Automatic 3D Gravity Optimization: Model Simulation by Multiple Polygonal Cross-Sections coupled with Exponential Mass Density Contrast

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Abstract

An automatic optimization is developed in the spatial domain to analyze the gravity anomalies produced by a concealed 3Ddensity interface with mass density contrast differing exponentially with depth. The sedimentary column above the interface is described with a stack of multiple vertical polygonal sections of unit thickness each. For such a case, the depth ordinates of the vertices of the cross-sections become the unknown parameters to be estimated from gravity data. Forward solution of the model space is realized in the spatial domain by a technique that involves both analytic and numeric approaches. Initial depths to the interface are calculated based on the Bouguer slab approximation and subsequently improved, iteratively, by solving a system of normal equations involving the partial derivatives of the anomaly and the incremental parts of the ordinates of the vertices. The iterative process continues till one of the predefined termination criteria is accomplished. Unlike the existing methods, the advantage of the proposed method is that the observed gravity anomalies need not necessarily be sampled/available at regular grid intervals. The applicability of the proposed optimization is exemplified with a set of noisy gravity anomalies attributable to a synthetic structure before being applied over a real world gravity data. In case of synthetic example, the method has yielded a structure that was compatible with the assumed structure even in the presence of random noise. Application of the proposed method to the gravity data set from the Los Angeles basin, California using a prescribed exponential density model has yielded a model that concurs reasonably well with the published models.

Key words: density interfaces, gravity anomalies, 3D optimization, multiple polygonal cross-sections, exponential density model.