# Geophysics Overview

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## Introduction

As part of its geoscience program, the OGS has acquired a large number of digital aeromagnetic data sets that it makes available to the public. Included with many of these data sets are first or second magnetic derivatives. Other types of derivatives can also be generated from the magnetic data. The following study has been made in order to illustrate and compare a range of enhancements that can be applied in order to add value to aeromagnetic data.

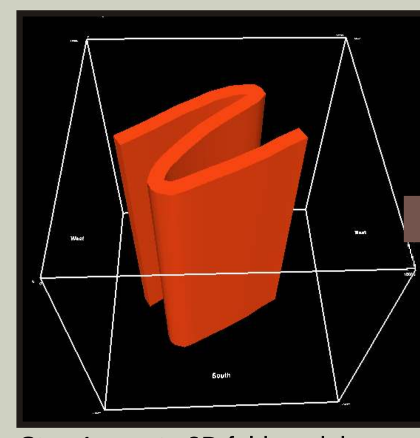
## Comparison Of Magnetic Derivatives

In order to improve the interpretation of magnetic data, many types of derivatives have been devised. The majority of magnetic derivatives have been designed to remove regional gradients and enhance near-surface responses. For most applications, such as geological mapping and mineral exploration, near-surface (within a few hundred metres of surface) magnetic features are of greatest interest. As well as enhancing the responses of shallow bodies, some magnetic derivatives can help define the edges of source bodies.

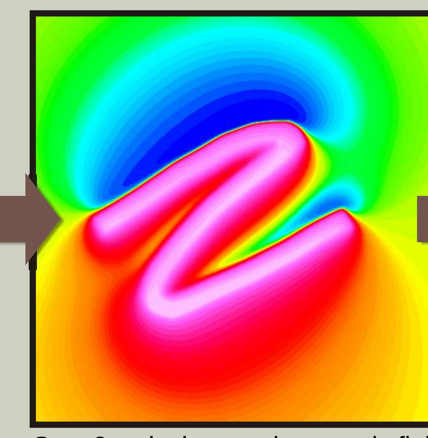
In order to compare the responses of some commonly used derivatives, two magnetic models were constructed and the total magnetic fields calculated. Several commonly used derivatives were then obtained from the total magnetic field models. The results from the first model, which represents a simple Z-shaped magnetic body, are displayed in the left panel below. The images of the second model, which comprise three pipe-like magnetic bodies with geometries similar to kimberlites, are displayed in the right panel below. The second model also provides a comparison of how the responses vary with depth to top of the simulated kimberlite bodies.

## Magnetic Modelling Sequence

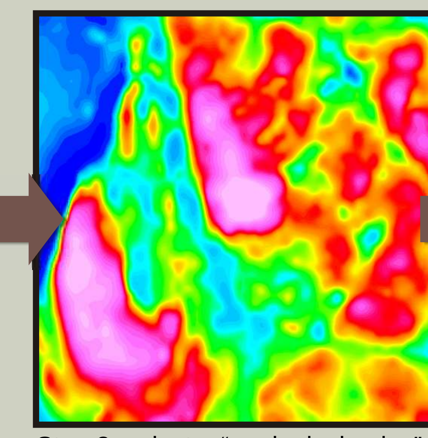
The modelling was carried out by constructing a 3-D model (see Step 1) and assigning the model a magnetic susceptibility. The total magnetic field was calculated by forward modelling (see Step 2). Although the result is mathematically correct, the lack of interfering responses or "geological noise" makes the model image appear unrealistic. Noise is added to the model by windowing real data from an aeromagnetic data set (see Step 3) and adding it to the model result (see Step 4). The modelled magnetic image, with the added noise, has an appearance and texture closer to images of real data than the model response alone. The same background noise was added to each model displayed on this poster. These "noisy" magnetic data were then used to calculate various derivatives for comparative purposes.



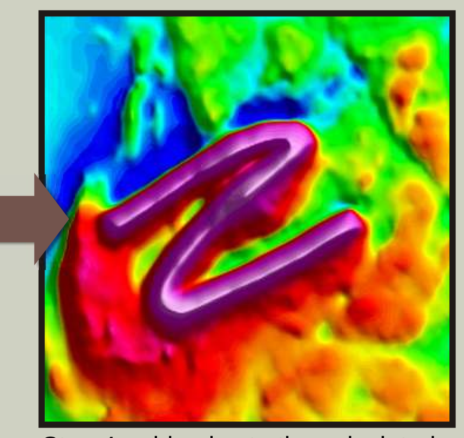
Step 1: create 3D fold model



Step 2: calculate total magnetic field response



Step 3: select a "geological noise" component

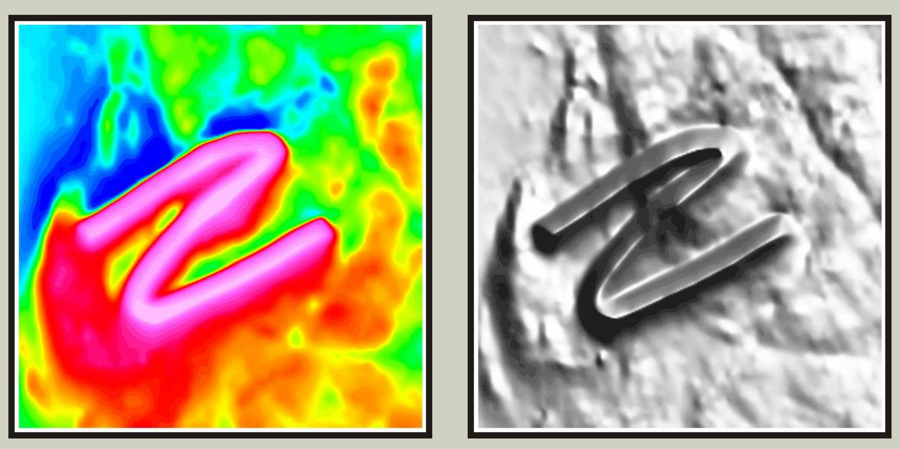


Step 4: add noise to the calculated response

## Calculated Derivatives: Z-fold Model

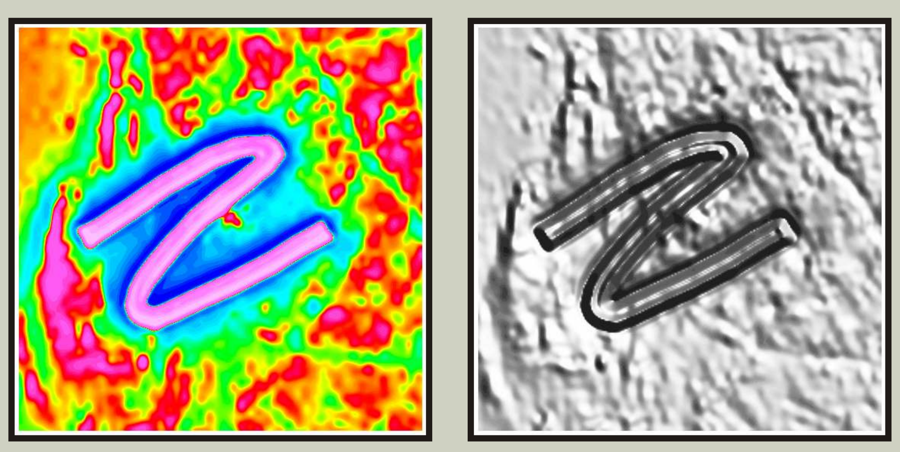
Using the model data generated as described in the Magnetic Modelling Sequence, five derivatives were calculated and displayed below, along with the modelled total field data. Colour and greyscale images are displayed to demonstrate the relative benefits of each type.

**Total magnetic field**



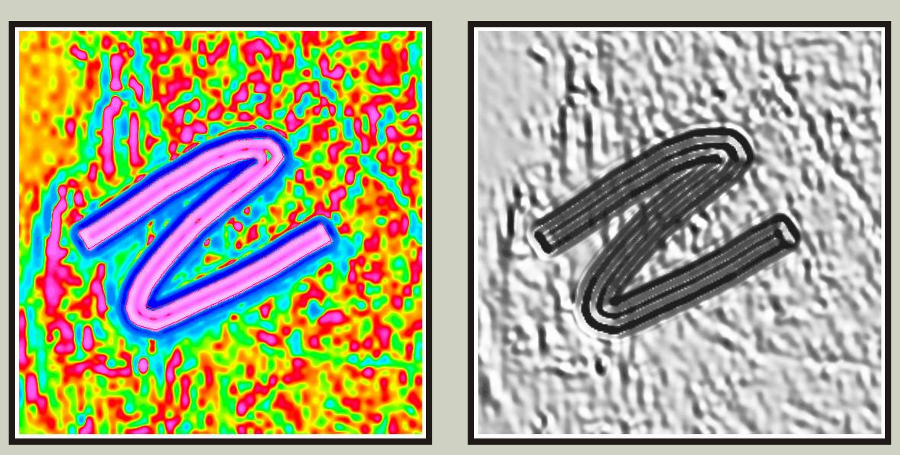
Modelled total magnetic field with "geological noise" added.

**First vertical derivative**



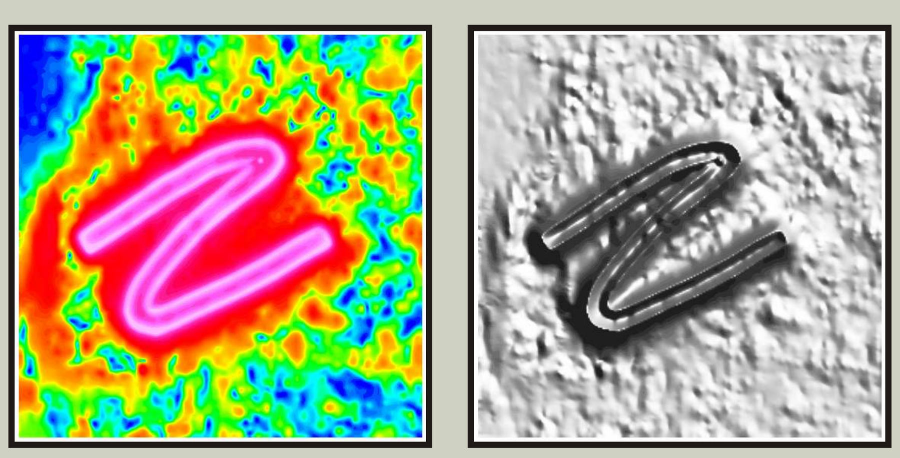
The first vertical derivative does an effective job removing the regional gradients and provides for better resolution of features.

**Second vertical derivative**



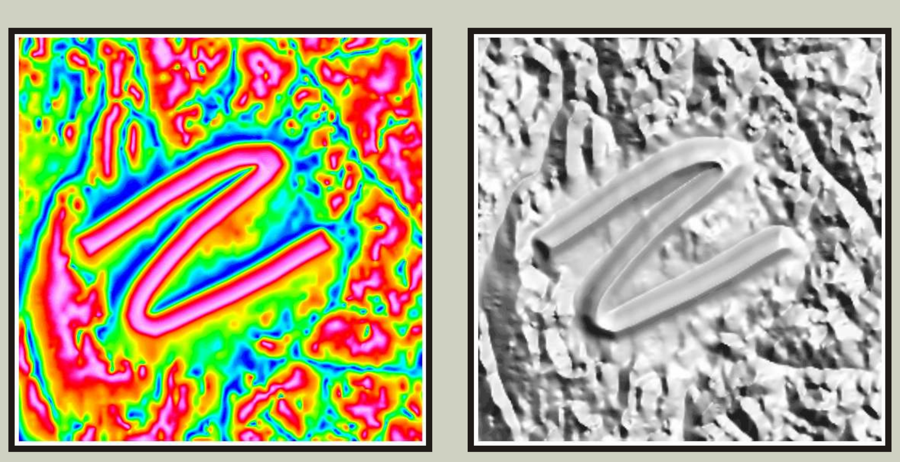
The second vertical derivative (2VD) provides tighter definition of bodies than the first derivative. The zero crossovers of the 2VD coincide with the edges of a wide, vertical, induced magnetic body. As with any higher derivatives, the 2VD tends to amplify "noise". Small incoherent features should therefore be discounted. However, the noise component often creates distinctive magnetic textures which can be used to distinguish rock types.

**Analytic signal**



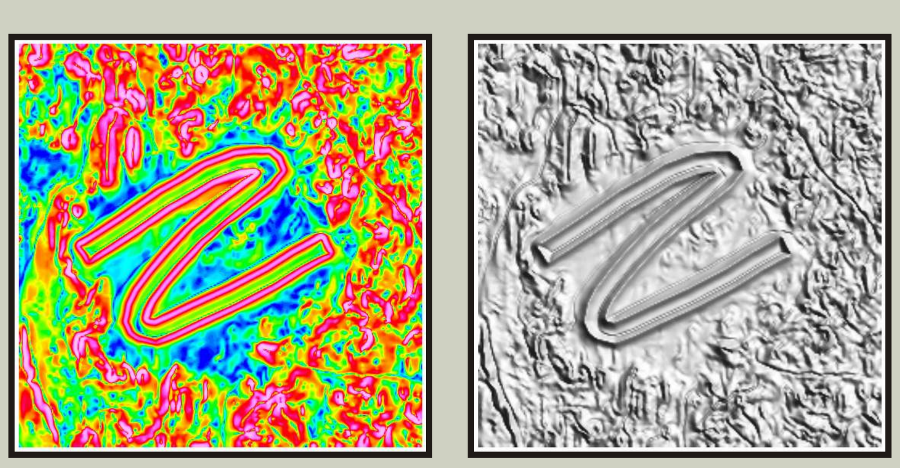
The Analytic Signal combines calculated first derivatives in the x, y and z directions. The technique creates peaks over the edges of wide magnetic bodies and the centres of small bodies. The analytic signal is frequently used in areas of low magnetic latitude or high magnetic remanence.

**Tilt Derivative**



The tilt derivative is the angle between the total horizontal derivative (x and y directions) and the first vertical derivative. Tilt derivative values vary between +90° and -90°, thus reducing amplitude variations between anomalies and at the same time removing regional gradients.

**Horizontal gradient of tilt derivative**

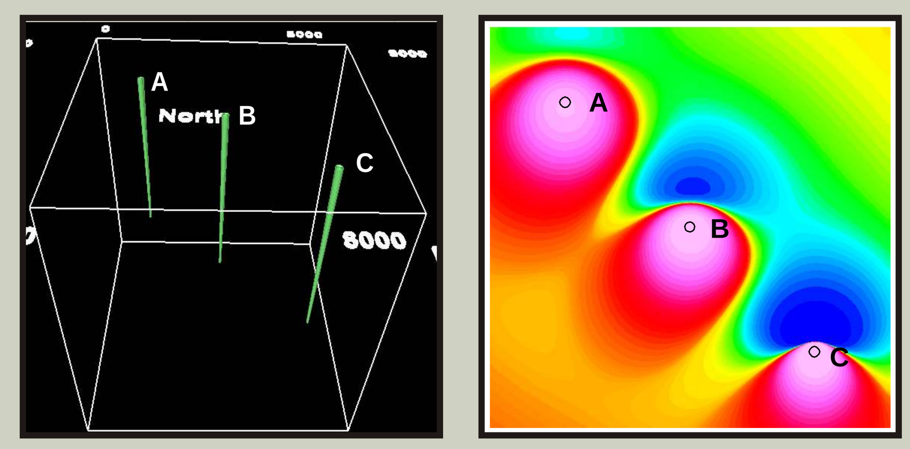


The total Horizontal Gradient of the Tilt Derivative (THDR),` like the analytic signal, is insensitive to the inclination of the magnetic field, a concern in low latitudes and with remanent bodies. However, the THDR offers better edge detection than the analytic signal. Like the 2VD this derivative strongly amplifies noise.

## Calculated Derivatives: Kimberlite Model

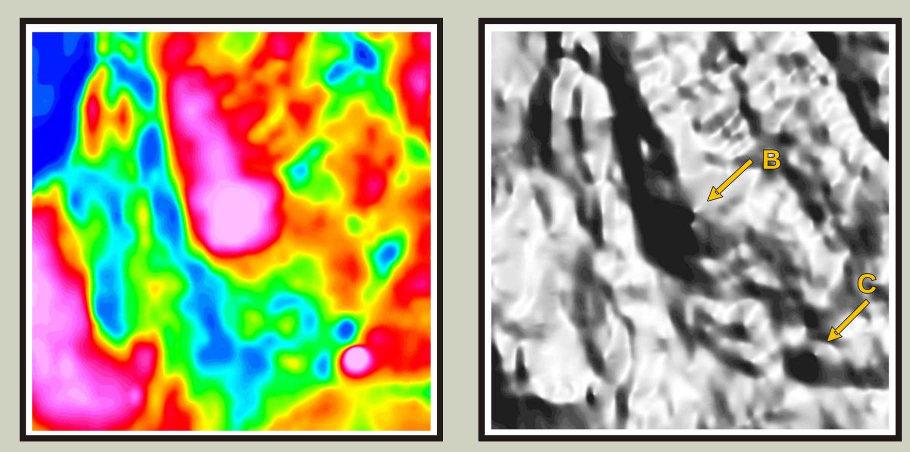
In order to compare the responses that might be expected from magnetic kimberlites using different derivative calculations, the following images were prepared. Three pipe-like bodies were modelled with tops at 0, 200m and 500m below surface to show how the responses vary with depth. The responses were obtained using the same process that was used for the Z-fold model (left panel).

**Total magnetic field -** ***no noise***



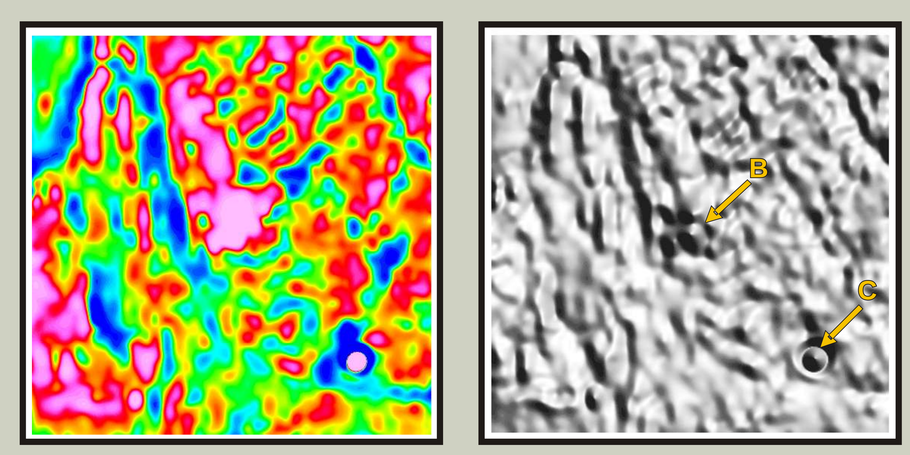

Perspective view of the three modelled pipes (left). Depth to top: A=500m, B=200m, C= 0. Pipe diameter (at top) = 200m. Magnetic susceptibility = $1X10^{-2}$ SI. Modelled total magnetic field response (right)

**Total magnetic field -** ***noise added***



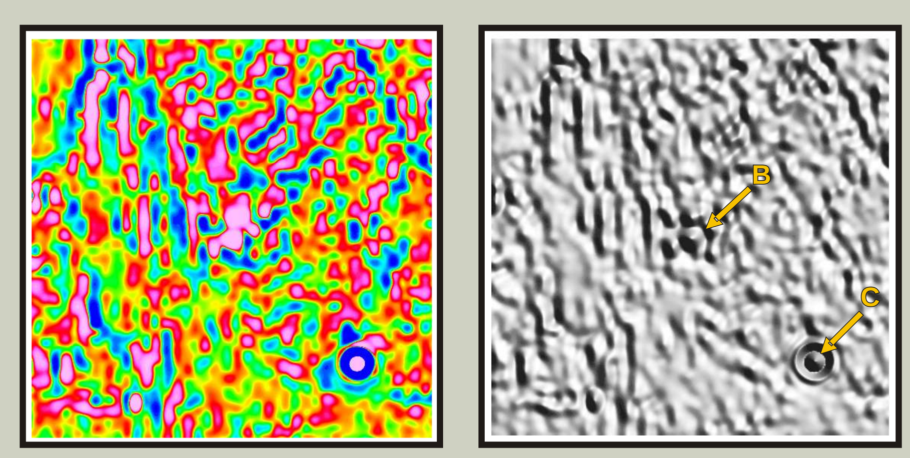
After geological noise was added to the modelled total magnetic field data, pipe A (top at 500m) is not imaged and pipe B (top at 200m) is only marginally detectable. Pipe C, which comes to surface, is clearly visible.

**First vertical derivative**



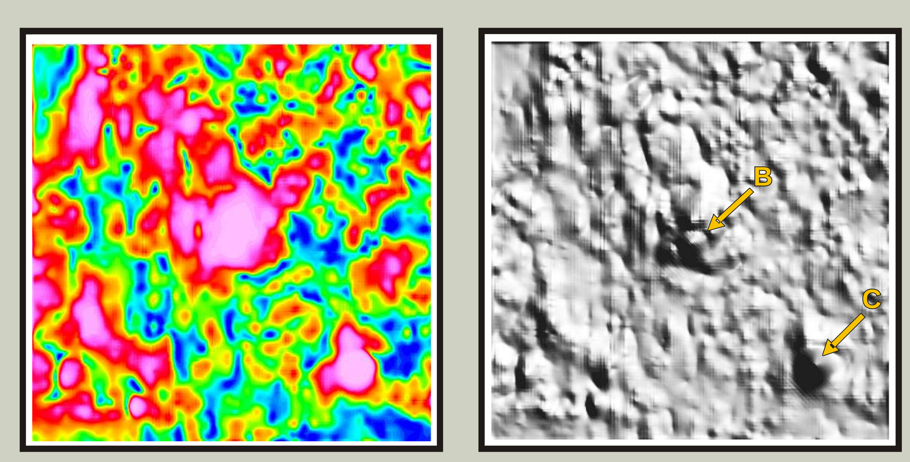
In spite of the geological noise, model pipes B and C are clearly visible in the first vertical derivative presentation. The response of pipe C, which comes to surface, is enhanced by the negative undershoot that surrounds the anomaly peak.

**Second vertical derivative**



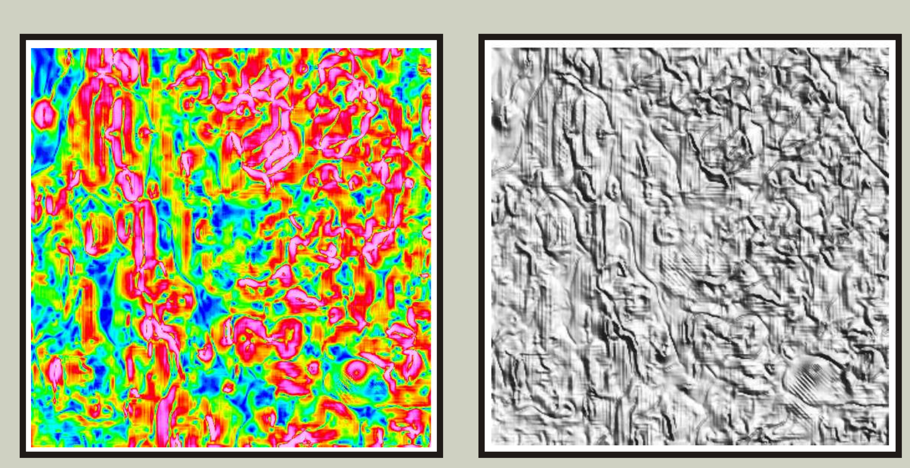
Model pipes B and C are evident in the Second Vertical Derivative images. The shallow pipe (C) is particularly well displayed by this derivative.

**Analytic signal**



The Analytic Signal highlights pipe C satisfactorily. The response from Pipe B, although visible, is less readily identified.

**Horizontal gradient of tilt derivative**



The Total Horizontal Tilt Derivative (THDR) does a poor job of imaging the modelled pipes. The response from shallowest pipe (C) is just visible.

In the presence of typical host rock background magnetic responses ("geological noise") none of the derivatives were able to image the deepest pipe (A). The first and second vertical derivatives appeared to be the most successful in highlighting the responses of the pipe models B and C which are buried at 200m and come to surface, respectively. The analytic signal and THDR, both of which incorporate horizontal derivatives and are good for edge detection, imaged the models only moderately well to poorly.

***Precambrian Geoscience Section***

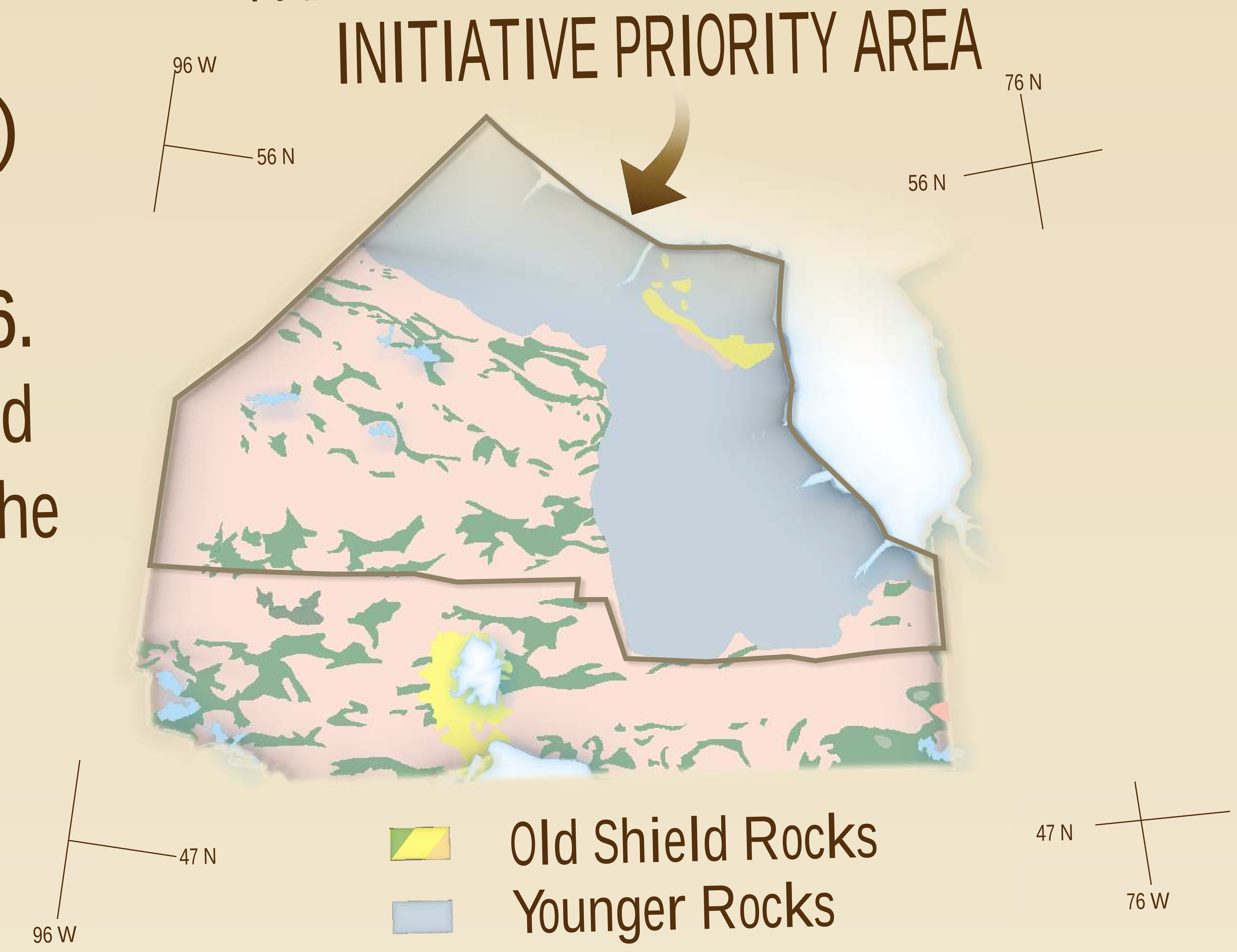
# WANTED

## Airborne Geophysical Data

As part of the geophysical component of the Far North Geological Mapping Initiative, the Ontario Geological Survey (OGS) is looking to buy airborne geophysical data in the Far North region. The data will be reprocessed to conform to OGS formats and standards prior to publication. It is hoped that these data sets will provide a valuable resource for companies exploring in Northern Ontario.

A "Request for Data" is presently in effect. This document can be viewed and downloaded from the MERX website (www.merx.com) by searching for "OSS-074345". The closing date is **Dec. 29, 2006.** All submissions will be evaluated according to criteria set out in the Request for Data document. Offers to purchase data will be made according to the highest ranking submissions.

FAR NORTH GEOLOGICAL MAPPING INITIATIVE PRIORITY AREA



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