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Gravity and Seismic Tomography Joint Inversion: A synthetic study modelling magmatic massive sulphide type bodies

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Gravity methods have long been used in mineral exploration. However, gravity methods have difficulty resolving small details. Seismic methods provide high resolving potential for use in mineral exploration. However, complicated hard-rock geology can make seismic data processing and interpretation difficult. By jointly inverting seismic tomography data with gravity data these difficulty may be overcome. We investigated the viability of deterministic minimum-structure style joint inversion of seismic traveltime and gravity data for the delineation of magmatic massive sulphide type geological targets. These tests also assessed the potential of employing borehole gravity. A number of synthetic Earth models were created. These models were built on triangular unstructured meshes, allowing for efficient generation of complicated, realistic geological structures. 2D models were based on conceptualized models of the magmatic massive sulphide body similar to the Eastern Deeps of the Voisey's Bay, Labrador, Canada. Single property and joint inversions were performed with seismic traveltimes and both ground-based and borehole gravity. There is a known relationship between seismic velocity and density for both silicate rocks and sulphide minerals for the models constructed; this lithological relationship was used to design an appropriate coupling strategy in the joint inversions.

Joint inversions were able to successfully locate a buried high contrast target with a variety of survey designs. 2D inversions results provided guidance to 3D inversion. Experimentation with noise levels, mesh design, and various inversion parameters has led to a better understanding of how to practically apply joint inversion of traveltimes and gravity data to this and similar exploration problems.