GEOLOGICAL SURVEY OF CANADA
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Preliminary observations on the geological environment of the Paleoproterozoic auriferous volcanogenic massive sulphide deposit of Lalor, Snow Lake, Manitoba

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A. Caté, P. Mercier-Langevin, P.S. Ross, S. Duff, M. Hannington, B. Dubé, S. Gagné

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Introduction

The Lalor research project is part of the VMS (Volcanogenic Massive Sulphide) activity of the TGI 4 (Targeted Geoscience Initiative) program of the GSC. The Lalor research project is a collaborative effort that includes Hudbay, the GSC, the INRS, the University of Ottawa and the MGS. It consists in a Ph.D. (A. Caté) and a M.Sc. (S. Duff) programs. Its goal is to establish the geological footprint of the deposit.

Auriferous VMS deposits are highly desirable exploration targets. Their polymetallic nature, comprising large amounts of gold together with base metals makes them very attractive exploration targets which may turn out to be highly profitable mining operations. Moreover, the gold content of a VMS deposit is a critical factor to the economic viability and profitability of a deposit. Many of the key features of auriferous VMS deposits have not yet been fully documented and their genetic attributes understood, (e.g., metal tenor and zonation, geochemical and mineralogical budget and zonation, etc.). The underlying controls on gold enrichment in VMS deposits, and the geologic processes that control the source(s) of Au in Au-rich VMS are still not fully understood despite the urgent need for better exploration criteria for such concealed deposits.

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Introduction

The Lalor auriferous VMS deposit in the Proterozoic Flin Flon-Snow Lake belt of Manitoba is a recent deep (>500 m) discovery by HudBay Minerals that is currently being developed for commercial production. It contains approximately 27 Mt of ore potentially including 75 t of Au as well as 684 t of Ag, 1.38 Mt of Zn and 0.2 Mt of Cu. This deposit is an ideal "natural laboratory" to better understand the signature and key characteristics of auriferous VMS deposits and elucidate characteristics that can be used to vector toward them (Mercier-Langevin *et al.*, 2012).

The deposit is situated in the Flin Flon greenstone belt which is part of the Paleoproterozoic Trans-Hudson orogen. Lalor has been affected by several hydrothermal events, an intense polyphase deformation and an amphibolite grade metamorphism.

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Introduction

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The aims of the ongoing research project is to test the following hypotheses and questions about Lalor:

i) Do the discrete Zn- and Au±Cu-rich lenses result from primary geologic processes (volcanic and/or magmatic)? How can these be identified? Identifying these controls and their signature is critical to develop more effective exploration guidelines for similar deposits elsewhere in the belt and throughout Canada.

ii) Is gold sourced from magmas and introduced during volcanism as part of the VMS-forming hydrothermal system rather than being introduced during younger hydrothermal, deformation and/or metamorphic event(s)?

iii) Is gold, and its associated hydrothermal alteration mineral assemblages, heterogeneously distributed? Can such zonations be recognized and used as exploration vectors to ore?

iv) If secondary processes (i.e. hydrothermal overprint, deformation and metamorphism) control the geometry and distribution of Au-rich zones in VMS systems, can these be recognized through geologic mapping and study of mineralization and alteration assemblages.

The study of Lalor includes, among many other aspects, the understanding of the primary volcanic environment, which is partly covered in this presentation.

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Plan

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- Introduction
- The Lalor deposit
- Geochemistry of the protoliths
- Cross-section
- Conclusions

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The Lalor deposit

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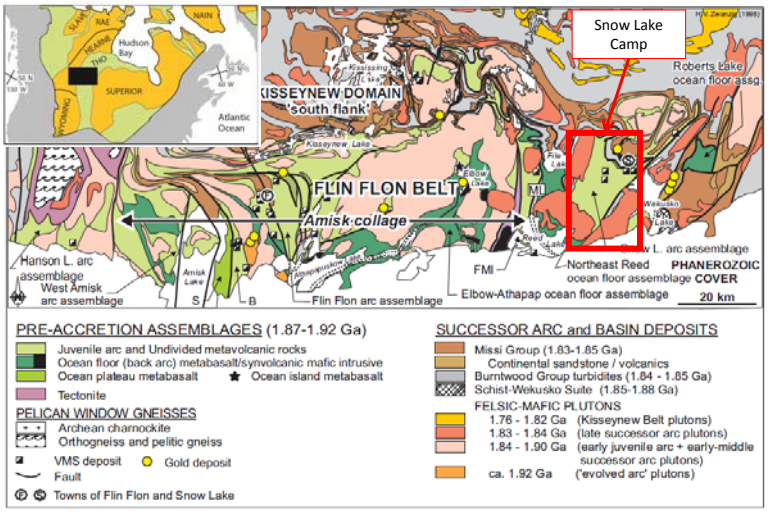

Galley *et al.*, 2007

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The Lalor deposit

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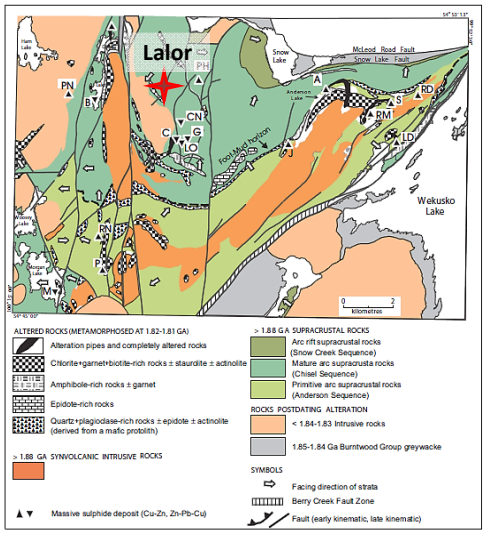

- Lalor is situated in the Snow Lake arc assemblage, within the Chisel sequence, interpreted as a mature arc.
- Several bimodal mafic VMS deposits (Chisel, Chisel North, Ghost, Lost) have been exploited in this sequence.

Galley *et al.*, 2007

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The Lalor deposit

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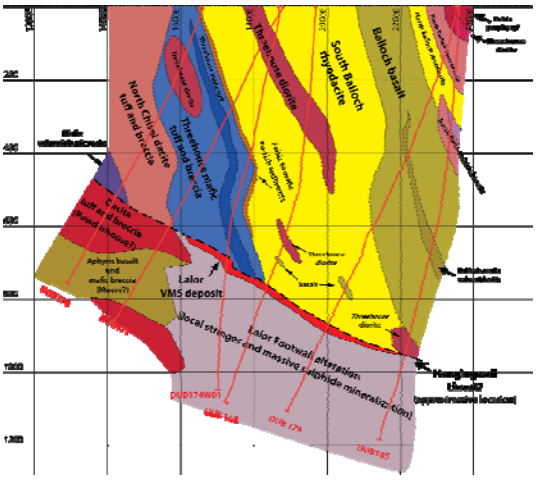

The deposit is situated in the Chisel sequence at the contact between the lower and upper series.

•The hanging wall contact with the deposit could be a structural discordance.

•The footwall is composed of an intense and extensive alteration zone, including several ore lenses.

Bailes, 2008

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The Lalor deposit

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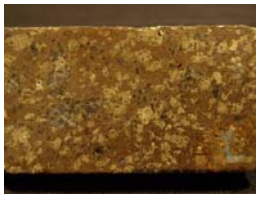
At least 11 alteration styles, including:

Sericite-Pyrite-Biotite-Kyanite

Anthophyllite-Garnet-Biotite-Staurolite

Carbonate-Chlorite-Amphiboles

At least five mineralization types, including:



Massive sulphides: Zn-Cu-(Au)

Mineralized Amphiboles-Qtz assemblages: Au-Ag-Pb-Cu

Semi-massive sulphides: Au-Cu

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Geochemistry of the protoliths

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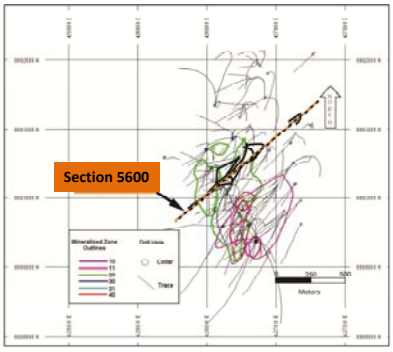
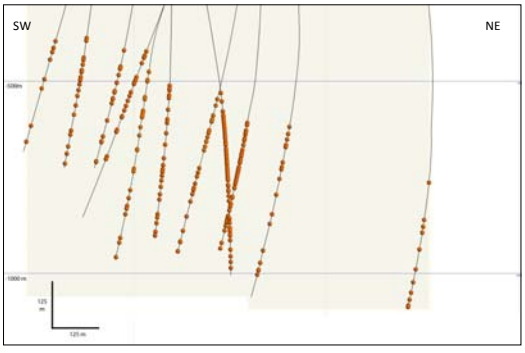
Method:

- A representative cross-section through the deposit has been selected.
- 11 drillholes have been described and sampled from 50 m above the base of the hanging wall to the end of hole (ie. as deep as possible in the deposit footwall).



Plan view of the Lalor ore zones



5600 section

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Geochemistry of the protoliths

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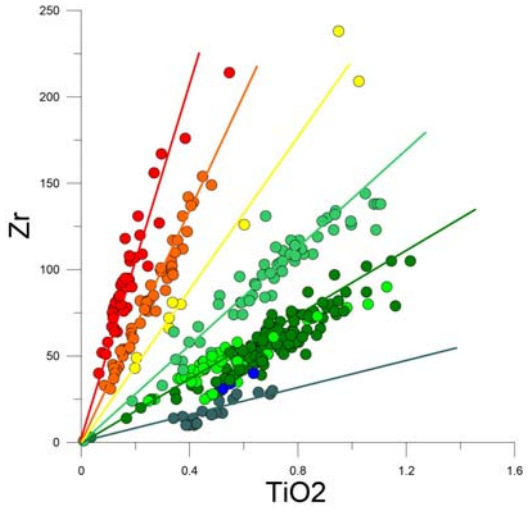

- Several trends are visible on the Zr vs. TiO2 diagram. They could represent different protoliths.
- The results are spread along the trends, showing the important alteration of the host rocks, in agreement with the complex mineralogy described in the footwall (Mercier-Langevin *et al.*, 2012).

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Geochemistry of the protoliths

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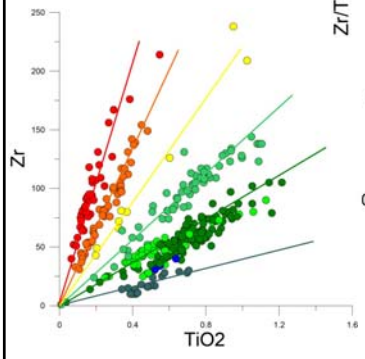

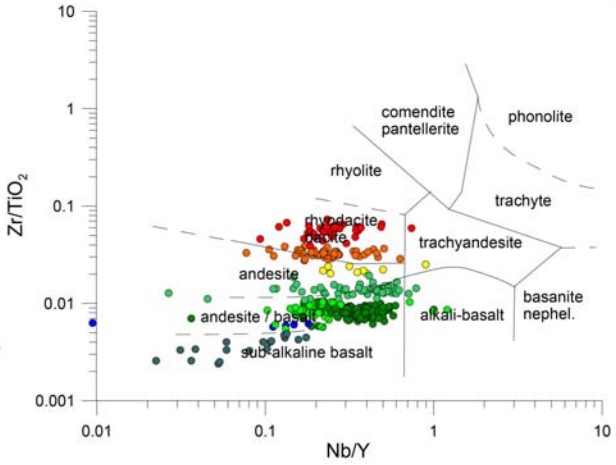

From Winchester and Floyd, 1977

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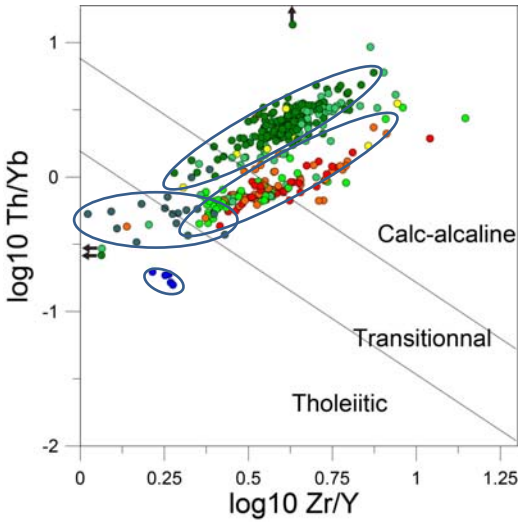
Geochemistry of the protoliths



From Ross and Bédard, 2009

- Several groups representing distinct magmatic affinities can be discriminated, suggesting a complex interaction between rocks of different magmatic affinities.

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Geochemistry of the protoliths

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Volcanic rocks hosting the Lalor deposit can be classified based on their differentiation level and their magmatic affinities:

- 1: transitional to calc-alcaline felsic rocks
- 2a: transitional to calc-alcaline felsic rocks
- 2b: calc-alcaline felsic rocks
- 3: calc-alcaline intermediate rocks
- 4a: calc-alcaline mafic rocks
- 4b: transitional to calc-alcaline mafic rocks
- 4c: tholeiitic mafic rocks
- 5: tholeiitic to transitional mafic rocks

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Cross-section

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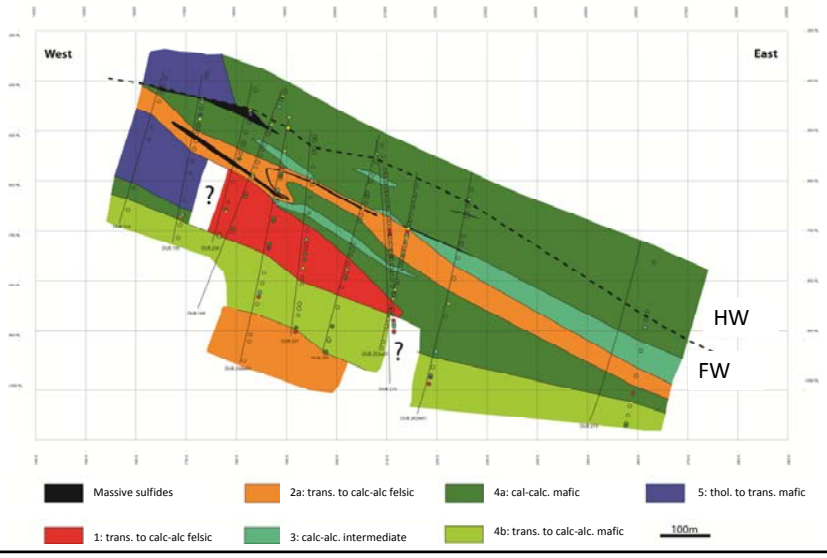
Simplified interpretation of the 5600 section



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Conclusions

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A wide diversity of volcanic rocks are present but are difficult to differentiate visually because of the intense alteration and overprinting metamorphism and deformation:

Felsic volcanics (type 1)
Sample: Lalor-GSC-2012-062
Minerals: Qz-Am-Bt-Chl-Stau
SiO2: 80 %
Al2O3: 9 %

Mafic volcanics (type 4b)
Sample: Lalor-GSC-2012-172
Minerals: Am-Stau-Bt-Qz-Cord
SiO2: 63 %
Al2O3: 15 %

Geochemistry allows protolith identification and reconstruction of the volcanic stratigraphy.

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ID	Differentiation	Affinity	Nature	Location
1	felsic	trans. to calc-alc.	?	FW
2a	felsic	trans. to calc-alc.	?	host & FW
2b	felsic	calc-alcaline	?	FW
3	intermediate	calc-alcaline	?	FW & HW
4a	mafic	calc-alcaline	volcaniclastics	FW, HW & host
4b	mafic	trans. to calc-alc.	volcaniclastics & dykes	FW (& HW)
4c	mafic	tholeiitic	dykes	FW & HW
5	mafic	thol. to trans.	flows & dykes	HW (& FW)

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Conclusions

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- The footwall succession consists of a complex volcanic stratigraphy. Both mapping and lithogeochemistry are necessary to properly define the nature and distribution of the host units.
- At least two units are hosting the massive sulphide lenses.
- The succession is composed of rocks with different magmatic affinities.
- The Powderhouse Dacite has not been recognized so far, based on geochemistry and previously published data, along section 5600 in the Lalor immediate footwall.

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Conclusions

Future work on the protoliths:

•Find geochemical differences between units with similar compositions;

•Better define the nature of the units (lava flows vs. volcaniclastics vs. intrusive rocks;

•Find mineralogical characteristics that would allow discrimination of the volcanic units during core description.

Future work on other aspects:

•Mineral chemistry (silicates, carbonates and sulfides)

•Geochemistry and mineralogy of the alteration facies

•Stable and radiogenic isotopes

•Structural analysis

•Relative (and absolute) timing of the geological events

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  - J. Lam
  - M. Engelbert

Refer to Hudbay's website for any information about the Lalor Project R&R, technical data and development status.

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