Structural Mapping from High Resolution Aeromagnetic Data in Namibia using Normalized Derivatives

D. Fairhead\textsuperscript{1,2}, S. Williams\textsuperscript{1} and A. Ben Salem\textsuperscript{1}

\textsuperscript{1}Getech, \textsuperscript{2}University of Leeds

Summary
We generate a range of normalized derivatives for high resolution aeromagnetic data from Namibia, and illustrate their effectiveness for structural mapping. A rapid method of mapping the depth of cover is also applied to the study area.

Introduction And Methodology
Magnetic maps contain signals with a wide range of amplitudes, reflecting the varying depth, geometry and susceptibility contrasts of sources. Such maps are often dominated by large amplitude anomalies which can obscure more subtle anomalies. Modern methods of color display such as histogram color equalization and false shaded relief help to some extent to enhance these subtle anomalies.

In the last few years there have been a number of methods proposed to help normalize the signatures in images of magnetic data so that weak, small amplitude anomalies can be amplified relative to stronger, larger amplitude anomalies. Examples of normalized derivatives discussed here include the Tilt derivative (Miller and Singh, 1994, Verduzco et al., 2004), Theta derivative (Wijns et al., 2005) and TDX derivative (Cooper and Cowan, 2006).

These methods were reviewed and critically evaluated using geologically relaistic models by Fairhead and Williams (2006). Here, we apply the methodologies to high resolution aeromagnetic data from Namibia. We also use a range of local wavenumber methods to determine the depth to top of sources to investigate the variability of these estimates and determine which is best. These results will be presented and discussed.

Namibia Case Study
We have used normalized derivatives to study an aeromagnetic data from north-central Namibia, the same data used by Verduzco et al (2004) in their work on the tilt derivative. The 12 x 14 km study area contains the Erindi gold prospect, located on the eastern boundary of the Central Zone of the Damara Orogen. Gold occurrences in this area are associated with metamorphism and magmatic intrusions within the Swakop Group marbles. The associated ore minerals are dominated by pyrrhotite, pyrite, and magnetite, thus the mineralized zones are highly magnetic. Basement is covered by extensive soil and calcrete, up to 10 m thick.

The TMI anomaly grid (Figure 1) is derived from a survey with flight spacing 200 m, flying height 80 m and flight-line direction N-S. The data was reduced to the pole using a magnetic inclination of $-62^\circ$ and declination $-12^\circ$ (Figure 2). Gradients and normalized derivatives were calculated from the RTP data, and are shown in figures 3-11.

In common with the model data examples, the figures illustrate the ability of normalized derivatives to amplify subtle signals within the magnetic anomaly grid. Although all the derivatives shown are first order derivatives of the RTP anomaly grid, the normalized derivative maps offer sharper definition and greater lateral continuity of features in many areas.
Figure 1. TMI magnetic anomaly.

Figure 2. RTP magnetic anomaly.

Figure 3. First Vertical Derivative.
Figure 4. Total Horizontal Derivative.

Figure 5. Analytic Signal.

Figure 6. Tilt Derivative.
Figure 7. Tilt Derivative > 0.

Figure 8. Theta Map.

Figure 9. Theta Map > 0.8.
Conclusions
Since each of the normalized derivatives described here exploit the local phase in subtly different ways, the choice of which derivative to use is somewhat subjective for structural mapping. The zero contour of the Tilt and DTX and the maxima of the Theta track the zero contour of the vertical derivative. Under certain assumptions, the normalized derivatives may be used to track magnetic contacts. However, for data from areas of low magnetic inclination or data that is Reduced-to-Equator, tracking edges or interpreting structural dip from the asymmetry of normalized derivatives (Wijns et al., 2005) should be carried out with caution. Finally we have applied a range of local wavenumber methods to estimate and map the thickness of cover.

References