DMEC workshop series:
Driving exploration success in deep exploration through multi-disciplinary collaboration and data integration

Wednesday, March 9, 2011
Introduction

Decennial Minerals Exploration Conferences (DMEC) was created in 2007 as the legal entity responsible for managing the Exploration 07 conference and is the corporation that now holds the copyright for the proceedings of the conference. The Exploration 07 conference, held in September 2007, was the fifth and most successful of a series of conferences which have been held every 10 years since 1967. These meetings have been designed to summarize the advancements in the different fields of mineral exploration science and technology over the previous decade through a focused series of technology reviews and case studies given by world leaders in various aspects of geophysics, geochemistry, remote sensing and information processing and data management.

The fundamental objectives of DMEC are to promote the science and business of mineral exploration and the advancement of the geosciences. The board of directors and organizing committee of the corporation are all volunteers working actively in the mineral exploration industry and most are based in Toronto.

Each of the previous decennial conferences had concurrent sessions covering topics in various geosciences disciplines. However, in the last conference it became clear that one of the keys to improving exploration success will come from a better integration of disciplines as technology and art is brought to bear on all phases of mineral exploration from metallogenic modeling and regional-scale targeting to mine-scale resource conversion and mine life extension.

Although the next Decennial International conference is seven years away, the DMEC organizing committee decided that it should undertake an activity at a modest scale but on a recurring basis to advance exploration during the intervening years. To this end this workshop, organized under the auspices of the PDAC annual convention, is an excellent way to advance these objectives. This workshop will hopefully be a recurring event and have a unique theme and focus each year.

The DMEC organizing committee views this workshop to be part pedagogical and part innovation in the sense that we would like the material to be on the one hand within the reach of experienced explorationists of any specialty or discipline and, on the other, to present leading edge concepts, approaches and methodologies that can may help the specialist to “improve his or her game”.

Proceedings of the workshop will be available on the DMEC web site; www.dmec.ca.
DMEC workshop series:
Driving exploration success in deep exploration through multi-disciplinary collaboration and data integration

Agenda

1:00 to 1:10 Introduction, Beaudry
1:10 to 1:40 The Business Imperative for Integrated Exploration, McCuaig
1:40 to 2:10 Integrated approaches to sub-surface regional characterization; a GA perspective, Stolz
2:10 to 2:40 A Success Integrated Geoscience Program in Nevada, Jaacks
2:40 to 3:10 Break
3:10 to 3:40 Geophysics within the Abitibi MEGATEM project, Allard
3:40 to 4:10 Role of Geology in the Abitibi MEGATEM project, Dessureault
4:10 to 4:40 Partial/Selective Extraction Soil Geochemistry to Prioritize MEGATEM Anomalies, Beaudry
4:40 to 5:30 Panel discussion
DMEC workshop series: Driving exploration success in deep exploration through multi-disciplinary collaboration and data integration

Biographies

Michel Allard
Michel Allard obtained his degree in physics engineering in 1981 from Laval University and a Master degree from Queen’s in 1985. Since 2000, he has been a senior geophysicist for Xstrata Zinc Canada. His work was instrumental in the discovery of three volcanogenic massive sulphide deposits, one of which, the Perseverance deposit in the Matagami camp, is currently in production. He and his colleagues of the Perseverance discovery team received, in 2001, the prestigious PDAC Bill Dennis awards for the prospector of the year.

Charles Beaudry
Charles Beaudry is a Professional Geologist with over 30 years experience in project generation, business development, exploration chemistry and hands-on project management. Charles previously held the position of General Manager of new business opportunities with IAMGOLD Corporation from 2008 until 2009, after having spent nearly 17 years in various positions for Noranda-Falconbridge-Xstrata, including country manager of Brazil from 1996 to 2001 and manager of the Frieda River Project from 2005 to 2006. Charles holds a Bachelors of Science in Geology from the University of Ottawa and a Masters of Geology from McGill University and is currently President and COO of Xmet Inc., a gold Junior Mining company whose principal project is the Duquesne-Ottoman property, located on the Porcupine Destor fault immediately adjacent and along strike to the Osisko-Clifton Star’s Beattie-Donchester joint venture property. Charles has broad expertise in metallogenic modelling, project generation, geochemistry, QAQC, statistics and Six Sigma quality improvement methodologies.

Charles has a number of notable accomplishments to his credit. He was on Noranda’s Matagami exploration team who discovered the Orchan West and Bell Allard deposits, the latter which was put in production in 1997. His compilation and targeting work in the Troilus greenstone belt directly lead to the early discovery, through boot and hammer prospecting, of the Tortigny VMS deposit. Thanks to his generating efforts Hemlo Gold took a pioneer land position on Musselwhite-style Fe-formation-hosted gold targets in the Jame Bay greenstone belts or Quebec. In Brazil, his aggressive land acquisition strategy lead Noranda-Falconbridge to become the second largest mineral rights holder in the Carajas district in the early 2000’s. This lead indirectly to the discovery of the Serra de Tapa Ni-laterite deposit in early 2002, again by boot and hammer prospecting. Finally, his leadership on the Frieda River project lead to a significant expansion of the Nena high grade Cu-Au deposit.
Michel Dessureault

Michel Dessureault obtained his degree in Geological engineering in 1982 from Laval University. Since 1986, he has been working for Noranda then Xstrata Zinc Canada as project then senior project geologist mostly in Quebec and the Maritimes. He has been involved in the discovery of two VMS ore bodies in Abitibi: Tortigny deposit in Troilus belt and Bracemac-McLeod Mine in Matagami.

Jeff Jaacks

Dr. Jeff Jaacks has more than 30 years experience as a Chief Scientist and Geochemist/Geologist working with Anaconda Copper, Chevron Resources, Texasgulf Minerals, Freeport Copper and Gold Exploration, Coeur de Alene Mining, and BHP-Billiton.

From 1984 - 1993 Dr. Jaacks worked as the Chief Geochemist at Westmont Mining where he was responsible for geochemical programs that led to the discovery more than 2.5 million ounces of Au. He participated in the discovery and development of gold mines in Nevada and South Carolina, copper deposits in Arizona, and industrial mineral deposits in Montana.

From 1993 - 1999 Dr. Jaacks was Manager of Geochemistry, Americas, at BHP Minerals. He was responsible for building the geochemistry technical services group and led the effort to develop and commercialize several new exploration technologies. His services group played a key role in the discovery of the Lac de Gras diamonds (Ekati) and Hope Bay gold.

Since 1999 he has been President of Geochemical Applications International Incorporated, providing geochemistry/geology services to the mining community.

He is an advisor to the Colorado Technology Incubator, a Past President of the Association of Exploration Geochemists, and former Chairman of the Geochemical Committee of the Society of Mining, Metallurgy and Exploration. He is a Certified Professional Geologist (American Institute of Professional Geologists).

Dr. Jaacks received his B.A. in Chemistry with a Specialization in Earth Science from the University of California, San Diego and received his Ph.D. in Geochemistry from the Colorado School of Mines in 1984, specializing in economic geology and exploration geochemistry.
Cam McCuaig

Professor Cam McCuaig is currently the Director for the Centre for Exploration Targeting (CET), a joint venture between The University of Western Australia, Curtin University of Technology, and the Minerals Industry that is focussed on advancing the science of exploration targeting. Cam received his Honours degree in Geology and Energy and Fuel Science from Lakehead University in 1988, and his PhD in Geology from the University of Saskatchewan in 1996. In the subsequent employment with the international firm SRK Consulting, Cam rose to the position of Director in the Australasian practice, where he garnered 10 years experience in providing solutions to the mining and exploration industry, from greenfields exploration to mine-based geology and valuations of projects. Cam’s experience spans 6 continents and numerous commodities in geological terranes ranging from mid-Archaean to Eocene in age, including Au deposits of all styles, polymetallic intrusion-related and skarn deposits, volcanic-hosted massive-sulphide deposits, Archaean komatiite-hosted Ni, sediment-hosted Cu, amongst others. In August 2005, Cam left SRK to take up the Directorship of the CET.

Ned Stolz

Ned Stolz received an honours degree in geophysics from the University of Adelaide in 1985. For the following five years he was employed by CRA Exploration on regional exploration programs in Australia targeting uranium, gold, diamonds and base metals. Between 1992 and 1997 he completed a PhD on automatic interpretation of electromagnetic data at Macquarie University in Sydney.

In 1997 he joined WMC and spent ten years working on brownfields exploration for nickel and gold deposits in the Eastern Goldfields of Western Australia. Ned is currently Group Leader for Onshore Geophysics at Geoscience Australia where he supervises acquisition, processing and interpretation of government geophysical data.
Integrated interpretation and targeting under cover

T. Campbell McCuaig
Director, Centre for Exploration Targeting,
University of Western Australia

Premise

• Targeting mineralisation under cover requires a dramatic shift in how we visualise geology and mineral systems
• The shift will involve:
  • Use of non-traditional datasets
  • A shift from 2D to 4D visualisation of terranes and the largest scale ore footprints
  • A focus on optimising the human-data interface and a return to more human-centric interpretation
Mineral systems science

- Predicting the location of large mineral districts requires different datasets and concepts than those used on the camp- to prospect-scale
  - Leads directly to the datasets that government agencies should be collecting and products they should be delivering
- Need to be able to map regions of largest mass and energy transfer though the lithosphere

We need non-traditional datasets to see large footprints

Olympic Dam District:
N-S Oriented Reflection Seismic Traverse and Interpretation
(Goleby et al, 2004)
We need non-traditional datasets to see large footprints

Magnetotelluric Section through Olympic Dam
Modified after Hayward, 2004; Magnetotelluric section provided R. Gill, Uni. Adel; “hotter” colours are more conductive

Leads to a scale-dependent heirarchy in targeting models

McCuaig et al., 2010
Hierarchy similar at the largest scale across many mineral systems

Common elements

- Whole lithospheric architecture (not just uppermost crust) – 3D
- Geodynamics – 4D

So how to make a 4D Architecture?
Stratigraphy is number 1 tool, married with structure
Paleoproterozoic Tanami Inlier (Joly et al., 2010)

But terrane is covered!

Western Tanami Geophysics

gravity
magnetics
seismic

Joly et al., 2010
Converting geological stratigraphy to geophysical stratigraphy (and vice versa)

<table>
<thead>
<tr>
<th>Lithology/Petrophysics</th>
<th>Stubbins formation</th>
<th>Killi Killi formation</th>
<th>Granite</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Magnetics</strong></td>
<td>High contrast, Presence of dolerite/volcanic iron shale, source sequence</td>
<td>Low contrast, Turbidite/granite source sequence with few dolerites</td>
<td>From low to high magnetics susceptibilities</td>
</tr>
<tr>
<td><strong>Gravity</strong></td>
<td>High density</td>
<td>Low density</td>
<td>Low density</td>
</tr>
<tr>
<td><strong>Seismic</strong></td>
<td>Contrasted, high reflection</td>
<td>Transparent, uniform</td>
<td>Uniform</td>
</tr>
</tbody>
</table>

Petrophysical databases are often a limiting factor!

Joly et al., 2010
**Integrated 4D terrane analysis**

Could not have been achieved with any 1 or few datasets!

Joly et al., in review

**The targeting challenge**

Manual Targeting exercises consistently show:

- Range of locations and relative rankings between groups
- Clustering towards known mineral showings, even in sparse datasets
- **How can we manage this bias?**
We see what we want to see

...as in this picture of nine dolphins...

ABC

1234

Decision aids for exploration

Joly et al., in review

- Integration of all available geoscience datasets
- Mineral systems based targeting
- Multiple approaches to prospectivity analysis to quantify uncertainty

New 4-yr collaborative initiative with GSWA to provide 4D models and targeting products over greenfields terranes
Getting more from our data

• Speed, accuracy, objectivity, reproducibility
• Geosoft’s CET Grid analysis (Holden et al., 2010)

But the human brain has powers the computer cannot match

• What do proven ore-finders look for in datasets?
• How do we enhance data for the explorationist to interpret?
Heuristics – pattern recognition!

We commonly find what we are looking for or familiar with…

Tools using computing power to optimise human intuition

• CET Porphyry detection module developed with Barrick Gold

Holden et al., 2009
Conclusions

• Targeting mineralisation under cover requires a dramatic shift in how we visualise geology and mineral systems

• The shift will involve:
  • Use of non-traditional datasets
  • A shift from 2D to 4D visualisation of terranes and the largest scale ore footprints
  • A focus on optimising the human-data interface and a return to more human-centric interpretation
Data Integration to Expedite Discovery of Deep Mineral Resources

Ned Stolz
Group Leader – Geophysics
Onshore Energy and Minerals Division

Australian Gold Resources
Surface Geology map of Australia
1:1million Scale
Geoscience Australia 2009

Challenge of Exploring Under Cover (i)

What the . . . .
Effective Targeting and Reducing Risk in Exploration for Deep Resources

- Precompetitive geophysical data
- Fit for purpose processing, modelling and inversion
- Integration of geology, geophysics and geochemistry in 3D
- Holistic interpretation and assessment for resource prospectivity
- Understand the mineral system
Geoscience Australia
Australia’s National Geoscience Agency

• Commonwealth Government
• Located in Canberra
• Programs include:
  – Precompetitive mineral exploration data
  – Precompetitive hydrocarbon exploration data
  – Earth monitoring
  – Natural hazard assessment

Onshore Energy Security Program
Deep Crustal Seismic Traverses 2006 - 2011
North Queensland Project

- Funding from Commonwealth and Queensland Governments
- Four seismic & MT traverses
  - 1400 km
- Gravity and magnetic inversions
- Geodynamic interpretation and 3D models constructed
- Resource prospectivity assessment
- Results released at industry workshops and in publications

North Queensland Seismic line 07GA-IG1 440 km
North Queensland Seismic line 07GA-IG1
Seismic and MT Data

Southwest end – seismic line 07GA-IG1
Isa - Numil Structure

- Major change in seismic and MT response
- Step in Moho
- Possible suture between two crustal blocks
- Ernest Henry IOCG lies in the hanging wall
Isa-Numil Structure - Magnetic Expression

Magnetic Inversion at IG1

Regional TMI Image with Cu deposits

Isa-Numil Structure - Olympic Dam Analogy

Olympic Dam Seismic Traverse - 2003
Seismic Section and MT conductivity section

South

50 km

Olympic Dam

Interpreted Archean?

Interpreted Proterozoic?

Moho

North
North Queensland Seismic line 07GA-IG1
Orogenic gold potential

Lode gold potential underneath Eromanga Basin (?)

- Seismic data identify series of crust penetrating shears that reach surface SW of Croydon
- Reverse and normal offsets ⇒ complex history
- Similarities to crust penetrating shears in Eastern Goldfields
North Queensland gold deposits by deposit type

- Orogenic (lode style)
- Epithermal
- IOCG
- Intrusion related
- VMS
- Porphyry

- 2 million oz produced from orogenic gold deposits at Croydon

North Queensland Project

- Imaged structure under the Carpentaria Basin
- Imaged deep-crust structure giving context for known mineralisation and indicating other prospective areas
- Provides structural information about covered terrains which can change perceived prospectivity
Paterson Province Airborne EM Survey

Reducing risk and expanding the search space by mapping under cover

- First time regional scale AEM surveys flown for minerals mapping in Australia
- Proof of concept for “new” technology
- Enhance uranium prospectivity by mapping under cover
- Regional context for prospect scale surveys flown by industry

AEM Conductivity-Depth Section
Nifty Copper Mine

Resistive Broadhurst Fm greywacke facies
Permian and Quaternary cover

Conductive Broadhurst Fm Black shale facies

Resistive Broadhurst Fm greywacke facies
Permian (± Mesozoic) and Quaternary cover

Cover
Outcrop
Nifty pit
Topography
Depth of investigation line

Base metal deposit/prospect
Sand
AEM flight path: line 30860
Broadhurst Formation
AEM Conductivity-Depth Section
Coolbro – Rudall Unconformity

- Imaged on multiple conductivity-depth sections
- Extrapolated from drilled intersection
- Interpreted control on uranium mineralisation

Kintyre Cover (Cainozoic)
Paterson Formation (Permian)
Coolbro Sandstone (Neoproterozoic)
Rudall Complex (Paleoproterozoic)

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Mapping under Cover with AEM near Kintyre Uranium Deposit
Mapping under Cover with AEM near Kintyre Uranium Deposit

- Maps Phanerozoic cover including palaeovalleys
- Maps Proterozoic Unconformity related to uranium
- Maps Shales related to copper
- Images endowed province under adjacent recent basins
- Maps structures not detected by magnetics or gravity

Paterson Province Airborne EM Survey

Decennial Mineral Exploration Conference Workshop Series - PDAC March 2011
Data Integration to Expedite Discovery of Deep Mineral Resources

- New Government data for regional assessment and reducing risk
- New interpretations changing perceptions about prospectivity
- Expanding the search space into areas under cover
The Red Canyon Property, Nevada
An Integrated Approach to Geological, Geochemical and Geophysical Data and Model Interpretation

By

Jeffrey A. Jaacks
Geochemical Applications International Inc.

Craig W. Beasley
Wave Geophysics, L.L.C.

John Hogg
Montezuma Mines Inc.

Project Location

Deposits
Cortez – 1.4 M oz. Au
Buckhorn – 0.4 M oz. Au
Cortez Hills – 12 M oz. Au
Horse Canyon – 0.8 M oz. Au
Pediment – 1.3 M oz. Au
Tonkin Springs – 1.7 M oz. Au
Gold Ridge – 0.2 M oz. Au
Gold Bar – 1 M oz. Au
Datasets

- Geology
  - Detailed mapping
  - Drill-hole logs
- Geochemistry
  - Soil, rock and soil-gas data
  - Drill-hole assays
- Geophysics
  - Airborne magnetic data
  - Ground gravity data
  - Ground CSAMT data

Stratigraphy

<table>
<thead>
<tr>
<th>Time Interval</th>
<th>Units</th>
<th>Depositional Environment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eocene</td>
<td>Horse Canyon Fm.</td>
<td>Ephemeral fluvial, lacustrine, and eolian deposits</td>
</tr>
<tr>
<td></td>
<td>Denay Fm.</td>
<td>Low-energy fluvial and ephemeral deposits</td>
</tr>
<tr>
<td></td>
<td>McCollay Canyon Fm.</td>
<td>Fine- to medium-grained sandstone and carbonate gravel</td>
</tr>
</tbody>
</table>

- Early Eocene
- Middle Eocene
- Late Eocene

- Devonian
- Carboniferous
- Permian
### Geophysics – CSAMT Resistivity Models

<table>
<thead>
<tr>
<th>2-D resistivity model sections</th>
<th>3-D resistivity model volume (cut away) with 600 ohm*m surface</th>
</tr>
</thead>
</table>

### Geophysics – 3-D Models

<table>
<thead>
<tr>
<th>CSAMT resistivity volume (cutaway) with MAG3D surfaces</th>
<th>CSAMT resistivity volume (cutaway) with GRAV3D surfaces</th>
</tr>
</thead>
</table>

#### Surfaces
- **Gold**: 0.20 equiv. % MT
- **Pink**: 0.30 equiv. % MT
- **Blue**: 0.05 g/cm³
- **Yellow** (cutaway): 0.05 g/cm³
Drill-Hole Data – 3-D Geology and Mineralization

<table>
<thead>
<tr>
<th>Drill-hole geology block model</th>
<th>Drill-hole locations and Au volume</th>
</tr>
</thead>
</table>

- **Volume**
  - Colors: geology by formation

- **Volume**
  - Red: Au > 0.05 ppm

- **Drill-Hole Statistics and Target Concepts**

<table>
<thead>
<tr>
<th>MR09-03c: 40 m @ 4.75 g Au/t (subinterval: 10.4 m @ 10.46 g Au/t)</th>
</tr>
</thead>
<tbody>
<tr>
<td>KR-001: 6.1 m @ 9.56 g Au/t</td>
</tr>
<tr>
<td>RC-10: 6.1 m @ 10.72 g Au/t</td>
</tr>
<tr>
<td>RED96-05: 4.6 m @ 7.4 g Au/t</td>
</tr>
</tbody>
</table>

- **Selected Ice Intercepts**
- **Selected Ice Intercepts**
- **Total of 301 drill holes**
  - 47% < 100 m
  - 88% < 200 m
  - 95% < 300 m
- **63 of 301 drill holes penetrated Lone Mountain dolomite (Slm)**
- **The complete prospective Devonian section has not been drill tested over the majority of the property**
- **Drill intercepts to date are encouraging with multiple grams Au per tonne over multiple meters at Ice and lower-grade intercepts at Gexa and other locales.**
3-D Models 4414400 North

<table>
<thead>
<tr>
<th>Surface geology and geochemistry</th>
<th>CSAMT model and 600 ohm*m surface</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.png" alt="Image" /></td>
<td><img src="image2.png" alt="Image" /></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Drill-hole geology</th>
<th>Geology, 600 ohm*m surface and Au</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image3.png" alt="Image" /></td>
<td><img src="image4.png" alt="Image" /></td>
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</tbody>
</table>

Au > 0.05 ppm

Sim/Dmc contact at 600 ohm*m surface

Integrative Concepts

- Detailed geologic map identifying prospective lower-plate Devonian formations
- Structure is dominated by E-SE plunging fold axes, thrust faults, N-NW and NE-trending faults
- Geologically-derived target areas principally occur along thrust boundaries and at structural intersections
- Geologically-derived target areas coincide with structurally-controlled geochemically-derived targets
Integrative Concepts

• Subsurface Au is associated with boundaries and structure defined in the geophysical models
• Prominent structural directions in mapped geology are prevalent in the geophysical models
• Geologically-derived target areas and structurally-controlled geochemically-derived targets coincide with prominent features in the geophysical models
• Analyses of the available data and models have yielded a proposed drill program consisting of 28 holes.

Surface: 600 ohm*m
Volume: Au > 0.05 ppm

Integrative Concepts

View N-NW
An integrated team approach to data and model interpretation has produced a suite of priority drill targets. These data and model driven targets are quality targets supported by multi-disciplinary concepts. The proposed drill holes test for strata bound and structurally-controlled mineralization in fold axes with coincident unique geochemical signatures and geophysically-inferred subsurface geology. Drilling in 2010 will provide proof-of-concept for these integrated targets.
Acknowledgments

- The authors wish to thank Montezuma Mines Inc. and Miranda Gold Corp. for supporting the work on this property and for allowing presentation of the material.
Geophysics for blind VMS deposits in the Abitibi greenstone belt: past, present and future

Michel Allard
Xstrata Zinc Canada

THANK you

Ken Witherly of Condor Consulting
All my colleagues at Xstrata
PLAN

- Volcanogenic massive sulfide deposits (VMS) in the Abitibi Belt
- Physical properties
- The past: AEM success
- The recent past: A MEGATEM exploration program
- The present: Mature technologies and some experiments
- The future: Challenges, Geological models, Gravity methods
- Conclusion

VHMS Deposit District
Abitibi 2nd in tonnage

<table>
<thead>
<tr>
<th>District, country</th>
<th>Approx. Tonnage (Mt)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iberian Belt, Spain &amp; Portugal</td>
<td>1575</td>
</tr>
<tr>
<td><strong>Abitibi, ON &amp; QC</strong></td>
<td><strong>600</strong></td>
</tr>
<tr>
<td>Bathurst, NB</td>
<td>495</td>
</tr>
<tr>
<td>Southern Urals, Russia</td>
<td>400</td>
</tr>
<tr>
<td>Rudny Altai, Kazakhstan</td>
<td>400</td>
</tr>
</tbody>
</table>
Abitibi Subprovince of the Superior (2.79-2.64 My)

<table>
<thead>
<tr>
<th>MINING DISTRICT</th>
<th>%Cu</th>
<th>%Zn</th>
<th>g/tAu</th>
</tr>
</thead>
<tbody>
<tr>
<td>KIDD CREEK</td>
<td>161.4</td>
<td>2.41</td>
<td>6.17</td>
</tr>
<tr>
<td>NORANDA</td>
<td>132.2</td>
<td>1.86</td>
<td>2.36</td>
</tr>
<tr>
<td>CHIBOUGAMAU</td>
<td>123.2</td>
<td>1.66</td>
<td>3.15</td>
</tr>
<tr>
<td>SELBAIE</td>
<td>137.2</td>
<td>1.00</td>
<td>1.92</td>
</tr>
<tr>
<td>MATAGAMI</td>
<td>117.7</td>
<td>0.89</td>
<td>3.05</td>
</tr>
<tr>
<td>VAL D’OR</td>
<td>48.9</td>
<td>1.65</td>
<td>1.58</td>
</tr>
<tr>
<td>LA RONDE</td>
<td>173.3</td>
<td>0.65</td>
<td>3.21</td>
</tr>
<tr>
<td>GREVET</td>
<td>101.7</td>
<td>0.46</td>
<td>6.41</td>
</tr>
<tr>
<td>NORMETAL</td>
<td>121.6</td>
<td>2.17</td>
<td>2.00</td>
</tr>
<tr>
<td>KAMISKOTIA</td>
<td>7.9</td>
<td>1.23</td>
<td>1.47</td>
</tr>
<tr>
<td>JOUTEL</td>
<td>9.6</td>
<td>1.00</td>
<td>2.95</td>
</tr>
</tbody>
</table>

NSR $/ton vs VHMS tonnage 2011

<table>
<thead>
<tr>
<th>SIZE</th>
<th>0.50</th>
<th>1.0Mt</th>
<th>5.0Mt</th>
<th>10.0Mt</th>
<th>50.0Mt</th>
<th>500</th>
<th>2500</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAPEX</td>
<td>75</td>
<td>100</td>
<td>150</td>
<td>200</td>
<td>400</td>
<td></td>
<td></td>
</tr>
<tr>
<td>OPEX($50/t)</td>
<td>25</td>
<td>50</td>
<td>250</td>
<td>500</td>
<td>2500</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

$1.00/lb Zn
$3.50/lb Cu
$1000/on Au
$15/on Ag

Small higher grade (brownfield target)
Large lower grade (greenfield target)
NR y15%
Depth to the top
62 VHMS Deposits (>0.2Mt)

50 blind deposits

Geophysics
for blind VMS deposits in the Abitibi greenstone belt: past, present and future
PHYSICAL PROPERTIES
THE KEY FOR DIRECT DETECTION
**Physical properties**

**Perseverance deposit (PER-00-03)**

- **Mag susceptibility**: 0.173SI
  - Contrast > 20
  - Variation coefficient: 58%

- **Density**: 4.3kg/m³
  - Contrast: 1.5
  - Variation Coefficient: 7%
  - (31m of MS)

**Conductivity**

**McLeod deposit (MC-07-18W6)**

- **Sp Rich**
- **Po rich**
- **Cp-Py**
- **1440S/m**
- **960S/m**
- **480S/m**

- **20% Zn**
- **30% Zn**
- **6% Cu**
- **2% Cu**
1 MEG$ QUESTION

Statistically
Can we discriminate VMS with EM?

Deposit scale conductance (Siemens)

Geophysics
for blind VMS deposits in the Abitibi greenstone belt:
past, present and future

THE PAST
GEOPHYSICS vs VMS EXPLORATION

**DISCOVERIES**

- Matagami Lake, 1956
- Garon Lake, 1957
- Orchan, 1958

_Hunting Canso Dual Frequency FW_

- Poirier, 1962
- Joutel, 1962

_Rio Otter One Frequency FW_

- Kidd Creek (TGS), 1959/1963

_One Frequency fixed boom HEM_
AEM IN THE ABITIBI
1965-1985: The INPUT Era

DISCOVERIES
- Magusi-Iso, 1972
- New Insco, 1973
- Selbaie, 1973
- Lemoine, 1973
- Detour Lake, 1974
- Casa Berardi, 1985

Questor INPUT Time Domain FW

1968-1983 Quebec Gvt. flew 385,000 lkm of INPUT survey

VHMS Deposits (>0.2Mt)
Discovery vs time

Stone age
Experimental

Golden age
Analogue, qualitative

New age
Digital, quantitative

Geophysical
Fewer new VHMS discoveries?

**WHY? Based on perceptions (true or not?)**

- All the big deposits have been found
- The negative feedback loop...
- Intrinsic limits of the technologies and science
- Past exploration limited to the near surface

---

**The Recent Past**

*Geophysics for blind VMS deposits in the Abitibi greenstone belt: past, present and future*

**THE RECENT PAST**

*(THE LAST 10 YEARS)*
MEGATEM Project: 2001-2006

New Search space

- Relatively few deposits found at a depth below 50 m.
- Limited drilling below 100 m
- VHMS deposit has a high in-situ value.
- In-house tests had demonstrated that the MEGATEM system could detect typical VHMS at least to a depth of 250 m.
- Exploration risk could be shared with the government and junior companies
- Ground available for staking

MEGATEM Surveys

Areas flown 2001-2006
(180 207 lkm)
End Results

On the Québec side: 32 M$ dollars invested during 5 years

- 349 AEM anomalies were followed up
- 203 were drilled tested for a total 267 DDHs.

One small high grade showing (Montbray): 5.61% Cu, 1.70% Zn / 5.16 m
No economic discovery

False Positives

1. **A few in the right context** (ex: altered felsic rocks).
   - Barren sulfides (mainly Py-Po stringers)

2. **Numerous in the wrong context** (ex: fresh basalt)
   - Barren sulfides and few graphite

**WHY**
- No selection of "formational" conductors?
- No selection of Beshi or Cyprus type anomaly?
- Else ????

**THUS**
Need for better predictive models and screening tools

"Only good fishermen are successful, first by selecting the good lakes and then the good spots"
Geophysics for blind VMS deposits in the Abitibi greenstone belt: past, present and future

THE PRESENT

BHMAG and BHEM

McLeod deposit (MC-07-33W2) 12.68%Zn, 0.82%Cu /1.24m

Total Mag. Int.

Mag. Susc. (on core)

Z comp BHEM profiles

Off-hole MAG
**EM methods: out of bound deposits?**

- **MMR ?**: Deposits affected by late silification or Py-Sph rich deposits in Calc-alcine volcaniclastic.

- **B-Field (SQUID or fluxgate)**: For highly conductive Po-Cp in more primitive environment.

- **Standart EM system bandwidth**

  - Average Conductance (Siemens):
    - 1
    - 100
    - 10000

**MMR: Test**

- **BRC-04-24: 12.35 %Zn/0.2m**

  - Relatively weak off-hole anomaly at 405m suggesting a small conductor.

  - Conductive plates (MAXWELL) in green.
SQUID: Conductance Discrimination

**EARLY TIME**

**LATE TIME**

1.8m of MS (60% Po)

---

Geophysics for blind VMS deposits in the Abitibi greenstone belt: past, present and future

**THE FUTURE ?**
**GEOPHYSICS vs VMS EXPLORATION**

![Diagram showing cost vs benefit with stages of exploration ranging from regional area selection to detailed follow-up.](image-url)

**Canada Mining Innovation Council Exploration**

<table>
<thead>
<tr>
<th>INGREDIENTS</th>
<th>Prediction</th>
<th>Technology</th>
<th>Interpretation</th>
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<tbody>
<tr>
<td>Key Questions</td>
<td>Where and What</td>
<td>How to detect?</td>
<td>What does the data mean?</td>
</tr>
<tr>
<td>Challenges and objectives</td>
<td>More effective tool predict the right Terrane (camp) Area (property) Exploration under cover</td>
<td>More efficient tools to more effectively detect</td>
<td>Cost effectively improve data value: visualisation, interpretation integration</td>
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<tr>
<td>Research paths</td>
<td>• Definition of the entire ore deposit model • Mineralized terrane selection • Fundamental controls on ore deposit location and formation</td>
<td>• Airborne and ground techniques • Instrumentation to extract drill hole information • Drilling technology • Field portable instruments to secure real-time automated data acquisition • Exploration geochemical technology</td>
<td>Standardized data Physical property models Geophysical Inversion Technology transfer and training of the next generation</td>
</tr>
</tbody>
</table>

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*Modified from Hogson (1987)*
Where and What
MODELS
"HOW CAN GEOPHYSICS HELP IN MAPPING THE MODEL"

Reconnaissance Exploration

Extensional environment
• Arc/Back arc
• Mantle upwelling
• Caldera
• Subvolcanic intrusions

(Piercey and Galley 2009)
**Preliminary Follow-up**

- Volcanic center
- Dykes
- Synvolcanic Faults
- Volcaniclastics
- Felsic domes

*After Gibson, 1999*

**Detailed follow-up/ Delination**

- Massive sulphides
- Exhalite
- Hydrothermal alteration zone and pipe
- Chlorite, sericite, quartz
- Stockwork
- Cpx+Py+Po stringers
- Magnetite zones

*Adapted from J Lydon*
Core scale: properties

HOW TO BETTER PREDICT, DETECT and DISCRIMINATE GRAVITY?
Reconnaissance Exploration

Area selection

Near gravity highs?

Bouguer Map from GSC-OGS-MNR data

More than 56000 points

PRIMARY FOLLOW-UP SCALE
Vertical gradient GRAVITY
NORANDA CAMP
Primary Follow-up Scale
Vertical Gradient MAG
Noranda Camp

Detailed follow-up scale: Reid Mahaffy GDD example
Gravity data at this scale can help to constrain and refine
EM conductors in gravity lows
**Detailed follow-up scale: Downhole Gravity**

- **4.5 Mt**
- **Ano mass: 2.0 Mt**
  - $\Delta \rho = 2.0$

**Forward Modelling**

**SCINTREX GRAVILOG**
- Vale-Inco test (dec 2008)
- Norman deposit

---

**CONCLUSION**

**Now and into the future**

- Near mine exploration will remain quite effective.
- Incremental advances in technology can be expected and in the right geological circumstances, ex: Lalor Deposit
- More integrated understanding/interpretation/modeling of multiple data sets is expected to help define areas of interest.
- The efficacy of geophysical techniques to search at depth (2-3 km) will remain “challenging”.
- Specific targeting (i.e. where to drill) will likely require some new definitions of geoscience collaboration
- Economically the shortest returns could be realized if the means could be developed to target effectively in the areas classified now as “formational conductors”

"As exploration goes deeper success will require a more sophisticated and predictive model that integrates geophysics, geochemistry and geology in 3D GIS formats to improve identification of the key elements of the VMS model that will lead to more subsurface discoveries." Gibson et al (2007), Exploration 2007
More True Positive Anomaly

PERSEVERANCE MINE

2006-10-09

Less than 2 years

2008-09-19

BRACEMAC-MCLEOD

2010-10-10

2012-01-01
Slow, Broadband, Powerfull, 3-D

Future EXTREM

Multi time base (frequency):
• 0.1  1.0  4.0 ms

Full stream data
• on time-off time

Fixed in-loop
• 3 xyz coils
• 3 xyz SQUIDs

Towed bird
• 3 xyz coils
• 3 xyz SQUIDs

Gravity and MAG
The integrated Abitibi "MEGATEM" Project

Michel Allard, Michel Desureault
Xstrata Zinc Canada

TABLE OF CONTENT

1. INTRODUCTION & HISTORY
2. ABITIBI-MEGATEM PROJECT RATIONAL
   - WHY SEARCHING VMS
   - HOW SEARCHING THEM
   - HOW FINDING THEM
3. AREA & TARGET SELECTION: DATA INTEGRATION
   - SUBJECTIVE, SEMI-OBJECTIVE, OBJECTIVE PRIORITIES
4. "TECHNICAL SUCCESS"
   - Montbray
5. SUMMARY
1999 : Difficult time for Noranda and the industry

- October 1999: Closing of Mine Gaspé, Murdochville. 300 lay off
- November 2001: Noranda announces temporary closure of its smelting infrastructures
- April 2002: Definitive closure of the smelter. 300 more lay off.

$5.00 $0.00 $2010

“ask not what your country can do for you - ask what you can do for your country.”

Quebec government asked the industry:
"what your country can do for you?“
to prevent more infrastructure closings.

The industry (Noranda) suggested tax credits on exploration work!
- Solution : an incentive plan
  40% refundable tax credit for non-producing companies
  20% for producers + 40% non-refundable tax credit applicable on capital tax for all exploration work.
2001
Exploration Objectives:

- Generate high quality VMS exploration targets in order to discover 5-50 Mt deposit with NSR > 80$/t
- Find new ore to replace 3 years reserves of Louvicourt
- Provide Noranda Horne smelter with polymetallic concentrate having gold credits
- Prevent more closure following the one of Gaspe Smelter in Murdochville in August 2002.

The Main Objective:

Find new ore to feed the Horne
Why we thought the objectives were achievable

- The Abitibi Achaean Greenstone Belt is the second best VMS producer in the world
- World class Cu-Zn-Au mining camps with high-value NSR deposits
- Proximity to the Horne smelter
- Easy access, available infrastructure, manpower and lower cost of exploration and development
- Large historical database
- Many areas not subjected to modern exploration techniques
- Large portions of the ground available for staking due to systemic slowdown of exploration for VMS caused by low commodity prices

World VMS Deposit Districts: Abitibi 2nd in tonnage

<table>
<thead>
<tr>
<th>District, country</th>
<th>Approx. Tonnage (Mt)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iberian Belt, Spain &amp; Portugal</td>
<td>1575</td>
</tr>
<tr>
<td><strong>Abitibi, ON &amp; QC</strong></td>
<td><strong>600</strong></td>
</tr>
<tr>
<td>Bathurst, NB</td>
<td>495</td>
</tr>
<tr>
<td>Southern Urals, Russia</td>
<td>400</td>
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<tr>
<td>Rudny Altai, Kazakhstán</td>
<td>400</td>
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</table>
Abitibi Subprovince of the Superior

NSR $/ton vs VMS tonnage circa 2001

<table>
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<tr>
<th>SIZE</th>
<th>0.50</th>
<th>1.0Mt</th>
<th>5.0Mt</th>
<th>10.0Mt</th>
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<tr>
<td>CAPEX</td>
<td>75</td>
<td>100</td>
<td>150</td>
<td>200</td>
<td>400</td>
</tr>
<tr>
<td>OPEX $50/t</td>
<td>25</td>
<td>50</td>
<td>250</td>
<td>500</td>
<td>2500</td>
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</tbody>
</table>

- $0.35/lb Zn
- $0.65/lb Cu
- $300/on Au
- $6/on Ag

TARGET

NR y15%
NSR $/ton vs VMS tonnage 2011

<table>
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<tr>
<th>SIZE</th>
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<th>1.0Mt</th>
<th>5.0Mt</th>
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<tr>
<td>CAPEX</td>
<td>100</td>
<td>150</td>
<td>200</td>
<td>250</td>
<td>375</td>
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<tr>
<td>OPEX $/t</td>
<td>37.5</td>
<td>75</td>
<td>375</td>
<td>750</td>
<td>3750</td>
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</table>

$1.00/lb Zn
$3.50/lb Cu
$1000/on Au
$15/on Ag

Small higher grade (brownfield target)
Large lower grade (greenfield target)

VMS deposit size

1.2-1.8 Mt: median
20 Mt (12%)
100 Mt: 4%

421 deposits
807 deposits
62 VMS Deposits (>0.2Mt)
Discovery vs time

Fewer VMS discoveries?

WHY? Based on perceptions (true or not?)

- All the big deposits have been found.
- The negative feedback loop...
- Intrinsic limits of the technologies and science
- Past exploration limited to the near surface
The Strategy:

1. New Technology
   - Re-flying of extensive regional new airborne
   - Tests and recent discoveries (Perseverance) highlighted significant step in technologies (MEGATEM system)
   - Efficient generation of drill targets with this new advanced technology
   - Involvement in technology development (Fugro)
   - Historical database.

2. Low cost
   - Exploration costs very low at that time.
   - The Quebec government assistance for exploration in the mining sector:
     - Capital cost for mining development relatively low due to established infrastructure.

3. Partnership with juniors
   - The partnership has been favored to reduce exploration cost and risk.

One of the largest systematic exploration projects in Canada by flying the MEGATEM system

MEGATEM can see deeper

Lack of deposit due to the limitation of the previous technology. Potential range 50-200 m for VMS discoveries using the present technology
The Dream:

AEM Performance
Best Case
1975 = 10% (Input)
1990 = 46% (GEOTEM)
2001 = 100% (MEGATEM)

Repeat the sequence of discoveries generated by the first airborne surveys during the late '50s:
Brunswick 12, Mattagami Lake, Kidd Creek...

MEGATEM
the key tool to find new ore

Creation of JVs to finance an aggressive exploration program based on resurveying large portions of the Abitibi with the new MEGATEM system.

JV1-JV2 Novicourt-Virginia (Abitibi belt)
Falconbridge-Novicourt (Abitibi belt)
Falconbridge-Eastmain Ressources (Northern Abitibi-Ontario)
Falconbridge-Beaufield (Troilus belt)
Noranda-Alexis Minerals (Noranda Camp)
AEM Technology in 2000
Caber Test

INPUT 1981

Caber Test
Elevation test (ne-sw)

Caber

QUESTEM 25 Hz

SPECTREM 90 Hz

GEOTEM db-dt 30 Hz

GEOTEM db-dt 90 Hz

MEGATEM B-field 90 Hz

BxBxBx 650 ft 800ft 510 ft

BzBzBz

dBx/dt dBx/dt dBx/dt
**INPUT vs MEGATEM**

- **Bedrock conductor**
- **Cond. overburden**

---

**We have a discovery at Matagami – a start, but not enough**
MEGATEM Rational:
New Search space

- Relatively few deposits found at a depth below 50 m
- Limited drilling below 100 m
- In-house tests had demonstrated that the MEGATEM system could detect typical VMS at least to a depth of 250 m.
- Typical VMS deposit has a high in-situ value. A stand alone 20 Mt deposit with an NRS value of 275$US/t (at current prices) is deemed as an attractive target
- Exploration risk could be shared with the government and junior companies
- First survey over Matagami successful with the discovery of Perseverance. Chances are good to find more deposits if the rest of the Abitibi is flown!

MEGATEM SURVEYS
over favorable greenstone belts

<table>
<thead>
<tr>
<th>No.</th>
<th>Name</th>
<th>Partner(s)</th>
<th>LKm</th>
<th>Cost</th>
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<tr>
<td>1</td>
<td>AMOS JV-1</td>
<td>NOV-VIA</td>
<td>8806</td>
<td>$900,950</td>
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<tr>
<td>2</td>
<td>WEST-AMOS JV-1</td>
<td>NOV-VIA</td>
<td>2814</td>
<td>$283,688</td>
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<td>JOUTEL JV-1</td>
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<td>5025</td>
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<td>4666</td>
<td>$459,368</td>
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<tr>
<td>5</td>
<td>WEST-SELBAIE JV-1</td>
<td>NOV-VIA</td>
<td>2802</td>
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<td>EAST-CHEPSTON</td>
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<td>7</td>
<td>EAST-AMOS JV-2</td>
<td>NOV-VIA</td>
<td>3054</td>
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<td>2919</td>
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<td>LANGUEDOC</td>
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<td>5953</td>
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<td>7162</td>
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**Total:** $12,705,265
### MEGATEM SURVEYS

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</table>

**Total:** $4,900,440

### MEGATEM SURVEYS: over 180,000 line-Km

**Figure:**

Areas flown 2001–2006 (180 207 lkm)
MEGATEM SURVEYS
Target Selection

1) “Subjective” priorities based on the following criteria:
   - Favorable geology
   - Coincident MAG-EM anomalies
   - Isolated anomalies (avoid formational)
   - On Xstrata properties or open ground
   - Untested by previous drilling

2) “Semi-objective” priorities based on a Target selection matrix

3) “Objective” priorities based on a large geological-geochemical database was used in parallel to query AEM results using intelligent GIS algorithms.

MEGATEM SURVEYS
Decision Flowchart

Picking
Screening
Prioritisation and validation
Ground follow up
Drilling

MEGATEM anomalies
Identified and selected anomalies
GIS TARGETS
BASED ON EXPERIENCE TARGETS
MATRIX TARGETS
GEOLOGY, GEOCHEM, GEOPHYS
- Data compilation
- Data integration
- Generation of thematic maps
Consorem specific researches
Constantly improving databases
Priority
Ground follow up
Drill Target

40,000
2,500
450
350
268
MEGATEM SURVEYS:
over 40,000 picks

MEGATEM SURVEYS:
over 2,500 selected anomalies
MEGATEM II SURVEYS
Over 350 ground follow up

MEGATEM SURVEYS
268 targets drilled, (300ddh, >75,000m)
MEGATEM SURVEYS
Data Integration

- Geological compilation maps (Noranda & gov)
- Drillhole database (Noranda & gov)
- BM occurrence database (Gov)
- Lithogeochem database (Noranda)
- Alteration indexes (Normat software)
- Till sample compilation (Noranda)
- Regional and local Geophysics (Noranda)
- "Pre-Google" satellite imagery
- Claim maps (Gov)
- Historical work files (Gov)

CONSTANTLY IMPROVING DATABASES:

SPECIFIC RESEARCHES BY CONSOREM
Projet 2001-3 :
Typologie des intrusions syn-volcaniques pour l’exploration en Abitibi –

Identification de 11 intrusions syn-volcaniques (nouvelles)
Environnement de premier choix pour l’exploration des VMS en Abitibi

Damien Gaboury, PhD

Projet Mégalinéaments
Québec – Ontario Métaux base - Abitibi

Stéphane Faure PhD
Signatures géochimiques des rhyolites et leur fertilité pour les VMS: Mythe ou réalité…

Secteurs d'intérêt: Les choix du Capitaine

Tills – Traînées Cu

Nouvelles cibles d’exploration

Au et métaux de base

Stéphane Faure PhD
SUBJECTIVE TARGETING
BASED ON
EXPLORATIONIST
EXPERIENCE

MEGATEM SURVEY
Based on Experience Targeting

Personal picking and screening
Technical meeting with experienced explorationists
- All data in hands and on computers
- Compilation & thematic maps

One by one screening and prioritisation (1a, 1b, 1c, 2, 3) of selected anomalies
Amos MEGATEM Survey – Thematic Map #1

Amos MEGATEM Survey - Properties and Targets

37 selected new properties covering 48 anomalies
BRO-101 is located inside the southern part of the Brouillan Volcanic Complex, 8 km WSW of Selbaie mines. Volcanic sequences are composed of felsic to mafic flows and tuffs striking at N115° and dipping at 70° towards south. These volcanic rocks lie over the felsic tuffs hosting Selbaie mines. In 1993, Mine Selbaie Ltd performed an IP survey on a grid located just south of Bro-101. They added a line of IP to their grid to link it to the Main North grid. This line of IP defined an anomaly coincidental with Bro-101, but they did not recommend any follow up on this target.

Previous drilling performed by Billiton in that area defined altered tholeiitic rhyolite in contact with unaltered andesite. DDH B1094 was drilled to test a DEEPEM target on the north part of their grid. According to SIGEOM, this DDH is located 400 m south of BRO-101. B1094 intersected a massive non-mineralized andesite lying under the felsic tuffs. The DEEPEM target, their airborne anomaly (?), mineralized and unaltered andesite lying under the felsic tuffs, host a 1.4 m sheared zone with up to 30% Po, 9% Py and a 3 m thick graphitic horizons. The felsic transitional sequence is altered but non-mineralized.

In 1998, Billiton extended B1094 to the depth of 301 m following a reinterpretation of a private airborne EM survey which suggested a deep conductor in the area. At the depth of 201 m, B1094 intersected a massive non-mineralized and unaltered andesite lying under the felsic tuffs. The DEEPEM target, their airborne anomaly (?), and the MEGATEM conductor seem to be all confined in a close area and might be coincidental to each other. A closer examination of all these reports and maps helped us to localize B1094, 113 m to the NW of Bro-101. A WHEM survey in B1094 did not found any cellular anomalies.
BRO-101 LOOP LOCATION

DDH : L200E, 2+80S, -55, N20, 275m
LOOP : 200x200m, L1E-L3E, 2S-4S

Clear and strong in-hole anomaly at 135m.
Conducor center to the right and up-dip
BRO-101 SHORT LOG

MATRIX PRIORITISATION

SEMI-OBJECTIVE TARGETING
### MEGATEM SURVEY
#### Target selection matrix

#### Geophysical Factors (Mat 4-2930, 25% of total score)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Range</th>
<th>Weight</th>
<th>Comment</th>
</tr>
</thead>
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<tr>
<td>Anomaly Quality</td>
<td>Well Defined</td>
<td>4.00</td>
<td>Significant linear trend, well defined and consistent</td>
</tr>
<tr>
<td>Conductivity</td>
<td>200-1,000</td>
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<td>High conductivity, well defined and consistent</td>
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<td>Strike Length</td>
<td>1 line</td>
<td>4.00</td>
<td>Significant linear trend, well defined and consistent</td>
</tr>
<tr>
<td>Anomaly Type</td>
<td>Isolated Mag. high</td>
<td>4.00</td>
<td>Significant linear trend, well defined and consistent</td>
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<tr>
<td>Magnetism</td>
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<tr>
<td>Isolated Mag. high</td>
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#### Regional Geological Factors (Mat 4-2930, 25% of total score)

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<td>4.00</td>
<td>Significant linear trend, well defined and consistent</td>
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<tr>
<td>Anomaly Type</td>
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<td>Significant linear trend, well defined and consistent</td>
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<tr>
<td>Magnetism</td>
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<tr>
<td>Isolated Mag. high</td>
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<td>Significant linear trend, well defined and consistent</td>
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# MEGATEM SURVEY
## Target selection matrix

### Local Geophysical Factors Index = 4 x R -> 2% of total score

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<th>Score</th>
<th>Index</th>
<th>Score</th>
<th>Index</th>
<th>Score</th>
<th>Index</th>
<th>Score</th>
<th>Index</th>
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<td>1.00</td>
<td>Anomalous Ag</td>
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<tr>
<td>(Strongly dependent)</td>
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<td>Argillic Index</td>
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<tr>
<td>&gt;15</td>
<td>1.00</td>
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<td></td>
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<tr>
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<td>&lt;15</td>
<td>1.00</td>
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<tr>
<td>Altered Index</td>
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<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Volcanic Index</td>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Other</td>
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<td></td>
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<td></td>
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</tbody>
</table>

Note: Resulted Entries are intended as flags only. No weighting factor is applied to the anomaly.

\[
\text{% Rank} = \frac{100 \times \text{Product Geophysical Factors}}{100 + \text{Product Regional Geophysical Factors}} + \frac{100 \times \text{Product Regional Geophysical Factors}}{100 + \text{Product Local Geophysical Factors}} + \frac{100 \times \text{Product Local Geophysical Factors}}{100 + \text{Product Geophysical Factors}}
\]

---

# MEGATEM SURVEY
## Target selection matrix

### Detailed Description

1. **Conductivity**: Moderate conductivity, isolated target within highly prospective but well defined geology
2. **Metallurgy**: Low conductivity, isolated target within highly prospective but well defined geology
3. **Regional Geology**: High conductivity, isolated target within highly prospective but well defined geology
4. **Local Geology**: Low conductivity, isolated target within highly prospective but well defined geology
5. **Volcanic Index**: Proximal, isolated target within highly prospective but well defined geology
6. **Other**: Other, isolated target within highly prospective but well defined geology

---

### Table

<table>
<thead>
<tr>
<th>Property</th>
<th>Score</th>
<th>Score</th>
<th>Score</th>
<th>Score</th>
<th>Score</th>
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<td>Anomalous Cu</td>
<td>1.00</td>
<td>Anomalous Ag</td>
<td>1.00</td>
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<tr>
<td>(Strongly dependent)</td>
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<tr>
<td>Argillic Index</td>
<td>&gt;15</td>
<td>1.30</td>
<td></td>
<td></td>
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<tr>
<td>&gt;15</td>
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<td>Altered Index</td>
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<td>Weak</td>
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</tr>
<tr>
<td>Volcanic Index</td>
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<td></td>
<td></td>
<td></td>
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<tr>
<td>Other</td>
<td>1.00</td>
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<td></td>
<td></td>
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</tbody>
</table>

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### Notes

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- \[
  \text{% Rank} = \frac{100 \times \text{Product Geophysical Factors}}{100 + \text{Product Regional Geophysical Factors}} + \frac{100 \times \text{Product Regional Geophysical Factors}}{100 + \text{Product Local Geophysical Factors}} + \frac{100 \times \text{Product Local Geophysical Factors}}{100 + \text{Product Geophysical Factors}}
\]

---

### References

1. **Conductivity**: Moderate conductivity, isolated target within highly prospective but well defined geology
2. **Metallurgy**: Low conductivity, isolated target within highly prospective but well defined geology
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5. **Volcanic Index**: Proximal, isolated target within highly prospective but well defined geology
6. **Other**: Other, isolated target within highly prospective but well defined geology
## Abitibi Quebec GES Databases

<table>
<thead>
<tr>
<th>Category</th>
<th>Details</th>
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</thead>
<tbody>
<tr>
<td>Magnetics</td>
<td>80,368 km² 1:50K bedrock geology, including Noranda compilations.</td>
</tr>
<tr>
<td>Conductors</td>
<td>48,873 km² 1:100K quaternary geology</td>
</tr>
<tr>
<td>Tills</td>
<td>MNRQ INPUTEM and Mag airborne survey</td>
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<tr>
<td>Alteration</td>
<td>108,511 line km MegaTEM and Mag survey</td>
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<tr>
<td>Assay</td>
<td>214,017 Whole rock/geochem/assay samples</td>
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<td>Bedrock</td>
<td>175,083 Outcrop locations</td>
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<td>84,653 DDH Summary logs</td>
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<td>67,757 Till samples</td>
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<td></td>
<td>30,068 Structural measurements</td>
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<tr>
<td></td>
<td>189 Scanned &amp; registered geology maps</td>
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</table>
The Data Integration Technology: Geographic Expert System

GES allows us to compile more areas, more objectively, more quickly thereby enabling us to focus our human and financial resources on areas with the best mineral potential sooner.
Mineral Potential Map

A single measure of past success and future potential

GES Targets

500 anomalies reviewed
50 passed pre-screening
25 passed validation
15 drilled
Villemontel T-00-01

Ground Follow-up: Villemontel

Modelled Target Area

Ground Magnetics

TDEM ch x 10

Regional-scale coincident felsic volcanics euler picks, TDEM picks with anomalous till (Cu, Pb, Zn percentiles) down ice (circle = 1km dia).

Project-scale mag anomaly with 160 nt amplitude and 600m wavelength.

15 ch TDEM response
### Villemontel T-00-01
Drilling: DDH VIL-T-02-01

<table>
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<th>Interval</th>
<th>Description</th>
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<tr>
<td>0.00-66.00</td>
<td>OVERBURDEN</td>
</tr>
<tr>
<td>66.00-75.30</td>
<td>ANDESITE Dark grey-green, massive, fine-grained andesite flow</td>
</tr>
<tr>
<td>75.30-76.90</td>
<td>FAULT GOUGE 12% recovery</td>
</tr>
</tbody>
</table>
| 76.90-127.30 | AUTOCLASTIC BRECCIA DACITE
Primarily (flow-related ?) rhyodacite (?) breccias ranging from crackle to mosaic to lesser chaotic with re-brecciation developed locally. Could be a flow or subvolcanic intrusion. Chlorite with minor pyrrhotite occurs in breccia matrix at 117.8 - 127.3. |
| 127.30-137.70 | BLACK SHALE Black graphitic shale, 3% pyrite in mm-scale laminae and remobilized into random fractures |
| 137.70-168.20 | BLACK SHALE & SILTSTONE
Black graphitic shale as above but interbedded with an equal quantity of dark grey siltstone. 1% pyrite in laminae and fractures |
| 168.20-188.70 | SHALE, SILTSTONE, GREYWACKE
Interbedded black shale, grey siltstone (as in unit above) and m-scale beds of greywacke |
| 188.70-203.00 | GREYWACKE Dark grey, poorly bedded greywacke. Minor siltstone interbeds |

### ABITIBI MEGATEM
TECHNICAL SUCCESS: MONBRAY
Noranda Camp Survey

12,775 km de ligne
1,960 km²

Montbray Showing
Discovery
**MON-04-08 / BHEM**

- Anomalie Off-hole causée par un conducteur moyen situé à gauche (est) et légèrement en-dessous du forage.

- La bordure du conducteur se situe à environ 25 mètres du forage.

- Le prochain forage devrait viser 50 mètres à l’est et 25 mètres en-dessous.

---

**Section MON-04-09**

Forage de découverte !

- **Anomalie MON-06A**
  - Section 1+50E NW View

<table>
<thead>
<tr>
<th>MON-04-09</th>
</tr>
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<tbody>
<tr>
<td>(HW) Andesite Sil</td>
</tr>
<tr>
<td>(FW) Rhyodacite Chi-Sil</td>
</tr>
<tr>
<td>5-10 % Stg Py-Sp (Cp)</td>
</tr>
</tbody>
</table>

**Anomalies**

- 5.61% Cu, 1.70% Zn / 5.16 m (Massive Sulphides)
- 1.86% Zn, 1.35% Cu / 1.42 m (SMS)
- 0.50% Zn / 21.75 m

**Mineralization**

- Dacite variolites
- Py stringers
Lithogéochimie Montbray

**Forage MON-04-09**

5.61% Cu sur 5.16 m
Montbray / Section Longitudinale

Montbray / Plan de surface
### ABITIBI-MEGATEM SUMMARY

**Gross**
- 100% Noranda Abitibi Plan (Matagami not included):
  - 2002 Follow-up, data acquisition, TGS, TGS 2000 drilling: $5.53M
  - 2003 Follow-up and drilling (24 targets): $1.40M
  - 2004 Follow-up and drilling: $2.00M
  - 2002 Noranda Camp follow-up, 3D Modeling, Magusi drilling: $0.37M
  - 2003 Noranda Camp follow-up (38 ano), and drilling (29 targets): $2.09M
  - 2004 Noranda Camp follow-up, Metco option: $0.43M
  - 2004 3D targets dth, Titan-24, Megatem follow-up: $3.50M

- Novicourt – Virginia MEGATEM JV
  - 2001-2002 MEGATEM JV1-JV2 surveys: $5.0M
  - 2002 JV1 Ground follow-up (72 ano), drilling (43 targets): $1.41M
  - 2003 JV1-JV2 Ground follow-up (75 ano.), drilling (66 targets): $2.29M
  - 2004 JV1-JV2 Ground follow-up (70 ano.), drilling (60 targets): $2.15M
  - 2005 JV1-JV2 Ground follow-up (29 anom.), drilling (31 targets): $1.70M

- Beaufield Troilus Option:
  - 2004 Beaufield follow-up (18 anom.), drilling (12 targets): $0.50M

**Total** $32.55M

### ABITIBI MEGATEM BUDGET

**2001-2005**

<table>
<thead>
<tr>
<th>Year</th>
<th>Activities</th>
<th>JV1-JV2</th>
<th>JV1</th>
<th>JV2</th>
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<tr>
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<tr>
<td>2002</td>
<td>JV1 Ground follow-up (72 ano), drilling (43 targets)</td>
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<td>2003</td>
<td>JV1-JV2 Ground follow-up (75 ano.), drilling (66 targets)</td>
<td>$2.29M</td>
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<td>2004</td>
<td>JV1-JV2 Ground follow-up (70 ano.), drilling (60 targets)</td>
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<tr>
<td>2005</td>
<td>JV1-JV2 Ground follow-up (29 anom.), drilling (31 targets)</td>
<td>$1.70M</td>
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</tbody>
</table>

- **Novicourt – Virginia MEGATEM JV**
  - 2003 Novicourt Participation Val-d’Or JV: $(0.4M)
  - 2003 Novicourt Val-d’Or ground follow-up: $0.55M
  - 2004 Novicourt Val-d’Or, Grevet and Hunter follow-up (89 anom.), drilling (65 targets): $1.81M
  - 2005 Novicourt Val-d’Or, Grevet and Hunter follow-up: $2.02M

- **Beaufield Troilus Option**
  - 2004 Beaufield follow-up (18 anom.), drilling (12 targets): $0.50M

**Total** $32.55M
End Results

On the Québec side
- 350 AEM anomalies were followed up
- 268 were drilled tested for a total 362 DDHs.

While discoveries can occur well after the initial generative work, at this stage no new deposits have been attributed to the MEGATEM initiative.

WHY?

GLOBAL STATISTICS

<table>
<thead>
<tr>
<th>SURVEY</th>
<th>Ls km</th>
<th>Anomaly Pks</th>
<th>Anomaly Pre Selected</th>
<th>TARGET DDH TESTED (ft hole)</th>
<th>TARGET DDH TESTED (mbd hole)</th>
<th>total # ddhs</th>
<th>Ground follow. up but NOT DDH TESTED</th>
<th>TOTAL TARGETS</th>
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<tbody>
<tr>
<td>QV1 AMOS</td>
<td>806</td>
<td>5839</td>
<td>276</td>
<td>30</td>
<td>7</td>
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<td>10</td>
<td>19</td>
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<td>QV - OTTAWA</td>
<td>7162</td>
<td>2667</td>
<td>154</td>
<td>4</td>
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<td>5</td>
<td>19</td>
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<td>QV - NAGEZ</td>
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<td>3095</td>
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<td>2371</td>
<td>367</td>
<td>39</td>
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<td>42</td>
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<td>100% TOTAL MTDH容忍</td>
<td>7162</td>
<td>2667</td>
<td>154</td>
<td>4</td>
<td>1</td>
<td>5</td>
<td>19</td>
<td>23</td>
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<td>268</td>
<td>94</td>
<td>362</td>
<td>179</td>
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First DDH on Targets

<table>
<thead>
<tr>
<th>SURVEY</th>
<th>TESTED (first hole)</th>
<th>In-hole edge</th>
<th>Near off-hole</th>
<th>Off-hole</th>
<th>No related anomaly</th>
<th>Not surveyed</th>
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<tbody>
<tr>
<td>JV1 AMOS</td>
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<td>JV2 DE-PIPE</td>
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<td><strong>268</strong></td>
<td><strong>132</strong></td>
<td><strong>44</strong></td>
<td><strong>57</strong></td>
<td><strong>8</strong></td>
<td><strong>15</strong></td>
</tr>
</tbody>
</table>

Type of mineralisation vs BHEM anomalies

In-hole/edge

- Iron formation
- No conductor
- Graphite w/wo sulfides
- Diss. or stringer sulfides
- No anomaly
- Significant sulfides: M Fe or high Ga-Sp

Near off-hole

Off-hole

First ddh on targets

No survey
Following ddhs on targets

<table>
<thead>
<tr>
<th>SURVEY #2+</th>
<th>follow-up on off-hole</th>
<th>in-hole et edge</th>
<th>near off-hole</th>
<th>off-hole</th>
<th>No related anomaly</th>
<th>not surveyed</th>
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<tr>
<td>IV1 AMOS</td>
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<td>4</td>
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<td><strong>12</strong></td>
<td><strong>19</strong></td>
<td><strong>6</strong></td>
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1950 vs 2000

<table>
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<tr>
<th>All of Canada 1955-1959</th>
<th>ABITIBI MEGATEM 2001-2005</th>
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<td>125,000 square miles</td>
<td>324,000 km²</td>
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<tr>
<td>500,000 line miles</td>
<td>800,000 line km</td>
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<td>24,000 km²</td>
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<tr>
<td>10%</td>
<td>2,500</td>
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<td>33%</td>
<td>350</td>
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<tr>
<td>33%</td>
<td>268</td>
</tr>
<tr>
<td>80%</td>
<td>280</td>
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<tr>
<td>20%</td>
<td>93%</td>
</tr>
<tr>
<td>0%</td>
<td>93%</td>
</tr>
</tbody>
</table>

*Includes some areas flown more than once.
†Anomalies selected as probably significant by a process of interpretation or “skimming.”

We were more selective in our picking, selection and follow-up but less in our drilling decision.
CONCLUSION

1. Few good targets in the right geological setting.
   - Barren sulfides (mainly Py-Po stringers)
2. Numerous targets that appear like VMS targets but are not in the right geological setting (mostly basalt)
   - Barren sulfides and few graphite

- One easy solution: no selection of “formational” conductors
- Consequence: Lost opportunity or reduced search space.
- VMS have been found in the so-called “formational” settings
- THUS: Need for better predictive models or other screening tools

"Only good fishermen are successful, first by selecting the good lakes and then the good spots"

MEGATEM
Technology enhancement
(PDAC 2004)
MEGATEM
Technology enhancement

Three year research project (2003-2006)

• 3 documented test sites in the Noranda camp:
  ➢ 3 published papers in Exploration and Mining Geology (CIM)

• 2 Master Thesis at École Polytechnique
  ➢ Claprood: Rapid detection and classification of airborne time-Domain anomalies using weighted multi-linear regression
  ➢ Boucheddha: Sferics noise reduction in time-domain electromagnetic systems: application to MegaTEMII signal enhancement
Selective/Partial Extraction
Soil Geochemistry in the
Abitibi Megatem Program

Charles Beaudry, M.Sc, géo, P.Geo
President and COO
Xmet Inc.

DMEC Workshop Series: Driving exploration success in deep exploration through multidisciplinary collaboration and data integration
9 March, 2011

Content

- Conclusions and Recommendations
- Introduction
- Deep Penetrating Soil Geochemical Research at Xstrata Canada
- Xstrata Canada Abitibi Megatem Project
- Theory of Soil Geochemistry and Implications of Partial/Selective Extraction Methods
- Sampling Protocols
- QAQC
- Response Ratio and Normalization Methods of Interpretation of Selected Known and Blind Targets
- Essential Learnings
Conclusions/Recommendations

- Little difference between partial/selective extraction methods in spite of marketing; all give similar results.
- Deep Penetrating Soil Geochemistry Program concluded that under good conditions it is possible to distinguish barren graphite and base metal-rich VMS conductors but not between barren and mineralized sulfide conductors.
- Biggest variation in Abitibi is cause by soil type (A0 vs B horizon); need to consider samples as distinct datasets.
- Most important issue is to sample as near to surface as possible but above water table.
- Important to measure pH
- Rigorous sampling protocols important but documentation even more important.
- Very important to collect site duplicates (circa 30 within 1m or less)
- Very important to randomise samples before batch assembly.

Conclusions/Recommendations

- Grid surveys greatly helped by abundant background samples.
- Mineralized domains often reflected by increased variance of sampling rather than by absolute threshold anomalies.
- Ideal survey in the Abitibi would be entirely composed of B-horizon samples collected beneath thin humus layer at 15cm depth or less with a water table at 1-2 m depth. Shangri-la looks like the ideal hunting ground for Ruffed Grouse, i.e. well drained soil and forest populated by mixed species dominated by aspen and white birch.
- Worst case scenario (the usual case) is mixed soils, low lying fens and bogs alternating with well drained ridges.
- Note that pH may be a co-variant. You need to measure it but you may not want to normalize for it.
Introduction

- Xstrata’s Highly Extensive Abitibi Megatem program resulted in the identification of numerous conductors.

- The large number of lower order anomalies along with the presence of transported soils over much of the Abitibi lead to investigations of deep penetrating soil geochemistry to assist in prioritizing targets.

- The objective of the soil geochemical program was to sample EM targets for <$4K per target in order to cover 3-4 targets for the price of drill testing one.

Xstrata Zinc Canada Division Deep Penetrating Soil Geochemical Research Program

- Research Program undertaken between 2002 and 2006 (circa $500K).
- Objective to better understand the results that were being published by CAMIRO and to develop usable sampling and analytical protocols for deep penetrating soil geochemistry.
- Chronology of Research:
  - 2003 – SGH and SDP analyses of rock specimens from different deposits: Perseverance(VMS), Chance(VMS), Louvicourt(VMS), Prosser(Graphite), Raglan(magmatic Ni-Cu), Montcalm(magmatic Ni-Cu).
  - 2003 – Test soil sampling on selected targets: Perseverance(VMS), Caber(VMS), Gemini(VMS), Prosser(Graphite), Montcalm(magmatic Ni-Cu) and on 5 blind targets.
  - 2003 – Orientation soil sampling survey on McLeod grid in Matagami.
  - 2004 – Test soil sampling on 4 known and drill tested EM conductors (VMS, barren sulphide and graphite targets) and on 28 untested MEGATEM targets.
  - 2004 – Soil sampling program on McLeod grid in Matagami.
  - 2005 – Test soil sampling program on 14 magnetic anomalies at Raglan.
  - 2006 – Orientation soil sampling program on Perseverance deposit in Matagami.
A total of 32 targets sampled including:
- 4 known targets
- 28 unknown targets

Main consequence of last glaciation in Abitibi was to deposit a series of more or less allogenic sediments on top of bedrock which have little chemical relationship to underlying bedrock. Under these conditions conventional geochemical processes should not reflect any bedrock processes. However...
In Spite of Theory Geochem Processes are Reflecting Bedrock

(Hamilton, 2000)

CAMIRO Results at Cross Lake

(De Hamilton et al, 2002)
Partial Extraction Geochemistry Produce Stronger Contrast...
...but are Much Noisier.

Data log10 transformed

Std_Dups: Standard deviation of duplicate pairs
\[ \frac{\sum(X2-X1)^2}{2*(N-1)}^{0.5} \]

\[ P/T = 100*\left[5.15 * \text{Std}_\text{Dups} / (\text{Max} - \text{Min})\right] \]

GageRR = 100*\left(\frac{\text{Std}_\text{Dups}}{\text{Std}}\right)

\[ \text{Values of 30 or less are ideal} \]

Measures ratio between site variance and Range of concentration in survey

Measures ratio between site variance and Survey variance

SITE DUPLICATES

Sampling Protocols for Partial/Selective Extraction Soil Geochemical Sampling

OMET proposal remains method agnostic but recommends same for A and B hori.
**Megatem EM Conductor Sampling Protocol**

All Targets analyzed by Enzyme Leach. Three targets also analyzed by MMI-M.

**ANALYSES and QAQC**

- All targets analysed for Enzyme Leach
- Six targets analysed for SDP
- 3 targets also analysed for MMI-M (Norita, La Porphyre and Glandelet)
- QAQC procedures included:
  - Insertion of 2 drift monitors (A0 and B-horizon samples collected from McLeod property).
  - Randomization of all samples prior to final batch assembly.
  - Collection of field duplicates to measure total within site variance.
  - Analysis of preparation duplicates to measure sub-sampling variance.
Randomization of Samples

All samples randomized before batch assembly.

Good random pattern of results.

Precision of Drift Monitors

B-horizon  Average RSD% circa 18%

A-horizon  Average RSD% circa 40%

Drift Monitor composed of a bulk sample of several Kgs of soil that was dried, homogenized and split into aliquots.
Lab and Field Duplicates

Mean_Diff% between Laboratory Duplicates

Mean_Diff% between Field Duplicates

Variance of Field Dups more than twice that of Laboratory Prep dups.

Average mean difference circa 18%

Average mean difference circa 50%

QAQC Conclusions

- The control materials submitted with batches indicate that the relative accuracy of analyses was slightly negative for humus and constant for B-horizon samples over course of analysis.
- Precision for the B-horizon standard is considerably better than the A0-horizon standard (indicates higher variance in humus analyses).
- Precision of B-horizon standard and laboratory and field duplicates comparable to other partial/selective extraction methods used previously in the Abitibi. Humus samples increase overall variance.

QAQC Statement: Following a review of the QAQC data it is concluded that the analyses are acceptable for the stated purposes of prioritizing Megatem conductors on the basis of soil geochemical responses. Higher variance of humus samples requires larger differences for significance than B-horizon samples.
A total of 32 targets sampled including:
4 known targets
28 unknown targets

Magusi Deposit (VMS, Zinc-rich)

1.2 MT @ 7.1% Zn, 0.4% Cu and 1.89 g/t Au
0.84 MT @ 3.3% Cu, 0.3% Zn and 39 g/t Ag
Norita Upper Zone (VMS, Zn-rich)

Norita Upper-Zone never mined because part of crown pillar of mine. Circa 20m thick Zn-rich massive sulphide horizon sub-cropping beaneath 20m thick overburden.

Glandelet (Barren Graphite)

Glandelet target a drill-tested barren graphite horizon sub-cropping beneath 15m of overburden.
Lac Porphyre target a 12-15m wide zone of barren massive sulphide.

Zinc Response Ratio

Excellent Responses From Zinc both at Norita and Magusi

Response Ratio
- > 12
- 8 to 12
- 4 to 8
- 0 to 4

SOIL_HORIZON_CODE:
- A0
- Ae
- B
- C
Zinc Response Ratio

Glandelet
- Little or no response from Zinc both at on graphite or barren MS

Lac Porphyre
- Best Pb response at Norita but response extends to north in swamp.

Lead Response Ratio

- Weak Pb response over graphite

Copper Response Ratio

- No Copper Response over VMS Deposits
Copper Response Ratio

No Copper Response over Barren Graphite or Barren MS

Response Ratio
- > 12
- 8 to 12
- 4 to 8
- 0 to 4

SOIL_HORIZON_CODE
- A0
- Ae
- B
- C

Summary of Known Targets

Norita
- High: Bi, Pb, Hf, W, REE's,
- Med: Cs, Li, Be, Mn, Y
- Low: Cu, Th, Sr, U, Ba, Hf

Magusi
- High: Bi, Zn, Cs, Nb, Cl
- Med: Pb, U, Sr, B, Ca, Cu, Ba, Mn, W, Y
- Low: Cu, Th, Be, Bi, Br, In, REE's, Hf

Glandelet
- High: V, Th, Mo, Mo, Hf, Li, Sr, Sn
- Med: REE's, Cs, Cl, Ga, I, Nb, Ni, Pb, U, Y
- Low: Ba, Be, Bi, Cr, Cu, Zn, Cu, In, Nb, Sb, Sn, TI

Lac Porphyre
- High: Cu
- Med: Co, Hf, Mn, Nb, Ti, Th, Zn, Rb
- Low: Ba, Be, Zn, REE's, Cu, Ni, Pb, Sn, Sr, U, V
A total of 32 targets sampled including:
- 4 known targets
- 28 unknown targets

Assessment of Unknown Targets

- Amos
  - POU11, POU12, BER101, GYE107
- Chapais
  - LES104, LES105, LES109, BTN-T-04-03, GRE-T-04-05
- Courville
  - COU01, COU02, COU102
- Matagami
  - LET01, CPT04
- RouynN
  - Baie Mouilleuse, Dupras-nord
- RouynS
  - Dupras-sud1, Dupras-sud2
- Timmins
  - MCL04, MCL1b, WAR04
- Troilus
  - TRL03, Boulder, TRL103, TRL104, TOR01
- Val d’Or
  - VAU06, PAS19
Summary Response Ratio Method

- RR method highlights POU12 as the best potential but drilling failed to identify significant base metals. BER-101 on the other hand is not anomalous but clearly elevated in base metals.
- Other highlighted targets may be VMS or only graphite conductors with anomalous metals (i.e. like Prosser).
- Except for soil type and sector the data are basically uncorrected.
- Many of the anomalies are over swampy areas.
- Method of interpretation by RR remains difficult and unsatisfactory because of suspected surficial effects.

Normalization Method

- Data were interpreted by an alternate method designed to “normalize” results for factors thought to amplify or attenuate the weak signal coming from the bedrock.
- Method based on regression analysis for continuous variables and grouping for discreet variables.
- Results were mixed but clearly the effect of pH needs to be considered carefully. Better to measure but not normalize for pH.
Key Learnings

- Partial/Selective extraction soil geochemical methods are difficult to apply successfully in spite of some spectacular success stories.
- However it is clear that some sort of signal from bedrock can, in certain circumstances, cross 10's (sometimes 100's) of meters of transported overburden and be detected in surface soils.
- Three major difficulties with partial/selective soil methods is large site variance, large impact of soil horizon type (B vs A) and local surficial conditions which has large effect on background levels.
- Careful sampling and rigorous documentation can help to correct for many variables; Easier in principal with Normalization Method vs Response Ratio but Normalization dangerous.
- pH is an important variable but can be a co-variant which suggest that we should measure and plot pH but not normalize for it.

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