A Comparison of three current airborne systems designed to measure the Earth's gravitational field and the impact of instrument sensitivity on mining exploration.

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Summary

When deciding to acquire airborne gravity/gradient surveys explorationists can now choose from a variety of instrumentation i.e. conventional gravity systems or newer gravity gradient systems. Of the instrumentation available which one will meet the geological objectives? Which one is more sensitive? What impact do the different sensitivities have on geological models? This paper will look at three different airborne systems, discuss their relative sensitivities and highlight their respective impact on mining exploration.

Introduction

It is important to know how intrinsic instrument noise feeds through to how accurately a survey will measure the required signal from the Earth. We will consider three instrument types; the Sander's AIRGav system, Lockheed Martin's Full Tensor Gradiometer (FTG) and ARKeX's Exploration Gravity Gradiometer (EGG). In order to compare the differing instrumentation in the absence of a comparative survey, a synthetic model of typical geological targets will be used. Using the model, theoretical gravity and gravity gradient signals will be calculated and sampled over a typical acquisition footprint. Noise characteristics pertaining to each instrument type will then be added to the acquisition signal.

The data from each instrument will then be used to determine how well each instrument recovers the underlying geological signal in the presence of noise.

Method

The synthetic model consisted of a series of Kimberlite pipes of differing sizes at varying depths as shown in figure 1. The targets were chosen to represent the amplitude and wavelengths expected in an area of exploration interest.

The density model for each pipe and configuration is shown in figure 2. The depth of cover for each pipe varies from no cover to 150m cover across the plantation. Sizes of the pipes range from 50 Hectares to 6.25 Hectares. To be representative of typical survey height parameters, 80m was chosen as the flying height for the analysis.

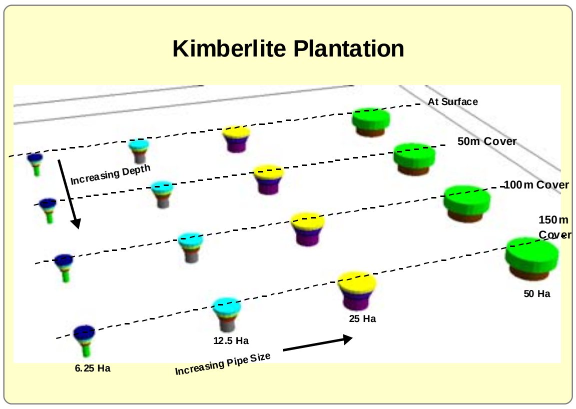

Figure 1: Input Kimberlite model

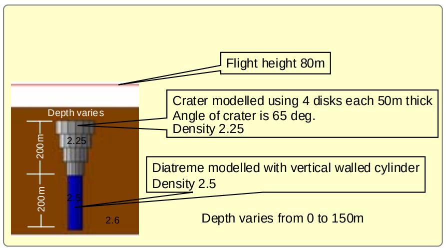

Figure 2: Kimberlite model.

Taking the input geological model the gravity (Gz) and the vertical gradient responses (Gzz) were forward calculated. The calculated response for Gzz varied between 6.5E –65E, with the largest, shallowest target giving rise to the larger signal. Clearly these represent the ideal signal amplitudes in a no noise environment and do not take into account any acquisition footprint or instrument noise.

For the analysis differing acquisition footprints were chosen to illistrate the senistivity to various flight patterns. For each instrument a representative sensitivity was chosen.

For the Sander's AIRGrav system data was taken from the Alexandra Campaign 2000 (Bruton, 2000) which when analysed placed the instrument sensitivty at 8.3 mgal/√Hz. Using information extrapolated from data processed by ARKeX, a sensitivity of ~7E/√Hz was chosen for the FTG. The EGG sensitivity is designed to be 1E/√Hz (Lumley, 2001). In addition to the overall sensitivities used in the analysis consideration should be given to the noise characteristics of the instrumentation outside its normal measurment bandwidth. In each case a suitable noise knee was chosen beyond which the noise exhibited a 1/f characteristic. For the EGG the 1E/√Hz operational bandwidth is between 1Hz – 1mHz, whereupon the noise will exhibit the 1/f trend as shown in figure 3.

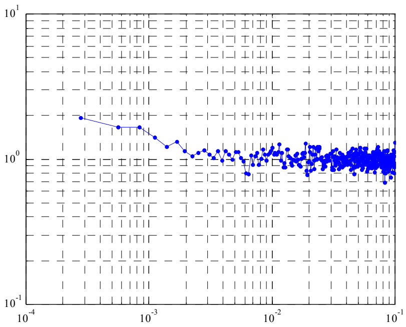

Figure 3: EGG Noise Characteristic

Having added the noise to the data a comparison can be made to show how well each instrument is capable of detecting the geological targets from the model. In order to offer a fair comparison no additional processing or filtering was applied to the data at this stage.

Highlighting the ability of each instrument to locate the geological anomalies is only a qualitative measure for each instrument, as shown in figure 4.

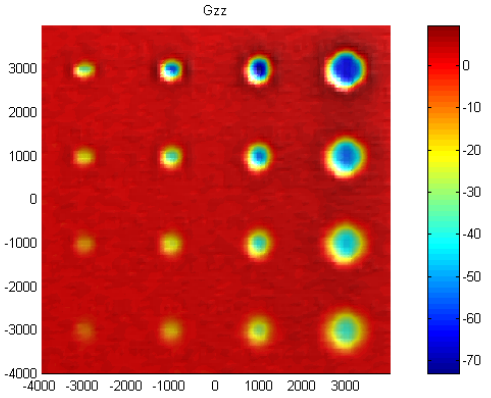

Figure 4: Gzz calculated from the EGG vs. target location.

Instrument noise and survey layout are only two parameters affecting the ability of an instrument to detect anomalies. In order to perform a thorough analysis one should also consider the noise on the flight lines and also the effects of poorly resolved terrain. All of these factors have been taken into account for this analysis and will be presented. The combination of all noise characteristics gives rise to what we refer to as the **'effective resolution'** of an instrument or survey.

Conclusions

The results clearly show the respective benefits of having an instrument with a good signal to noise ratio. The better the signal to noise ratio the greater the geological resolving power of the instrument. This is only part of the exploration problem and careful consideration should be given to what is the **'effective resolution**' of each survey. A 1E/√Hz system may be the most sensitive instrument, however, if flown badly and with poor knowledge of the terrain the true sensitivity of the instrument will never be realised. It is desirable in all cases to perform feasibility modeling for each survey to ensure that the design parameters and operational requirements are set correctly.

This paper has also not discussed the problems surrounding the interpretation and processing of gradiometry data once it has been acquired. The synthetic modeling results presented did not have any of the many sophisticated processing techniques applied to the data. If various noise reduction methods had been applied to the data their respective resolving power could have been improved, but not without some resolution penalty.

References

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