Airborne gravity for resource exploration

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Abstract

The AIRGrav system has been used for oil and mining exploration projects in North and South America, Africa and the Middle East. Results are presented for some representative surveys. Accuracy of the AIRGrav data is a function of aircraft speed, and line spacing. Better accuracy is achieved with a slower flying aircraft and closer line spacing. Aeromagnetic data is normally acquired at the same time as AIRGrav data. Surveys can be flown draped 100 to 250 m above the terrain, at a line spacing of 100 to 3,000 m. Modeling results indicate that in comparison with gravity gradients, AIRGrav data is inherently less susceptible to attenuation with height or depth of burial, and is also relatively less affected by terrain model errors.

Introduction

AIRGrav is a gravimeter designed and built by Sander Geophysics, specifically for airborne geophysical surveying. The system is based on three orthogonal accelerometers mounted on an inertially stabilized platform. Vertical aircraft movements are removed using dual frequency GPS, post processed using SGL's proprietary GPS processing algorithm.

A recent AIRGrav survey was evaluated for consistency and noise levels, by comparison with previously existing ground data, and by the evaluation of intersection misties. The RMS difference between AIRGrav grid data, and ground points, calculated for each individual point is 0.35 mGal. Possible components of the RMS difference include GPS and inertial noise in the AIRGrav data, and errors on the ground data set, which include uncorrected effects of near station terrain, anomalous shallow densities, and errors in the altitude and upward continuation of the ground data.

RMS of the misties of the line gravity data is 0.8 mGal. AIRGrav data is leveled by applying a linear slope to the flight data, based on gravity readings on the ground before and after each flight, an 85 second filter, and a constant leveling adjustment is applied to each line. No variable leveling has been applied within the line data.

AIRGrav gravity anomalies were calculated using a 3D modeling package developed by SGL for some representative mining and oil exploration targets. Gravity anomalies for Olympic Dam type deposits were calculated, at full scale, and with the dimensions of the model reduced half, quarter and eighth size of the Olympic Dam deposit. The calculated gravity anomalies were filtered with typical filters used for a fixed wing and helicopter AIRGrav survey. In all cases the deposit is detectable, with the eighth size deposit on the limit of detectability for a fixed wing system.

Normal faults with various offsets were also modeled, and processed with the AIRGrav software, for a fixed wing and helicopter situation. As with the Olympic Dam anomalies, the larger structural high would be clearly detectable using either a helicopter of fixed wing system. The smaller high would be detectable using a helicopter survey.

Gravity grids were also calculated for each model at different separations between the model and surface where the gravity is calculated, to measure the sensitivity to increased depth of burial, or flight height. AIRGrav data is relatively insensitive to depth of burial, or increased flying height, because of the lower attenuation of total field gravity data relative to gradient data, and because of the filters used in AIRGrav data processing.

Terrain corrections are, in many cases, the largest single source of error in gravity surveys. Terrain correction errors are caused by errors in the terrain model used to calculate terrain corrections. We have modeled the effect of a 20 by 350 by 350 m error in a terrain model, to simulate the effect of an error caused by vegetation, or steep topography, which can cause problems with radar and laser altimeters. Flying height above the terrain was assumed to be 150 m. The 20 m error causes a 0.23 mGal AIRGrav anomaly, small in amplitude and areal extent, compared to many AIRGrav anomalies.

Example

The Turner Valley survey (figure 1) consists of 12,000 lkm of combined AIRGrav and aeromagnetic survey data flown over a period of five weeks, over very difficult terrain. The combination of AIRGrav and aeromagnetic data corresponds well with known subsurface geology, but in addition provides new insights into the lesser known lineaments, which cut across the regional trend, and could be helpful to explain the morphology and segmentation of the Turner Valley oil and gas reservoir. The cross cutting lineaments are detectable by joining the terminations in the north south aeromagnetic features. The same lineaments mark changes in the amplitude and character of the calculated FVD gravity data.

In the North-West corner of the survey area is a gas field, which also shows good correspondence with the gravity data. The reservoirs consist of carbonate structures surrounded by less dense shale, which accounts for the distinctive gravity signature. The associated gravity anomalies are 0.5 to 1.5 mGal in amplitude, and are clearly discernable on the AIRGrav FVD data.

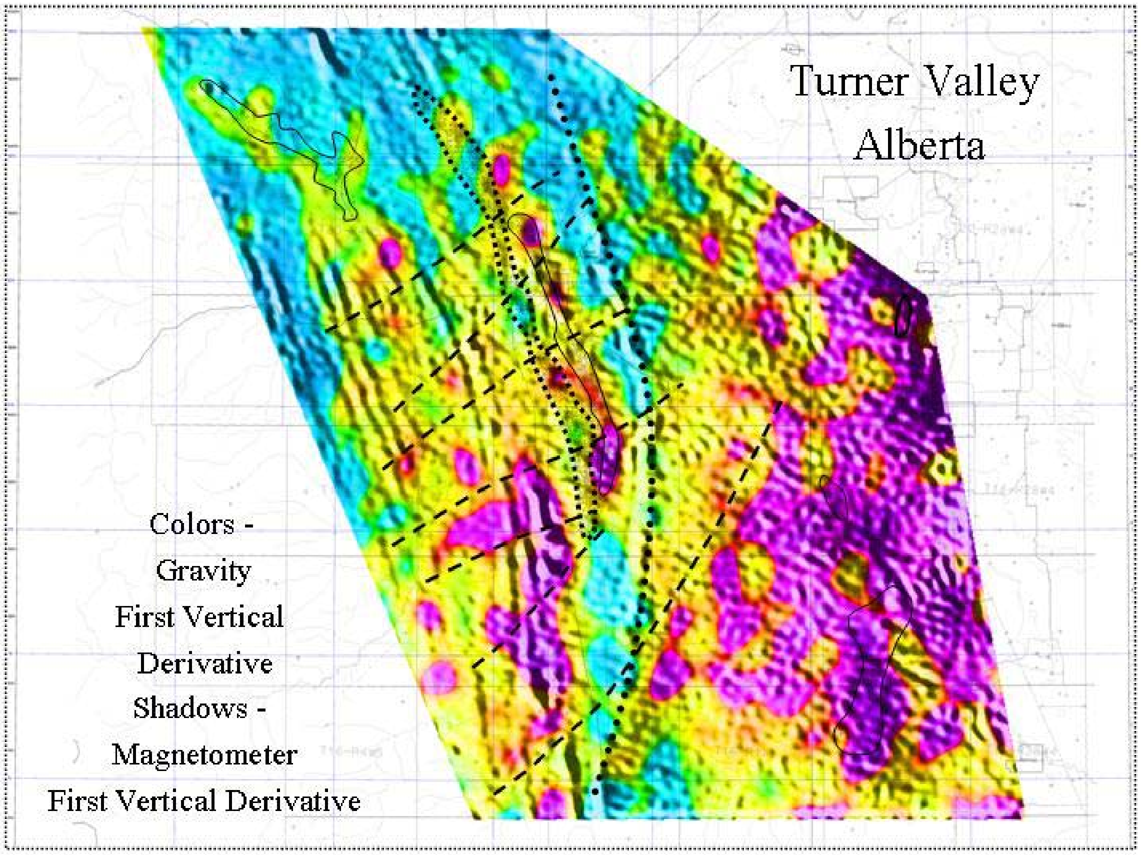

Figure 1 – The Turner Valley AIRGrav survey covers an area of about 60 km by 40 km, with 12,000 lkm of east west oriented survey lines, over the mountains of Western Canada, to the south of Calgary Alberta. The survey was acquired in five weeks of surveying, with 250 m line spacing, and a loose drape over the mountainous terrain. Major geological structure in the area trends North, and North-North West. The heavy dotted line represents the eastern edge of the foothills deformation. The solid lines enclose areas with gas production, while the lighter dotted line encloses the Turner Valley oil field. The NE-SW trending dashed lines represent major crosscutting lineaments interpreted from the aeromagnetic and AIRGrav data.