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Imaging a buried diamondiferous kimberlite using conventional geochemistry and Amplified Geochemical ImagingSM Technology



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Abstract

Accurate mapping of mineral deposits buried by tens to hundreds of meters of overburden will focus an exploration program, minimizing costs and time expended. Traditional surface geochemical techniques often focus on measuring and mapping metal ions in the soil or vegetation, water/soil chemical properties, and by-product gases such as oxygen and carbon dioxide. A new technique, Amplified Geochemical ImagingSM Technology, focuses on high sensitivity measurements of volatile compounds emanating from the mineral deposit itself, its contact zone, or associated redox systems. Compounds ranging from light sulphur species to organics with 18 carbon atoms, which are found at the surface, are collected and analyzed using a sensitive and sophisticated analytical technique. Differentiation of compounds associated with the mineralization and a robust image of the buried deposit are then obtained by processing the data using advanced modeling systems and multivariate statistical methods. This new technique works well with high content sulphur minerals such as those deposits hosted in Volcanogenic Massive Sulphide, porphyry Cu, Mississippi Valley-type, and some gold systems. In this paper, Amplified Geochemical ImagingSM Technology, along with conventional surface geochemical analysis, was used to image a kimberlite.

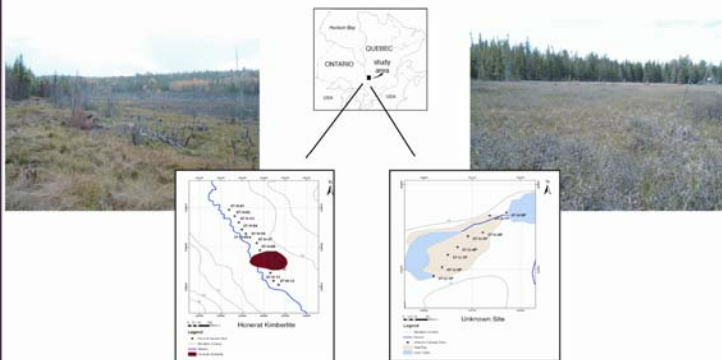
Location and Geology

The Honerat Kimberlite

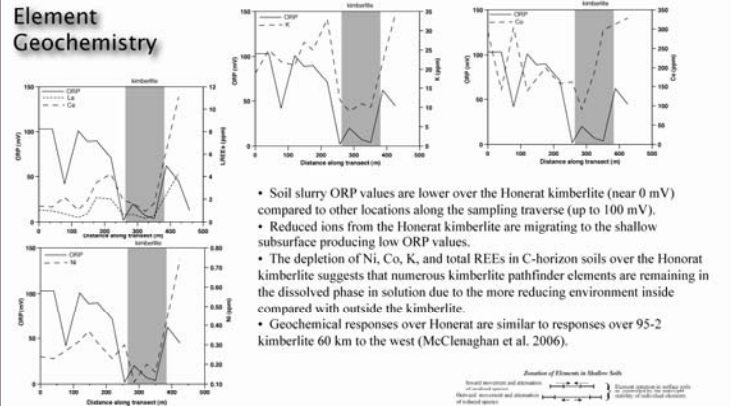
- Honerat kimberlite is Jurassic.
- The subcropping surface of the kimberlite consists of hypabyssal facies kimberlitic.
- Country rocks are dominantly Archean felsic to intermediate metavolcanics.
- The surficial sediments sampled at Honerat consists of glacial, glaciofluvial and glaciolacustrine sediments composed of clay with minor silt to silt with minor clay.
- The dimension of the kimberlite is approximately 85 m in diameter, based on company drill logs.
- Gravity surveys and drilling have indicated that the kimberlite was emplaced along a normal fault structure trending NW-SE.

The Unknown Location

- The location is approximately 5 km south of the Honerat kimberlite.
- Although there is no known kimberlite at this location, kimberlite boulders and elevated kimberlitic indicator mineral counts in glacial sediments have been found within 300 m.
- This location is also interpreted to be a possible site for a kimberlite pipe because it is along a NE-SW trending graben structure.
- The terrain at Unknown is saturated peat, between 1 and 4 m deep, and overlies fine gravel. Depth to bedrock is not known.

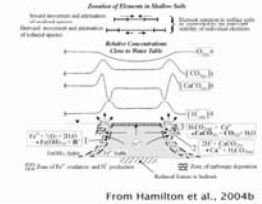


Element Geochemistry



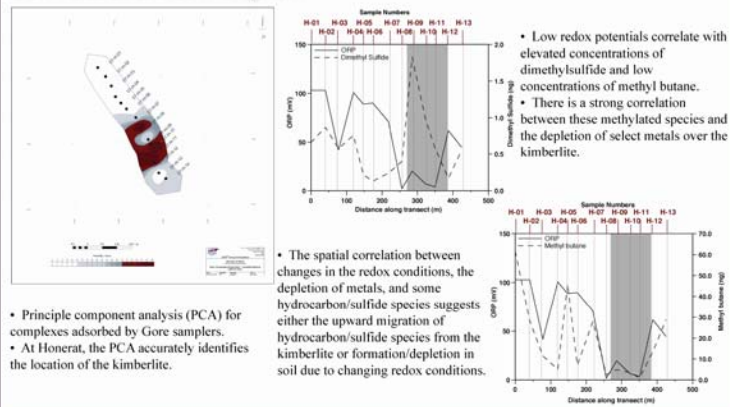
- Soil slurry ORP values are lower over the Honerat kimberlite (near 0 mV) compared to other locations along the sampling traverse (up to 100 mV).
- Reduced ions from the Honerat kimberlite are migrating to the shallow subsurface producing low ORP values.
- The depletion of Ni, Co, K, and total REEs in C-horizon soils over the Honerat kimberlite suggests that numerous kimberlitic pathfinder elements are remaining in the dissolved phase in solution due to the more reducing environment inside compared with outside the kimberlite.
- Geochemical responses over Honerat are similar to responses over 95-2 kimberlite 60 km to the west (McClenaghan et al. 2006).

- As elements migrate out of the kimberlite "reduced chimney" environment into a more oxidizing environment, they adsorb to soil particles, possibly as oxy-hydroxide complexes.



From Hamilton et al., 2004b

Gore Geochemical Samplers



- Principle component analysis (PCA) for complexes adsorbed by Gore samplers.
- At Honerat, the PCA accurately identifies the location of the kimberlite.

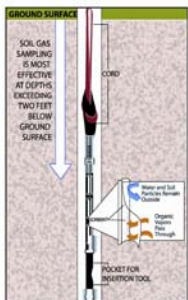
- Low redox potentials correlate with elevated concentrations of dimethylsulfide and low concentrations of methyl butane.
- There is a strong correlation between these methylated species and the depletion of select metals over the kimberlite.

- The spatial correlation between changes in the redox conditions, the depletion of metals, and some hydrocarbon/sulfide species suggests either the upward migration of hydrocarbon/sulfide species from the kimberlite or formation/depletion in soil due to changing redox conditions.

Sampling

Gore Geochemical Samplers

- Gore samplers were installed 60 cm below ground surface at Honerat.
- The samplers installed at Unknown were placed in piezometers and submerged in water at a depth of approximately 1 m below ground surface.
- The samplers, installed along traverses at both Honerat and Unknown, were left in place for 5 months before being retrieved.
- Adsorbed species were analyzed with a gas chromatograph/mass spectrometer (GC/MS).



Peat Groundwater Sampling

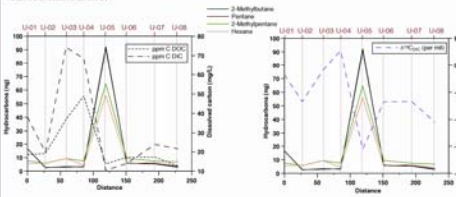
- Peat groundwater samples were collected at the Unknown Location in shallow piezometers along a traverse.
- Field geochemical parameters (ORP, pH, dissolved oxygen, electrical conductivity and temperature) were determined on site.
- Waters were analyzed in the lab for dissolved inorganic carbon (DIC) and $\delta^{13}C_{DIC}$, and dissolved organic carbon (DOC) and $\delta^{13}C_{DOC}$.

Soil Sampling

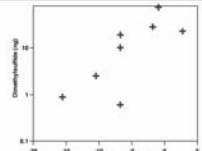
- Soil samples were collected from C-horizon soil because Gore samplers were placed at a depth of 60 cm (well below the B horizon).
- Within 8 hours of sampling, a portion of each soil sample was mixed with Milli-Q water (1:1) to create a slurry. The values of pH and oxidation-reduction potential (ORP) were determined in each slurry.
- Ammonia acetate leach of the soil samples was performed and metals were determined by inductively coupled plasma-mass spectrometry.

Carbon Isotopes

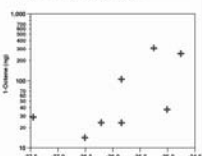
- The DIC, DOC and $\delta^{13}C$ values of near surface peat groundwaters correlate with hydrocarbon and sulfides species.
- Buried lithology is likely responsible for producing near surface conditions that are favorable for hydrocarbon and sulfide production that could be indicative of buried kimberlite.



- There are low concentrations of DIC and DOC at locations of elevated hydrocarbons.
- Methyl-type hydrocarbon production may be occurring, resulting in lower dissolved carbon concentrations.
- The low $\delta^{13}C_{DIC}$ values correlate with elevated hydrocarbons and methylated hydrocarbons, which could be a result of enhanced fermentation processes at U-05.
- Other locations along the transect with higher $\delta^{13}C_{DIC}$ values may indicate CO_2 reduction.



- Increasing concentrations of dimethylsulfide correlate well with $\delta^{13}C_{DIC}$ values.



- Increasing concentrations of 1-octene correlate well with $\delta^{13}C_{DOC}$ values.

Conclusion

In addition to soil geochemical exploration techniques, Gore Amplified Geochemical ImagingSM can be used in conjunction with geochemical data for exploration.

- 1) Kimberlite bodies can be identified at ground surface using soil geochemistry where 90 m of glacial sediment overlies a kimberlite. This is based on variations in element concentrations of pathfinder elements such as Ni, Co, K, and LREEs over versus off a kimberlite.
- 2) The Gore Amplified Geochemical ImagingSM technique, like soil geochemistry, shows anomalous responses in soils over the Honerat kimberlite.
- 3) Values of $\delta^{13}C_{DIC}$ correlate with some hydrocarbons and sulfide species at the Unknown Site and suggest that Amplified Geochemical ImagingSM responses could be the result of anomalous near-surface biological and abiotic reactions over kimberlites.

Acknowledgements

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