Evaluating Air-FTG® survey data: bringing value to the full picture

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SUMMARY

Fixed wing Air-FTG® data is now accepted as a viable technique in an exploration programme. Since its first commercial survey campaign in early 2003, data quality has improved from 15+ E resolution to a more acceptable 5 to 7 E over 400 to 600m wavelengths. Resolution has been determined against available ground gravity data. Where not available, we propose an alternative method. This computes a single potential field from the 5 independent gradiometer outputs and then recalculating the individual components, we make comparison with previously processed outputs. Such results allow us to statistically monitor residual noise inherent to each project.

Key words: Air-FTG®, gravity, processing, resolution, detectability

INTRODUCTION

Bell Geospace first acquired commercial fixed wing Air-FTG® surveys early 2003 in Southern Africa. Data resolution at the time was demonstrated to be quite poor, but showed significant improvement by its 2nd campaign later that same year (Hatch, 2004, Murphy, 2004). Much of this was attributed to surveying conditions (during winter due to reduced turbulence), but also to improvements made in data processing.

These early Air-FTG® surveys had the benefit of access to available ground gravity data to determine accuracy of response. These analyses were performed on airborne data that were processed to a levelled status only. Nevertheless it clearly demonstrated Air-FTG®'s ability to improve from 15+ E to the more acceptable 5.4 E resolution over 300 to 400m spatial wavelengths (Hatch, 2004). The level of improvement is significant as more subtle geological responses of 300 to 400m are now detectable.

Ground gravity data is not always available and so a more independent means of establishing survey accuracy is required. One mechanism is to take the levelled data through one more processing sequence that exploits the integrity of the full tensor data and then to compare the results against those previously produced. The result of this technique is a harmonic model of the tensor components which can then be used to isolate and remove certain noise characteristics. Bell Geospace name this procedure 'Full Tensor Processing' (FTP) which is now routinely employed on all projects.

The FTP'd data sets are then compared against their levelled counterparts. The resultant plots help demonstrate the advances made with Air-FTG® technology in recent years in terms of S/N and geological features now detectable.

This paper describes this analysis and makes reference to 2 Air-FTG® data sets, one acquired in Brazil and the other to a dataset first described by Hinks et al (2004) called Kokong that was acquired in Botswana.

METHODOLOGY: QUANTIFYING NOISE

Power Spectral Densities (PSDs) are computed for the levelled and FTP'd data for each survey and then compared. PSD's are a useful mechanism to understand the S/N ratios in a data set. However, the interpretation of such plots may not be entirely accurate as residual noise can be difficult to isolate. Nevertheless, this is a good mechanism to statistically monitor the minimalisation of residual noise inherent to each processed data set.

However, the units in which these analyses are expressed are not intuitive. The units are typically given in the form of E/√Hz, but it is preferred to express these in terms of distance on the ground. A simple multiplication by the speed of the platform allows for easier comprehension of what the PSD reveals in terms of noise thresholds, e.g. a 15 E/√Hz noise threshold on an aircraft travelling at 60m/s translates to a noise threshold of 13.5 E^2km.

PSDs for Air-FTG® data used in this analysis are shown in Figures 2 and 4.

The next part of the analysis is to take the computed noise thresholds, the known line spacing of each survey, and for increasing target size, predict the minimal Tzz response detectable. This can be described as:

$$Tzz = \sqrt{(N_e/2nR)}$$

where N_e is the Noise threshold of the survey, n the number of lines to transect a target and R the length of the target.

Figures 3, 4b and 5 show Detectability Charts for the 2 surveys presented in this analysis.

THE ANALYSIS

Figure 1 shows the levelled and FTP'd Tzz response from a survey acquired for Aurizonia Petroleum in eastern Brazil in

2005. The purpose of the survey was to locate possible areas of hydrocarbon entrapment beneath the low lying mud-flats for a more comprehensive follow-up seismic exploration programme. The anticipated targets are expected to yield short to intermediate wavelength anomaly responses. The survey was flown on a tight drape 80m above ground with 400m line spacings oriented NW.

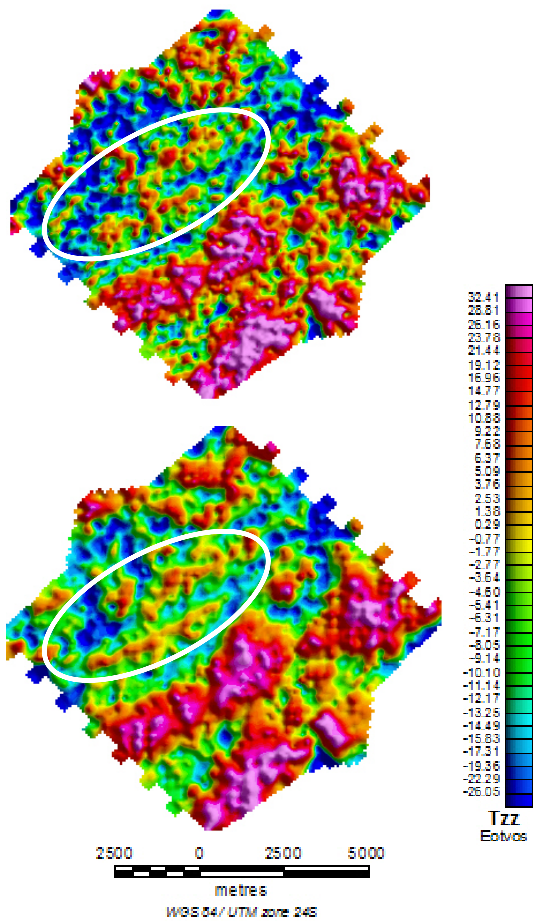

Figure 1. Air-FTG® Tzz data from Brazil. Data acquired for Aurizonia Petroleum in 2005. Upper image is levelled data, bottom result from Full Tensor Processing. See text for details.

The improved imagery of the short to intermediate wavelengths are evident in the FTP'd data with a more precise definition than that evident in the levelled data (see where highlighted). This improvement is summarised in the PSD plots shown in Figure 2a. The levelled data yield a noise threshold of 24.2 E^2km whereas that for the FTP'd data is 10 E^2km. The noise threshold concept is extended to investigate detectable responses for targets of varying size. The Detectability chart shown in Figure 2b predicts that for increasing target size, the lower the noise threshold. More important is that FTP'd data will enable more subtle small scale geological features to be detectable. For spatial targets of 400m surveyed with 400m line spacing this improvement in resolution is in the order of 3.5 E versus 5.8 E in the levelled data.

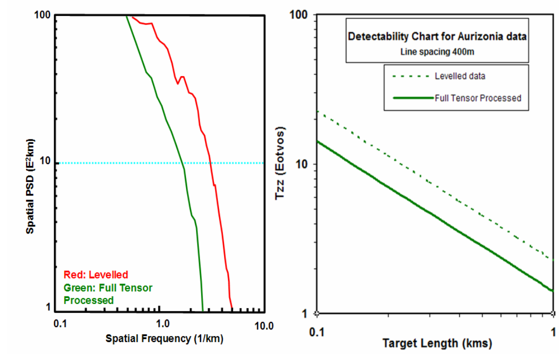

Figure 2. a) PSD for levelled and FTP'd Tzz data. Note the marked improvement in the FTP'd data; and b) Detectability Chart for levelled and FTP'd Tzz responses. Large targets require low detectability threshold.

The level of improvement offered by FTP is evident and gives an overall accuracy of 3.5 E over 400m spatial wavelengths. This has been demonstrated for surveys acquired with 400m line spacing. The result compares favourably with that previously described by Hatch (2004) and Hinks et al (2004). The latter noted that Air-FTG® as offered in early 2003 was probably of insufficient quality to be of use in resolving small scale geology such as Kimberlites in Botswana. A useful means to assess this is to reprocess that particular dataset acquired near Kokong in Botswana using FTP.

The Kokong data set was acquired on a tight drape 80m above ground with a 100 m line spacing. Figure 3a shows the PSD for the levelled data (Hinks et al in 2004) and the FTP'd result. The difference is remarkable with the noise threshold improving from 70.6 E^2km to 23.7 E^2km. The corresponding Detectability Chart (Figure 3b) indicates that the resolution of the Kokong data set is now 5.44 E for a 200m sized target versus 9.4 E in the levelled data. This improvement is significant in that more discernable geology becomes detectable.

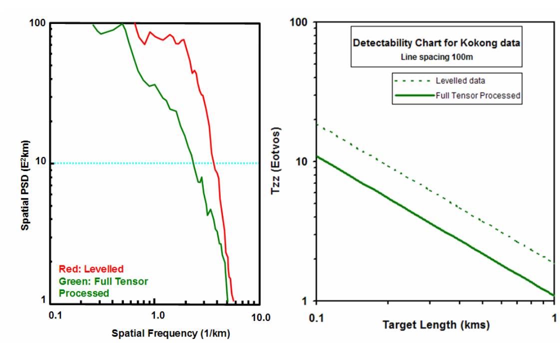

Figure 3. a) PSD for levelled and FTP'd Tzz data from Kokong. Note the marked improvement in the FTP'd data; and b) Detectability Chart for levelled and FTP'd Tzz responses. Large targets yield low noise values.

DISCUSSION

The analyses presented in this paper suggest that Air-FTG® has improved in quality since deployment in early 2003. The Aurizonia survey data acquired in 2005 suggest a 10 E^2km resolution for Tzz as compared to values in excess of 23 E^2km for the Kokong survey acquired early 2003. A better assessment of Air-FTG® would include its ability to resolve geology on the ground.

Given that Air-FTG® now has accuracies of 10 E^2km, we can expect better detectability on tight line spaced surveys than that possible for Kokong. Figure 4 assesses this concept. The blue curves plot the minimal responses for a survey with 100m line spacings assuming a noise threshold of 10 E^2km. Comparing with the Kokong result described above, we now would expect to resolve a 200m sized target generating a 3.54E response.

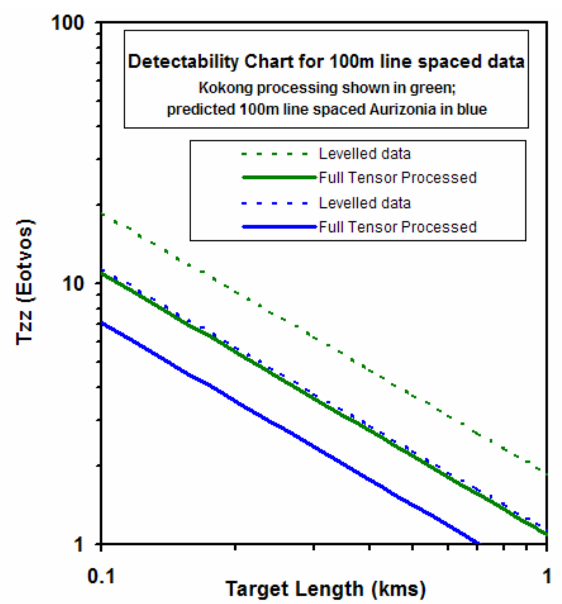

Figure 4. Comparison of Tzz Detectability responses for Kokong (green) and a simulated 100m line spaced Aurizonia survey (blue).

This compares favourably with figures reported by Hatch (2004) describing Air-FTG® accuracy as 5.4 E over 300 to 400m. The analysis described in this paper suggests that this figure is now improved to near 3.0 E over 300 to 400m spatial wavelengths.

CONCLUSIONS

Air-FTG® is a viable technology in any exploration programme. Its accuracies are now improved since 2004 and typically have noise thresholds of 10 E^2 km. This translates to an on-the-ground detectability threshold of 3 to 4 E for targets under 300m in size.

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