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Targeted Geoscience Initiative 4: Increasing Deep Exploration Effectiveness

Recognizing optimum Banded-Iron Formation-hosted gold environments in ancient, deformed and metamorphosed terranes: Preliminary results from the Meadowbank deposit, Nunavut, Canada

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Geological Survey of Canada with Provincial and Territorial Collaboration

TGI 4 Ore Systems

INTRODUCTION

The Meadowbank project is part of the Lode Gold Project of NRCan's TGI4 Program that aims at improving geological exploration models where gaps exist in our understanding of Canada's major gold systems with respect to footprint, vectoring and fertility as indicators for hidden/buried deposits. The Lode Gold Project investigates a selected group of deposits in various settings, with some emphasis on underexplored styles/types of mineralization, including Banded Iron Formation (BIF)-hosted gold deposits, which represent prime exploration targets in northern Canada. The BIF-hosted gold deposits theme consists of a systematic investigation of the proximal and distal geological and hydrothermal signatures or footprints, structural controls and timing of the mineralization with respect to the overall geologic evolution of their host rocks and camp-scale settings. Such research is underway at the Musselwhite mine and Hardrock deposit in Ontario, and at the Meadowbank mine in Nunavut.

Some of the key scientific hypotheses that will be tested include:
- BIF–hosted gold deposits in the Churchill Province are genetically related and structurally controlled by Paleoproterozoic (1.83 Ga) tectono-metamorphic events superimposed on Archean rocks.
- BIF–hosted gold deposits commonly form large isolated entities without an associated district.
- The first-order exploration criteria in area selection need to be refined by establishing the main geological controls on gold concentration in relationship to the geological setting. These include:
    - Major shear zone
    - Macroscopic tight isoclinal folds
    - Unconformity
    - Presence black shales or ultramafic rocks
- Differentiating hydrothermal activity from regional or contact metamorphism and establishing the nature and timing of distal vs. proximal hydrothermal alterations (footprints) lead to better exploration vectors.

This poster was presented at the 2013 PDAC-SEG Canada Student Chapter Minerals Colloquium, March 4, 2013 (Janvier et al., 2013)

GEOLOGICAL SETTING

Agnico-Eagle Mines' Meadowbank mine is located in the Kivalliq region of Nunavut, 70 km north of the community of Baker Lake. The deposit is hosted in the Neoarchean Woodburn Lake Group, in the Rae domain of the Western Churchill geological province (Figs. 1 and 2).

The lithologic succession of the deposit consists of, from east to west, intermediate to felsic volcaniclastic rocks, banded iron formation, ultramafic rocks, locally interlayered with the BIF, and quartzite (Figs.3 to 6). The predominant gold mineralization found at the Portage and Goose zones is associated with pyrrhotite and pyrite, which have replaced magnetite or that occur as narrow stringers of disseminated sulphides. The ore zones are typically 6-7 m wide (5 up to 40 g/t Au) and hosted in the BIF, predominantly along the contacts with ultramafic rocks. Gold also is found in high-grade quartz veins (up to 300 g/t Au) crosscutting the BIF and adjacent volcaniclastic rocks. At least four phases of regional deformation affect the host rocks of the Meadowbank deposit, which have been metamorphosed to mid-greenschist through amphibolite facies.

Regionally, the main phase of deformation (D2) consists of tight to isoclinal folds, axial planar foliation and shear zones, although mesoscopic F2 folds are rare in the mine area. Regional D3 (shallow-inclined open to closed folds and axial planar crenulation cleavage) and D4 (NE-SW-plunging, steeply inclined cross-folds) deformation also affect the mine sequence and the mineralization.

Although the geometry of the Portage zone is typically portrayed as an isoclinal F2 fold, preliminary new mapping suggests that mine succession is also shear zone imbricated by two late-(?)D2 shear zones preferentially developed within the ultramafic units (Fig. 5). These shear zones appear to truncate the ore zones, and possibly control their distribution.

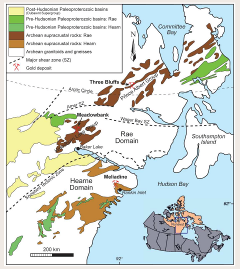
Post-Hudsonian Paleoproterozoic basins (Dubawnt Supergroup)
Pre-Hudsonian Paleoproterozoic basins: Rae
Pre-Hudsonian Paleoproterozoic basins: Hearn
Archean supracrustal rocks: Rae
Archean supracrustal rocks: Hearn
Archean granitoids and gneisses
Major shear zone (SZ)
Gold deposit
Committee Bay
Three Bluffs
Meadowbank
Rae Domain
Hearne Domain
Hudson Bay
N
200 km

Figure 1: Schematic tectonostratigraphic map of the western Churchill Province (from Davies et al., 2010).

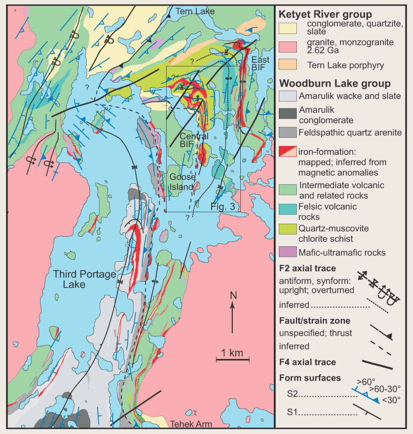
Tern Lake
East BIF
Central BIF
Goose Island
Fig. 3
Third Portage Lake
Tehek Arm
N
1 km
Ketyet River group
conglomerate, quartzite, slate
granite, monzogranite 2.62 Ga
Tern Lake porphyry
Woodburn Lake group
Amarulik wacke and slate
Amarulik conglomerate
Feldspathic quartz arenite
iron-formation: mapped; inferred from magnetic anomalies
Intermediate volcanic and related rocks
Felsic volcanic rocks
Quartz-muscovite chlorite schist
Mafic-ultramafic rocks
F2 axial trace
antiform, synform: upright; overturned
inferred
Fault/strain zone
unspecified; thrust
inferred
F4 axial trace
Form surfaces
S2
S1
>60°
>60-30°
<30°

Figure 2: Geology and structure of the Third Portage Lake area (modified after Pehrsson et al., 2006, unpublished).

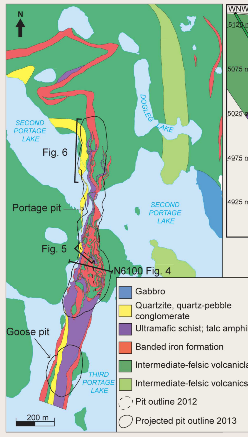
N
SECOND PORTAGE LAKE
DOGLEG LAKE
Fig. 6
Portage pit
Fig. 5
N6100 Fig. 4
Goose pit
THIRD PORTAGE LAKE
200 m
Gabbro
Quartzite, quartz-pebble conglomerate
Ultramafic schist; talc amphibolite
Banded iron formation
Intermediate-felsic volcaniclastics
Intermediate-felsic volcanics
Pit outline 2012
Projected pit outline 2013

Figure 3: Geology of the Meadowbank mine area, based on pre-mining surface, trench and drill core data (modified after Sherlock et al., 2001).

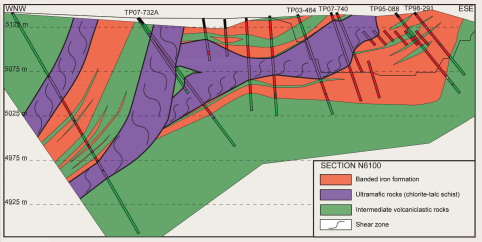
WNW
ESE
TP07-732A
TP03-464
TP07-740
TP95-088
TP98-291
5125 m
5075 m
5025 m
4975 m
4925 m
SECTION N6100
Banded iron formation
Ultramafic rocks (chlorite-talc schist)
Intermediate volcaniclastic rocks
Shear zone

Figure 4: Geological interpretation of the N6100 drill section across the southern Portage pit. The structural style is dominated by imbrication of shear zones, preferentially developed within the ultramafic units. These shear zones appear to truncate the ore zones, and possibly control their distribution (see Fig. 3 for location).

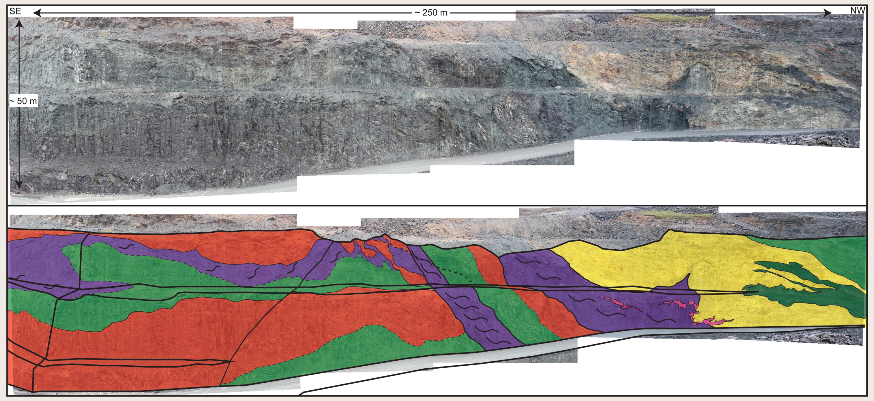
SE
NW
~ 250 m
~ 50 m

Figure 5: Photo mosaic and preliminary geological interpretation of part of the western wall of the southern Portage pit (see Fig. 3 for location). In the footwall of the quartzite, the western shear zone, marked by the ultramafic unit, appears to be concordant with the footwall iron formation. The eastern shear zone, also marked by an ultramafic unit, apparently truncates the mineralized iron formation along its footwall, which suggest a fault ramp geometry or late- to post-folding faulting.

🟨	Quartzite
🟫	Phyllite
🟪	Feldspar-quartz porphyry
🟥	Banded iron formation
🟪	Ultramafic rocks (chlorite-talc schist)
🟩	Mafic volcaniclastic rocks
🟩	Intermediate volcaniclastic rocks
🟩	Felsic volcaniclastic rocks
∫	Shear zone

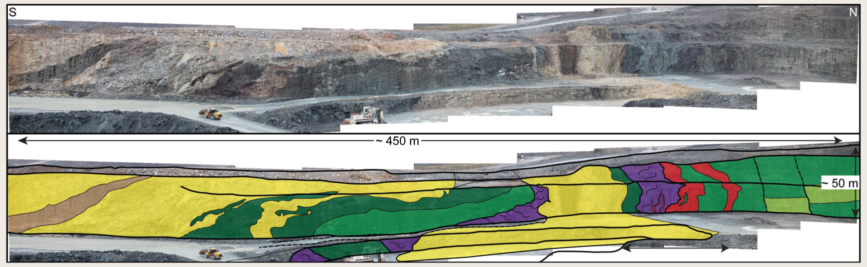

Figure 6: Photo mosaic and preliminary geological interpretation of part of the western wall of the northern Portage pit (see Fig. 3 for location). There, the mine succession, including the mineralized iron formation and sheared ultramafic units are affected by a macroscopic SW-plunging F4 syncline. See photo 6 for a simlilar view. Note also late brittle faults cutting the volcaniclastic rocks.

Photo 1a: Typical banded iron formation with magnetite, chert and fine-grained grunerite layers.

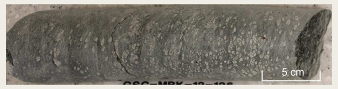

Photo 2a: Ultramafic volcanic rock with carbonate alteration

Photo 1b: Barren banded iron formation with grunerite aggregates and chlorite replacement of magnetite.

Photo 2b: Ultramafic volcanic rock with quartz-carbonate veins.

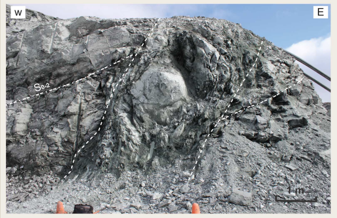

Photo 3: Eastern shear zone marked by shear ultramafic rocks cutting the layering in the volcaniclastic rocks.

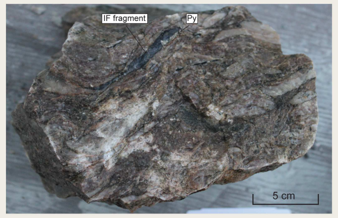
IF fragment
Py
5 cm

Photo 4: Basal conglomerate of the quartzite unit dominated by quartzite fragments, but also dark gray siliceous and pyrite-bearing IF fragments.

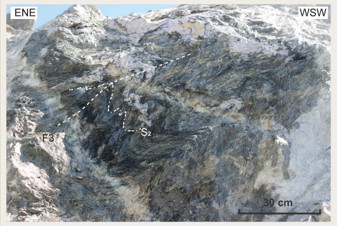
ENE
WSW
F3
S2
30 cm

Photo 5: Strongly foliated (S2) sericite schist affected by mesoscopic NW-plunging F3 folds.

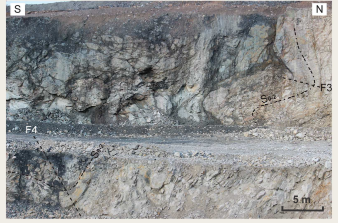
S
N
F3
S0-2
F4
5 m

Photo 6: Polyphase F3-F4 folding of the quartzite and sheared ultramafic units along the western wall of the northern Portage pit.

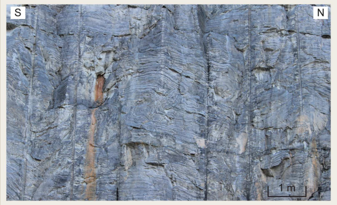

Photo 7: Complexly folded, weakly mineralized banded iron formation (western wall of the southern Portage pit).

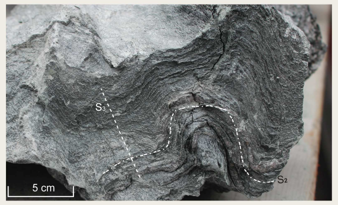

Photo 8: Strongly foliated chlorite-altered volcaniclastic rock showing a penetrative S3 crenulation cleavage affecting the main S2 foliation.

GSC-MBK-12-008
5 cm

Photo 9: Chlorite-quartz-carbonate veins cutting pyrite-rich BIF.

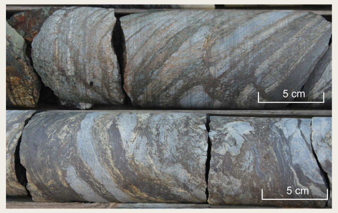

Photo 10: Pyrrhotite-rich, chlorite-altered iron formation.

Photo 11: Typical banded iron formation with layer-parallel pyrite.

Photo 12: Quartz-gold vein cutting sericite-altered volaniclastic rock.

ONGOING RESEARCH

Ongoing research, mapping and data/sample acquisition to date have mostly been concentrated on the Portage and Goose zones, which now represent a ca. 3 km-long open-pit operation. The main field research activities were:

- Geologic and structural mapping of the ore zones and host rocks.
- Core logging and sampling on selected drill sections through the best zones and covering the spectrum of metamorphic/structural settings.
- Sampling for U-Pb and Re-Os geochronology.

Preliminary mapping and structural analysis suggest that current deposit geometry portrayed as a folded succession may rather be shear zone imbricated, or a combination of both structural styles, with at least two major N-S shear zones controlling the ore zones. Mineralization is concentrated in the BIF along the footwall of shear zones, but also remobilized (?) in the volcaniclastic rocks. Both mesoscopic F3 and macroscopic F4 folds further affect the mine sequence and the mineralized zones.

Preliminary U-Pb geochronology on different units of sedimentary rocks suggest that the mineralized succession may be >2700 Ma (Archean in age and consistent with data from Sherlock et al. constraining the age of the footwall to 2710 Ma), and possibly repeated (panels), with probable major first-order faults close to the deposit (central BIF).

More than 500 samples were taken from the pit and selected drill sections, and half of them were selected for geochemical and petrographic analyses. These will serve to establish the metamorphic, hydrothermal and metallogenic characteristics, and ultimately footprint of the deposit.

ANTICIPATED IMPACTS

- Constraints on the relative and absolute timing of events in the Meadowbank area including specific data on the timing of gold emplacement, with implications on genetic and exploration models for BIFs in the Churchill Province.

- Key information and knowledge on the footprint and fertility indicators of the Meadowbank deposits applicable to other prospective environments elsewhere in the Canadian Shield.

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ACKNOWLEDGMENTS

This project is a cooperative research endeavour between the Geological Survey of Canada (NRCAN), *l'Institut National de la Recherche Scientifique (INRS-ETE)* and Agnico Eagle Mines (Meadowbank and Exploration divisions) with the collaboration of the Canada-Nunavut Geoscience Office.

This publication is available for free download through GEOSCAN (http://geoscan.ess.nrcan.gc.ca/).
doi:10.4095/292589

Recommended citation
Janvier, V., Castonguay, S., Mercier-Langevin, P., Dubé, B., McNicoll, V., Malo, M., Pehrsson, S., Bécu, V., 2013. Recognizing optimum Banded-Iron Formation-hosted gold environments in ancient, deformed and metamorphosed terranes: Preliminary results from the Meadowbank deposit, Nunavut, Canada; Geological Survey of Canada, Open File 7407. doi:10.4095/292589

OPEN FILE
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7407
GEOLOGICAL SURVEY OF CANADA
COMMISSION GÉOLOGIQUE DU CANADA
2013

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