*Paper 82*

# Cutting Edge Geochemistry Detects Organic Signatures in Surficial Samples Originating from Bacterial-Mineral Interactions to Locate and Identify Deeply Buried Exploration Targets

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**ABSTRACT**

*Surficial soil surveys analyzed for inorganic elements have proven to be a useful predictive geochemistry in determining the location of deeply buried exploration targets. Organic components have also been sited as a potentially useful geochemical tool. In the last ten years, our research has been conducted to study and improve upon the use of organic compounds as a geochemical exploration tool. Bacteria that leach and metabolize compounds from mineral deposits or petroleum plays at depth eventually release hydrocarbons that migrate to the surface. Surficial samples such as soil, sediments, peat, humus, etc., act as collectors of these hydrocarbons. Past researchers have used very volatile compounds in the C1 to C4 carbon series range (Ilchik et al), and have also hypothesized the use of heavier hydrocarbons (Kesler et al). Our research has resulted in a geochemistry, defined as Soil Gas Hydrocarbons (SGH), which extracts the organic compounds absorbed on the surface of B-Horizon soil samples specifically for the heavier organic compounds in the C5 to C17 carbon series range. These compounds may migrate from depth in a volatile form but are not gaseous at ambient temperature and pressure. The SGH technique analyzes each sample for over 160 specific hydrocarbons at a detection limit of one part-per-trillion (ppt) now proven to be the remnants of these bacterial actions. The data was reviewed forensically resulting in specific combinations and ratios of the hydrocarbons monitored which defined different organic signatures found to be directly related to the target. The surficial geochromatographic dispersion of these organic compounds has also been researched and found to be able to vector to the location of buried exploration targets. SGH is thus a dual purpose deep penetrating predictive geochemistry that both locates and identifies the type of target that may be present. The SGH geochemical signature has been demonstrated at successfully locating mineral targets at depths of up to 700 metres and has identified targets of Uranium, Gold, SEDEX, VMS, Nickel, Copper, Kimberlite formations and Petroleum plays from actual surveys.*

## INTRODUCTION

The use of organic geochemical surveys for exploration has historically been confined to C1 to C4 (methane, ethane, propane, butane) compounds in the carbon series that are "gaseous" at room temperature. These compounds are at high enough concentrations to be detected often with portable hand held instruments. However these compounds are also actively cycled by the biosphere, affecting both their abundance and their flux from natural systems. The alteration of C1 to C4 signals by the biosphere and the effect of barometric pressure and precipitation on gas flux reduce their use in delineating buried targets. An alternative then to these light hydrocarbons, are relatively heavy hydrocarbon compounds. It has been hypothesized that heavier hydrocarbons are also present but at much lower concentrations. With new laboratory instrumentation and customization, research has been conducted into detecting these heavier hydrocarbons. A new geochemical technique was defined and entitled "Soil Gas Hydrocarbons" (SGH). Originally in this research B-Horizon surficial soil samples were collected for SGH surveys that focused on the analysis of hydrocarbons in the C5 (pentane) to C17 (heptadecane) carbon range which are not gaseous at ambient temperatures. Through the analysis of these more robust compounds with Gas Chromatography-Mass Spectrometry, over 160 specific hydrocarbons are reported for each sample. The large resultant spreadsheet is rich in information. To study whether SGH could be used as a deep penetrating geochemistry, research proposals were submitted to CAMIRO (Canadian Mineral Industry Research Organization). The proposals were favourably accepted and several major mining companies sponsored a multi-year CAMIRO research project in 1997 (CAMIRO 97E04). From this research SGH signatures were forensically derived and were successful at locating nine of the ten targets in the blind case studies. The targets studied in this project included Copper, Gold, Nickel, Uranium and Volcanic Massive Sulphide deposits. Interest in this geochemistry grew and a new proposal was submitted to expand the types of targets and gain a further understanding of the possible

In "Proceedings of Exploration 07: Fifth Decennial International Conference on Mineral Exploration" edited by B. Milkereit, 2007, p. 989-992

source of these hydrocarbons. In 2001, the CAMIRO 01E02 research project was initiated. This three year project was sponsored by additional major mining companies, the Ontario Geological Survey, Manitoba Geological Survey, Alberta Geological Survey and the Ontario Mineral Exploration Technologies (OMET) program and also included SEDEX, Kimberlite and Olympic Dam type targets.

## METHOD

Only one trip to the field is necessary to obtain a fist sized sample (~500 grams) from a transect or grid design consisting of at least 50 samples. These samples are shipped to the laboratory and dried in temperature controlled drying rooms kept at 60°C. The samples are sieved and the fraction that falls through a 60 mesh sieve (<250µm) is sent on for analysis. A 0.5 gram aliquot is typically analyzed from this homogenized sample. The analysis is conducted using high resolution chromatography coupled with mass spectrometry (GC/MS). The concentrations are reported in a Microsoft Excel spreadsheet for the 162 targeted hydrocarbon compounds.

## RESULTS

The analysis of soil gas hydrocarbons incorporates a very weak leach that only extracts the surficial bound hydrocarbon compounds from the sample particulates that are mobile and have migrated from depth. A forensic pattern recognition approach was used that looked at the presence or absence of various classes of hydrocarbons in the suite of 162 compounds as well as the ratios of these classes to each other. This resulted in defining specific SGH signatures for various types of targets. Early research in CAMIRO 97E04 indicated some imprecision in the measurement of the compounds detected. This was measured from laboratory duplicate results that were in the 18 to 25 percent relative standard deviation range over a wide range of sample types. As this method utilized very high resolution chromatography with very narrow peak shapes, it was found that the quantitation software often did not properly integrate the compounds peak area. New integration software was researched and purchased to more accurately measure these signals. This software was fully integrated and refined and from the period of 2004 to present day, laboratory duplicates result in an average precision of 7 percent relative standard deviation having a range of 4 to 10 percent.

In the second research project, CAMIRO 01E02, microbiological laboratory experiments where conducted. A consortium of bacteria was grown directly on various samples of ore and it was discovered that many of the SGH compounds detected were present in both the ore and surficial soil samples. It was also determined that the death-phase of the bacteria released many of the compounds detected presumably after eventual cell membrane rupture. Thus the results from surficial samples are directly influenced by the bacterial activity on the specific ore type at depth. As there were seven Kimberlite targets submitted for study, a significant amount of research was conducted on the geochromatographic dispersion of SGH compounds originating from Kimberlites. From this study, Ontario Geological Survey staff have commented that SGH appears to be an excellent tool for identifying reduced areas in overburden and possible microbiological activity at depth that are related to buried kimberlite pipes and sulfide mineralization (S. Hamilton, pers. commun., 2004).

Various sample types have been investigated through the research of case studies in different geographical environments. The soil gas hydrocarbon test originally used a near-surface sample as was used in other inorganic geochemical approaches. Research at the Ontario Geological Survey indicated that the upper B-horizon soil resulted in the higher SGH signal as a collector of these heavier hydrocarbons. The soil gas hydrocarbons compounds were determined to be very robust to general sampling, shipping and sample preparation procedures, largely due to their lower volatility due to their higher molecular weight than previous research from literature using the C1 to C4 carbon range. It is also robust to cultural activities, even to the point that successful analysis and interpretation has been done from samples taken along roadside right-of-ways. From in-house research since 2004, the variation of sample media that included lake-bottom sediments, peat, and humus were found to also act as hydrocarbon collectors with very similar results to soil. etc., can be collected within the same sample survey or transect.

The case studies researched show us that it is far more important to the ultimate interpretation of the results to take a complete sample transect or grid than to skip samples due to different sample media. Sampling design uses sample spacing from 15 to 100 m and line spacing from 50 to 500 m, depending on the size and type of target. Ideally, the sample transects or grid should have one third of the samples over the target and one third of the samples on either side of the target. There should be a minimum of two to three lines across the target with a minimum of five to six sample points along each line that are inside the target.

This design will allow the proper assessment of geochromatographic vectors within soil gas hydrocarbon data, and observations of background concentrations of each site. Samples can be drip dried in the field but need no special preservation for shipping. The soil gas hydrocarbon method has also been specifically designed to avoid common contaminants from sample handling and shipping. It is also robust to cultural activities, even to the point that successful analysis and interpretation has been done from samples taken along roadside right-of-ways.

A consistent characteristic of soil gas hydrocarbon data is the clearly defined anomalies as seen in Figures 1 and 2. Figure 1 illustrates the mapping of raw soil gas hydrocarbon data for WMC's Diana Gold prospect in Western Australia, without any additional statistical massaging, aside from a Kriging algorithm option in the Geosoft Oasis Montaj software. Figure 2 illustrates the clear anomaly that can be obtained from a kimberlite target in the Franklin area, North West Territories.

## Conclusions

The hydrocarbons detected by this very unobtrusive geochemical technique have originated from bacteriological activity at depth. It can vector to the vertical projection of a target as well as confirm the identity of the buried target through forensically determined combinations and ratios of the specific hydrocarbons monitored. SGH signatures have the ability to identify and locate a wide variety of commodities. Survey results typically have very easily

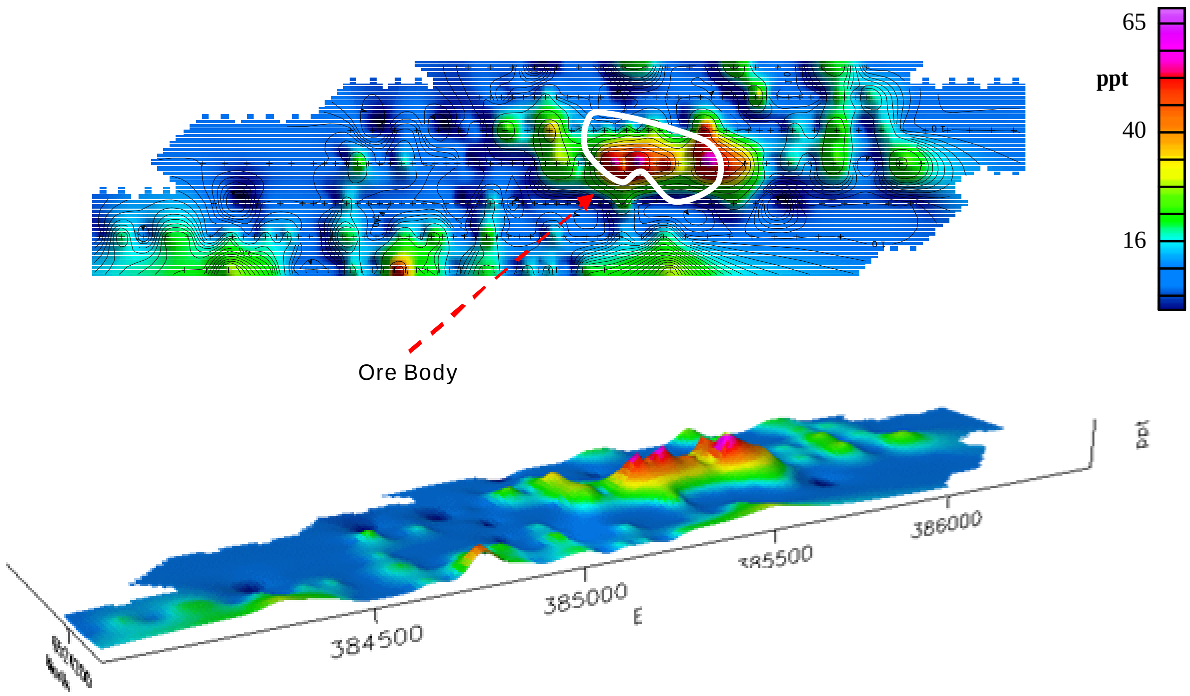


**Figure 1:** Soil gas hydrocarbon method provides characteristically clear anomalies, as illustrated here for the Diana Gold prospect, Kambalda, Western Australia. This paleochannel gold mineralization found in the gabbro is located in a hyperarid environment. The mineralization is in a series of stacked flat lying structures. The top of the first structure is approximately 25 metres in depth. The vertical projection of the outline of the buried gold deposit in the following diagram is in white. The soil gas hydrocarbon maximum value was 70 parts-per-trillion (ppt), which coincided with the location of the deposit.

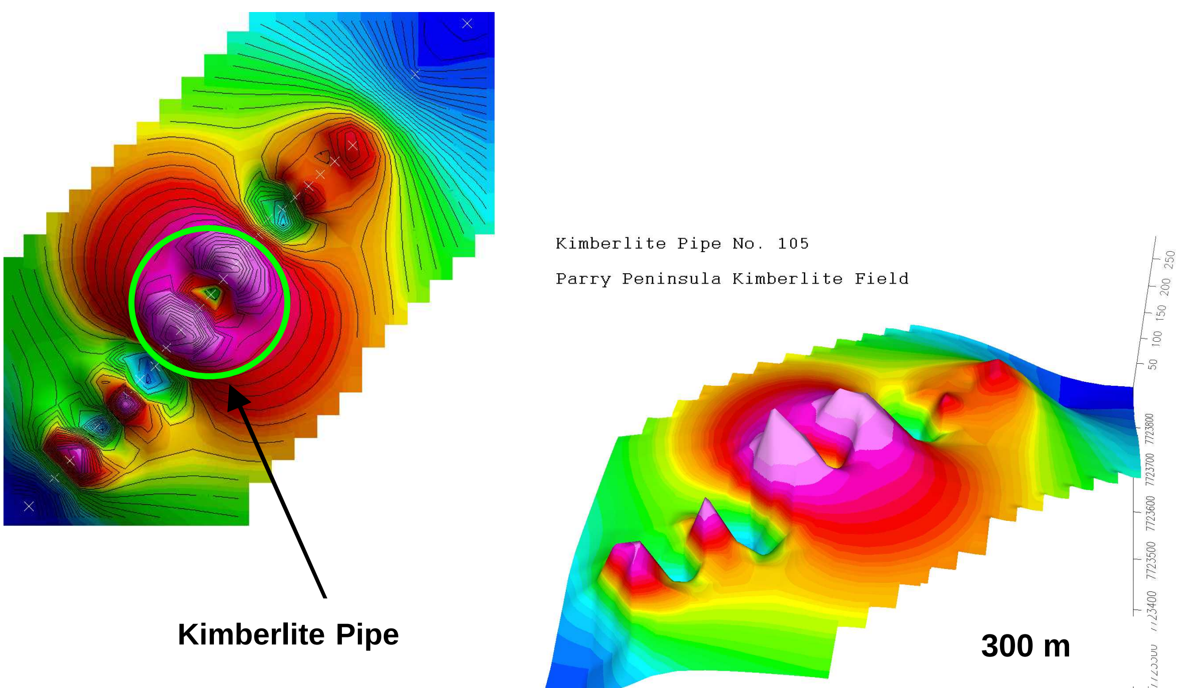


**Figure 2:** Soil gas hydrocarbon results (in plan and 3D view) from a sample transect taken over a drill-confirmed diamondiferous kimberlite under Cretaceous cover (pipe 105), Parry peninsula, Franklin area, North West Territories.

interpretable anomalies. SGH has also been shown to be able to confirm the identity of magnetic anomalies prior to the use of more expensive techniques and discriminate between barren or ore bearing conductors. The capabilities of SGH have been researched and developed for over 10 years and has incorporated research projects with the Canadian Mineral Research Organization (CAMIRO) and other studies conducted by exploration companies. Additional case studies for will be presented that show the characteristic clear and easily located anomalies associated with the vertical projection of the buried target obtained from the soil gas hydrocarbon data.

## ACKNOWLEDGMENTS

CAMIRO research projects 97E04 and 01E02, had sponsor participants from Cameco Corporation, Outokumpu, Western Mining Corporation, Inco, Cominco, BHP-Billiton, Rio-Algom, Barrick Gold, Newmont, Noranda, Anglo American, Codelco, HBED, Xstata, OGS, AGS, MGS, and the Ontario Mineral Exploration Technologies Program (OMET).

The independent consultants involved in CAMIRO 01E02 included Dr. Ronald Klusman, Dr. Gordon Southam, Dr. Joel Leventhal, and Dr. Barbara Sherwood-Lollar.

Geosoft kindly donated training and software to these projects. Mapping of SGH signatures were exclusively conducted using Geosoft Oasis Montaj.

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