Modern Geochemical Techniques For Exploration In Glaciated Terrains: An Overview

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Global Geoscience Group,
Minerals, Exploration,
BHP Billiton World Exploration Inc.
In regions glaciated in the Quaternary, mineral exploration can be hampered by the scarcity of bedrock outcrops and by the complex nature and thickness of the surficial glacial sediments that mantle, and often conceal, the bedrock and mineral deposits beneath.

In this day and age, both “Conventional” and a variety of newer “Deep Penetrating” geochemical exploration techniques are being employed for Mineral Exploration in Glaciated Terrains.
“Conventional” geochemical exploration techniques attempt to use the primary glacial sediments themselves (mainly till), or products derived therefrom (i.e. heavy minerals, fine fraction, etc.), in the context of their glacial depositional history – i.e. understanding the glacial sediment stratigraphy and ice movement direction(s).

Techniques involving the sampling and analyses of surficial till or secondary sediments derived therefrom, have been successful in exploration in areas of generally thin glacial drift (a few to 10s of metres).
Provided the glacial history and stratigraphic framework have been established, overburden drilling techniques can be successfully employed in mineral exploration in areas of thicker (several 10s to 100s of metres) glacial drift.

In addition, drainage sediments (i.e. lake and stream) have been successfully used to detect secondary hydromorphic dispersion associated with concealed mineralization in glaciated terrains.
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Conventional Geochemistry

**Hope Bay Greenstone Belt, NWT, Canada**

An example of working out the glacial history and stratigraphic framework of an area and using fine fraction till geochemistry to locate gold mineralization.

**Piling Project, Baffin Island, Nunavut, Canada**

An example of using regional HMC and stream silt geochemistry with fine fraction till geochemistry to locate BHT-style mineralization.
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Hope Bay Greenstone Belt, NWT, Canada
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Hope Bay Greenstone Belt, NWT, Canada

Glaciated Landscape

Au-bearing shear zone

Last Ice flow direction
NNW (avg. 335°)
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- Unraveled ice flow history and glacial stratigraphy;

- Last ice flow was to the NNW (avg. 335°) and it smeared till along the E and SE sides of the outcrops;

- Therefore by digging through the relatively thinner glaciomarine sediments on the E and SE sides of the bedrock ridges we were able to collect till, the chemistry of which was indicative of the bedrock geology and/or mineralization in the valley to its SE.
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Hope Bay Greenstone Belt, NWT, Canada

- Glaciomarine sediments overlying till;
- Till collected, on S-SE slopes of bedrock ridges, by digging through the glaciomarine sediments.
- 5931 till samples were collected across the entire area;
- 500 gm to 1 kg of till were collected, coarse fragments removed, dried and sieved to -250 mesh (<63 microns);
- Au was determined by FA/AAS and an additional 32 elements by nitric/aqua regia - ICP-ES;
- QA/QC was facilitated through the analyses of reference control standards and duplicates.
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- Sampled till - SSE slopes
- Coherent till anomalies
- Several new targets in the belt
- South Patch mineralization identified by till geochemistry and proven up by drilling.
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Piling Project, Baffin Island, Nunavut, Canada

• Government geology maps, airborne geophysical data and lake sediment geochemical data used to target potential BHT province;

• BHP carries out a reconnaissance geological survey coupled with HMC and stream silt sampling which confirm area to be prospective for BHTs;

• Ground picked up and alliance formed with Falconbridge to jointly explore combined properties;

• Regional geological, till geochemistry and airborne hyperspectral surveys conducted;

• Target scale prospecting and rock sampling, till geochemistry and “Beep Mat” geophysics carried out; and,

• Initial results produced bedrock samples with 40% combined Zn / Pb with 1000 g of Ag.
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Piling Project - TMI over 1st VD Magnetics Drape

Prospecting Permits
- BHP
- Cominco
- Falconbridge

Image: TMI over 1st VD Magnetics Drape

Area of hyperspectral survey

West Piling Area
- Qimmiq Area
- East Piling Area

1600-m line data
800-m line data

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Piling Project - Regional Geology and HMCs

New Bedrock Mapping
- Paleozioc Platform
- PROTEROZOIC
- Granitoids
- Amphibolite, minor volcanioclastics
- Psammitic, semipelite, pelite
- Sulphidic schist, minor iron formation
- Calc-silicate
- Qtz-fld granofel
- ARCHEAN
- Granite-Greenstone

Prospecting Permits
- BHP
- Cominco
- Falconbridge
- BHP-NTI Agreements

HMC Sample Results (gahnite)
- 0
- 1
- 2
- 3 - 4
- 5 - 12

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Piling Project - Tuktu - Till Samples

Outcrops
- Amphibolite
- Pelite, Semipelite
Image
- Regional Airphoto

Till ICP data
- Silver
- Lead
- Zinc

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There is still a need for further evaluation of Tuktu, as well as other as yet untested, targets in this project area.
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 Talks and Posters:  
On the  
Application of Conventional Geochemical Techniques  
In Glaciated Terrains
Drift Prospecting and Exploration Geochemistry in Glaciated Terrain, Northwestern New Brunswick, Canada

Michael A. Parkhill

New Brunswick Geological Surveys Branch
NATMAP contribution
“Geological Bridges of Eastern Canada”
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Distribution of Appalachian and Laurentide erratics and Ice flow sequence
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Figure 2

Glacial Striae

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GEOCHEMICAL EXPLORATION FOR PALLADIUM IN ONTARIO

Keiko Hattori and Eion Cameron
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Regional Lake Sediment Surveys (OGS)

Pd ppb

34
30
26
22
18
14
10
6

10 km

Lac des Illés

Ice

2800 km²
675 samples

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High Mobility of Palladium in Surface Environment may Create False Anomalies

Palladium in Soils

Swamp Humus

C-Horizon

B-Horizon
Geochemical and Mineralogical Dispersion Models in Till: Physical Process Constraints and Impacts on Geochemical Exploration Interpretation

Cliff Stanley
Dept. of Geology
Acadia University
Wolfville, Nova Scotia
B4P 2R6, Canada
cliff.stanley@acadiau.ca
The **Exponential and Linear Dispersion Models** are numerically inconsistent with the physical model for which they are ascribed.

An alternative **Aggradational Dispersion Model** is proposed that has both physical justification and explains both observed dispersion patterns (‘pseudo-exponential’ and ‘pseudo-linear’).
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Aggradational Dispersion Model

- Originally identified by Prest (1911) & Miller (1984)
- With data from
  - Bedrock
  - Anomalous
  - Background
PUBLIC DOMAIN COMPILATIONS OF KIMBERLITE INDICATORS AND THEIR MINERAL CHEMISTRY FROM AN EMERGING DIAMOND REGION: ARCHEAN SLAVE CRATON, NORTHERN CANADA

John P. Armstrong, C.S. Lord Northern Geoscience Centre, DIAND NWT GEOLOGY DIVISION, Yellowknife NT Canada

- Since 1991 over 350 kimberlites have been discovered in the region underlain by the Archean Slave Craton, northern Canada
- 2 producing diamond mines
- Exploration data generated by exploration companies is filed with the Federal Government to maintain mineral claims
- Data for diamond exploration has consisted of glacial till sampling and kimberlite indicator mineral (KIM) picking results, electron microprobe analyses of indicator minerals, airborne magnetic and electromagnetic surveys, and diamond drilling
- This hard copy data has been digitized and compiled into a series of GIS compatible products
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TILL SAMPLE LOCATIONS – SLAVE CRATON

- Till Samples > 125,000
- Mineral Chemical Analyses > 110,000
- Drill Logs > 1,600 with over 500 kimberlite intersections
- Total Field Magnetic Images > 1,500 maps scanned and geo-referenced

Compilations are designed in such a manner that allows for quick integration with clients existing GIS datasets.
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Late Wisconsin ice flow and regional KIM dispersion

Generalized Late Wisconsin ice flow directions from Kerr
(unpublished data, 2003), KIM trains from RIDD compilation

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GEOCHEMICAL PROSPECTING IN ICE MARGINAL SETTINGS: INSIGHTS FROM RARE-METAL PEGMATITE EXPLORATION IN THE BRAZIL LAKE AREA, SOUTHWESTERN NOVA SCOTIA

Andrea Locke, Cliff Stanley, Ian Spooner
ACADIA UNIVERSITY
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- 2nd derivative aeromagnetic map
- NE-SW trending syncline
- Shaded relief model
- N-S trending glacial features
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Subglacial Till: The “Upwardly Mobile Sediment”

by

Mark Tarplee

Queen Mary, University of London
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In recent years, considerable effort has been focused on the development of surficial geochemical techniques to “see through” thicker, compositionally complex, sedimentary (glacial, marine, etc.) sequences.

In this context, i.e. discovery of economic mineral deposits concealed beneath thick cover, a number of modern “Deep Penetrating” surficial geochemical techniques, that focus on giving an in situ response vertically above the target mineralization, have been developed.
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These techniques include a variety of selective extraction, soil gas, physiochemical, electrochemical and biological (bacterial and microbial, etc.) methods.

The key to the successful application of these targeting techniques for “seeing through thick cover” is understanding the processes controlling the elements/compounds “vertical redistribution” to the near surface and their modification / redistribution within the near surface environment.
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What are selective extractions:
Analysis of a sample to selectively release the metals associated with a specific component of the sample.

Why are they Used in Exploration:
- Areas with cover, in particular exotic overburden;
- Particular fraction of sample desired (Carbonate, Mn Oxide, Fe Oxide, Clay, Organic);
- Measure a component of the chemically rather than mechanically transported elements; and,
- Separate recent chemical signature from background geological signature of the parent material.
Emphasize secondary chemical processes

- Hydromorphic Dispersion
- Evapotranspiration
- Electrochemical dispersion
- Gaseous Diffusion
- Seismic Pumping
- Organic/Bacteria/Microbial Activity
+ Others?

Limit chemical contribution from resident surficial medium sampled
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1. **Ore forming** primary geochemical signature during ore formation
2. **Release** of elements during ore weathering (e.g. oxidation)
3. **Transport** of elements through cover to the surface
4. **Accumulation** of elements at surface

Geochemical signature at the surface varies according to the deposit type, type and depth of cover, surface environment.
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Examples:

- Water-Bound Ions (MMI)
- Cyanide Extraction (BCL)
- Carbonate Extraction (Na Acetate)
- Organic Extraction (Organomet)
- Amorphous Mn Oxides (Allegro)
- Amorphous Mn Oxides (Enzyme Leach)
- Amorphous Fe Oxides (Foxy)
- Crystalline Mn or Fe Oxides
- Sulphides (Aqua Regia)
- Near Total Extraction (3 or 4-acid)
- Total (Fusion)
Climate and geomorphology are radically different throughout the world resulting in a range of processes at work in transport through cover and in the media where dispersed elements will be trapped at the near surface.

In geochemical exploration, recognition of the nature of the local (soil) cover is particularly important as this provides a useful indication of both the potential mobility of elements of interest in the surficial environment and of the potential effectiveness of specific (soil) components (horizons) as geochemical sample media.
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Global Climate & Soils

Modified after Pedro (1985)
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Caber Deposit, Quebec, Canada / Crandon Deposit, Wisconsin, U.S.A.
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Caber Deposit, Quebec, Canada
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Caber Deposit, Quebec. Canada

412,000 T @ 12.4% Zn
1.0% Cu, & 15.0 g/t Ag
(Noranda has since upgraded this resource)

Diabase
Hanging Wall Mafics
VMS Mineralization
Key Tuffite
Foot Wall Felsics
Granodiorite

Line 3N
Line 4N
Line 17S
1 Km

412,000 T @ 12.4% Zn
1.0% Cu, & 15.0 g/t Ag
(Noranda has since upgraded this resource)
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- Extremely valuable tool in areas of thick overburden;
- A selective extraction (OrganoMet) used on 100% organic sample medium (humus);
- Analyses by (ICP-ES/MS);
- Extremely low background, but high contrast anomalies
- Multi-element anomalies directly over mineralization at Caber.
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Crandon Deposit, Wisconsin, U.S.A.

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- **Massive Ore, Zinc Rich**
- **Stringer Ore, Copper Rich**

Subcrop of Crandon
Massive Sulfide Deposit

Reserves: 65Mt at
1.4% Cu, 5.8% Zn

Baseline

1000 Feet

Line 2250E
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- Extremely valuable tool where you have thick overburden;
- A selective extraction (OrganoMet) used with a 100% organic sample medium (humus);
- Analyses by (ICP-ES/MS);
- Extremely low background, but high contrast, anomalies; and,
- Multi-element anomalies directly over mineralization at Crandon.

Line 2250E

Glacial Overburden  Sulphide Horizon

Tuffs & Breccias  Massive Ore  Vol. SS  Tuffic Tuff  Welded Ash & Tuffs  Cherty Tuff
Kimberlite Detection

Ekati Area, N.W.T., Canada
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Impala Kimberlite Pipe

Marlene - Mafic Body / Sulphides

D54 - Ultramafic Body

Big Horn Kimberlite Pipe

Jenelle - Metaseds / Sulphides

Mamba, Ronza and Garter Kimberlites

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Land Based Targets:
Geophysical Expressions
Geochemical Expressions
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Geophysics:
EM Colour Drape on Magnetics

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Jenelle

Marlene

Big Horn

Impala

Allegro - Till: Factor-1

\[ f_{1+10} > 0.00000 \text{ and } <= 0.14211 (1 \text{ %ile}) \]
\[ f_{1+10} > 0.14211 \text{ and } <= 0.56750 (40 \text{ %ile}) \]
\[ f_{1+10} > 0.56750 \text{ and } <= 10.21931 (80 \text{ %ile}) \]
\[ f_{1+10} > 10.21931 \text{ and } <= 10.95084 (50 \text{ %ile}) \]
\[ f_{1+10} > 10.95084 \text{ and } <= 11.32905 (90 \text{ %ile}) \]
\[ f_{1+10} > 11.32905 \text{ and } <= 11.85047 (95 \text{ %ile}) \]
\[ f_{1+10} > 11.85047 \text{ and } <= 12.04935 (98 \text{ %ile}) \]
\[ f_{1+10} > 12.04935 \text{ and } <= 12.25284 (99 \text{ %ile}) \]

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Allegro - Till: Factor-2

<table>
<thead>
<tr>
<th>Factor 2 + 10 Conditions</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤ 0.00000</td>
<td>1%</td>
</tr>
<tr>
<td>&gt; 0.00000</td>
<td>2%</td>
</tr>
<tr>
<td>≤ 0.00720</td>
<td>3%</td>
</tr>
<tr>
<td>&gt; 0.00720</td>
<td>4%</td>
</tr>
<tr>
<td>≤ 0.05716</td>
<td>5%</td>
</tr>
<tr>
<td>&gt; 0.05716</td>
<td>6%</td>
</tr>
<tr>
<td>≤ 0.85842</td>
<td>7%</td>
</tr>
<tr>
<td>&gt; 0.85842</td>
<td>8%</td>
</tr>
<tr>
<td>≤ 10.34560</td>
<td>9%</td>
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<tr>
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<td>10%</td>
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<tr>
<td>≤ 11.16905</td>
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<tr>
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<td>12%</td>
</tr>
<tr>
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<td>13%</td>
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<tr>
<td>&gt; 12.04680</td>
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</tr>
<tr>
<td>≤ 13.44473</td>
<td>15%</td>
</tr>
<tr>
<td>&gt; 13.44473</td>
<td>16%</td>
</tr>
<tr>
<td>≤ 13.64386</td>
<td>17%</td>
</tr>
<tr>
<td>&gt; 13.64386</td>
<td>18%</td>
</tr>
</tbody>
</table>

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Allegro - Till: Factor-3

- f3+10 > 0.00000 and <= 8.62435 (1 % ile)
- f3+10 > 8.62435 and <= 9.50717 (40 % ile)
- f3+10 > 9.50717 and <= 9.79463 (60 % ile)
- f3+10 > 9.79463 and <= 10.72173 (80 % ile)
- f3+10 > 10.72173 and <= 11.38244 (90 % ile)
- f3+10 > 11.38244 and <= 11.92282 (95 % ile)
- f3+10 > 11.92282 and <= 12.42991 (98 % ile)
- f3+10 > 12.42991 and <= 12.99951 (99 % ile)
- f3+10 > 12.99951 (99 % ile)
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Jenelle

Big Horn

Impala

OrganoMet - Humus: Factor-1

- f1>0.00000 and <= 8.86652 (1 %ile)
- f1>8.86652 and <= 9.42767 (10 %ile)
- f1>9.42767 and <= 9.84715 (20 %ile)
- f1>9.84715 and <= 10.54395 (60 %ile)
- f1>10.54395 and <= 11.34206 (90 %ile)
- f1>11.34206 and <= 12.54130 (95 %ile)
- f1>12.54130 and <= 13.00317 (98 %ile)
- f1>13.00317 and <= 13.04603 (99 %ile)
- f1>13.04603 (99 %ile)
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Marlene

Big Horn

Impala

OrganoMet - Humus: Factor-2

- $f_2 + 10 > 0.00000 \ and \ <= 0.98261$ (1 % ile)
- $f_2 + 10 > 0.98261 \ and \ <= 0.99060$ (50 % ile)
- $f_2 + 10 > 0.99060 \ and \ <= 0.99820$ (60 % ile)
- $f_2 + 10 > 0.99820 \ and \ <= 1.01206$ (80 % ile)
- $f_2 + 10 > 1.01206 \ and \ <= 1.04405$ (90 % ile)
- $f_2 + 10 > 1.04405 \ and \ <= 1.17280$ (95 % ile)
- $f_2 + 10 > 1.17280 \ and \ <= 1.36961$ (98 % ile)
- $f_2 + 10 > 1.36961 \ and \ <= 15.31437$ (99 % ile)
- $f_2 + 10 > 15.31437$ (99 % ile)

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OrganoMet - Humus: Factor-6

- $f_5 + 10 > 0.00000$ and $\leq 8.31295$ (1 %ile)
- $f_5 + 10 > 0.31295$ and $\leq 9.47838$ (40 %ile)
- $f_5 + 10 > 9.47838$ and $\leq 9.98302$ (60 %ile)
- $f_5 + 10 > 9.98302$ and $\leq 10.81280$ (80 %ile)
- $f_5 + 10 > 10.81280$ and $\leq 11.56647$ (90 %ile)
- $f_5 + 10 > 11.56647$ and $\leq 11.82563$ (95 %ile)
- $f_5 + 10 > 11.82563$ and $\leq 12.31717$ (98 %ile)
- $f_5 + 10 > 12.31717$ and $\leq 12.46352$ (99 %ile)
- $f_5 + 10 > 12.46352$ (99 %ile)
Lakes:

Bathymetry

Geophysical Expressions

Geochemical Expressions
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Bathymetry

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Lake Sediments: Factor-1

- f1 + 10 > 0.000 and <= 8.120 (1 % ile)
- f1 + 10 > 8.120 and <= 9.764 (40 % ile)
- f1 + 10 > 9.764 and <= 10.109 (60 % ile)
- f1 + 10 > 10.109 and <= 10.583 (80 % ile)
- f1 + 10 > 10.583 and <= 11.236 (90 % ile)
- f1 + 10 > 11.236 and <= 11.699 (95 % ile)
- f1 + 10 > 11.699 and <= 12.185 (98 % ile)
- f1 + 10 > 12.185 and <= 12.692 (99 % ile)
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Lake Sediments: Factor-4
- f4+10 > 0.000 and <= 8.561 (1 %ile)
- f4+10 > 8.561 and <= 9.563 (40 %ile)
- f4+10 > 9.563 and <= 9.970 (60 %ile)
- f4+10 > 9.970 and <= 10.788 (80 %ile)
- f4+10 > 10.788 and <= 11.324 (90 %ile)
- f4+10 > 11.324 and <= 11.820 (95 %ile)
- f4+10 > 11.820 and <= 12.451 (98 %ile)
- f4+10 > 12.451 and <= 12.504 (99 %ile)
- f4+10 > 12.504 (99 %ile)

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Conclusions and Recommendations

There is a distinct geochemical expression in soils/tills and lake sediments over kimberlite pipes compared to other geological and/or geophysical targets in the northern environment around the Ekati area, NWT, Canada. Surficial geochemistry can be effective for prioritization and discrimination of geological and/or geophysical expressions which are variably related to kimberlites, mafic bodies, metasedimentary units, etc..
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Talks and Posters:
On the
Application of Deep Penetrating Geochemical Techniques
In Glaciated Terrains
Modern Geochemical Techniques For Exploration
In Glaciated Terrains: An Overview

DEEP-PENETRATING GEOCHEMISTRY: NORTHERN CHILE

by

Eion M. Cameron
Eion Cameron Geochemical Inc.

and

Matthew I. Leybourne,
University of Texas
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Surface Flooding by Seismic Pumping

Miocene Gravel

Basement

Mineralized Groundwater Passes up Fracture Zone in Gravels to Surface

Water Ascends Fault, Entraining Groundwater from Porphyry Copper

Earthquake: Dilational Collapse, Water Expelled from Fractures to Fault
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Gaby Sur: Chlorine in Soil

Spence: Copper in Soil

Cl ppm

Cu ppb

Gravel

Oxide

Sulfide

Granodiorite

Andesite

Oxide

Sulfide

Porphyry

Eastern Fracture Zone

1 km

500 m
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Electrochemical Transport of Metals Due to Redox Gradients: Highly Predictive and Somewhat Problematic

- But Whose Problem Is It?

Stewart Hamilton (Ontario Geological Survey)

Gwendy Hall (Geological Survey of Canada)

Beth McClenaghan (Geological Survey of Canada)

Eion Cameron (Eion Cameron Geochemical)

Keiko Hattori (University of Ottawa)
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Cross Lake, Line 6 - 3D Redox & pH
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Development of a Redox Anomaly

1. Reduce feature in rock
   - +300
   - +200
   - +100
   - 0 mV
   - Redox equipotentials

2. Development of reduced area in overburden

Result: constant upward movement of reduced species, especially metals

Development of Geochemical Anomalies

1. Iron oxidation, acid production
2. Carbonate dissolution
3. Carbonate reprecipitation
4. \( H^+ \) & \( CO_2 \) dispersion; \( O_2 \) depletion

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“SEEING THROUGH THICK GLACIAL OVERBURDEN WITH GEOCHEMISTRY”

Gwendy Hall (GSC)
Beth McClenaghan (GSC)
Stew Hamilton (OGS)
Eion Cameron (EC Geochemical Inc.)
Bahram Daneshfar (Ottawa U)

funded by
OMET (Ontario Mineral Exploration Technology Pgm),
GSC and OGS
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In Glaciated Terrains: An Overview

Location in the Abitibi Greenstone Belt
“3D Geochemistry in the Abitibi: Development of Geochemical Exploration Methods”

Builds on previous work under Camiro’s DPG project (Eion Cameron) by examining in 3D geochemical signatures in soil, overburden, groundwater and gaseous media to identify:

1. element migration pathways to surface,
2. resident sites of these hitherto labile elements,
3. those elements redistributed by acidic ‘low’
4. optimum sampling and analytical methods

The focus is on the Zn-Cu-Pb VMS Cross Lake deposit and the syenite-hosted Au deposit at Marsh Zone, both east of Timmins, ON, Canada
Mechanism for Vertical Ionic Migration

A.W. Mann, T.F. Foster, D.A. Mann

MMI Technology,
Perth, Western Australia
Main Points of Model

- Sulphide oxidation reactions are exothermic
- That heat has to be dissipated
- Density differences will be caused in the saturated water column
- Ions in the water will ascend with the convective flow
- They will then be subjected to the effects of capillary rise above the water table
- Model applies to situations with high water tables and ore-bodies undergoing oxidation
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Soil anomaly is created above mineralization

Transfer of ions to surface is via Capillary Rise

Heat of Reaction produces temp & density differential

Density differential creates upward movement of ions

Reaction: ZnS → Zn^{++} (190 kcal/mole)

Convective cell is very wide

Convective Mechanism for Rapid Upward Migration of Ions from an oxidizing ore-body
Detection of Concealed Kimberlites: A Preliminary Evaluation of SDP Soil Gas Geochemistry

D.S. Thiede
W.B. Coker
S.J. Windle

21st IGES, Dublin
August 2003
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SDP - B Soil / Till: Impala Template - Sum

SDP - B Soil / Till: Impala Template - Count

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SDP - B Soil / Till: Summary

SDP data give a clear response over and somewhat peripheral to Impala which clearly distinguishes this kimberlite pipe from all of the other bodies studied.

There is no response at Big Horn, Marlene or Jenelle.

This technique definitely shows promise for discrimination of kimberlite pipes from other types of geophysical and/or geological features. However, there needs to be some further study of the situation at Big Horn.
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Crandon Orientation
Highsmith, Jaacks, Closs, Klusman

- Proterozoic Ladysmith-Rhinelander Volcanic Complex: Flambeau and Lynne Deposits
- Early Proterozoic Zn-Cu VMS Deposit
- 65MT at 5.8% Zn and 1.4% Cu
- Lower Greenschist Facies Metamorphism
- Temperate Forest Environment
- Subcrops beneath 100-200 feet of mixed glacial deposits
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Crandon Orientation
Soil Gas and Aqua Regia - ICP Soils

ICP Cu (5-17 ppm)
ICP Zn (0-70 ppm)

Soil CO₂ (1-4%)
Soil O₂

Stringer Ore
Massive Ore

2000 Feet
Crandon Orientation Results

- CO₂ and O₂ anomalies over mineralization
- Weak soil anomalies
- Gas and soil anomalies coincident
- CO₂ and O₂ discriminates conductor types
- Soil gas – inexpensive and effective
TILL GEOCHEMISTRY AT THE CLEAR LAKE SEDIMENTARY EXHALATIVE DEPOSIT,
Yukon Territory, Canada

W.K. Fletcher, J. D. Bond and A. Plouffe
Department of Earth and Ocean Sciences, University of British Columbia
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Fig. 1. Aqua regia lead and zinc

Fig. 2. Pb by aqua regia & hydroxylamine

This anomaly only present in aqua regia and total digestion

Main deposit subcrop
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Fig 3. Ca content and pH of till

Distance (m)
Application of the Mobile Metal Ion process for exploration in areas of thick overburden: a Canadian perspective.

Hugh de Souza¹, Alan W. Mann², Criş Dragusanu³

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³Geochemistry Research Centre, Perth, Australia
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The MMI Process

- Weak non-specific extraction that targets mobile metals ions related to mineralization.
- Controls re-adsorption for consistent measurement of low level abundances typical in glaciated terrains
- Sampling at constant depth of 15-20 cm depth or at peat/sediment interface is critical in identifying anomalous zones
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Example – Hunt Gold Zone
Northern Manitoba

20cm Muske

10m Lacustrin clay

Sample at the top of capillary fringe – commonly 10 - 15cm below interface

20m Till

Bedrock hostin ore
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On-Site Selective Leach Geochemistry

Dr Robert Ellis, GEDEX, Mississauga, Canada

Step 1: Orientation sampling
Step 2: Analysis by Site-Portable ICP-MS
Step 3: Data review
Step 4: Follow-up sampling & further methods

2 – 3 days per cycle

• Deliver samples to on-site lab for overnight turnaround
• Use data to define further sampling while crew is in place
• Multiple, user defined methods with ICP-MS finish
• Make fast, accurate, detailed studies

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