Cooperative inversion of gravity and seismic data with different spatial coverage

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Combining two or more geophysical datasets with different resolutions and characteristics is now a common practice to recover one or more physical properties. Building 3D geological models for mineral exploration targeting is often an expensive task even for inversion of a single dataset, because of extremely complicated structures with small scale targets. In this context, seismic methods, among all other traditional techniques in mineral exploration, are receiving increasing attention due to their higher resolution in depth. With more limited spatial coverage and higher resolution, they are usually used to refine the interpretation of potential field data.

As each seismic survey is designed for a particular intention with specific targets and may not be available in all regions of interests, we develop an iterative cooperative inversion algorithm for inverting gravity and seismic travel-time data. This enables the utilization of localized high-resolution seismic data in larger full 3D volume which is covered by gravity data. Geological information in the form of probabilistic geological modelling is used to extend information away from the high-resolution data and constrain the inversion result. We use these data as the prior model and to derive constraints incorporated into the objective function of gravity inversion. This allows us to obtain information about the probability of the presence of lithologies associated with the formation of mineral systems. To ensure structural consistency between density and velocity we develop a geologically constrained structure-based coupling technique following the same principle as the cross-gradient technique but with a higher degree of freedom in spatial directions. We apply local structure-based constraints conditioned by a geological probability distribution, which is considering direction and magnitude and provide a higher degree of freedom for model variations. An investigation of the proposed methodology and a proof-of-concept using realistic synthetic data are presented. Our results reveal that the methodology has the potential to constrain the gravity inversion results using the limited seismic data.