

# The KO-Zone: A New Occurrence of PGE-Cu-Ni Mineralization in Fox River Sill, Northern Manitoba

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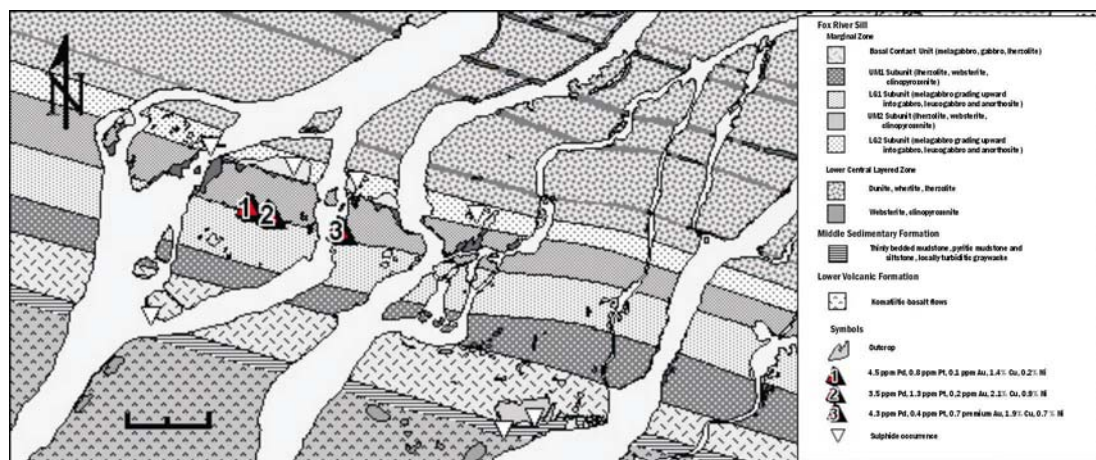
## Introduction

The Fox River Sill (FRS) is a Paleoproterozoic (1883 Ma) intrusion that extends for most of the length of the >250 km long Fox River Belt in northeastern Manitoba (Scoates 1990). The sill is a predominantly ultramafic layered intrusion having an average thickness of 1.5 km. The Great Falls area on the Fox River provides a rare, well-exposed section through the lower part of the FRS and the upper part of the Lower Volcanic Formation in the Fox River Belt (Figure 1). The sill has been subdivided into four main stratigraphic units, *viz.* (from stratigraphic base to top): (1) Marginal Zone; (2) Lower Central Layered Zone; (3) Upper Central Layered Zone; (4) Hybrid Roof Zone. In 1999, a new target for PGE-Cu-Ni mineralization, the KO Zone, was recognized in outcrops of the Marginal Zone. Results obtained from detailed mapping and chemostratigraphic studies are summarized below and provide constraints on the genesis and economic potential of this mineralization.

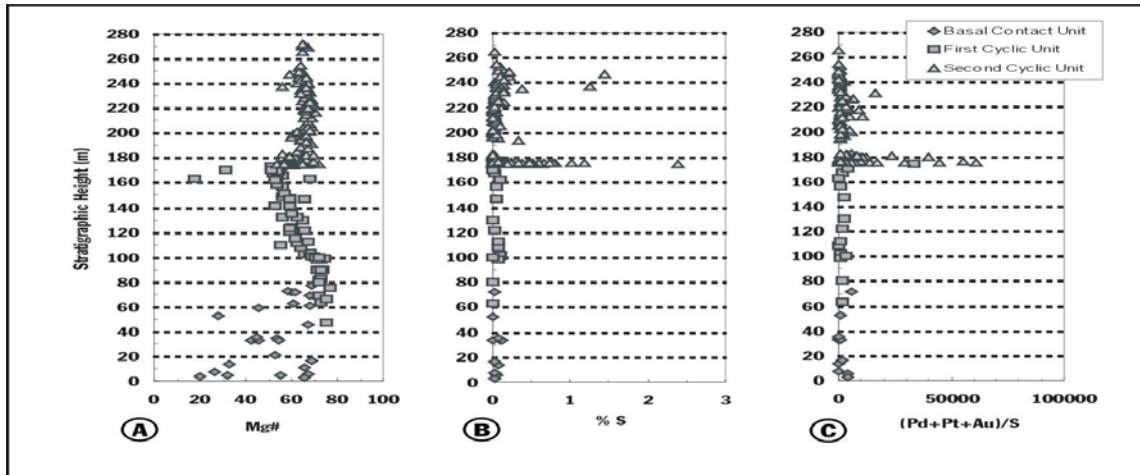
## Geology

As observed in the Great Falls study area, the FRS

was emplaced into pyritic argillites of the Middle Sedimentary Formation, which are thoroughly hornfelsed within several meters from the base of the sill (Scoates 1990). The Marginal Zone comprises three main subunits. The lowermost is the Basal Contact Unit (BCU), which is overlain by two cyclic units (Figure 2a). BCU contains xenoliths and xenomelts derived from the underlying Middle Sedimentary Formation. Minor disseminated pyrrhotite and chalcopyrite are locally present at the base of this unit (Figure 2b). The BCU is overlain by the ~100 m thick Cyclic unit 1, which grades from lherzolite (UM1) at its base through melagabbro, gabbro, leucogabbro and, locally, tonalite or anorthosite at its top (LG1) (Peck et al. 1999). Cyclic unit 2 is about 100m thick and is interpreted to have been generated from a separate pulse of magma that was intruded before Cyclic unit 1 was fully solidified (Desharnais et al. 2000). The KO Zone occurs at the contact between leucogabbro and anorthosite from the top of Cyclic unit 1 (LG1) and ultramafic rocks from the base the Cyclic unit 2 (UM2). Above the KO-Zone, Cyclic unit 2 grades into several meters of lherzolite (UM2).



**Figure 1.** Geological map of the Great Falls area on the Fox River. Numbered triangles show locations of mineralized samples of the KO Zone. Locations 1 and 2 are examples of the mineralization found in the basal websterite, while location 3 is an example of a mineralized varitextured gabbro pod at the top of the KO Zone.



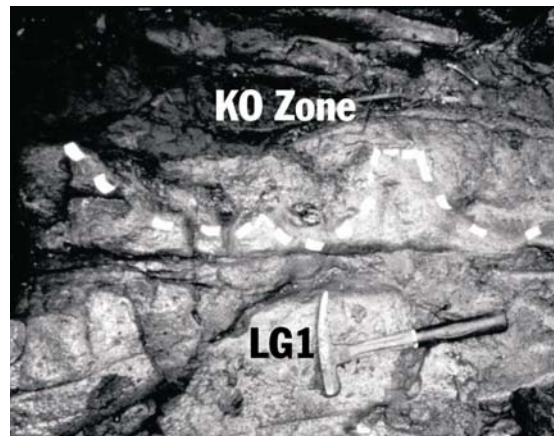
**Figure 2.** Chemostratigraphic plots of the Marginal Zone, where stratigraphic height is measured from the base of the FRS. A. The variability in Mg# in the BCU is related to the inherent heterogeneous nature of this unit as well as variability in amount of crustal contamination. B. Shows variation of sulphur concentration with stratigraphic height. C.  $(Pt+Pd+Au)/S$  represents variations in PGE tenor of sulphides in the Marginal Zone.

The Iherzolite is a fine- to medium-grained olivine cumulate containing both clinopyroxene and orthopyroxene oikocrysts and local disseminated sulphides (<1%). The Iherzolite unit grades upward into a dm-scale layered sequence comprising Iherzolite, melagabbro and gabbro that in turn is overlain by massive gabbro and leucogabbro that correspond to the LG2 subunit. Up to 15% disseminated pyrrhotite and chalcopyrite having low PGE tenors are present in the LG2 subunit (Peck et al. 1999).

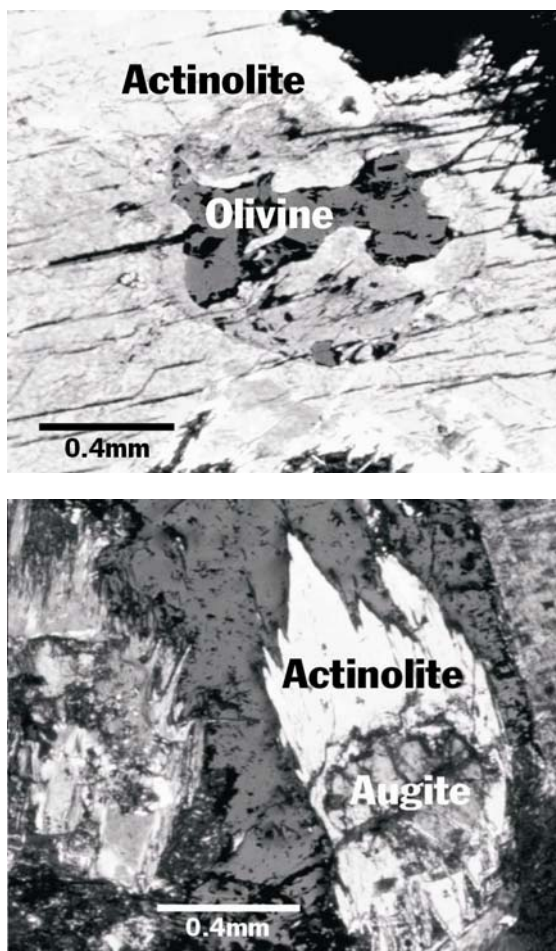
### KO Zone

Detailed mapping of bush and river outcrop areas has delineated a several meter-thick, heterogeneous sequence of mineralized (PGE-Cu-Ni) ultramafic and mafic rocks referred to as the KO Zone (Desharnais et al. 2000). The KO Zone is the stratigraphically lowermost interval in the FRS to contain significant amounts of sulphides. The base of the KO Zone is represented by an irregular, commonly scalloped and undulating contact between gabbroic to anorthositic rocks of the LG1 subunit and coarse-grained actinolite-bearing websterite of the KO Zone (base of UM2 subunit) (Figure 3). The websterite layer ranges from <1 to 3 m in thickness. It typically contains net-textured, blebby, disseminated sulphides that are concentrated within dm to m-scale trough structures along the irregular LG1/UM2 contact. The mineralized websterite is typically one meter thick and generally decreases both in its grain size (3 cm to <0.5 cm) and sulphide concentration (15% to

<1%) upwards (Desharnais et al. 2000). Chalcopyrite is the dominant sulphide, and attains a maximum of 15% near the base of some of the troughs. Given the primitive composition of Cyclic Unit 2, a Cu:Ni ratio of <1 is expected (e.g. Naldrett 1989); however the Cu:Ni ratios are typically between 2:1 and 3:1. The websterite layer contains up to 10 % fine-grained gabbroic material occurring as pockets (up to 5cm wide) or as interstitial material between the larger grains. Actinolite makes up approximately 15% of the rock, and occurs as a secondary mineral replacing olivine and augite (Figure 4).



**Figure 3.** Photograph of the scalloped contact between the top of Cyclic unit 1 and the KO Zone. The mineralization is often concentrated in base of the troughs.



**Figure 4.** Photomicrographs showing replacement textures. Top. Olivine relict found in a grain of actinolite with a “grain-shadow” representing the original size and shape of the grain. Bottom. Relict augite grain found within an actinolite crystal that is growing into chalcopyrite.

Cumulus orthopyroxene and accessory ilmenite are present in the websterite; this represents a significant change in the normal order of crystallization (olivine → clinopyroxene → plagioclase → orthopyroxene) that is commonly recorded by mafic and ultramafic rocks in the Fox River Belt. The PGE tenor of sulphides in the KO Zone is much higher than for sulphides present in any other units in the Marginal Zone of the FRS (Figure 2c).

Locally, crescent-shaped pods and discontinuous, m-size layers of varitextured gabbro, diorite, leucogabbro and leucodiorite occur within weakly mineralized lherzolite in the upper part of the KO Zone. These pods are also commonly mineralized and locally display normal size- and compositional-grading of sulphide and silicate

components. The pods are thought to reflect rheomorphic melts derived from the underlying, gabbroic upper part of Cyclic Unit 1 (LG1) that ascended into the lower part of Cyclic Unit 2 (Desharnais et al. 2000).

The proposed model for the formation of the KO Zone is as follows:

1) A single pulse of magma is emplaced into the Middle Sedimentary unit that gives rise to the BCU and Cyclic Unit 1.

2) A second pulse of magma is emplaced into the chamber before Cyclic Unit 1 has had time to crystallize completely. Unlike the first pulse of magma, this one was sulphur saturated at the time of emplacement, or became sulphur saturated soon after.

3) Sulphides and an olivine-clinopyroxene cumulate are deposited onto the crystal-mush/magma interface corresponding to the top of LG1.

4) Accumulation of the crystal pile above the Cyclic Unit 1 causes compaction and volatile-rich intercumulus liquid in LG1 to percolate upward through the base of the UM2 subunit.

5) The Cu and PGE tenor of pre-existing sulphides present at the base of the UM2 subunit are upgraded by interacting with the ascending intercumulus liquid. This more evolved liquid would account for the high observed Cu:Ni ratio in the mineralization.

6) The upward movement of the liquid causes the LG1-KO Zone contact to sag and become convoluted in a similar fashion to that of unlithified sediments during dewatering. It would also cause the base of the crystal pile to partially recrystallize (replacement of olivine and pyroxene by amphibole), and eventually, crystallization of a gabbroic interstitial material. High volatile content of the intercumulus fluid could account for the large grain size observed at the base of the KO Zone.

7) The upward percolating volatile-rich intercumulus liquid may have reached a level of neutral buoyancy a few meters above the base of the UM2 subunit where it ponded to form the varitextured gabbro pods. Alternatively, the pods resulted from trapping of the volatile-rich gabbroic liquid beneath several meters of olivine-rich cumulates (lherzolite) that acted as an impermeable barrier.

Assays obtained from grab samples of the KO Zone confirm that the sulphide mineralization is prospective for PGE, Cu and Ni (Figure 1). Maximum metal contents obtained to date from this zone are 2.1% Cu, 0.9% Ni and 5.5 g/t combined Pd + Pt + Au. Metal concentrations recalculated to

100% sulphide are as high as 27% Cu, 4% Ni and 110 g/t combined Pd + Pt + Au. These findings, coupled with previous investigations of stratiform sulphide mineralization in the lower part of the Upper Central Layered Zone (e.g. Scoates and Eckstrand 1986, Schwann 1989, and Naldrett et al. 1994), demonstrate the significant potential for both magmatic Ni-Cu sulphide deposits and PGE deposits in the FRS.

## References

- Desharnais, G., Peck, D.C., Theyer, P., Potter, L., Huminicki, M., Scoates, R.F.J., Halden N.M., and Kohut G., 2000. Geology and mineral occurrences of the Fox River Sill in the Great Falls Area, Fox River Belt. Manitoba Industry Trade and Mines Report of Activities. GS-9: 42-48.
- Naldrett A.J., Asif, M., Scoates, R.F.J., Eckstrand, O.R., and Schwann, P.L., 1994. Platinum-group elements in the Fox River Sill, Manitoba, Canada: Implications with respect to influxes of fresh magma and exploration for PGE deposits. Transactions of the Institution of Mining and Metallurgy, v. 103, p.10-21.
- Peck, D.C., Huminicki, M., Wegleitner, C., Theyer, P., Olshefsky, K., Potter, L., Hulbert, L. and Scoates, R.F.J., 1999. Lithostratigraphic framework for PGE-Cu-Ni sulphide mineralization in the Marginal Zone of the Fox River Sill. Manitoba Industry Trade and Mines Report of Activities. GS-13: 46-50.
- Schwann, P.L., 1989. Petrology, geochemistry and PGE distribution of the Layered Zone, Fox River sill, western lobe, 462W section, northeastern Manitoba; Unpublished M.Sc. thesis, Carleton University, Ottawa, Canada.
- Scoates, R.F.J., 1990: The Fox River sill: A major stratiform intrusion. Manitoba Energy and Mines, Geological Report GR82-3, 192p.
- Scoates, R.F.J., and Eckstrand, O.R., 1986. Platinum-group elements in the Upper Central Layered Zone of the Fox River Sill, northeastern Manitoba, Economic Geology, v. 81, pp. 1137-1146.