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Similarities and differences in the hydrocarbon geochemical signature of various Uranium lithologies

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ABSTRACT:

Redox conditions develop over many types of buried geological bodies including those of sought after mineral targets. Above these geological occurrences a chemically reduced zone or reduced “chimney” is often formed. This leads to the development of the generally accepted electrochemical cell model. However, the detection of redox conditions in the overburden, or data from geophysical induced potential type measurements, or direct measurements of helium or radon residues as actual soil gases, are not sufficient evidence to confidently state the existence of the presence of buried uranium targets.

Bacteria leach elements from the ore body which are then used as a catalyst to synthesize organic hydrocarbons in their cytoplasm. In the death phase of these microbes, cell membranes break down and the intracellular hydrocarbons they have synthesized are released. These hydrocarbons provide a complex, and thus highly specific, forensic signature directly related to the identification of various types of mineralization at depth.

The Soil Gas Hydrocarbon (SGH) geochemistry developed by Activation Laboratories has been referred to as a redox cell locator, but it is much more than that. Although a misnomer, SGH can use a wide variety of surficial sample types in a survey, and detects a suite of 162 unique non-gaseous semi-volatile hydrocarbons. The spatial diffusion and effusion of these hydrocarbons shaped by the electro-potential gradients in the overburden provides a multi-measurement forensic signature for identification of buried exploration targets including those for uranium.

Specific combinations of the hydrocarbon classes identify the target type even at over 500 metres in depth. The expected order of dispersion or geochromatography of these classes is also able to vector to the central vertical projection of mineral targets at depth. SGH is a dual purpose deep penetrating predictive geochemistry that can thus both locate and identify blind Uranium, Gold, SEDEX, VMS, Nickel, Copper and Polymetallic mineral targets, as well as Lithium Pegmatites, Kimberlite pipes and Petroleum plays.

This poster will illustrate examples of the different types of SGH anomalies found in the results from over unconformity, roll-front, breccia pipe and IOCG type Uranium deposits in areas of difficult terrain.

METHOD:

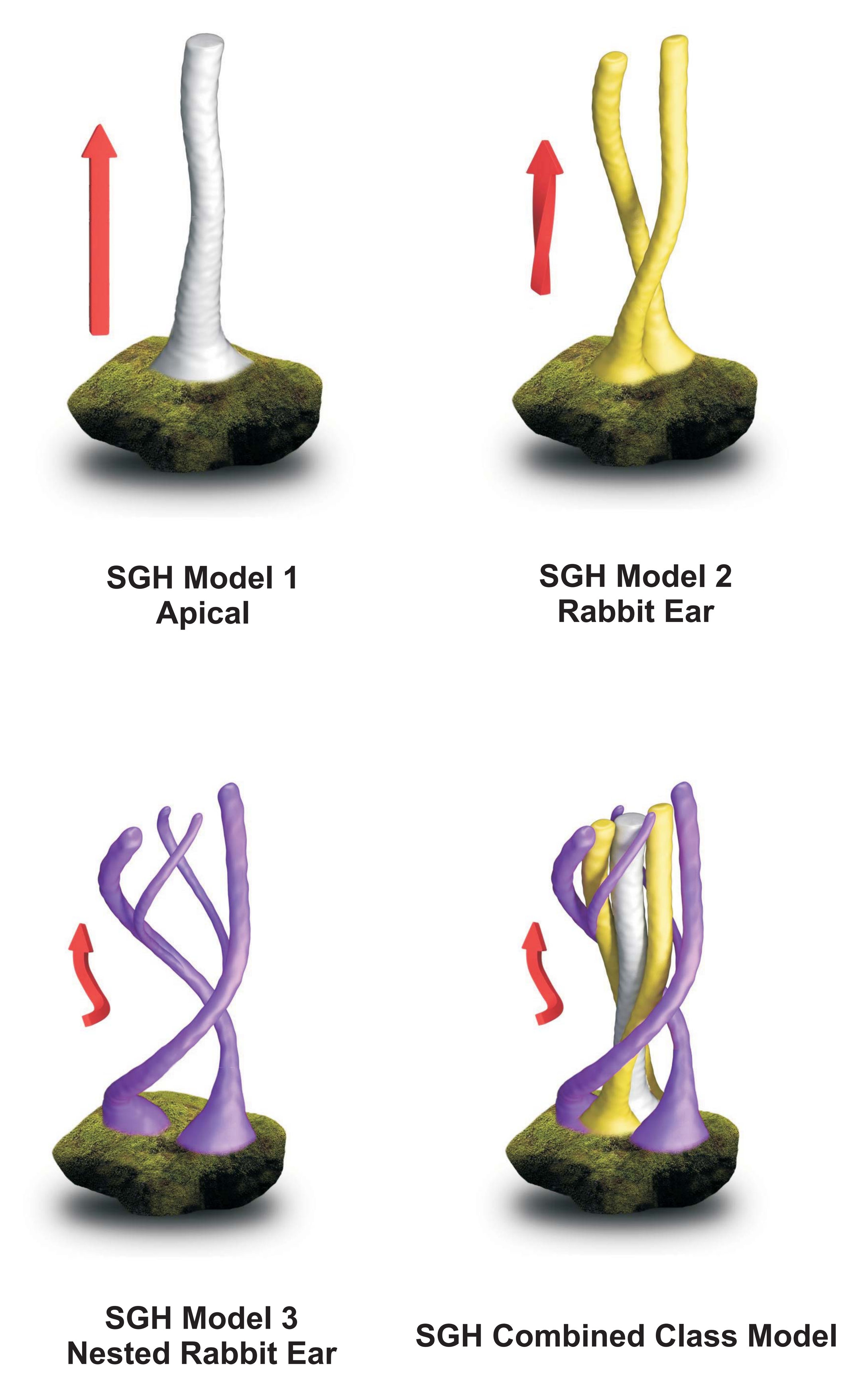
The SGH geochemistry has been proven to be able to use a wide variety of sample types that include: soils, lake bottom sediments, humus, peat, sand, silt, and even snow. The SGH method is based on a very weak leach to strip those hydrocarbons that have temporarily adhered to the particle surfaces of these substances. It is not a whole sample heated desorption technique. Aside from using snow, different sample types can be collected for SGH and used together in surveys that have a wide variety of terrain.

Samples for SGH are dried in temperature controlled rooms at 30°C and then sieved. The fraction that falls through an 80 mesh sieve is collected as the pulp sample for analysis. The weak leach extract is then separated using a Gas Chromatograph equipped with a high resolution fused silica capillary column that separates the hydrocarbons contained in the extract. The separated hydrocarbons eluting from the end of the capillary column enter a Mass Spectrometer where the computerized detector isolates by mass fragmentation a specific target list of 162 individual hydrocarbons. These hydrocarbons are not gases but are heavier molecular weight hydrocarbons in the C5 (Pentane) to C17 (Heptadecane) carbon range. The list of results is a forensic signature of identification of the sample that contains 19 different chemical classes or groups of hydrocarbons. Their different chemical characteristics determine a variation in their rates of rise of these different classes through the Redox zone in the overburden which results in a geochromatographic separation as hydrocarbon flow pathways.

RESULTS:

In an electrochemical system, nonlinear chemical systems are able to self-organize taking on ordered states such as spatially periodic variations of concentrations of chemical species (Strasser, 2000). The geochromatographic separation of the different classes of hydrocarbons results in self-organized pathways that reflect the physics and forces of the electrochemical cell.

The hydrocarbon flux pathways models have been estimated by observations of the data from hundreds of SGH surveys. These pathways correlate very well to the average molecular weight of the compounds within each of the SGH class groups. There is a natural separation of the classes of compounds by the process of geochromatography as the hydrocarbons migrate through the overburden. The lightest molecular weight class moves through the overburden to surface most rapidly and thus their pathway is near vertical as in the 3D-SGH model #1. This class is responsible for apical SGH anomalies the majority of the time. A slightly heavier class of hydrocarbons takes longer to move through the overburden and thus is dispersed more laterally, and is shaped to a greater extent by the effect of the electromotive forces of the Redox zones electrochemical cell.



(Ben Pilgrim, Graphic Artist, Toronto Ontario)

The hydrocarbon flux gradually coalesces above the deposit and self-organizes to result in a saddle-node bifurcation as the rabbit-ear type anomalies commonly observed above Redox conditions above a deposit. This is illustrated as the 3D-SGH model #2. The observation of the rotational vector of the hydrocarbon fluxes has been most readily observed in SGH results from over breccias-pipe uranium deposits and Kimberlite pipes. The detailed study of the hydrocarbon flux bifurcation that describes nested-halo anomalies has verified the rotational “screw-like” shaped rise of the hydrocarbon flux as illustrated by the 3D-SGH model #3 for higher molecular weight hydrocarbon classes.

Once these different classes of hydrocarbons reach the surface, taking a convenient near-surface sample of soil, lake-bottom sediment, sand, till, peat, humus, or even snow coupled with an SGH analysis will provide a snap-shot of the occurrence of these hydrocarbon fluxes in a survey grid. It is hoped that further study of these hydrocarbon pathways and the variety of the various bifurcations that explain geochemical rabbit-ear, nested halo, and other types of anomalies will provide an insight into the predicted depth of the target deposit in exploration surveys.

As the forensic hydrocarbon signature found over mineralization is made up of multiple classes, multiple types of anomalies are observed from the analysis of a grid of surficial samples over all types of targets. The 3D-SGH “combined-class” model illustrates the self-organizing relationships between these classes as a complete signature. Other bifurcations also exist. Some of the illustrations from over Uranium mineralization are illustrated in the case studies below. Two types of anomalies are illustrated for each of three examples of orientation or exploration surveys from over Unconformity type Uranium deposits from the Athabasca and Thelon basins and from Labrador in Canada. Three examples of Breccia Pipe Uranium lithology from three sites in North Arizona are shown in the second row. The third row illustrates sandstone hosted Roll-Front and Tabular Uranium type deposits from Mongolia and Niger as well as an example of IOCGU mineralization in Australia. The same Uranium template of classes of hydrocarbons has been used for all of these 9 case studies.

Due to the high molecular weight class of compounds important to the identification of Uranium based targets, the sample spacing can even be extended to regional surveys as illustrated in the example from Mongolia where sample spacing is 1.6 kilometres. The study of these anomalies is not an attempt to discern the different Uranium lithologies but is used to dissect the hydrocarbon flux pathways to predict the amount of time they have interacted with the electrochemical cell and thus an insight into the depth to mineralization.

CONCLUSIONS:

The specific mixture of the hydrocarbon class pathways found over a target results in a forensic signature that identifies the mineralization present and has been shown to be able to discriminate false anomalies over barren systems from those over mineralized bodies. Many templates of hydrocarbon class signatures have been defined with pathways that vector to blind mineralization and also identify the target type as either Copper, Gold, Nickel, Uranium, SEDEX, VMS, Lithium Pegmatite, Polymetallic and Kimberlite for shallow mineralization and to over 750 metres in depth, as well as for Coal, Gas, Conventional and Unconventional Oil plays, in a very wide variety of geologic and geographic settings.

The benefits from using the 3D-SGH geochemistry are:

- SGH is well known for its success in areas of difficult or disturbed terrain and/or complex overburden;
- Redox conditions and self-potential electromotive forces aid the geochromatographic separation of the hydrocarbon classes. Their differential in time during ascent through the electrochemical cell results in regular and symmetrical self-organized hydrocarbon pathways providing spatial vectoring anomalies at surface;
- The unique hydrocarbon fluxes are detected as clear symmetrical anomalies;
- The occurrence of multiple and specific hydrocarbon classes defines a template as a forensic signature to identify the type of target mineralization or play at depth;
- The interpretation of the presence of predictable 3D spatial hydrocarbon anomalies provides the highest confidence in interpretation.

The SGH analysis remains the same but the interpretation of the data using this new 3D-SGH model as “Spatiotemporal Geochemical Hydrocarbons” adds another layer of confidence and may soon enable a statement regarding depth to the target.

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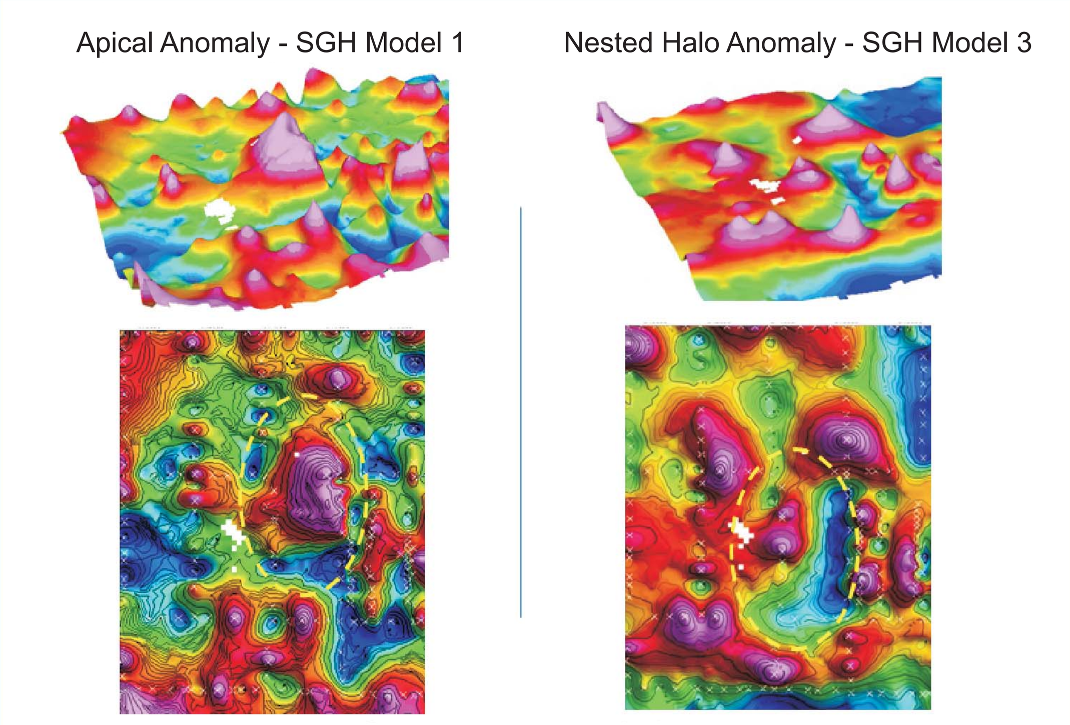
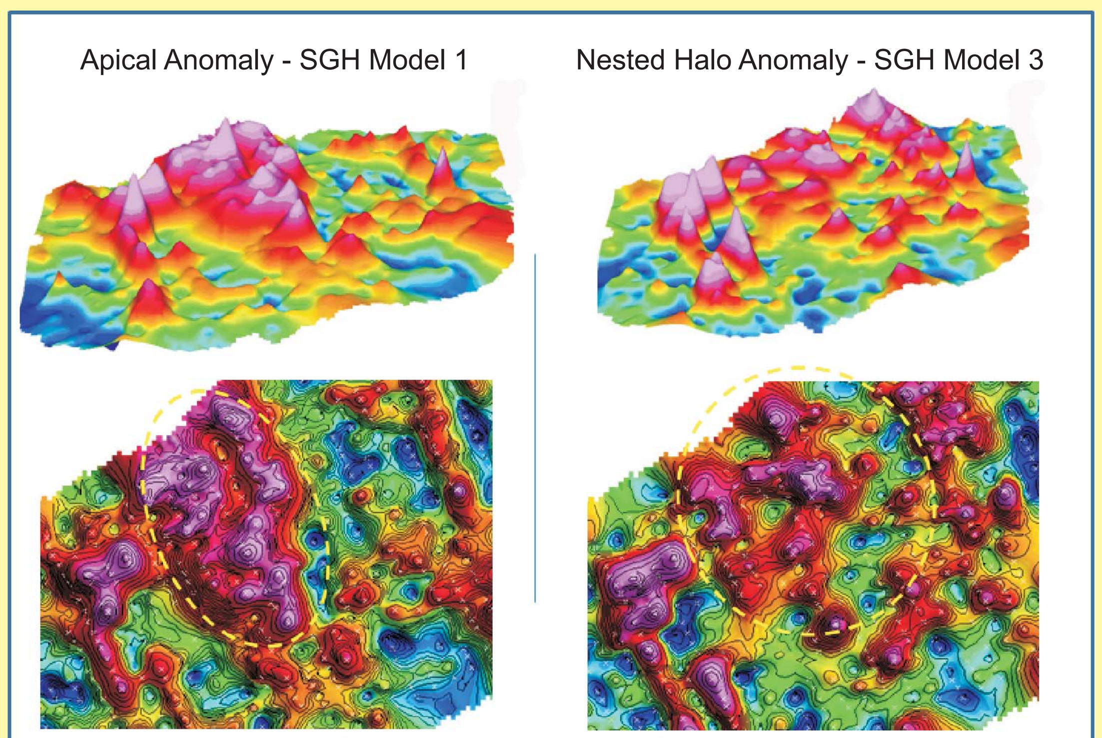
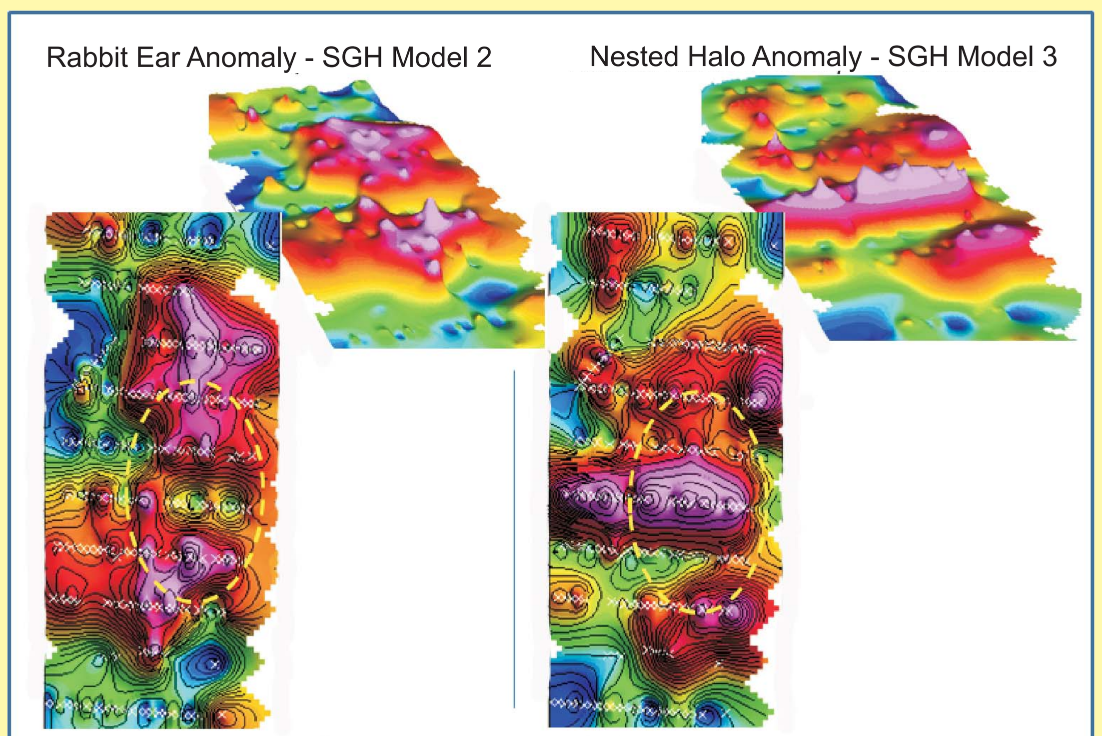


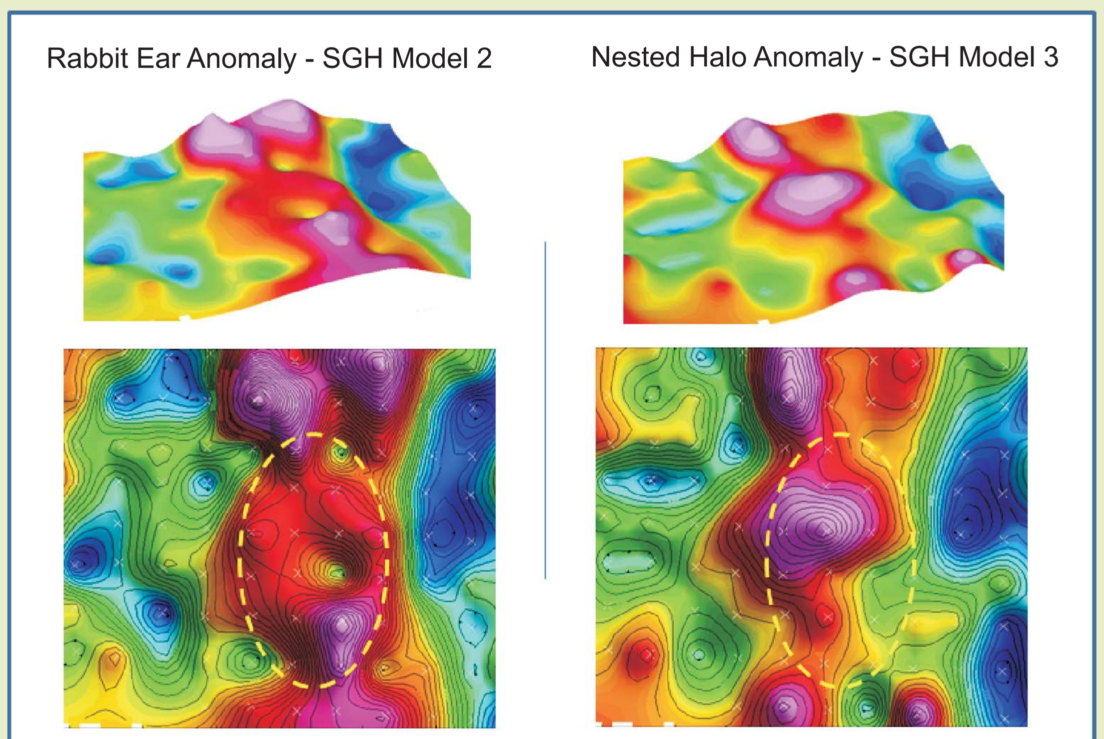
Unconformity Uranium - Thelon Basin



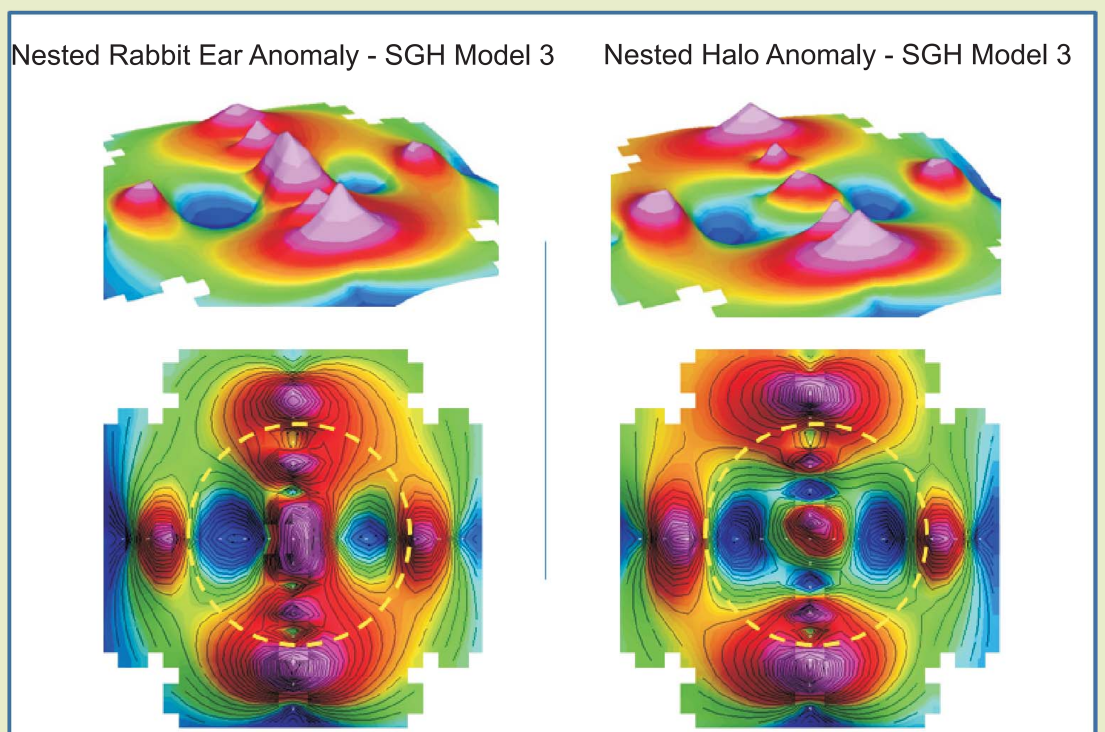
Unconformity Uranium - Labrador



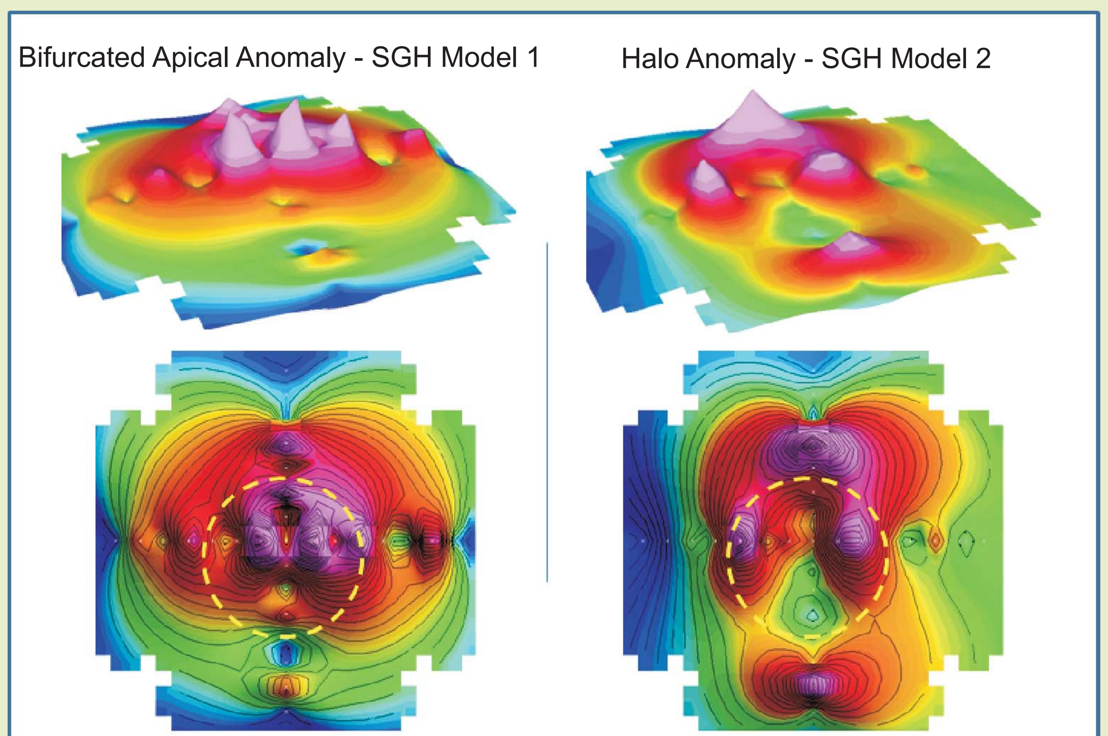
Unconformity Uranium - Athabasca Basin



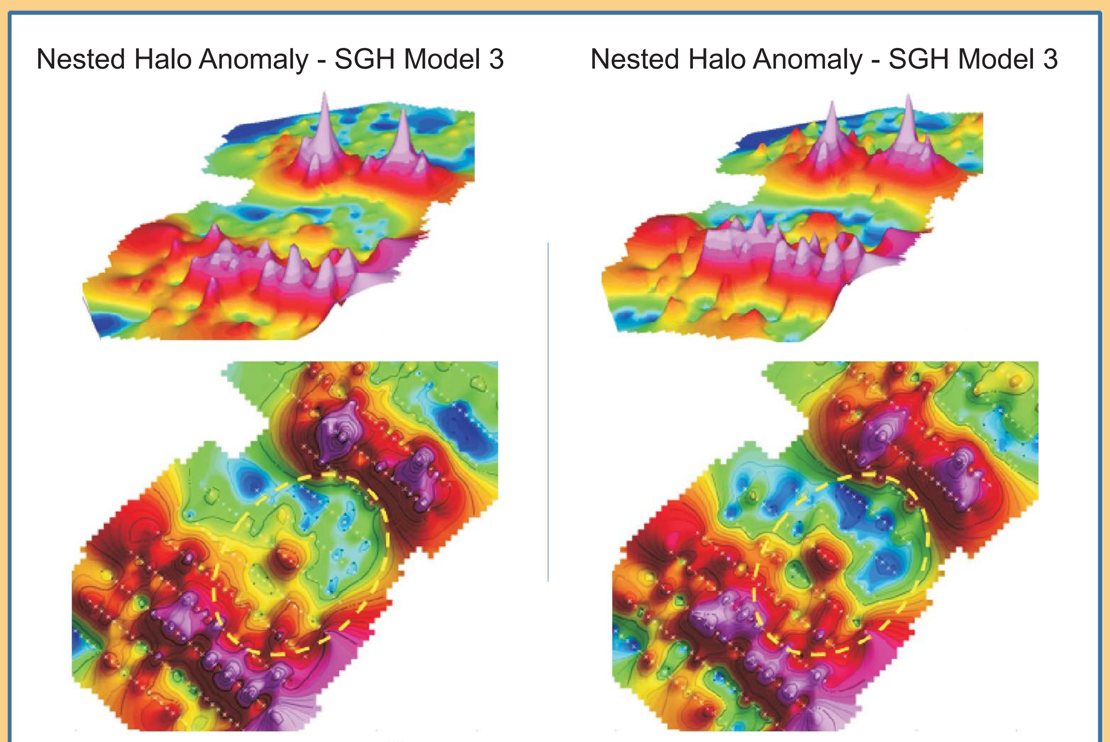
Breccia Pipe - Northern Arizona



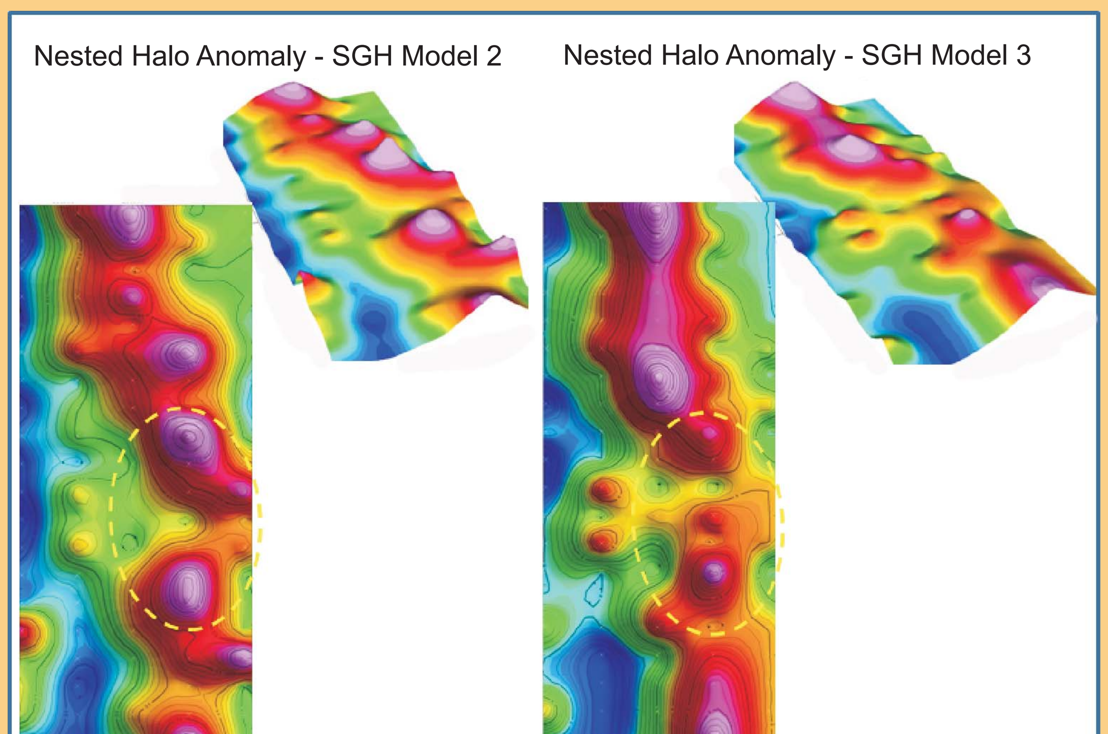
Breccia Pipe - Northern Arizona



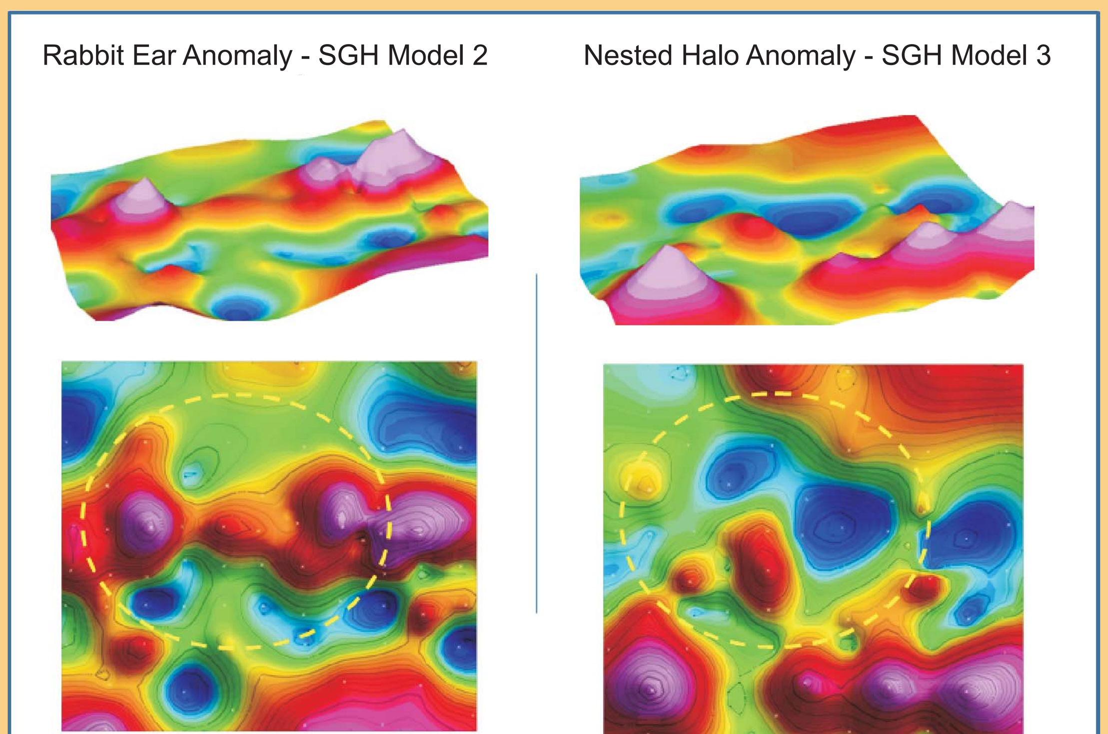
Breccia Pipe - Northern Arizona



Roll Front Uranium - Mongolia



Tabular Sandstone Hosted Uranium - Niger



IOCG-Uranium - Australia