

Imaging a Buried Diamondiferous Kimberlite Using Conventional Geochemistry and Amplified Geochemical ImagingSM Technology

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ABSTRACT: Accurate mapping of the 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 itself, its contact zone, or associated redox systems.

Compounds ranging from light sulphur species to organics with 18 carbon atoms, which reach the surface more easily than the metal ions associated with the mineral deposit, 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 modelling systems and multivariate statistical methods.

This new technique works well with high sulphur containing minerals such as VMS, porphyry copper, Mississippi Valley-type deposits, and some gold systems. In this paper, Amplified Geochemical ImagingSM Technology, along with conventional surface geochemical analysis was used to image a Canadian Kimberlite.

KEYWORDS: *diamond, kimberlite, geochemistry, imaging, volatile*

INTRODUCTION

In regions where bedrock is hidden by thick sediments, surficial geochemical exploration has had a great deal of success. This paper identifies responses of Gore Amplified Geochemical ImagingSM compounds ranging from light sulphur species to organics with 18 carbon atoms over kimberlites, which correlate well with geochemical responses in soil. This study indicates that, in addition to soil geochemical exploration techniques, Gore Amplified Geochemical ImagingSM is another tool for the exploration geochemist.

GEOLOGICAL SETTING

The Honerat kimberlite is located in western Quebec approximately 45 km east of the town of Ville-Marie, Quebec. The site is located in a gently sloped

valley near a stream with beaver dams. Kimberlites in this region are Jurassic and the Honerat kimberlite is 85 m in diameter (based on ground magnetic data and drilling). Country rocks are dominantly felsic to intermediate volcanic of Archean age. Glaciolacustrine and glaciofluvial sediments of thickness ranging between 45 and 90 m overlie the kimberlite. Sampled soil varies from clay with minor silt to silt with minor clay.

METHODS

Soil samples were collected along a traverse over the Honerat kimberlite and extended off the kimberlite approximately 75 m SE and 225 m NW of the pipe. Although it is common practice to collect samples from upper B horizon soil, our samples were collected from the C horizon because Amplified Geochemical ImagingSM samplers were placed at a

depth of 60 cm (well below the B horizon). Within 8 hours of sampling, a portion of soil samples were 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 were performed at Acme Analytical Laboratories, Vancouver, where 20 ml of ammonium acetate was mixed with 1 g soil sample and analyzed by ICP-MS.

The samples collected as part of the Amplified Geochemical ImagingSM Technology were placed in the soil at the Honerat kimberlite at a depth of 60 cm; these samplers were left in place for an exposure of 5 months. Several samples were also placed in an area of unknown mineralization within a peat bog. These samplers were placed in piezometers for an exposure period also of 5 months. Retrieved samples were sent to Gore laboratories where they were thermally desorbed and analyzed with a gas chromatograph/mass spectrometer (GC/MS).

RESULTS AND DISCUSSION

Soil slurry ORP values are lower over the kimberlite (near 0 mV) compared to other locations along the transect (up to 100 mV) and indicates that reduced ions are migrating from the kimberlite to the surface. The low ORP values with high values near the margins suggest the presence of a “reduced chimney” (HAMILTON et al., 2004a; HAMILTON et al., 2004b), where reduced species (such as Fe²⁺) are migrating from the underlying body through the overburden.

The partial leach results suggest that soil samples can indicate the location of a hidden kimberlite. At the Honerat kimberlite, a marked depletion in concentrations of a variety of metals such as Ni, Mg, Co, K, and total REEs is observed directly over the kimberlite (Fig. 1). Conversely, enrichments of these elements at the margin(s) of the kimberlite are evident. These results are in agreement with soil geochemical results over kimberlites from the Kirkland Lake

region, Ontario (McCLENAGHAN et al., 2006). Metal depletions over the kimberlite suggest that many elements are not adsorbed on soil particles and are remaining in the dissolved phase. However, as elements migrate out of the kimberlite location into a more oxidizing environment, they may adsorb to soil particles, possibly oxyhydroxide complexes and produce elevated metal responses.

The data obtained by Amplified Geochemical ImagingSM correlate well with soil geochemical data. Individual components of the Gore analysis support the presence of a kimberlite where elevated concentrations of some sulfide compounds and hydrocarbons are observed (Fig. 2a & b). The spatial correlation suggests either the upward migration of hydrocarbons and sulfide compounds from the kimberlite or their formation in soil due to a reducing environment. We suggest the latter interpretation based on the variation of $\delta^{13}\text{C}$ for dissolved inorganic carbon (DIC) in groundwaters in peaty soil. The value of $\delta^{13}\text{C}$ increases with increasing amounts of hydrocarbons, suggesting biogenic reduction of inorganic carbon.

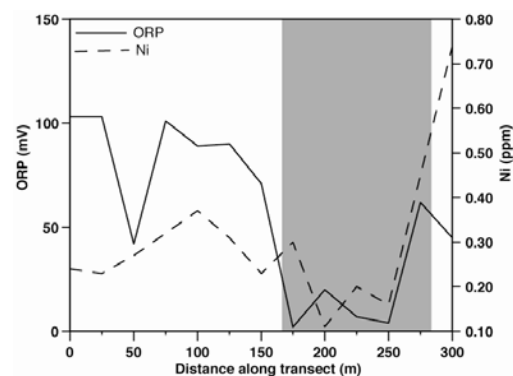


Fig. 1. Low relative ORP values correlate with low Ni values in soils over the Honerat kimberlite. Grey zone is kimberlite location.

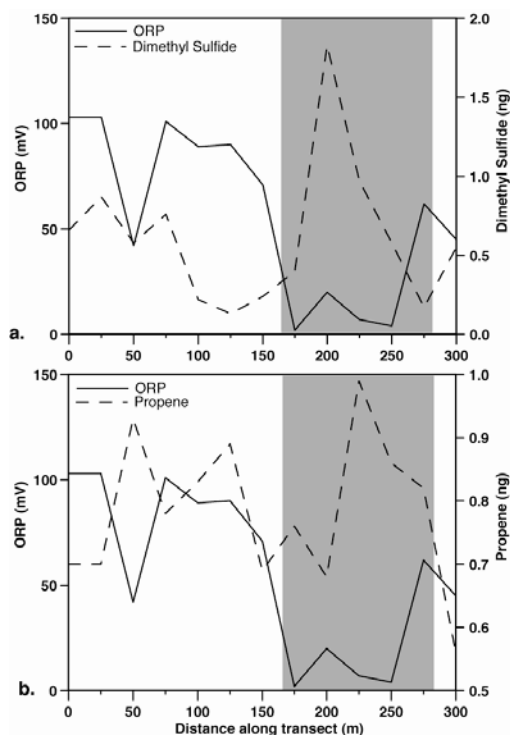


Fig. 2. High concentrations of dimethyl sulfide (a) and propene (b) correlate with reducing soils over the kimberlite. Grey zone is kimberlite location.

CONCLUSIONS

- 1) Kimberlite bodies can be identified at the ground surface using soil geochemistry where up to 90 m of glacial sediment overlies a kimberlite.
- 2) The Gore Amplified Geochemical ImagingSM technique, like soil geochemistry, shows responses such as sulfides and hydrocarbons over the kimberlite.
- 3) Values of $\delta^{13}\text{C-DIC}$ correlate with some hydrocarbons and suggest that Amplified Geochemical ImagingSM responses could be the result of surficial bacterial communities that thrive over ore deposits.

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