled margin of the Chisel Lake intrusion (Peck et al., 2000; J. Young, pers. comm., 2004). Considering that common background Pt+Pd concentrations in mafic rocks range from approximately 5 to 15 ppb (Crocket, 2002), the Pt+Pd concentrations in the chilled margin of the pluton indicate that this magma was very 'fertile' (i.e., it could easily generate PGE-enriched sulphide masses if sulphur was introduced at the proper developmental stage into the melt).

High PGE concentrations in the chilled margins of the intrusion could be interpreted in two ways:

- The pessimistic view is that the Chisel Lake intrusion was a very 'fertile' sulphur-undersaturated magma that did not assimilate crustal sulphur and thus did not produce PGE-enriched sulphides; however, this interpretation is contradicted by the quoted evidence of the Pt+Pd+Au–rich pods.
- The optimistic view holds that the chilled margin, reflecting the original PGE-rich composition of the Chisel Lake intrusion, is a thin, rapidly frozen veneer and that the bulk of the intrusion assimilated crustal sulphur. The introduced sulphur would have scavenged any PGE resident in the igneous melt and may therefore have separated as immiscible sulphides that may eventually have concentrated in layers, forming PGE-bearing sulphide deposits.

Regional setting

The Flin Flon greenstone belt, which belongs to the juvenile (internal) zone of the Trans-Hudson Orogen (Hoffmann, 1988), is a collage of 1.92–1.88 Ga tectonostratigraphic assemblages juxtaposed during the 1.88–1.87 Ga intraoceanic accretion and subsequent 1.84–1.78 Ga terminal collision of the bounding Archean cratons (Lucas et al., 1996). Volcanic rocks in the Flin Flon Belt include juvenile-arc, juvenile-ocean-floor, and minor oceanic-plateau, ocean-island-basalt, plutonic-arc and oceanic-arc assemblages (Syme and Bailes, 1993; Stern et al., 1995a, b; Syme et al., 1999). These volcanic assemblages are unconformably overlain by a terrestrial metasedimentary sequence (Missi Group) and are intruded by an array of rock types (Bailes and Syme, 1989).

Stratigraphic relations near Snow Lake are complicated by the occurrence of at least one thrust fault and several periods of folding. The Amisk Group comprises interlayered felsic and mafic volcanic sequences capped and interlayered with greywacke and argillite. The Missi Group consists of a metamorphosed arenitic sequence. The relative and absolute ages of the various plutons intruding these supracrustal rocks are poorly known. The earliest intrusions, thought to be synvolcanic, are folded tonalitic sills that may have been the heat source driving hydrothermal systems that generated alteration zones and massive sulphide deposits (Walford and Franklin, 1982; Bailes, 1986).

Chisel Lake

The Chisel Lake pluton, located approximately 7 km southwest of Snow Lake near the east end of the Flin Flon greenstone belt, is a teardrop-shaped, 10 km long by 1.8 km wide, north-trending mafic-ultramafic intrusion. The southern end of the pluton truncates the Chisel Lake VMS deposit that was mined for Zn and Cu between 1960 and 1993 (Figure GS-3-1). The age and tectonic setting of the Chisel Lake pluton are uncertain. Some workers considered it to be part of the Amisk Group and therefore presumably synvolcanic (Froese and Moore, 1980; Walford and Franklin, 1982); however, Williams (1966) and Young and Ayres (unpublished report prepared for 1984–1989 Canada-Manitoba Mineral Development Agreement, 1985) considered the pluton to be of late-tectonic age.

The Chisel Lake pluton intruded the stratigraphically lower part of the Amisk Group, which consists of felsic, intermediate and mafic volcanic and volcanic fragmental rocks, and derived volcaniclastic sedimentary rocks and wacke.

The contact of the pluton with its hostrock is largely subvertical, but a detailed profile from the Chisel Lake mine shows apophyses and bulges up to 100 m in size (Martin, 1966). Generally inward-dipping layers in the southern part of the pluton suggest that it has a basinal shape with inward-dipping outer contacts. The only known surface exposure of the margin of the pluton occurred at the south end of Chisel Lake; however, this outcrop is currently covered with rubble, likely due to contouring and landscaping that took place after mine closure. The following descriptions are thus paraphrased from Young and Ayres (unpublished report prepared for 1984–1989 Canada-Manitoba Mineral Development Agreement, 1985). They documented the contact between the gabbro and the volcanic hostrocks as an approximately 30 m long, straight to irregular boundary in which marginal gabbro protrudes into the country rock as decimetre-size flame-shaped projections and dike-shaped apophyses up to 6 m long; in places, the gabbro forms stockworks resembling magmatic breccia in which volcanic blocks, up to 1.2 m long, are surrounded by gabbroic dikes. The dark green to black-weathering marginal gabbro is characterized by a fine-grained chilled margin up to 50 cm thick.

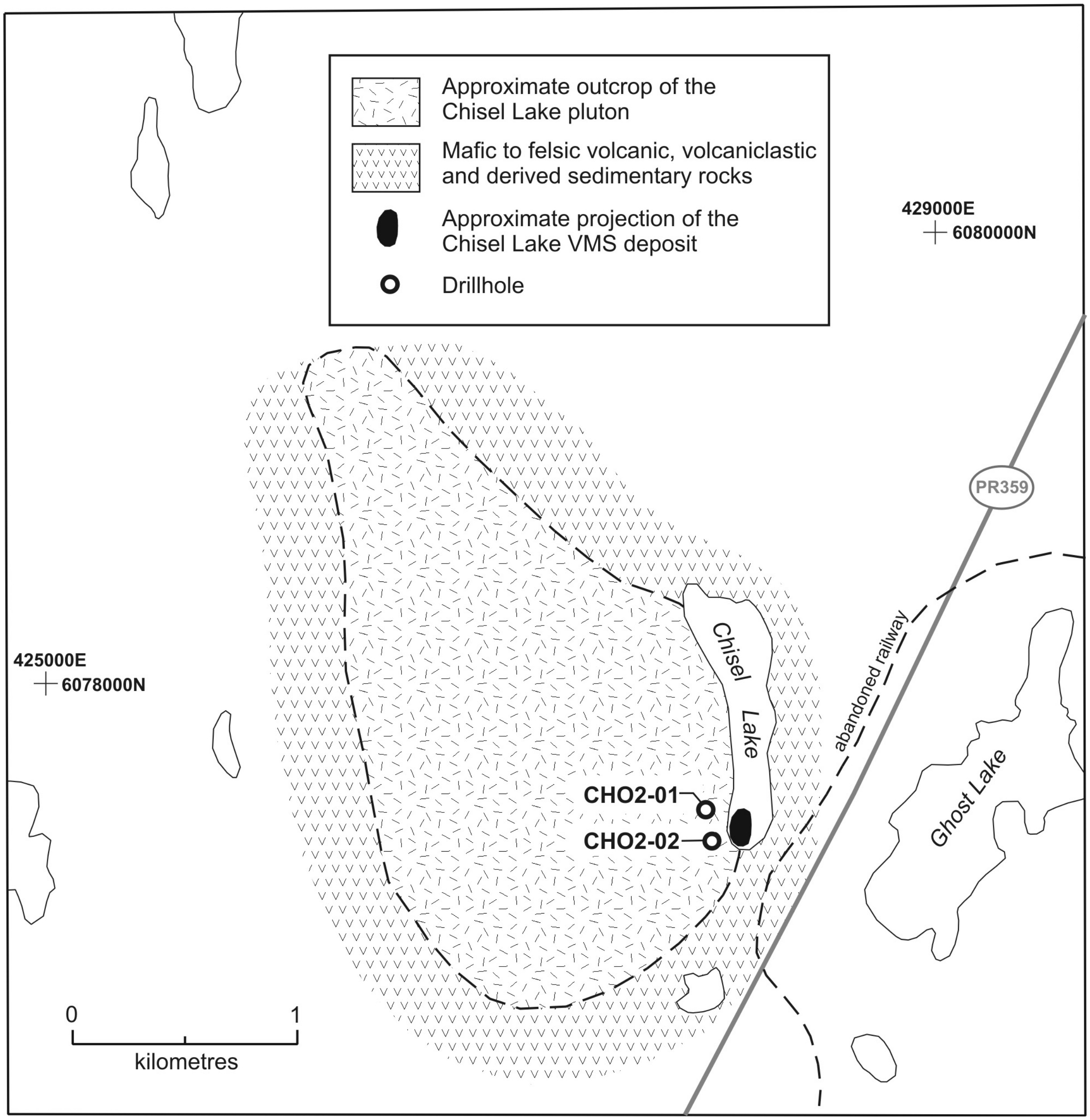

Figure GS-3-1: *Geological sketch map, showing the location of Chisel Lake, the Chisel Lake volcanogenic massive sulphide (VMS) deposit, the Chisel Lake pluton and the drillholes discussed in the text.*

Selected drill logs

Drillhole CH02-01

Drillhole CH02-01, collared near the eastern edge of the Chisel Lake pluton in mafic igneous rocks (Figure GS-3-1), was drilled on an angle of –87° at an azimuth of 90° (true). It intersected approximately 70 m of gabbro and troctolite, followed by dunite, peridotite and an approximately 150 m thick unit of oikocrystic peridotite. Plagioclase, first appearing at 470.2 m, abruptly displaces olivine at 471 m, resulting in anorthosite. This lithological change is also accompanied by an increase in the amount of sulphides (disseminated pyrrhotite and minor chalcopyrite), from trace quantities in most of the core to as much as approximately 30% pyrrhotite and 5% chalcopyrite at 473.9 m, and by the appearance of up to 3% garnet. At 478.3 m, the amount of sulphides gradually decreases to 1% pyrrhotite hosted by foliated quartzofeldspathic gneiss. At approximately 491 m, this unit is succeeded by felsic volcaniclastic rocks and quartzofeldspathic gneiss, which continue until the end of hole at 510 m.

Drillhole CH02-02

Drillhole CH02-02 was collared near the eastern edge of the Chisel Lake pluton, approximately 350 m north of drillhole 02-01 (Figure GS-3-1) This hole was also drilled on an angle of –87°, but at an azimuth of 127° (true). The top 55.5 m intersected two-pyroxene gabbro, underlain by approximately 150 m of monotonously homogeneous poikilitic peridotite. At 402.3 m, the peridotite is in sharp contact with foliated gabbro, characterized by a modal banding with millimetre-thick alternating plagioclase- and amphibole-rich bands. This unit is in contact with a 60 cm thick, beige to tan, highly siliceous unit interpreted to be either chert or part of a rhyolitic flow. At 412.1 m, the drillhole intersected anorthosite and anorthositic gabbro, mineralized with up to 7% pyrrhotite and traces of chalcopyrite. The mineralization gradually decreases to <1% sulphides at 431 m. From 431 m to approximately 471 m, the drillhole intersected milky white anorthosite with abundant chlorite- and pyrrhotite-bearing fractures. More intense sulphide mineralization, ranging from 5 to 10%, was intersected between 471.9 and 480 m. Highlights in this interval are 1) a 0.5 m thick layer of semimassive pyrrhotite at approximately 472 m; 2) an approximately 1 m thick layer of massive pyrrhotite+chalcopyrite between 475 and 476 m depth; and 3) semimassive to massive sulphide mineralization that tapers to trace pyrrhotite between 480 and 480.5 m. The balance of the hole intersected garnetiferous mafic gneiss.

Discussion

The two drillholes described above, drilled almost vertically through the eastern edge of the Chisel Lake intrusion, intersected rock units that are progressively more distal from the pluton with increasing depth, owing to the keel-shaped configuration of the intrusion. The comparable location of the drillholes at the edge of the pluton and the relatively short distance between holes (350 m) allow the following conclusions to be drawn:

- The stratigraphic succession in both holes is similar, progressing from poikilitic peridotite to gabbro, anorthosite and terminating in mafic garnetiferous gneiss, suggesting continuity of the layers.
- Sulphide mineralization occurs in both holes in stratigraphically similar locations, at or near the transition from peridotite to anorthosite, suggesting the existence of an extensive sulphide-rich layer near the edge of the intrusion.

Radar Lake

This Ni-Cu-PGE occurrence, located north of the Reed Lake mafic-ultramafic complex (NTS 63K10NE; Figure GS-3-2), is located in a xenolith-rich granodiorite to tonalite (NATMAP Shield Margin Project Working Group, 1998).

Six drillholes were investigated in the Radar Lake area. Rock types intersected encompass mafic to intermediate volcanic rocks, gabbro, felsic to intermediate detrital rocks and sulphide-facies iron formation. Sulphide mineralization is sporadic and consists of disseminated to massive intervals up to a decimetre thick. Drillhole EEL-302 intersected gabbro, detrital rocks and an approximately 14 m long intersection of sulphide-bearing (pyrrhotite and minor chalco-pyrite) mafic volcanic–derived sedimentary rocks intruded by a felsic intrusive body. Assessment files report values of 0.98% Cu, 0.52% Ni, 102 ppb Pt and 170 ppb Pd, with individual, exceptionally high analyses of up to 2.2 g/t Pt and 0.9 g/t Pd (Assessment Files 94669 and 94660, Manitoba Industry, Economic Development and Mines, Winnipeg)

Discussion

Relogging of drillcore largely corroborated the data included in the assessment files, namely that the Radar Lake Ni-Cu-PGE occurrence is underlain by mafic volcanic, detrital and intrusive rocks and, in places, contains substantial quantities of sulphides.

The quoted assay results reflect the existence of significant Ni-Cu and PGE mineralization; however, the quoted results should be approached with caution since 1) neither the laboratory that did the analyses nor the analytical method employed is quoted; and 2) the Pt:Pd ratio is 2:1 in places, highly unusual for this kind of environment.

Economic considerations

The interaction of the Chisel Lake mafic-ultramafic intrusive body with the Chisel Lake massive sulphide deposit potentially created economically significant accumulations of PGE-bearing sulphides. Deposits of PGE-bearing sulphides, formed in a dynamic magmatic environment similar to the one proposed to have been active in the Chisel Lake area, are not uncommon, and the physicochemical and geological parameters leading to their formation are quite well understood. They are thought to be due to the introduction and efficient dispersion of sulphides into sulphide-poor but PGE- rich, turbulent igneous melts at a high crustal level, preferably near or at the site of final emplacement of the

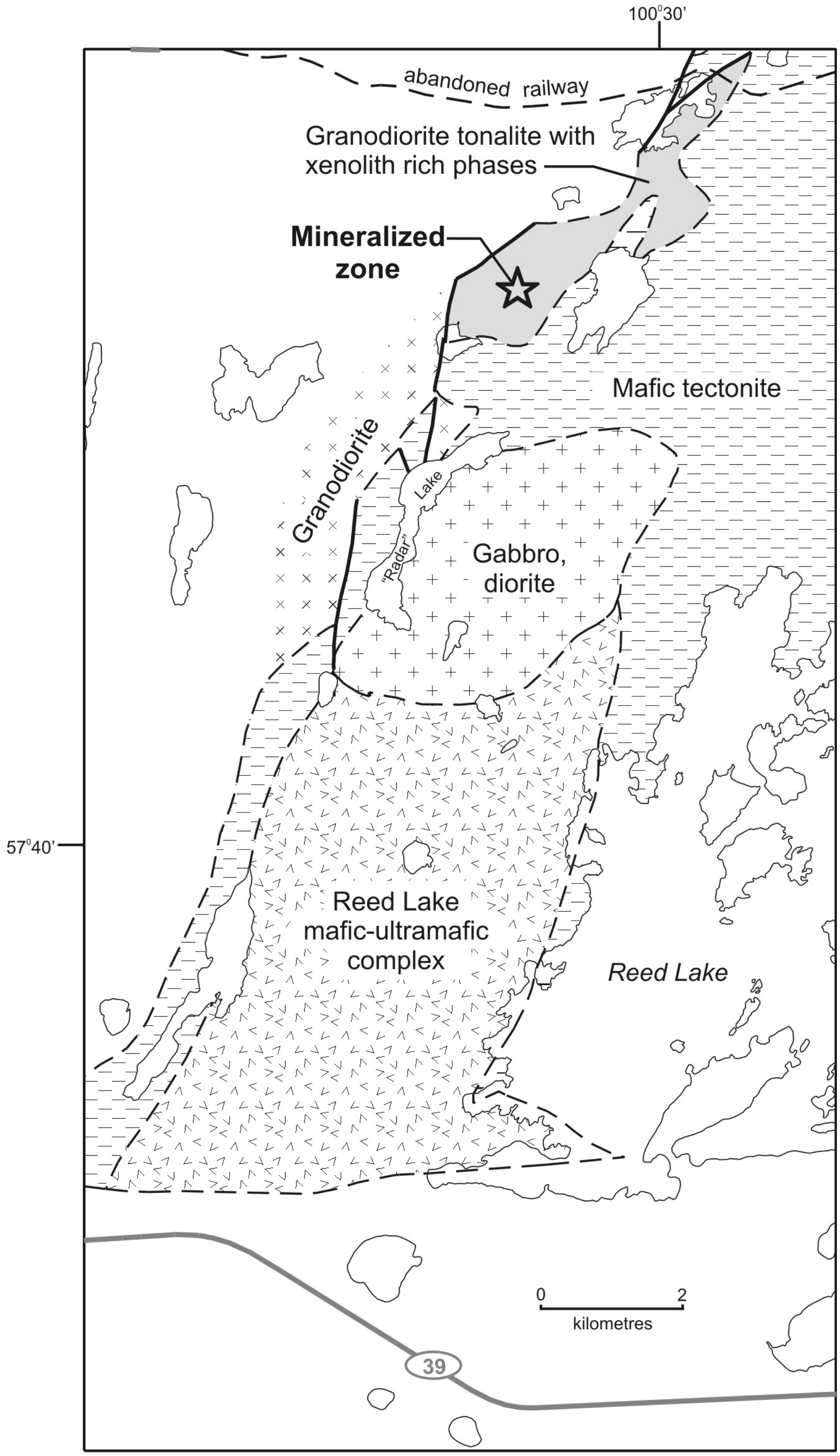

***Figure GS-3-2:** Geology of the Radar Lake area (*modified from *NATMAP Shield Margin Project Working Group, 1998).*

melt. The introduced sulphides would have scavenged any PGE resident in the igneous melt and subsequently may have separated as immiscible sulphides that may have eventually concentrated in layers to form PGE-bearing sulphide deposits. This report presents evidence that many of these processes were active in the vicinity of the pluton, raising the possibility that PGE concentrations may exist in sufficient quantities to justify a renewed exploration effort for these minerals in the vicinity of the pluton.

Despite uncertainties regarding the analysis of drillcore from the Radar Lake Ni-Cu-PGE prospect, the property appears to merit further exploration work, such as geological mapping of the site and reanalysis of sulphide-bearing samples.

Acknowledgments

This project relied, to a significant extent, on geological information provided by a number of people from industry, academia and government, and on the exemplary cooperation received from Hudson Bay Exploration and Development Company Limited (HBED). Crucially important in 'getting the ball rolling' was geological information provided by N. Provins, a geologist formerly employed with Hudson Bay Mining and Smelting Co., Limited. Complementing and reinforcing the significance of this information was data provided by J. Young of the University of Manitoba. Supporting evidence was culled from the vast exploration files of HBED. Personnel of HBED, under the guidance of K. Gilmore, not only identified these targets but extended further assistance by providing full access to pertinent geological and geophysical data, making available relevant drillcore for logging and sampling, and allowing the authors to use of their core storage and logging facilities in Flin Flon and Snow Lake.

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