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A Bayesian approach to geophysical inversion for quantifying geological uncertainty

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Performing inversion on gravity or magnetic data sets may have multiple goals, but here we outline a Bayesian inversion workflow which usefully provides, amongst other products from posterior models, a quantifiable outcome for uncertainty surrounding geological boundaries within solid geology models. The workflow begins with building a 3D reference geology model (Figure 1), constrained by both contact data points (formation boundaries from mapping or drilling), and structural orientation data (dip, azimuths from bedding). Rock property tables are then created per geological unit in the model (densities and magnetic susceptibilities).

Using observed geophysical data sets for gravity and magnetics, the workflow then proceeds. We advocate a Bayesian-style litho-constrained inversion, based on a Markov Chain Monte Carlo formulation, in which model perturbations from 'beginning' to 'end' of iterations progressively explore potentially millions of valid models rather than iterations ceasing when misfits reach a specified low limit (alternatively a 'Deterministic ' approach).

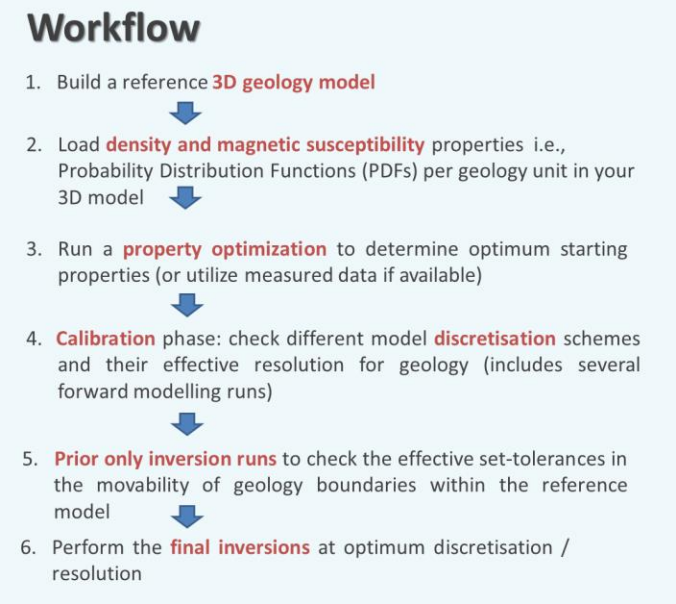


Figure 1 (left): Inversion workflow best applied to the joint inversion of gravity and magnetic survey data combined.

Step 1: Build a reference geology model, constrained by observed dips and contacts

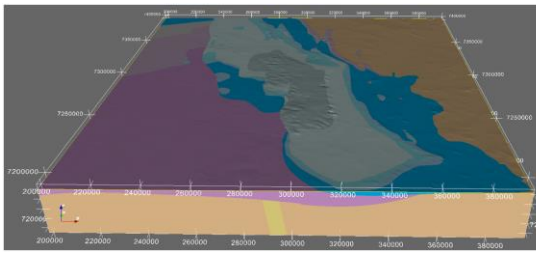
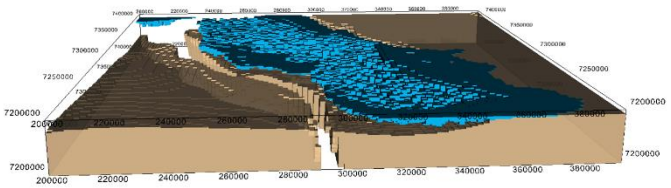


Figure 2 (right): Posterior models including the lithology voxet shown, are fully attributed in 3D and can be queried for volume, likelihood probabilities, etc. Their metadata can be compared against those of the reference model.



Inversion outcomes include a set of geology models which honour the geology observations (contacts and dips, fixed during inversion) *and* geophysical data, to within user-set tolerances of all 3 independent data sets.

References:

[1] Lane R. and Guillen, A. (2005) Proceedings of IAMG'05: GIS and Spatial Analysis, Vol. 1 181-186.