BEYOND SINGLE-SENSOR MAGNETIC SURVEYING. THE PAST, PRESENT AND FUTURE OF AIRBORNE MAGNETIC ACQUISITION FOR KIMBERLITE EXPLORATION

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The airborne magnetic surveying method is the single most important geophysical tool in diamond exploration. It is cost effectiveness and large areas can be covered rapidly. De Beers Exploration has continuously strived to increase the effectiveness of this method within diamond exploration. This paper illustrates the advantages of magnetic gradient data over total magnetic field data, concentrating on De Beers' in-house developments and briefly introduces the concept of full tensor magnetic gradiometry. This framework essentially covers the past, present and future of magnetic data capture for kimberlite exploration.

PAST – SINGLE SENSOR SURVEYING

Historically, magnetic data was routinely acquired by single sensor platforms. However, forward modeling has shown that the total field reconstructed from the gradient data more accurately represents the true magnetic field than the measured total field. Most contractors have developed multi sensor platforms very few single sensor airborne platforms remain in service.

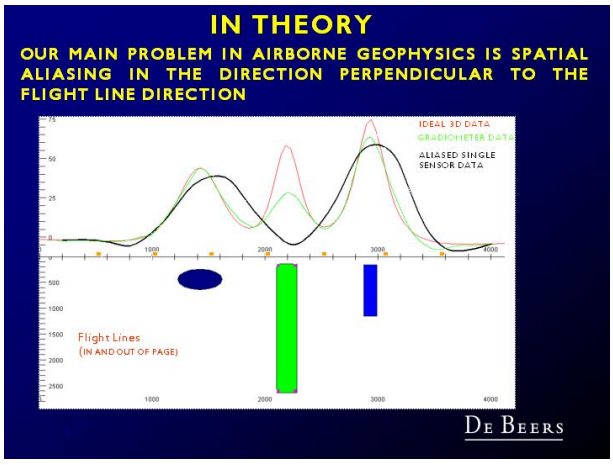

Figure 1A. In Theory.

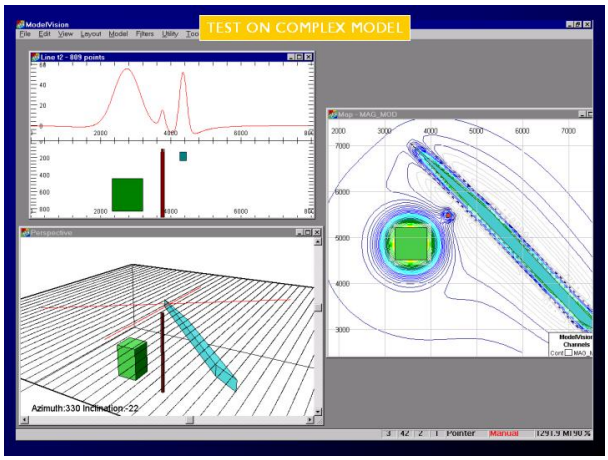

Figure 1B. Test on Complex Model.

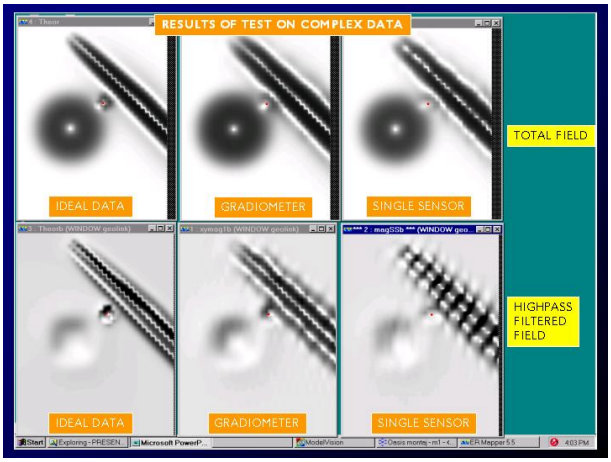

Figure 1C. Results of Complex Tests.

PRESENT – MULTIPLE SENSOR OR GRADIENT SURVEYING

Until recently, no commercial software was available to process data from such platforms, so De Beers developed in-house software to achieve this. The software was unimaginatively named "MagGrad Tools". Using this software, entire datasets could be processed in the order of hours rather than days, as is required with conventional leveling routines.

Single sensor data suffers from aliasing and consequently, most anomalies are spatially located under flight lines. MagGrad tools was developed in order to:

- Reduce the extent of Aliasing.
- Correctly locate anomalies.
- Reduce processing time (no need to wait for final products)
- Reduce processing and acquisition costs (minimal or no tie lines required)
- Reduce the exploration time cycle

Apart from reducing data alising, gradient is independent of diurnal activity and the form of the anomaly is more correct.

MagGrad Tools Methodology (GX Development and Compatibility with the OasisMontaj environment)

- The number of sensors on the aircraft and their relative separations can be specified in the "platform" GX.

- Leveled gradient channels are computed and the median value removed from each line.

- The longitudinal component (dy) is calculated by taking the difference between the average of the wingtip sensors, and the bottom tail sensor, and dividing this value by the distance between the midpoint of the wingtips and the tail sensor. The lateral gradient (dx) is calculated from the difference in wingtip sensors divided by the distance between them. The vertical gradient (dz) is calculated from the difference in the tail top and bottom sensors divided by the distance between them.

- The anomalous total magnetic field may be estimated from the measured gradients using the two dimensional Hilbert transform relationship between the gradients of a potential field and the field values or by integrating the measured vertical component (Dz). This is best achieved by using Fourier Transform methods (See Nabighian, 1984 & Nelson, 1994).

The regional field which is filtered out by the gradiometer system, is re-introduced back into the anomalous total magnetic field grid. The resultant grid is dubbed the reconstructed total field.

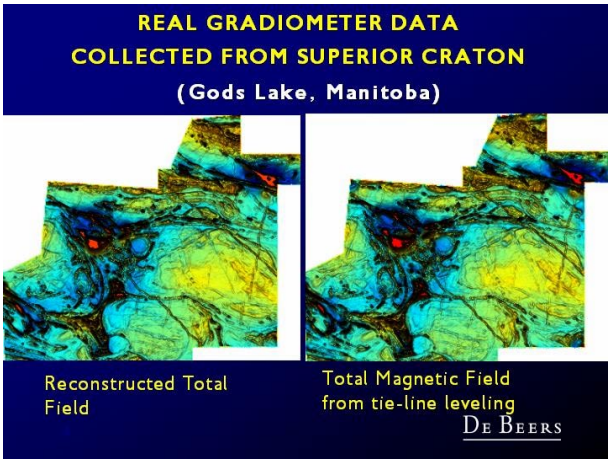

Figure 2A. Comparison of Data.

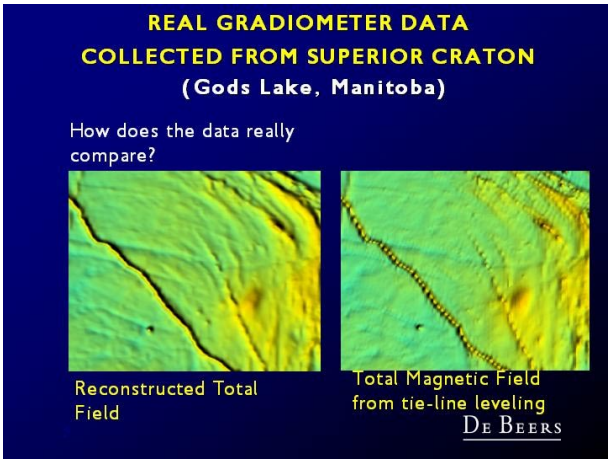

Figure 2B. Zoomed in Comparison of Data.

FUTURE – FULL TENSOR SURVEYING / ADVANCED PROCESSING METHODS

Contractors are processing magnetic data using conventional tie line leveling methods. This is an inferior product to gradient leveling methods. The DBCEI product is not the perfect solution but it is a significant improvement. There is 'cross talk' or a mixing of gradients due to roll, pitch and yaw aircraft motion which degrades the data. Development is continuing to try and deconvolve the data. Synthetic data examples produced by Petros Cikon show profile data true to the original form. Even though MagGrad Tools represents a significant advancement in magnetic gradiometer processing, there is scope for additional enhancement. Presently the total field is derived from the horizontal gradients using the two dimensional Hilbert Transform.

Other methods of enhancing the total field grid are now available and are being evaluated. These methods fall

under the general category of "gradient enhanced gridding". Research is aimed at reducing the effects of aircraft maneouvre on the raw gradient measurements. The main limitation and probably the largest error is the accurate determination of the aircraft heading . Most platforms presently do not provide this information. The next step is to accurately define the exact movements of the sensors. It is still to be determined how many sensors are actually needed and what is the optimum sensor configuration. Additionally, the total field, analytical signal and vertical derivative will be reconstructed from 1-D (profile data). This research is ongoing and as much data will be presented as is available.

De Beers is also a sponsor of the GETMAG research project managed by the CSIRO in Australia. The aim is to develop a full tensor magnetic gradiometer system. Data acquired with such a system would not be degraded by aircraft maneouvre, and could be used in sophisticated algorithms to determine magnetic remanent properties in-situ and develop more accurate modeling and inversion software. De Beers are also carrying out research with Bedrock Research Corp. to generate, display and manipulate three dimensional vectors on a 2-D surface.

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