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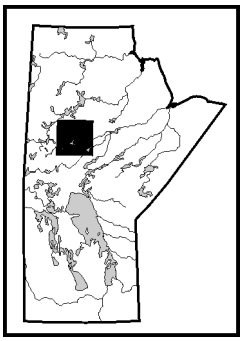
GS-11 Hydrothermal iron-sulphide copper-graphite mineralization in the northern Kisseynew Domain, Trans-Hudson Orogen, Manitoba (NTS 63O and 64B): evidence for deep-seated IOCG (Olympic Dam)–style metal deposition?

by A.H. Mumin[1] and M. Trott[1]



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Summary

A unique style of iron-sulphide copper-graphite (ISCG) mineralization is exposed in relative abundance along the northern margins of the Kisseynew Domain. This ISCG mineralization is hosted within late structures that cut the highest grade metamorphic fabric. These structures also host felsic±mafic intrusions that appear intimately associated with the sulphides, and many of the intrusions are themselves mineralized. Pyrrhotite is the dominant sulphide, with subordinate pyrite, and chalcopyrite is intimately intergrown with the pyrrhotite. Crystalline graphite is abundant, constituting up to 10 modal percent of the rock, and magnetite is present locally in minor amounts. All significant showings are associated with quartz veining and/or silica alteration. The purpose of this study is to investigate the possibility that this mineralization has a magmatic-hydrothermal origin, similar to some types of iron-oxide copper-gold (IOCG) deposits.

Introduction

A scoping study for hydrothermal iron-oxide copper-gold (IOCG) Olympic Dam–type mineralization was initiated in 2002 for Manitoba. Initial investigations identified the Trans-Hudson Orogen as the geological province of greatest interest (Mumin, 2002a). In 2002, a large, REE-rich carbonatite complex was discovered at Eden Lake (Mumin, 2002b). Further work at Eden Lake in 2003 revealed a system of high-grade but narrow REE-Y-U-Th veins that occur sporadically over a zone that extends for more than 2 km in length. The geology, mineralogy and geochemistry of this material are very complex, and will be presented in a future report when investigations are completed.

The present report focuses on a unique style of mineralization that is abundant in the Kisseynew Domain and may be related to IOCG-type deposits. Preliminary fieldwork in June 2002 included sampling of several sulphide showings exposed between Thompson and Leaf Rapids, along the northern margin of the Kisseynew Domain. Geochemical analyses of this material returned anomalous copper values, and some polished thin sections showed a surprisingly high copper (chalcopyrite) tenor to the sulphides. The presence of ubiquitous copper, and the structural and hydrothermal association of this mineralization, raises the possibility of an igneous hydrothermal or IOCG-type association, and brings into question previous suggestions of a syngenetic origin for the sulphide mineralization (i.e., sedimentary or exhalative stratabound iron formation). Consequently, this style of mineralization was reexamined during the summer of 2003 along an approximately 160 km long stretch of the northern Kisseynew Domain. At least 15 showings were examined, of which several are considered significant and the remainder are either minor or have unknown extents. This paper presents the general characteristics of this type of mineralization (hereafter referred to as ISCG or Manitoba iron-sulphide copper-graphite mineralization), as well as brief descriptions of three of the more significant showings.

A full report on the IOCG–Olympic Dam scoping study is in preparation and will be released to the public on completion. The final report will discuss all aspects of the scoping study, including regional investigations, the discoveries at Eden Lake and the complete investigation of the Manitoba ISCG occurrences. Additional work in progress related to these studies includes both graduate and undergraduate theses.

Trans-Hudson Orogen

The Trans-Hudson Orogen constitutes a major Paleo- to Mesoproterozoic tectonic collage of varied terrains that amalgamated and sutured to the northwestern Archean Superior Province. The collage includes early island-arc terrains, accretionary prisms, continental orogenic belts, arc- and continental-rift environments, collisional suture zones and granitoid gneiss belts (Lewry and Stauffer, 1990). These continental and protocontinent rift and orogenic belt environments constitute a number of belt-scale metallogenic terrains capable of hosting igneous-hydrothermal or IOCG-type

[1] Department of Geology, Brandon University, Brandon, Manitoba R7A 6A9

deposits. The focus in this report, however, is on the northern margin of the Kisseynew Domain.

Northern Kisseynew Domain

The Kisseynew Domain encompasses a vast area extending from the Thompson Nickel Belt westward well into Saskatchewan, and from the Flin Flon belt north to the Lynn Lake and Leaf Rapids belts. The Kisseynew comprises highly metamorphosed marine wacke, turbidite and pelite, with marginal facies of clastic sedimentary rocks. These metasedimentary units are intruded by felsic to intermediate plutons, stocks and dike swarms. Only some late intrusions and pegmatite and aplite bodies lack the high-grade metamorphic fabric.

The Burntwood Group constitutes much of the northern margin of the Kisseynew in the area of interest. It comprises amphibolite- to granulite-facies metawacke, metapelite and metaturbidite, intercalated with stratiform lenses of mafic to ultramafic intrusive and volcanic rocks. Sickle Group clastic metasedimentary rocks overlie the Burntwood. Pegmatite dikes and swarms are very common, and more localized aplitic dikes and stockworks also occur. The northern margin has been described as an accretionary assemblage that is disrupted by a series of steep, northeast-dipping structural breaks, largely resulting from thrust faulting (Zwanzig, 1990, 1998).

The eastern margin of the Kisseynew is sutured to the Thompson Nickel Belt (TNB), where evidence suggests that the TNB dips shallowly westward beneath the Kisseynew, along a former subduction boundary.

Iron-sulphide copper-graphite mineralization

A unique style of iron-sulphide copper-graphite (ISCG) mineralization is exposed at numerous locations along the northern margin of the Kisseynew Domain, where the authors examined at least fifteen outcrop, roadcut and quarry exposures. Their general characteristics are presented here, followed by brief descriptions of three significant showings. Mineralogy is preliminary, as it is based on only a few thin sections. At most locations, the style of mineralization is very similar and hosted within garnet-biotite gneiss (probable metaturbidite-metawacke). The sulphides consist of pyrrhotite with subordinate to minor pyrite. Approximately 0.1 to 7 modal percent of the sulphide is chalcopyrite that is intimately intergrown with pyrrhotite. Total sulphides range from trace amounts of disseminated mineralization up to approximately 80 modal percent of the rock. Geochemical analyses show low to modest copper enrichments in all analyzed showings, ranging up to 8718 ppm Cu. Other sulphide minerals identified to date in one or more of the showings are molybdenite, pentlandite, arsenopyrite and sphalerite, all in trace amounts.

All ISCG deposits contain abundant graphite (2–20 modal percent), commonly as shiny, rounded, metallic-looking platelets and flakes. The graphite is intimately intergrown with sulphides, and with associated sheared hostrocks (predominantly garnet-biotite gneiss). Minor iron-oxides are present in most showings as magnetite. Magnetite is also occasionally present in minor amounts within the garnet-biotite gneiss, where it forms small, millimetre-thick, discontinuous wispy bands. Most of the magnetite is presently thought to be metamorphic and/or hydrothermal in origin. Other gangue minerals found intergrown with the mineralization include quartz, albite, pyroxene, biotite, phlogopite, amphibole, carbonate, chlorite, epidote, sericite, cordierite and some combination of pinite, chlorophaeite, iddingsite and staurolite.

Selected ISCG showings

Kilometre 54

The Kilometre 54 showing is exposed in a roadcut along Highway 391, approximately 54 km west of Thompson (Fig. GS-11-1). It forms a domal structure with subparallel, shallow-dipping, arcuate fracture joints bounded by near-vertical shears, fracture breccia and stockwork (Fig. GS-11-2). The shallow-dipping and near-vertical structures are infilled with ISCG-style mineralization (pyrrhotite±pyrite, minor chalcopyrite and abundant graphite) that ranges from minor to near-massive sulphide lenses up to approximately 0.5 m thick (Fig. GS-11-3). Geochemical analyses of the sulphidic material returned values up to 1211 ppm Cu.

The eastern margin of the mineralized zone is a felsic intrusion that ranges from aplite to very course grained, and is itself sheared, brecciated and mineralized. Interlayered between flat-lying sulphidic layers are fine-grained, homogeneous felsic rocks that locally grade into, or interfinger with, very coarse grained granitic dikes and/or quartz veins. East of the mineralized zone, hostrocks are predominantly biotite-garnet gneiss; on the west side, migmatite and gneiss are cut by felsic intrusions. The domal jointing, marginal shear and breccia, and felsic igneous association all suggest mineralization associated with an intrusive stock; however, this is a preliminary interpretation pending further investigation.

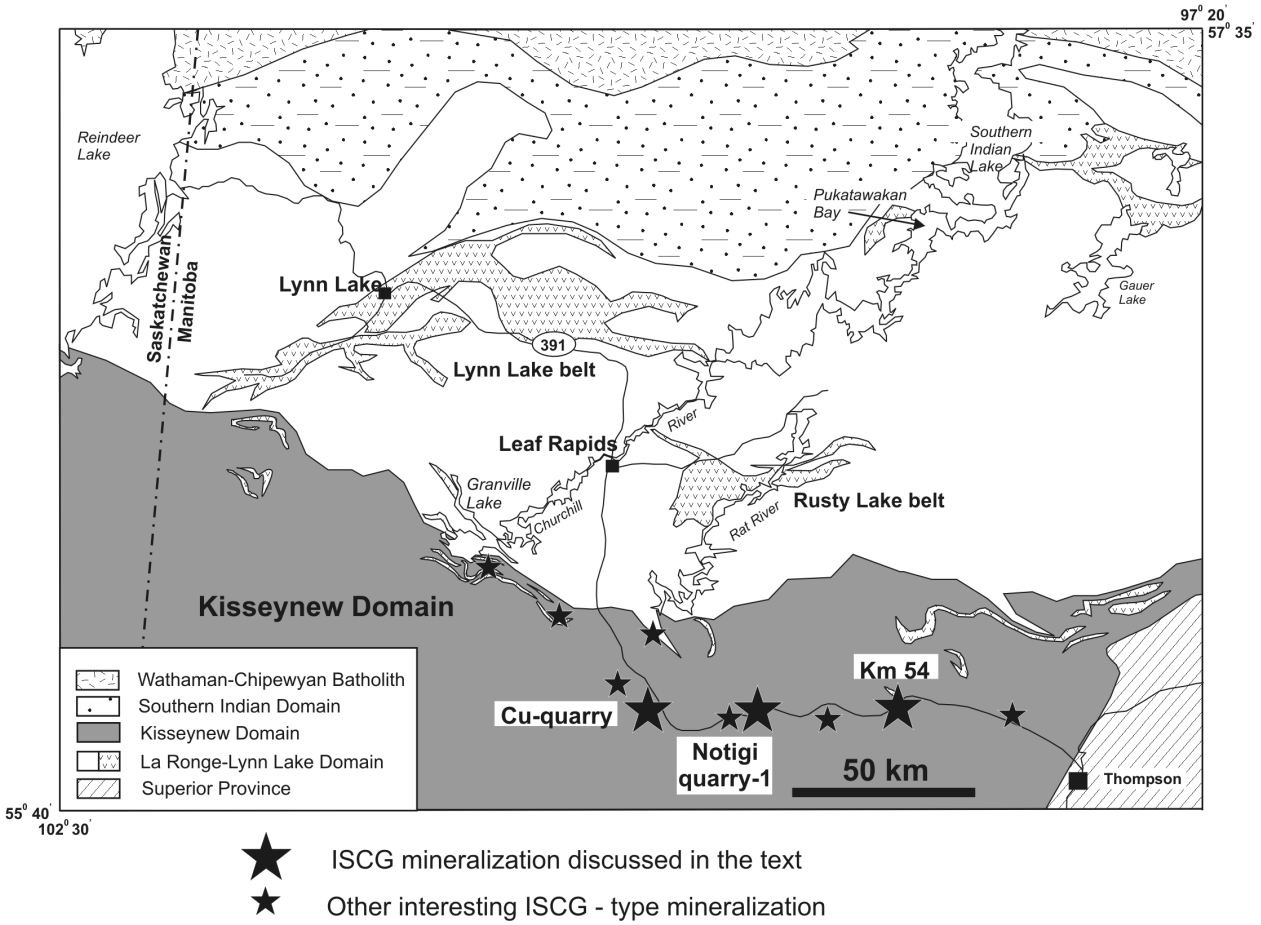

Figure GS-11-1: Trans-Hudson Orogen, showing the region of the northern Kisseynew Domain where ISCG mineralization is presently known to occur.

Figure GS-11-2: Domal structure exposed on the side of Highway 391 at kilometre 54, showing sulphide-rich horizons intercalated with siliceous and granitic layers; the margins of the structure are shear bounded and sulphidic.

Notigi quarry no. 1

Notigi quarry no. 1 (NQ-1) was excavated immediately south of Highway 391 in a roadcut several kilometres west of the Notigi hydro control dam (Fig. GS-11-1). It has a significant exposure of sulphide mineralization in garnet-biotite migmatite and gneiss of sedimentary origin. Felsic and mafic dikes and stocks of variable composition locally intrude the gneiss. Sulphides at NQ-1 are pyrrhotite with subordinate pyrite, and minor amounts of chalcopyrite intimately intergrown with the pyrrhotite. The sulphides infill an extensive steeply dipping structural breccia zone that crosscuts the metamorphic foliation (Fig. GS-11-4 and -5). The sulphide zone is exposed over a width in excess of 60 m, and varies from disseminated to near-massive sulphide in lenses that can exceed 1 m in thickness. The sulphides infill near-vertical to oblique, strongly contorted, brittle fracture breccias and also form lenses subparallel to the metamorphic fabric and/or flat-lying jointing planes. Locally, steeply dipping quartz veins and both felsic and mafic dikes (all locally mineralized) crosscut metamorphic foliation. The mineralization extends at least 500 m along strike.

As with other ISCG showings, crystalline graphite is abundant in sheared, altered and mineralized rocks, but not in surrounding garnet-biotite gneiss. Gangue minerals include quartz, albite, biotite, carbonate, magnetite, actinolite, chlorite and other secondary alteration phases.

Copper quarry

Copper quarry is a new ISCG showing discovered in 2003 approximately 75 km south of Leaf Rapids and approximately

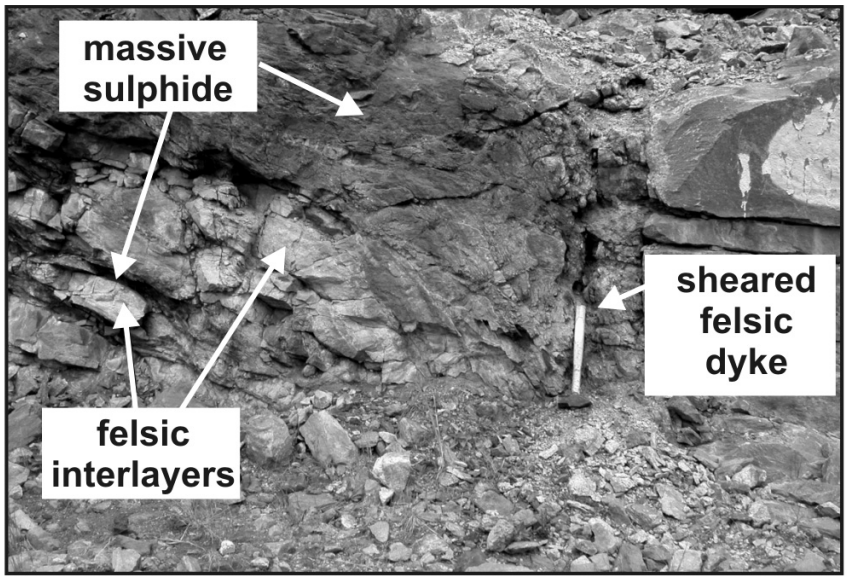

Figure GS-11-3: Close-up of the east margin of the kilometre 54 structure, showing a 0.5 m thick sulphide layer and other sulphide-rich layers intercalated with siliceous material; the eastern margin is a sheared and mineralized granitic dike.

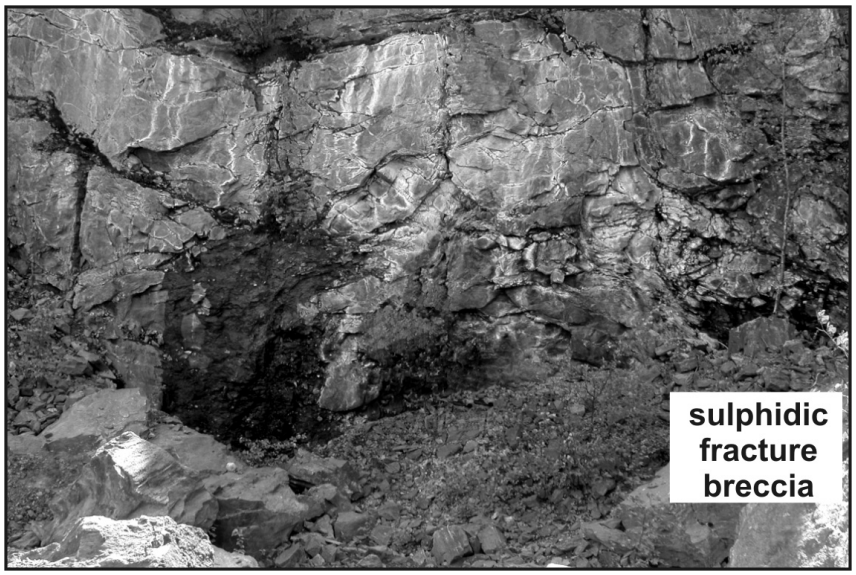

Figure GS-11-4: South wall of Notigi quarry no. 1, oriented perpendicular to a large sulphide-bearing structure; abundant sulphides occur in zones that both crosscut and appear subparallel to a strong metamorphic fabric.

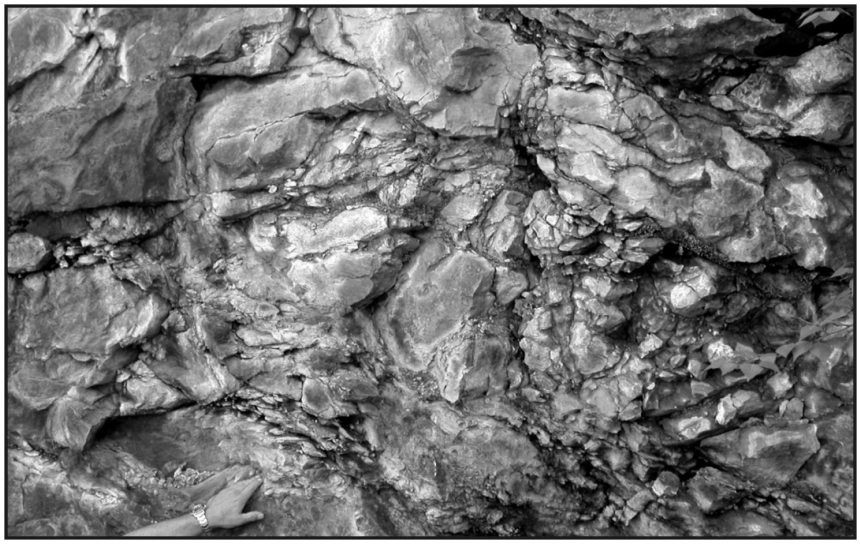

Figure GS-11-5: Close-up of part of the area in Figure GS-11-4; structure appears to be the result of late, brittle cataclasis infilled with sulphide-rich material.

200 m west of Highway 391. The Copper quarry mineralized horizon is exposed in surface outcrop, and can be traced for at least 400 m along strike, in a zone up to 100 m wide (the full extent of the surface exposure is unknown). It is partially exposed in an intermittently active quarry used to obtain crushed rock for road maintenance. A sulphidic zone is hosted in a horizon of ductile shearing that transects garnet-biotite gneiss of sedimentary origin. Total sulphides range up to near-massive lenses of pyrrhotite with minor pyrite. Chalcopyrite is also present and is somewhat more abundant than at other locations. Grab samples of chalcopyrite-bearing material assayed up to 8718 ppm Cu and 5.4 g/t Ag. As with the other showings, crystalline graphite flakes are relatively abundant in association with the mineralization. At surface, the sulphides are completely weathered out, leaving only wispy irregular patches of iron-stained biotite-garnet gneiss in a zone of ductile deformation (Fig. GS-11-6 and -7). Remnants of quartz veins occur as boudinaged lozenges in the sheared rocks.

Discussion

Iron-sulphide copper-graphite (ISCG) mineralization is exposed in relative abundance along the northern margins of the Kisseynew Domain. Pyrrhotite is the dominant sulphide, with subordinate pyrite, and chalcopyrite is intimately intergrown with the pyrrhotite in amounts up to 7 modal percent of total sulphides. Copper values ranged up to 8718 ppm, and silver values up to 5.4 g/t. Crystalline graphite is abundant, locally constituting up to at least 10 modal percent of the rock, and magnetite is present locally in minor amounts. The gangue assemblage in samples examined to date is characterized by quartz, pyroxene, albite, biotite, carbonate, amphibole and a variety of minor secondary

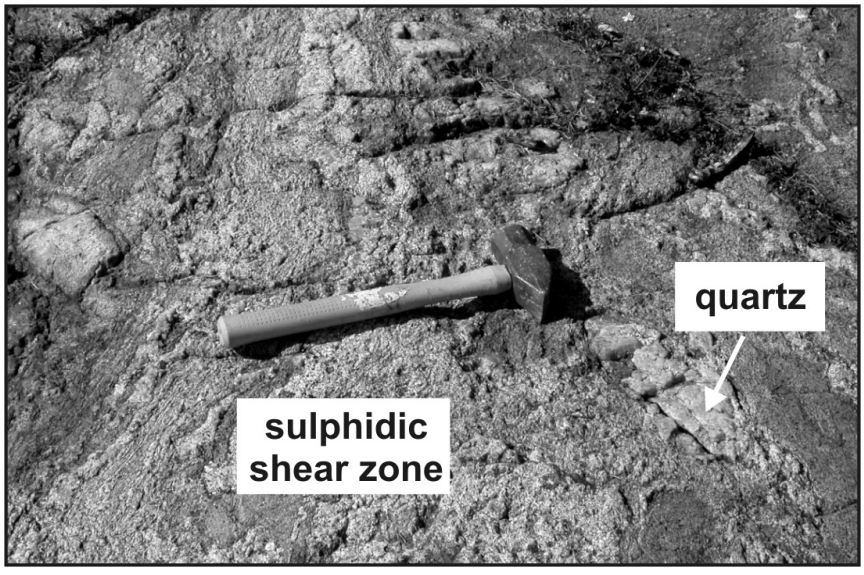

Figure GS-11-6: Weathered surface exposure of the Copper quarry shear-zone, showing wispy iron-stained bands and boudinaged remnants of quartz veins.

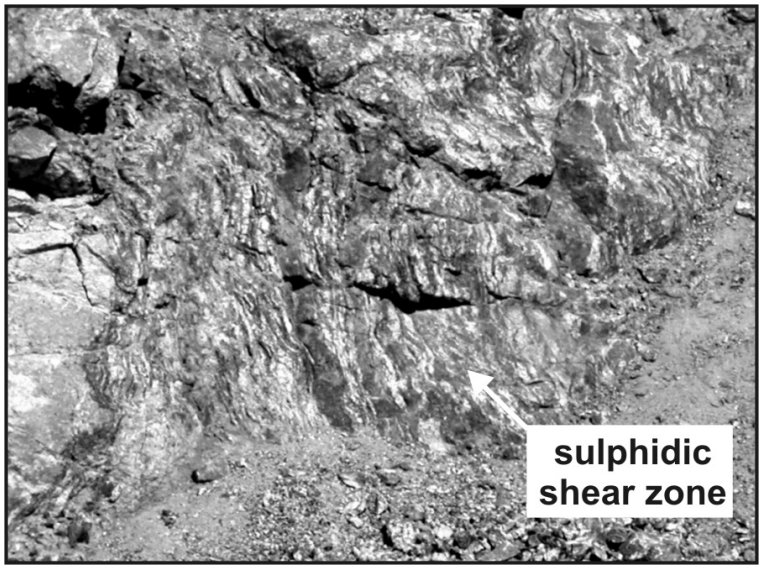

Figure GS-11-7: Part of the sulphidic shear zone exposed at Copper quarry.

alteration minerals. The ISCG mineralization is hosted within late structures that cut the highest-grade metamorphic fabric. All significant showings are associated with quartz veining and/or silica alteration. The structures also host felsic±mafic intrusions that appear intimately associated with the sulphide zone, and many of the intrusions are themselves mineralized. In at least two showings, felsic dikes with mineralized selvages grade into quartz veins.

The mineralization discussed in this report occurs in rocks that are thought to be remnants of a deeply buried and subsequently exhumed accretionary complex. The characteristics of the sulphide occurrences discussed here are consistent with magma-derived hydrothermal systems, presenting an alternative explanation to the previously suggested syngenetic stratiform mode of origin. In particular, some pyrrhotite-hosted IOCG deposits in the Cloncurry district of Australia have a number of features similar to the Manitoba mineralization (Williams and Pollard, 2002). Despite this possible similarity, the work is still in progress and alternative explanations continue to be examined.

Exploration potential

Manitoba ISCG deposits are strongly enriched in copper, graphite and silver. They are widespread and abundant in the northern Kisseynew Domain and may also occur elsewhere in the Kisseynew. This type of mineralization remains essentially unexplored. The ISCG deposits occur in significant structural features, and most are intimately associated with late intrusions.

At surface, the sulphides are weathered out and appear as wispy to larger iron-stained patches, which in many cases extend over very large areas. Given the paucity of outcrop throughout much of the Kisseynew, however, most of the mineralized showings will be hidden beneath overburden. A peculiarity of this mineralization is that weathering of the copper has not produced visible secondary copper minerals such as malachite and azurite, either at surface or along fractures. This phenomenon may account, in part, for the lack of exploration.

These deposits will be relatively easy to delineate at surface with magnetic surveys due to the abundance of pyrrhotite, and should also respond well to a variety of electromagnetic techniques. Ultimately, a number of ISCG showings need to be explored and drilled to determine their potential to host economic quantities of copper and a variety of other possible metals.

Acknowledgments

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