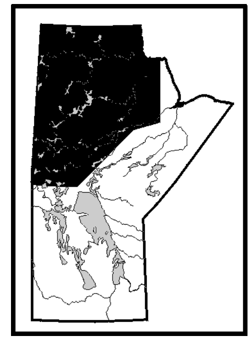
SCOPING STUDY FOR HYDROTHERMAL IRON-OXIDE COPPER-GOLD DEPOSITS (OLYMPIC DAM–TYPE), MANITOBA

by A.H. Mumin[1]



Mumin, A.H. 2002: Scoping study for hydrothermal iron-oxide copper-gold deposits (Olympic Dam–type), Manitoba; *in* Report of Activities 2002, Manitoba Industry, Trade and Mines, Manitoba Geological Survey, p. 303-308.

SUMMARY

A preliminary scoping study was undertaken to assess the geological potential of Manitoba to host hydrothermal iron-oxide copper-gold (IOCG- or Olympic Dam–type) deposits. At the outset of this project, there were no known examples of IOCG-type deposits in the province, nor has there been any recorded exploration for these deposits. To date, a review and compilation of regional geological and geophysical data has been completed and approximately 87 targets identified for further investigation. Preliminary fieldwork was carried out, including a regional overview and reconnaissance visits to several of the priority targets. Reconnaissance fieldwork confirms the presence of widespread alkali±Fe and other related metasomatic effects associated with late intrusive bodies and large structural lineaments. However, the most important finding to date resulting from this initiative is the discovery of a large, mineralized, carbonatite complex near Eden Lake (Mumin, GS-21, this volume). The scoping study is still in the very early stages, so this article reports only on preliminary investigations and observations, and outlines the intended direction for continued work.

INTRODUCTION

Hydrothermal iron-oxide copper-gold (IOCG-type) deposits are attractive targets for modern exploration and development. They are typically polymetallic, with one or more economic metals that may include various combinations of Fe, Cu, Au, Ag, U, Th, F, Co, Bi, W, rare earth elements (REE) and other metals. The size of deposits varies up to 2 billion tonnes. Examples include the following deposits (Frietsch et al., 1979; Reeve et al., 1990; Hitzman et al., 1992; Smith and Chengyu, 2000):

- Olympic Dam in Australia (2 billion tonnes grading 1.6% Cu, 0.5 g/t Au, 3.5 g/t Ag and 0.6 kg/t U_3O_8)
- Kiruna in Sweden (2–3 billion tones grading 60% Fe)
- Bayan Obo in China (48–100 million tones grading approx. 6% REE oxides).

These deposits are found along modern and ancient continental margins, including extensional and collisional, mature and incipient environments. Most known deposits are Proterozoic, although Phanerozoic and Archean examples occur in many regions of the world. The deposits form from hydrothermal fluids associated with alkali-rich, felsic to intermediate intrusions. They are situated within and marginal to these intrusions, and may occur in any type of host rock (Hitzman et al., 1992; Hitzman, 2000).

This study was undertaken in Manitoba following consultations with staff at the Manitoba Geological Survey. The basic characteristics of IOCG-type deposits were reviewed and considered in the context of the geology of the province, and it was determined that a scoping study should be carried out.

METHOD OF INVESTIGATION

Prospective regions of Manitoba were selected, on the basis of known and suspected tectonic environments, to encompass those areas that were former continental margins, either mature or incipient. Attention was also paid to the presence or possibility of late felsic to intermediate intrusions. The IOCG deposits occur along and at the intersections of major structural lineaments, and this is one of the important exploration guides. The areas of Manitoba that are known and potential continental margins, and were therefore targeted for the initial scoping study, fall within the Trans-Hudson Orogen and include the Churchill-Superior Boundary Zone (including the TNB), the Kisseynew Domain, the Lynn Lake–Leaf Rapids Domain, the Southern Indian Domain, the Chipewyan Domain, the Seal River Domain and the Great Island Domain.

Most IOCG deposits are characterized by large iron and alkali±uranium-thorium enrichments within the host rocks. Consequently, they can be targeted by the presence of coincident magnetic and potassium±uranium-thorium radiometric signatures. Although effective for some potassium- and magnetite-rich systems, this approach will not recognize IOCG deposits characterized by high hematite and/or sodium enrichment. Also, the radiometric signatures are easily masked

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by water and/or overburden greater than 1 m in thickness. Cultural factors can cause spurious radiometric potassium anomalies and many are due to primary igneous rocks; however, hydrothermal potassium enrichments can be distinguished from natural igneous enrichments by their low radiometric thorium/potassium ratios.

To date, regional radiometric and airborne magnetic survey data have been reviewed for approximately 70% of the target region, in order to locate areas with coincident radiometric and magnetic anomalies. The anomalous areas were further discriminated on the basis of their regional geological setting, and the presence or possible presence of late felsic to intermediate, preferably alkali-rich intrusions. Of particular interest are 'out of place' geophysical anomalies associated with the late intrusions, and any evidence of alkali-iron metasomatism. Approximately 87 target anomalies have been identified, and these were subsequently prioritized into first-, second-, third- and fourth-priority targets for follow up fieldwork and study. Several of the 19 first-priority targets were further researched in the literature and assessment files in preparation for field examination.

PRELIMINARY FIELD INVESTIGATIONS

During June of 2002, preliminary reconnaissance fieldwork was conducted over the Thompson Nickel Belt and an east-west corridor extending from Assean Lake in the east to west of Lynn Lake. Regional rocks in these areas were examined for evidence of IOCG-type hydrothermal and magmatic features. Additionally, specific targets were examined at the Nichols dome and Burntwood River intrusion along the Thompson Nickel Belt, the Wapisu anomaly in the Kisseynew Gneiss Belt, the Eden Lake Alkaline Complex, and part of the region between Eden Lake and the Churchill River.

Churchill-Superior Boundary Zone (Thompson Nickel Belt)

The Thompson Nickel Belt (TNB) is a complex continental terrain boundary with both compressional and extensional phases of deformation. It hosts a number of late felsic to intermediate intrusions. Abundant iron formations are of further interest, and these were examined for evidence of hydrothermal modification related to late igneous activity. The belt was reviewed on a reconnaissance basis from the Williams Lake pluton, beneath the Paleozoic cover in the south, to the Burntwood River granodiorite intrusion, which extends from the town of Thompson northeast for approximately 26 km. Both drill core and surface exposures were examined.

Many but not all rocks of the Thompson Nickel Belt are eroded to levels too deep to be considered highly prospective for IOCG-type deposits. No clear evidence of igneous-associated hydrothermal activity was found in or adjacent to the intrusions that were examined, in other country rocks surrounding these intrusions, or in spatially associated iron formation units. However, the amount of terrain that was examined during the present reconnaissance was quite limited. Felsic pegmatitic segregations associated with partial melting of TNB rocks, particularly pelitic and semipelitic sedimentary rocks, are widespread and form abundant alkali-rich material with minor iron oxides. These melt segregations may have suitable chemistries for the generation of alkali-iron–rich intrusions, if they had been able to accumulate in large masses. One exception that remains of interest is the Burntwood River granodiorite intrusion.

Thompson – Assean Lake

East of the TNB, the most significant features observed to date with possible implications for IOCG deposits were in rare exposures of the Boundary Cataclastic Belt (Fig. GS-36-1). Evidence of widespread hydrothermal potassic and chloritic alteration is present in the brittle deformed rocks. The structurally high-level cataclastic rocks in a major deformation zone, widespread medium-temperature hydrothermal alteration, and evidence for late intrusions with iron metasomatism present a possible scenario for IOCG-type deposits.

Thompson – Lynn Lake

Extending from west of Thompson to Lynn Lake, sedimentary and igneous rocks of the Kisseynew Gneiss Belt were found to be episodically potassium±iron metasomatized to varying degrees. Sulphide-enriched zones and gossans are relatively common, and some of these are proximal to late felsic intrusions. The mineralization is primarily pyrrhotite and/or pyrite, with trace to minor chalcopyrite. In some instances, the sulphide mineralization is associated with weak oxide and silicate facies iron formation. However, most of the sulphide mineralization is situated in crosscutting structures (Fig. GS-36-2). The relationship of this type of mineralization to the abundance of late felsic intrusions in the Kisseynew Belt remains a key question in the context of the present IOCG scoping study.

Figure GS-36-1: Brittle deformed rocks with potassic and chloritic alteration, along with minor hematite and epidote, exposed in a quarry west of Assean Lake.

Figure GS-36-2: Abundant sulphide mineralization in structures disrupting Kisseynew metasedimentary rocks, roadcut along the Thompson–Nelson House corridor.

Wapisu anomaly

The Wapisu anomaly consists of strong, coincident, radiometric potassium and magnetic anomalies associated with a late felsic intrusion into Kisseynew metasedimentary rocks. The source of the anomaly was found to be potassic porphyroblastic granodiorite where it intrudes and encompasses lensoid bodies of magnetite-bearing rocks, possibly metasedimentary rocks (Fig. GS-36-3). It is not presently known whether the magnetite in these rocks is primary, hydrothermal or metamorphic in origin. No other evidence of mineralization was observed; however, only a very small portion of the potential zone of interest was visited in the current program.

Eden Lake

The eastern shore of the Eden Lake area was selected as a first-priority target due to the presence of adjacent radiometric potassium and magnetic anomalies, previously reported rare earth element (REE) showings, anomalous uranium signatures, and associated late aegirine-augite–bearing syenite and monzonite (Cameron,1988; McRitchie, 1989; Young and McRitchie, 990; Fedikow et al., 1993; Gunter et al., 1995). Regional reconnaissance carried out over an area between the southeastern shore of Eden Lake and the Churchill River was followed up with a five-week program of detailed mapping and sampling. The present investigations revealed a large hydrothermal and magmatic stockwork and breccia complex with widespread REE enrichments (Fig. GS-36-4). The detailed work resulted in the discovery of several small but well-mineralized carbonatite dikes and plugs within a very large (greater than 7 km^2) carbonatite complex. Rare earth element mineralization occurs in a variety of altered hostrocks and veins. The discovery and nature of the carbonatite complex are presented in a separate paper (Mumin, GS-21, this volume).

CONCLUSIONS

Results from the preliminary stages of this investigation are very encouraging, even though only a small fraction of the target zones has been visited. Evidence of mineralization and/or hydrothermal alteration related to late intrusions and major structures is widespread.

The most important finding to date is the discovery of the mineralized carbonatite complex at Eden Lake. Considering that Eden Lake was selected as a priority IOCG target and a carbonatite complex was discovered, this

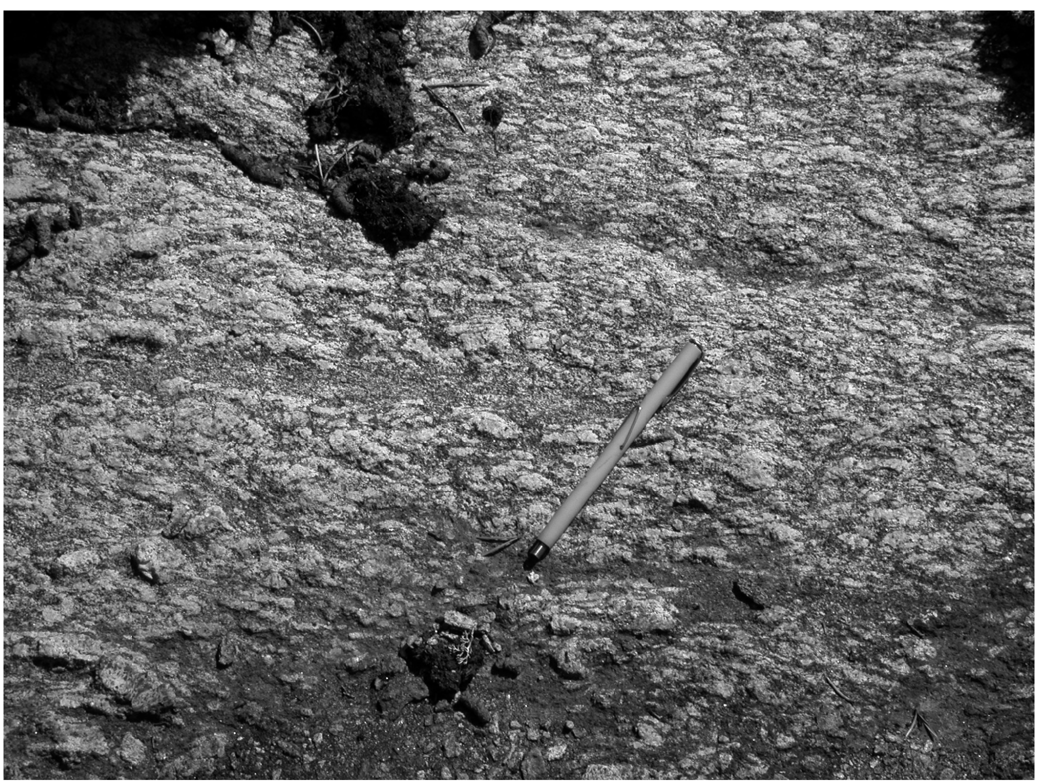

Figure GS-36-3: Porphyroblastic, magnetite-bearing rocks occur as lenses and thin sheets in potassic, porphyroblastic granodiorite, 2 km west of the hwest tip of Wapisu Lake.

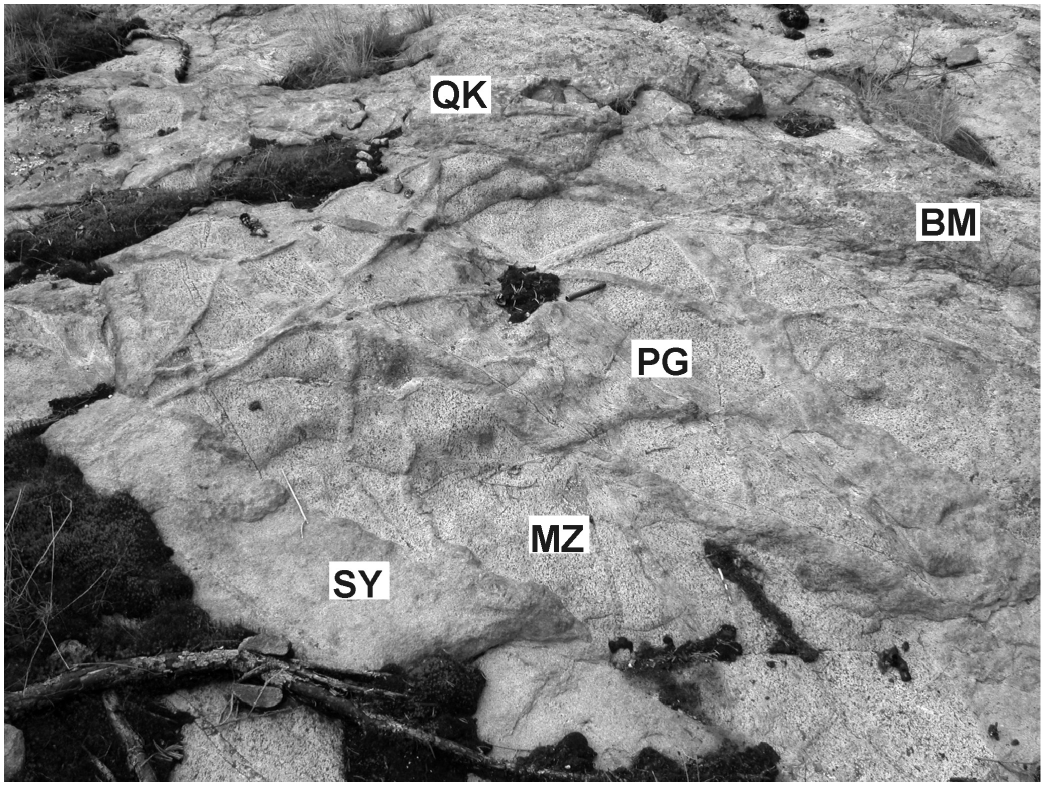

Figure GS-36-4: Small portion of the extensive stockwork and breccia the characterize much of the Eden Lake carbonatite complex, East grid. Narrow syenite veins intrude and disaggregate aegirine-augite–altered monzonite. Abbreviations: BM, blocky mafic breccia; MZ, monzonite; PG, paragneiss; QK, quartz plus K-feldspar pegmatite; SY, syenite.

raises the very intriguing question of the relationship between IOCG (Olympic Dam–type) deposits and carbonatite complexes. This interesting relationship has also been noted and discussed by several other investigators in recent years. The world's largest source of rare earth metals is Bayan Obo in China, which is consistently classified as an IOCG-type deposit. However, some investigators (Zhou et al., 1980; Mariano, 1989; Smith and Chengyu, 2000) consider that the source of mineralization at Bayan Obo may be unexposed carbonatite. Another good example is the Phalaborwa carbonatite complex in South Africa (Africa's largest copper mine), which has recently been discussed in terms of its similarities to, and possible genetic relationship with, IOCG-type deposits (Vielreicher et al, 2000; Harmer, 2000). Equally intriguing is the well-known and documented genetic and spatial relationship of carbonatite complexes with kimberlites. They are generally intergrown or proximally situated. This is an area of ongoing investigation at Eden Lake.

RECOMMENDATIONS AND FUTURE WORK

Most of the priority targets generated during the regional overviews have not yet been examined in the field. A continued program of reconnaissance mapping and sampling is planned in order to examine the remaining priority targets, and to follow up the reconnaissance with more detailed work where warranted. Whole-rock and trace-element geochemistry and petrographic examinations are planned for the more promising targets.

ACKNOWLEDGMENTS

The author is grateful for the consultations and assistance provided by many members of the Manitoba Geological Survey (MGS), and to MGS for funding this project. Inco Technical Services Limited granted access to their property and drill core, and several staff members offered generous assistance and advice. Falconbridge Limited granted access to their drill core. Rare Earth Metals Corp. assisted with some of the reconnaissance at Eden Lake, and funded the subsequent detailed work. Shea Martindale worked diligently on the regional geophysical survey and geology overviews and compilations. John Camier was an invaluable partner in carrying out the fieldwork. This project was funded in part by an NSERC research grant to the author.

REFERENCES

Cameron, H.D.M. 1988: Geology of the Eden Lake area; Manitoba Energy and Mines, Geological Services Branch, Geological Report GR84-2, 18 p.

Fedikow, M.A., Dunn, C.E. and Kowalyk, E. 1993: A vegetation geochemical and radiometric study of a part of the Eden Lake aegirine-augite syenite, northwestern Manitoba (NTS 64C/9); *in* Report of Activities 1993, Manitoba Energy and Mines, Geological Services, p. 5–10.

Frietsch, R., Papunen, H. and Vokes, F.M. 1979: The ore deposits of Finland, Norway and Sweden – a review; Economic Geology, v. 74, p. 975–1001.

Gunter, R., Fedikow, M.A.F., McRitchie, W.D. and Kowalyk, E. 1995: The Eden Lake rare earth element occurrence – metallurgy, geochemical and ground scintillometer surveys (NTS 64C/9), *in* Report of Activities 1995, Manitoba Energy and Mines, Geological Services, p. 11–16.

Harmer, R.E. 2000: Mineralisation of the Phalaborwa Complex and the carbonatite connection in iron oxide-Cu-Au-U-REE deposits; *in* Hydrothermal Iron Oxide Copper-Gold and Related Deposits, A Global Perspective, Australian Mineral Foundation, p. 331–340.

Hitzman, M.W. 2000: Iron oxide-Cu-Au deposits: what, where, when, and why; *in* Hydrothermal Iron Oxide Copper-Gold and Related Deposits, A Global Perspective, Australian Mineral Foundation, p. 9–25.

Hitzman, M.W., Oreskes, N. and Einaudi, M.T. 1992: Geological characteristics and tectonic setting of Proterozoic iron oxide (Cu-U-Au-REE) deposits; Precambrian Research, v. 58, p. 241–287.

Mariano, A.N. 1989: Economic geology of rare earth elements; Reviews in Mineralogy, v. 21, p. 309–337.

McRitchie, W.D. 1989: Ground scintillometer reconnaissance of the Eden Lake aegirine-augite monzonites; *in* Report of Activities 1989, Manitoba Energy and Mines, Geological Services, p. 7–12.

Reeve, J.S., Cross, K.C., Smith, R.N. and Oreskes, N. 1990: Olympic Dam copper-uranium-gold-silver deposit; *in* Geology of the Mineral Deposits of Australia and Papua New Guinea, F.E. Hughes (ed.), Australasian Institute of Mining and Metallurgy, Monograph No. 14, p. 1009–1035.

Smith, M. and Chengyu, W. 2000: The geology and genesis of the Bayan Obo Fe-REE-Nb deposit: a review; *in* Hydrothermal Iron Oxide Copper-Gold and Related Deposits, A Global Perspective, Australian Mineral Foundation, p. 271–281.

Vielreicher, N.M., Groves, D.I. and Vielreicher, R.M. 2000: The Phalaborwa (Palabora) deposit and its potential connection to iron-oxide copper-gold deposits of Olympic Dam type; *in* Hydrothermal Iron Oxide Copper-Gold and Related Deposits, A Global Perspective, Australian Mineral Foundation, p. 321–329.

Young, J. and McRitchie, W.D. 1990: REE investigations, Eden Lake intrusive suite (NTS 64C/9); *in* Report of Activities 1990, Manitoba Energy and Mines, Geological Services, p. 9–19.

Zhou, Z., Gongyuan, L., Tongyun, S. and Yunguan, L. 1980. On the geological characteristics and the genesis of the dolomitic carbonates at Bayan Obo, Inner Mongolia; Geological Reviews, v. 26, p. 35–42.