Paper 63

Air-FTG® For Regional Scale Mapping

Mataragio, J. [1], Brewster, J. [1], Murphy, C. [2], Mims, J. [1]

1. Bell Geospace Inc., Houston Texas
2. Bell Geospace Inc., Aberdeen, UK

ABSTRACT

Airborne Full Tensor Gradiometry (Air-FTG®) was flown at high altitude coincident with airborne gravity (GT1A) flown in 2003 in West Arnhem Land, Australia. A preliminary analysis of two data sets indicates that the Air- FTG® system has the capability of resolving intermediate to long wavelengths features that may be associated with relatively deeper geological structures. A comparison of frequency filtered slices and power spectral density (PSD) for both data sets using the short (> 5 km), intermediate (10 km) and long (20 km) wavelengths reveals that high altitude Air- FTG® data show greater response in high frequency anomalies than GT1A and matches well with the GT1A even at the longest wavelengths anomalies.
The effect of line spacing and target resolution was examined between the two data sets. Reprocessed gradient and airborne gravity data at 2, 4 and 6 km line spacing suggest that Air- FTG® could be effectively flown at a comparatively wider line spacing to resolve similar targets the GT1A would resolve with tighter line spacing.

INTRODUCTION

Airborne Full Tensor Gradiometry (Air-FTG®) data have been available to the mining industry since 2002 and their use for geologic applications is well established. However, Air-FTG® data has been mostly considered and used in mapping and delineation of near surface geological targets. This is due to the fact that gravity gradiometer measurements are well suited to capture the high frequency signal associated with near-surface targets (Li, 2001). This is possible because the gradiometer signal strength falls off with the cube of the distance to the target. Nonetheless, in recent years there has been an increasing demand from the mining, oil, and gas industry in utilizing Full Tensor Gravity Gradiometer as a mapping tool for both regional and prospect level surveys.

Air-FTG® as a Regional Mapping Tool

Several, relatively low altitude surveys have been successfully flown in Brazil, Canada and Australia mostly targeting large, regional- scale crustal structures as well as regional mapping of both lithology and regolith. Air-FTG® mapping is especially effective in areas of thick lateritic and/or clay cover where other geophysical methods such as airborne magnetics or electromagnetics become less effective. For instance, an Air-FTG® survey was successfully flown in Brazil in the Province of Minas Gerais, where several crustal-scale structures associated with iron oxide mineralization were identified (Mataragio et. al., 2006). In addition, in 2006 Air-FTG® had good success in the regional mapping of structures associated with Iron Oxide Copper Gold (IOCG) and uranium mineralization in the Wernecke Mountains in the Yukon, and Northwest Territories, Canada.

On the basis of these successful surveys, Bell Geospace has initiated a number of high altitude test surveys aiming at evaluating the performance of the Air-FTG® system in capturing

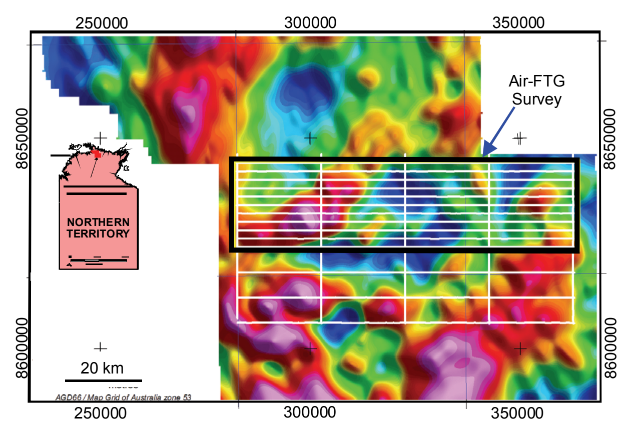

Figure1: The location map of a test survey at West Arnhem Land, Australia and the free Air Gravity data from the 2003 GT1A survey. The Air-FTG® survey location is shown in black rectangle. The GT1A data is obtained from Australian Geoscience's website.

In "Proceedings of Exploration 07: Fifth Decennial International Conference on Mineral Exploration" edited by B. Milkereit, 2007, p. 885-888

low frequency signal that may be associated with regional, deeper structures.

One of the test surveys was conducted in December of 2006 in Australia, where the performance of Air-FTG® and the conventional airborne gravity (GT1A) were evaluated. GT1A is currently considered well suited for capturing low frequency signal.

The matching Air-FTG® survey was flown at a high altitude drape coincident over a portion of a 2003 GT1A survey (Figure 1) at an altitude of 655 m above mean sea level.
Survey lines were flown in the east-west direction at spacing of 2 km, whereas the tie lines were flown in the north – south direction at a 20 km spacing. The results from both surveys are compared and evaluated in this study.

METHODOLOGY AND DATA PREPARATION

The GT1A data flown in 2003 is in public domain data and was obtained through download from the Geosciences of Australia website. For the GT1A data to be directly compared with Air-FTG®, the vertical gradient of the GT1A data was computed by taking the first vertical derivative of the airborne gravity data. Figure 2(A) shows the calculated Tzz response (Tzz_GT1A_1VD).

The measured Air-FTG® free air data was micro leveled and full tensor processed (FTP) prior to evaluation and comparison. Full Tensor Processing is a de-noising technique which takes into account of all the five tensor components of the gradient to remove noise in the data (Colm et al., 2006). Figure 2(B) shows a free air full tensor processed vertical component of gradient data (Tzz_FA_FTP). Both Tzz_GT1A_1VD and Tzz_FA_FTP are compared with the digital elevation model (Figure 2(C)).

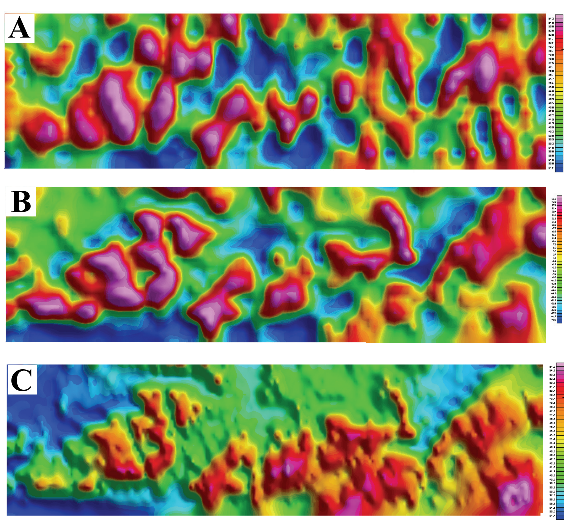

Figure 2: (A) First vertical derivative of airborne gravity (Tzz_GT1A_1VD), (B) Free air full tensor processed vertical gradient data as measured by the Air-FTG®, (C) Digital Elevation Model.

DISCUSSION OF RESULTS

Frequency filtering of both data sets focusing on short, intermediate and long wavelengths was performed to examine the strengths of each data set in capturing the respective signals. In addition to frequency capture capability, the effects of line spacing for each system in resolving subtle targets were investigated.

Frequency Content Analysis

Frequency analysis of both data sets was performed using Geosoft Oasis Montaj software. Both data sets were low pass filtered using a Butterworth filter at 5, 10, and 20 km cutoff wavelengths.

At 5 km cutoff wavelength the two data sets broadly seem to correlate in terms of capturing near surface high frequency signals, however a close look at the shape and size of the anomalies in black box reveals considerable differences in resolution between Figures 3(A) and 3(D).

For this study a ten kilometer low pass filter is considered to be somewhat representing intermediate to short frequency contents. Both data sets resolve similar linear gravity highs and lows anomaly features mostly trending northeast-southwest (Figures 3(B) and 3(E)).

In view of the size of this survey, a 20 km low pass filter is considered a practical cut off wavelength associated with low frequency contents. Anomaly correlation at this filter level seems to be fairly good with anomalies being dominated by regional structure across the area. Differences exist as well such as a north-south trending gravity high that is more or less located to the east side of the survey area in Figure 3(C). This feature is more obvious in Air-FTG® data than in GT1A data. The relatively round northern and southern gravity highs anomalies are well resolved in each data set (Figures 3(C) and 3(F)).

Spectral Comparison

The power spectral density (PSD) was taken for both Tzz measured directly by the FTG (Tzz_TC_FTP) and the Tzz response derived from the GT1A (Tzz_GT1A_1VD). The PSDs were 1-D, taken along the FTG flight lines. The GT1A data was sampled from the grid to the FTG flight lines. It can be seen in Figure 4 that the energy level in FTG Tzz is higher than that of the GT1A response over a broad range of wavelengths. It was found that the FTG measurement could be made to match that of the airborne gravimeter at the long wavelength end of the spectrum by application of a low-pass filter. The cut-off wavelength of this filter was approximately 4km.

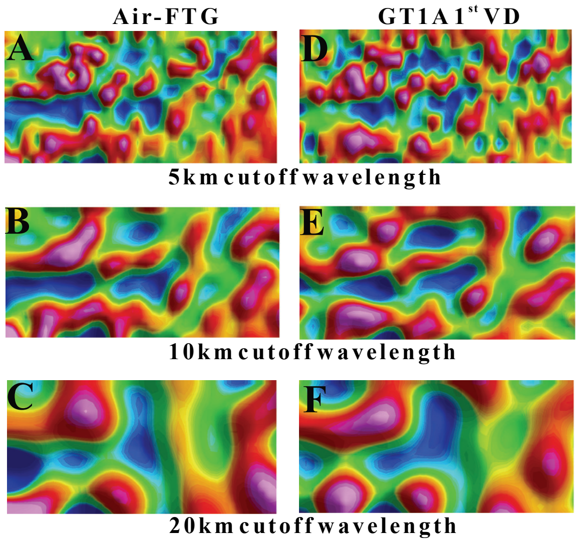

Figure 3: Frequency filtering analysis slices between Air-FTG and GT1A at short (A and D), intermediate (B and E) and long wavelengths (C and F).

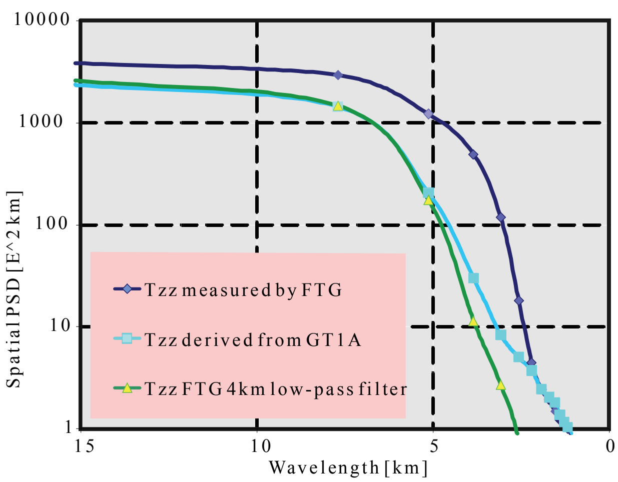

Figure 4: Spectral comparison of Tzz measured by the FTG and derived from GT1A airborne gravimetry. The FTG spectrum is shown with and without application of a 4 km low-pass filter. Note that the horizontal is reversed.

Line Spacing Comparison

The original 2 km spaced Tzz_TC_FTP and Tzz_GT1A_1VD data were decimated to a line separation of 4 and 6 km. For the 2 km line spacing every other line was selected and for the 6 km every third line was selected.

The grids were then generated by using minimum curvature gridding of their respective flight line data. A minimum curvature grid with an increment on the order of 1/2 the closest line spacing was used for each grid.

Six colour-shaded grid images corresponding to 2, 4, and 6 km line spacing are displayed in Figure 5A through F. Images A, B, and C on the left hand side represent Air-FTG® grids for 2, 4, and 6 km line spacing respectively. Images on the right hand side D, E, and F represent GT1A for 2, 4 and 6 km line spacing, respectively.

The black box, yellow and white circles highlight selected anomalies where the resolution of the two data sets is compared with respect to the line spacing. It is evident from the images that the anomalies in the black box in image A and D compares well in terms of their shapes. However, the anomalies in image A show more detail in terms of resolving subtle features than in image D. The resolution in image B can be correlated to some extent to those in image D.

The yellow circle highlights a geological target which is clearly detectable using Air-FTG® even at wider line spacing, but the same target almost disappears in GT1A data with the same line spacing. The white circle (image F) also indicates that at wider line spacing GT1A data becomes of lower resolution in resolving edges of the target in question nearly as effective as Air-FTG® does.

CONCLUSIONS

High altitude Air-FTG® data compares well with airborne gravity and resolves intermediate to relatively long wavelengths anomalies that may be associated with deeper geologic features.
As expected, the high frequency response of Air-FTG® is greater than that of the GT1A. After filtering the low frequency response of Air-FTG® matches well with the GT1A even at the longest wavelengths that could be measured in this test survey.
Line spacing analysis indicate that Air-FTG system is more cost effective, since surveys could be flown at wider line spacing with the same or better resolution than the conventional airborne gravity (GT1A).

ACKNOWLEDGMENTS

Thank you to Geosciences of Australia, (http://www.ga.gov.au), for the GT1A data flown in 2003.

REFERENCES

Li, X., 2001, Vertical resolution: gravity versus vertical gravity gradient: The Leading Edge, 20, 901-904.

Mataragio J.P., et. al,., 2006, Exploring for Iron Oxide Deposits in Brazil using Airborne Full tensor Gradiometry (Air-FTG®). In: Abstracts from PDAC 2006, Toronto, Canada.

Murphy, C.A., Brewster, J., Robinson, J., 2006) Evaluating Air-FTG® Data: Bringing Value to the Full Picture. In: Abstracts from the AESC 2006, Melbourne Australia.

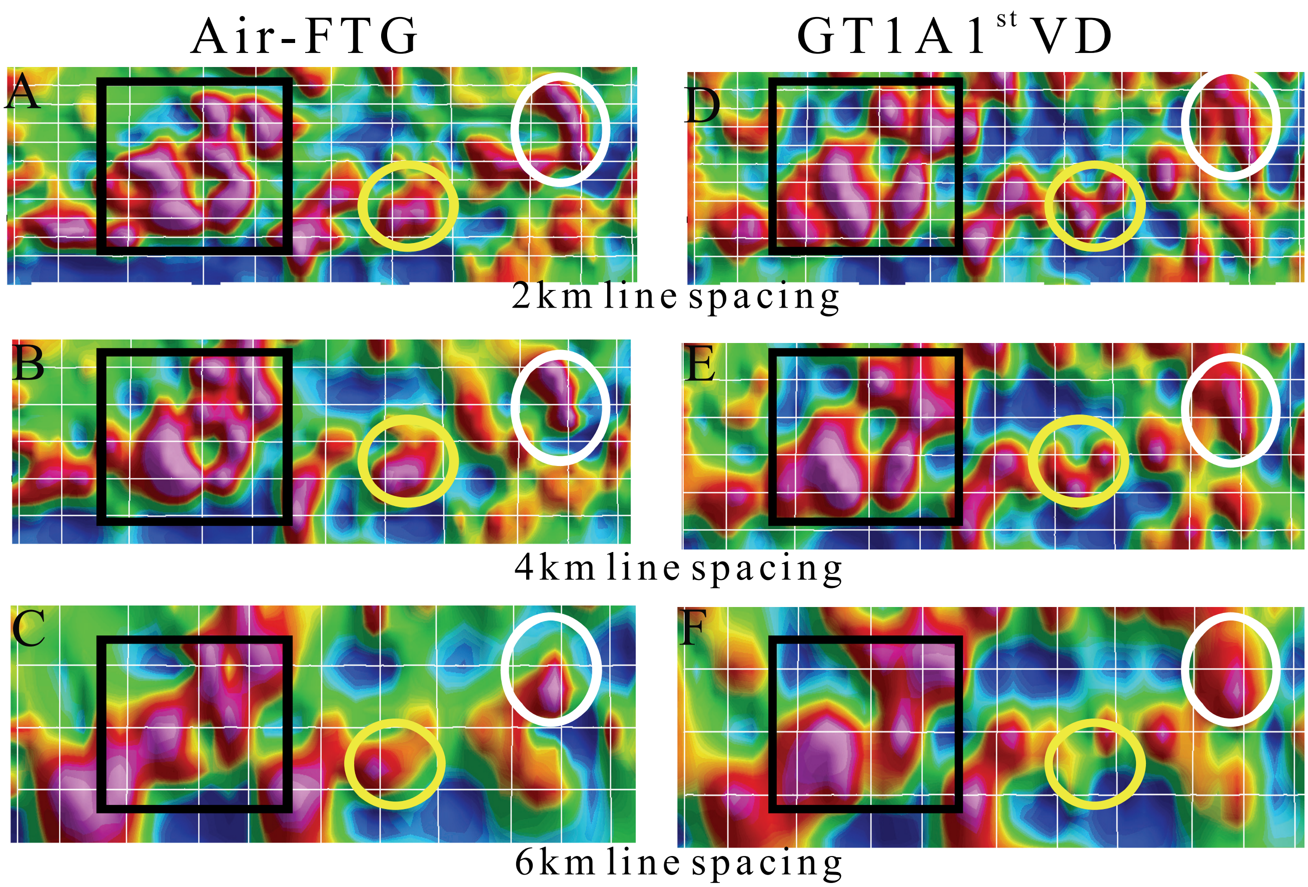

Figure 5: Images illustrating line spacing issues. A survey flown with 2 km lines spacing shown in (A and B) were reprocessed for line spacing of 4 km (B and E) and 6 km (C and F).