SGL AIRGrav Anomaly Detection from Modeling and Field Data using Advanced Acquisition and Processing

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Summary

Sander Geophysics (SGL) has operated its AIRGrav airborne gravity system for over ten years and continues to work to improve the accuracy and resolution of the entire system. Recent advances in SGL's gravity data acquisition and processing methods, involving advanced analysis of system dynamics and improved filtering, have enhanced the gravity data. New data processing techniques have also allowed the extraction of the horizontal gravity components of the airborne gravity data in addition to the traditionally used scalar gravity measurement. The effect of survey parameters and improved noise levels on the detectability of various geological features is investigated using forward modeling.

Introduction

Airborne gravity data have been collected since the late 1950's (Thompson and LaCoste, 1960). In the late 1990's, improvements in GPS processing and the introduction of a new gravity instrument, the AIRGrav system (Argyle et al., 2000), resulted in a significant reduction in airborne gravity noise levels. To date, more than 1,500,000 line km of AIRGrav data have been collected on surveys flown throughout the world.

Processing

The AIRGrav system uses three orthogonal accelerometers, mounted on a three-axis, gyroscopically stabilized platform in conjunction with a specialized data acquisition system to monitor and record the data and parameters measuring gravimeter performance. In this paper, 'standard' airborne gravity data processing refers to a sequence of processing steps that includes the subtraction of the vertical accelerations of the aircraft that are measured using high quality differentially corrected GPS data from the vertical accelerations measured by the gravimeter, and the application of standard corrections to remove the effects of the rotation of the Earth, the movement of the platform over the globe, and terrain effects (Sander et al., 2004). Standard processing techniques have proven successful at extracting gravity data from the very dynamic aircraft environment where accelerations can reach 1 m/s^2, equivalent to 100,000 mGal. High precision differential GPS processing techniques and a robust gravimeter system have resulted in final processed gravity grids with noise estimates of 0.1 to 0.3 mGal with a resolution of 2 kilometres, for data acquisition speeds of between 150 and 185 km/hr and line spacing between 100 m and two km. A processing procedure, which we will call 'enhanced' data processing, involving advanced analysis and improved filtering, has been added to the data processing stream to lower the noise and improve the resolution of the gravity data.

Helicopter-mounted AIRGrav System

Airborne gravity data have traditionally been used to define regional scale geology, an application for which standard acquisition parameters using a fixed wing aircraft were adequate. However there are applications where a higher resolution data set is preferable. Recently, the AIRGrav system was installed in a helicopter and six small survey blocks were flown at an extremely slow acquisition speed (average of 55 km/hr) with 50 m or 100 m line spacing, depending on the block, and draped average terrain clearance of 145 m. Scanning laser elevation data were concurrently acquired in order to create a high resolution 1 m grid cell size digital terrain model. This configuration, coupled with the enhanced processing technique, resulted in a gravity data set that met the requirements of this exploration project with an accuracy of 0.4 mGal at a 300 m resolution. Figure 1 shows the gravity data superimposed on the derived terrain model for a small region of the survey.

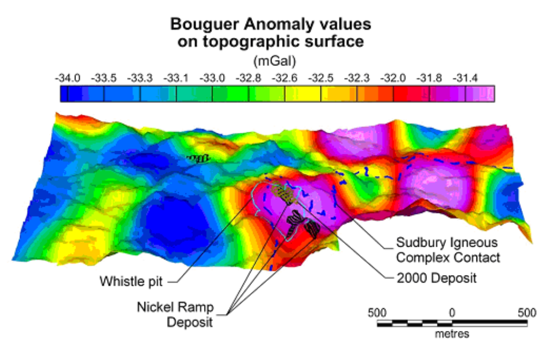

Figure 1: Bouguer gravity anomaly values for the helicopter-mounted AIRGrav survey of the Podolsky Mineral Exploration Project (300 m resolution gravity data)

Horizontal Gravity Components

A repeat line was flown in two directions, each 1325 km long, acquiring AIRGrav data in NASA's DC8 as part of the ICEBRIDGE 2010 mission. Data were processed using the enhanced procedure to extract the three gravity components and compared to the EGM 2008 gravity model. The test successfully demonstrated that the three spatial components of the gravity vector can be measured with high repeatability using the AIRGrav system and that the measured horizontal components agree well with geoid models of the highest order available.

Figure 2 illustrates the gravity east component, and a comparison profile extracted from the EGM 2008 gravity model. Comparison statistics are listed for each line and after fitting the AIRGrav data to the model using a 1st, 2nd and 3rd order fit. From these results we can conclude that the AIRGrav system has repeatability better than the agreement of its estimates with the model data. The consistency of the short wavelength data in the AIRGrav data shows greater detail than the model data.

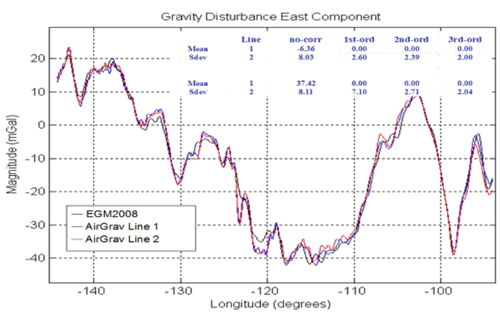

Figure 2: Gravity East Component, ICEBRIDGE Repeat Line

Modeling

Field data and geological interpretations from a variety of airborne gravity surveys were used to construct a model to test the detectability of a wide variety of geological features with gravity data. The model consists of two linked basins, one deeper and the other shallower, which incorporate intrabasinal faults and basement highs at various depths, and a basement high between the basins. Located alongside the basins is an area of exposed basement containing a variety of ore bodies at various depths (Figure 3). The detectability of the features in the model were evaluated using a 3D modeling program which calculates the gravitational field, and gravity gradient. Images were prepared for the data assuming it was collected as an airborne survey using a gravimeter (SGL's AIRGrav system) and the enhanced AIRGrav data processing. Survey altitude (the survey aircraft's height above the ground) and line spacing (the distance between adjacent survey lines) were varied to evaluate the effect of data acquisition parameters on the detectability of the modeled features.

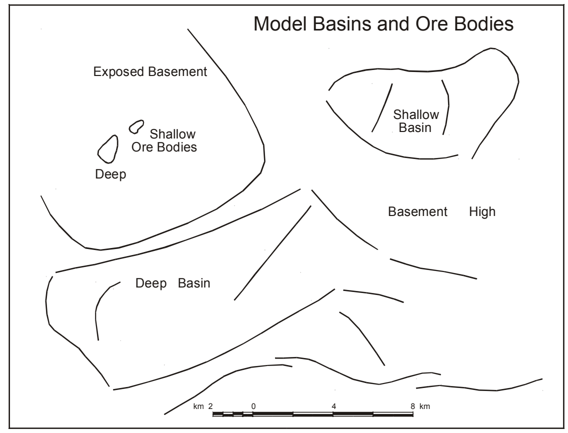

Figure 3: Map View of Model Basins and Ore Bodies

Conclusions

Recent advances in SGL's gravity data processing methods have been shown to produce higher quality, lower noise gravity data. Modified survey design parameters involving the use of a helicopter rather than a fixed wing aircraft have been used to acquire data for a mineral exploration project resulting in an accuracy of 0.4 mGal at a 300 m resolution. The new processing techniques have also allowed horizontal gravity components of the airborne gravity data to be extracted. Detectability of anomalies is reduced by decreasing the size of the geological feature, or by increasing the depth of burial, the line or station spacing of the survey, the survey height above ground, and the amount of measurement noise of the survey system. Incorrect terrain corrections due to errors in the DEM, and unmodeled near surface density changes can also cause significant “noise” which can obscure the geological features of interest.

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