Decorrelating measured airborne gravity gradiometry data with topography

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Abstract

When there is rugged terrain and you wish to directly detect anomalously dense near surface ore-bodies such as VOC copper/nickel, use is being made of low-flying draped gravity gradiometry surveys. The geophysical signal collected is dominated by the topography response. Depending upon how many independent components are collected, a method is devised to quickly decorrelate the topographic signal, leaving a residual anomaly that shows the buried bodies. The resolving power of existing gradiometer systems approaches what is necessary for minerals applications, provided the best possible care is taken with processing, gridding and data reduction. Typically, 200m wavelength low pass filtering is applied to airborne gravity gradiometer data by the contractors. Predicted average surface density maps are created in this rapid process, which can be inspected and then used to judge how to control the decorrelation with terrain in selected areas of interest to the explorer. Existing surficial density anomalies, such as dumps, water filled pits and hills are identified and removed allowing the explorer to focus on the unexplained potentially more prospective anomalies.

Introduction

Low-flying draped airborne gravity gradiometry (AGG) surveys, measuring the lateral variations in the Earth's gravitational field, as caused by lateral density variations, are being used in rugged terrain for detection of anomalously dense near-surface ore-bodies, such as Iron Oxide Copper Gold deposits (IOCG) and volcanogenic massive sulphide ore deposits (VMS).

The ~200m resolving power of existing gradiometer systems approaches what is necessary for minerals applications, provided the best possible care is taken with processing, gridding and data reduction. In particular, beyond the aircraft, the topographic surface represents the largest and most proximal density contrast encountered in an airborne survey. Hence terrain effects can have significant impact on AGG data. These effects should be removed prior to data interpretation.

AGG Terrain Corrections

Terrain corrections are routinely applied as part of post-survey processing: for every point of observation, the theoretical gravity tensor response from the terrain alone is computed using a Digital Elevation Model (DEM) and a suitable bulk terrain density value. The theoretical gravity tensor response from the terrain is subtracted from the observed AGG data, yielding a terrain-corrected AGG highlighting subsurface density variation with a minimal overprint from terrain effects.

The advent of satellite-derived regional DEM and survey-scale "LIght Detection And Range" (LIDAR) derived DEM has improved the quality of AGG terrain correction considerably.

With modern software the theoretical gravity tensor response for the terrain model can be readily computed for all operational AGG systems (Falcon and FTG), as well as for systems currently under development. However, this does require full insight and understanding of the reference coordinate systems used by the various instrument designers and survey operators.

A new method for determining a representative bulk terrain density value from AGG data

Whilst a representative bulk terrain density value could be established from in-field density measurement, such an approach is often impractical for large scale AGG surveys in difficult terrain.

Traditionally, an optimum bulk terrain density has been established iteratively by seeking zero correlation between the terrain corrected AGG survey data and the the terrain model. This is often achieved by trial-and-error visual inspection of a series of terrain corrected AGG data sets covering a broad range of bulk terrain densities, typically from ~1.8 g/cm3 to ~3.5 g/cm3 in steps of 0.1 g/cm3. This approach has been formally quantified in Fugro's terrain density estimation tool (originally developed by Rod Paterson for FALCON data processing) in which the computed covariance between the terrain corrected gzz survey data and the terrain model - for selected subregions with significant terrain response within the survey area - is plotted as a function of bulk terrain density. The optimum bulk density is determined from the zero crossing. Figure 1 shows such a plot for an AGG survey in Brazil, with a predominant zero-crossing around a bulk terrain density of 2.5 g/cm3.

We describe a new AGG tensor-based multi-component approach to estimating an optimum bulk terrain density, which seeks to identify and quantify any scalar relationship between uncorrected AGG survey data and the theoretical gravity tensor response from the terrain model of unit density.

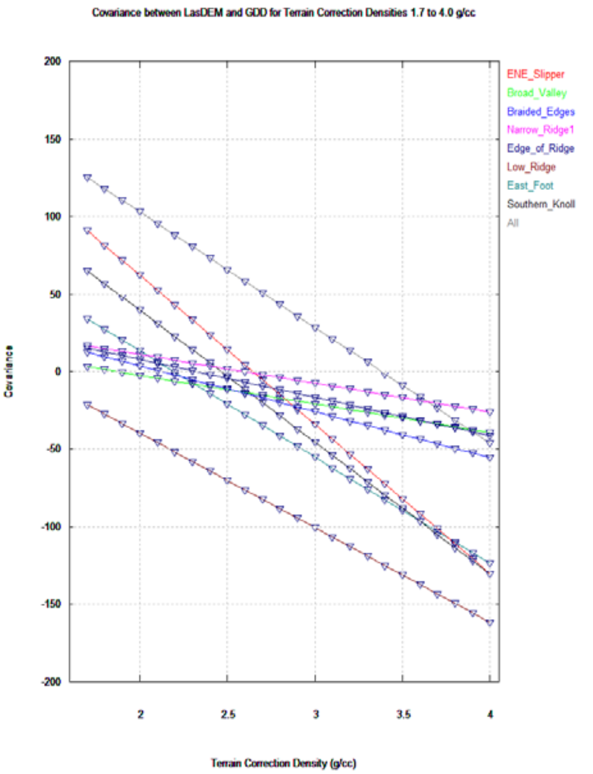

Fig.1 - Plot of the computed covariance between the terrain corrected g_{zz} survey data and the terrain model - for a number of subsections within the survey area - as a function of bulk terrain correction density for an AGG survey in Brazil. The optimum bulk terrain correction density is determined from the predominant zero crossing, yielding a bulk terrain density of ~2.5 g/cm^3

The proposed method is quick to compute and can be readily analysed and interpreted by any geoscientist, without specialised training. An AGG survey of ~3,000 line/km takes ~5 minutes to compute.

Predicted average surface density maps are created in this rapid process, which can be inspected and used to judge how to control the traditional terrain correction in selected areas of interest to the explorer. Existing surficial density anomalies, such as tailings dumps, water filled pits and hills are identified and removed allowing the explorer to focus on the unexplained potentially more prospective anomalies.

If operating on a single point of tensor observations, the robustness of both methods is improved as the number of recorded tensor components increases.. If only two tensor components are available, then a window-based method should be considered. The method is well suited for rugged terrain, where terrain corrections are even more pronounced and important.

Lateral variability of terrain density is effectively highlighted with this method. However, if a terrain feature is associated with a geological unit, which extends further into the subsurface, then the derived terrain density will be exaggerated.

Figure 2 (top) shows the DEM from a Bell Geospace FTG survey in Mauritania. The survey area is predominantly flat with the exception of outcropping banded iron formations (BIF) in the central and northern parts, and a belt of sand dunes in the south-eastern corner.

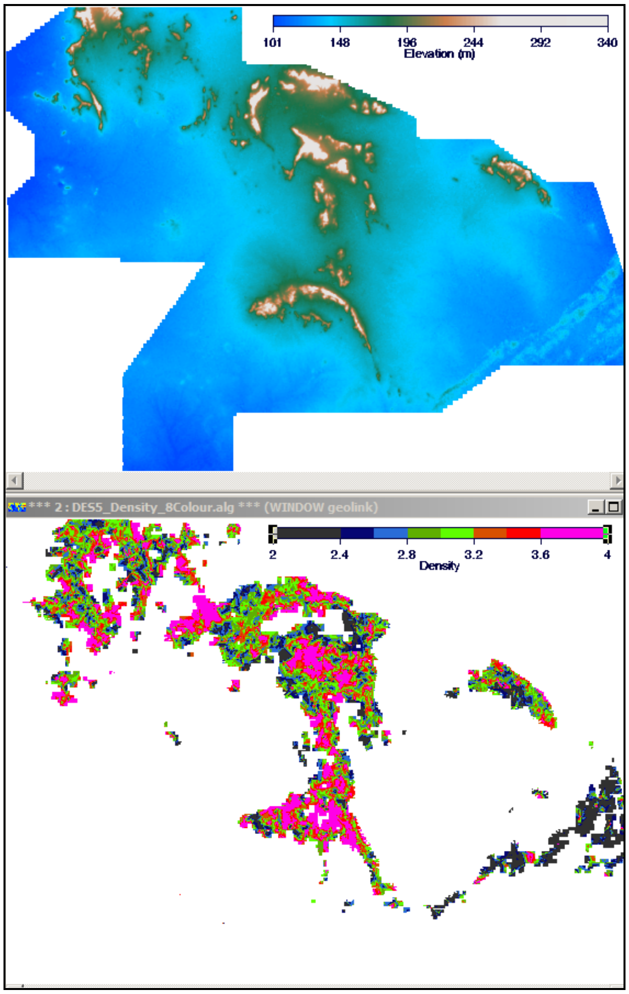

Fig 2 - (Top) Digital Elevation Model (DEM) from a Bell Geospace FTG survey in Mauritania. The survey area is predominantly flat with the exception of outcropping banded iron formations (BIF) in the centre and northern parts, and a belt of sand dunes in the south-eastern corner. (Bottom) Predicted optimum terrain densities derived from correlating observed AGG tensor components with the theoretical tensor response for the terrain model. The density of the sand dunes is estimated correctly, whilst the density of the BIF is somewhat exaggerated due to the geology extending well into the subsurface beyond the vertical relief.

Figure 2 (bottom) shows the optimum terrain densities as derived from correlating observed AGG tensor components with the theoretical tensor response for the terrain model. The density of the sand dunes is estimated correctly, whilst the density of the BIF is somewhat exaggerated due to the geology extending well into the subsurface beyond the vertical relief.

Summary

Terrain corrections are a necessary step in the processing of observed AGG data in rugged terrain, in order to highlight subsurface density variations with a minimal overprint from the terrain. We propose a simple and rapid AGG tensor-based method to estimate an optimum bulk terrain density for subsequent terrain-correction.

The method produces predicted average surface density maps, the quality of which is improved as the number of recorded tensor components increases, and the method is well suited for rugged terrain, where terrain corrections are ever more pronounced and important.

Acknowledgments

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