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Geostatistical joint inversion of seismic and potential field methods

Pejman Shamsipour (1), Michel Chouteau (1), and Bernard Giroux (2)

(1) Ecole Polytechnique de Montreal, Montreal, Canada, (2) Institut national de la recherche scientifique, Quebec, Canada

Interpretation of geophysical data needs to integrate different types of information to make the proposed model geologically realistic. Multiple data sets can reduce uncertainty and non-uniqueness present in separate geophysical data inversions.

Seismic data can play an important role in mineral exploration, however processing and interpretation of seismic data is difficult due to complexity of hard-rock geology. On the other hand, the recovered model from potential field methods is affected by inherent non uniqueness caused by the nature of the physics and by underdetermination of the problem. Joint inversion of seismic and potential field data can mitigate weakness of separate inversion of these methods.

A stochastic joint inversion method based on geostatistical techniques is applied to estimate density and velocity distributions from gravity and travel time data. The method fully integrates the physical relations between density-gravity, on one hand, and slowness-travel time, on the other hand. As a consequence, when the data are considered noise-free, the responses from the inverted slowness and density data exactly reproduce the observed data. The required density and velocity auto- and cross-covariance are assumed to follow a linear model of coregionalization (LCM). The recent development of nonlinear model of coregionalization could also be applied if needed.

The kernel function for the gravity method is obtained by the closed form formulation. For ray tracing, we use the shortest-path methods (SPM) to calculate the operation matrix. The jointed inversion is performed on structured grid; however, it is possible to extend it to use unstructured grid.

The method is tested on two synthetic models: a model consisting of two objects buried in a homogeneous background and a model with stochastic distribution of parameters. The results illustrate the capability of the method to improve the inverted model compared to the separate inverted models with either gravity or seismic data.

The technique can be applied to other geophysical variables and it can accommodate more than two variables. Greater gains from the joint inversion with respect to the separate inversions are expected when the data are not co-located. The algorithm is non iterative and the error of recovered models can be estimated by this stochastic approach.