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Inversion of gravity and magnetic gradient data

Peter K. Fullagar[1] and Glenn A. Pears[2]

1. Fullagar Geophysics Pty Ltd, Brisbane, Queensland, Australia
fullagargeophysics@yahoo.com
2. Mira Geoscience Asia Pacific Pty Ltd, Brisbane, Queensland, Australia
glennp@mirageoscience.com

ABSTRACT

Gradiometry has come of age in the past decade, with the development of airborne systems capable of measuring full gravity and magnetic gradient tensors. Airborne gravity gradiometry in particular represents a stunning technical achievement, delivering a completely new capability to exploration. Gravity gradients can now be acquired rapidly in remote and inaccessible areas. Airborne magnetic gradiometry has been available for many years, albeit for a limited number of components. Full tensor magnetic gradiometry is a very recent development.

There are several technical advantages of gradiometry, including interpolation between lines and, for magnetics,suppression of diurnal effects, potential for characterisation of remanence, and (for the theoretically minded) the satisfaction of dealing with true potential fields.

In terms of interpretation, gradiometry offers greater sensitivity to the near-surface than conventional gravity or magnetics. This is a blessing for resolution of shallow structure and stratigraphy, and for definition of outcropping or sub-cropping targets, e.g. kimberlites. However, enhancement of shallow features can be a disadvantage in exploration for buried targets. The problem is compounded by the inherent variability of the shallow sub-surface, owing to weathering and to transported cover. Finally, sensitivity to the near-surface also implies sensitivity to topography and flying height.

This paper explores these issues and others arising during geologically-constrained inversion of gradiometer data. Analysis of gradiometer data alone is not sufficient to fully prescribe the sub-surface distribution of density or susceptibility: acquisition of full tensor data does not deliver us from non-uniqueness. Geological and petrophysical information, primarily derived from drill holes, is required to reduce uncertainty in interpretation. In order to capture both geology and physical properties, a model must be both categorical and quantitative. Such ‘geo-physical’ models are a force for integration in their own right, and also offer a number of practical advantages over pure property models. In particular, geological boundaries can be recognised, and therefore modified (subject to drill hole pierce point constraints); thus, when applied to a geological model, inversion can adjust its geometry as well as its density or susceptibility distribution.