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Joint and constrained inversions in the Skellefte District

María de los Ángeles García Juanatey (1), Peter Lelièvre (2), Christopher Juhlin (1), and Colin Farquharson (2)
(1) Uppsala University, Earth Sciences, Solid Earth Physics, Uppsala, Sweden (maria.garcia@geo.uu.se), (2) Memorial University, Department of Earth Sciences, St. John's, Newfoundland, Canada.

The Skellefte district is a Paleoproterozoic, mainly metavolcanic, region in northern Sweden, and one of the richest metallogenic provinces in the country. In the last decade it has been the target of a great number of geological and geophysical measurements. The purpose of these investigations were to provide key information for the design of successful exploration strategies for targets at greater depths (> 1 km) by unraveling the current geological structures at a regional scale and developing an evolutionary model of their development.

We are focusing on the Kristineberg mining area in the western part of the Skellefte District. Here the geological setting is rather complex. The area has been subject to several stages of deformation and it is difficult to establish clear relationships between the different occurrences of the same formations. The lithologies of interest are covered by younger, massive, sheet-like intrusions. Outcrops are fairly rare due to an extensive cover of post-glacial sediments. Hence, even though this area has been intensively studied and our knowledge of it has increased significantly, the geological setting is not yet clearly understood and the existing 3D models carry large uncertainties.

We are using pre-existing geophysical data to improve our understanding of the geology and reduce 3D model uncertainties. This includes regional gravity and magnetic data acquired by the Geological Survey of Sweden in the 1970s, four lines of seismic reflection data totalling approximately 70 km, and more than 60 magnetotelluric sites spread across the area. The existing geological models have been constructed by interpreting these datasets independently, along with geological observations, providing different models of the various physical properties. Considering that different geophysical methods are responsive to different physical properties, interpreting the data together should help provide improved models, provided that the physical properties show some form of correlation in the subsurface. Before this work, no attempt had been made to integrate the geophysical and geological data into an integrated 3D Earth model consistent with all information available. For this task, we are considering geologically-constrained joint and cooperative inversion of the different geophysical datasets. Petrophysical information is available to help develop joint coupling approaches, but there are many practical questions regarding how best to integrate the data via inversion.