Geophysical Research Abstracts
Vol. 14, EGU2012-1309, 2012
EGU General Assembly 2012

Parameterization of the Earth’s subsurface to flexibly emphasize distinct rock units

P. G. Lelièvre, P. Zheglova, T. Danek, and C. G. Farquharson
Memorial University, Department of Earth Sciences, St. John’s, Newfoundland, Canada

Throughout the growth of a mineral exploration site, geological ore deposit models are developed based on available data and subsequent interpretations. The accuracy of these models is crucial when used to determine if a deposit is economic. 3D geological Earth models typically comprise wireframe surfaces that represent the geological contacts between different rock units. Wireframe surfaces, comprising tessellated triangular facets, are sufficiently flexible to allow the representation of arbitrarily complicated geological structures. In contrast, geophysical forward and inverse modelling methods typically parameterize the Earth on rigid rectilinear meshes because this simplifies the development of numerical methods. Complicated geological structures are often difficult or impossible to represent adequately on rectilinear meshes.

Typical minimum-structure inversions work on meshes that thoroughly discretize the Earth into many elements and seek smoothly varying models without unreasonably high values. This approach provides generality and is appropriate in early stages of exploration when little geologic knowledge is available. In contrast to the smooth models obtained from minimum-structure inversion, geologists’ interpretations about the Earth typically involve sharp interfaces between rock units. That scenario does not fit with typical minimum-structure approaches. Although there has been some work to encourage sharp features in minimum-structure inversions, there is potential to be gained from performing fundamentally different inversions that seek the interfaces between proposed rock units. Most geologists would like to work with such models as they can better emphasize distinct rock units and the contacts between them.

We are developing and researching several possible methods for parameterizing 3D contact surfaces. A simple method is to use a wireframe of nodes connected into tessellated triangles or other polygonal planar facets, as is typically used in geologic models. Another option is to use a level set approach where the interface between rock units is parameterized as the level set of a higher dimensional function. The advantages include flexibility in the shapes that can be recovered and reduction in the number of model parameters. Yet another possibility is to use spherical harmonics to represent the 3D contact surface, also allowing for a reduction in the dimensionality of the problem and introducing a simple means of regularization.

Working with these fundamentally different parameterizations of the Earth’s subsurface requires different computational methods to solve the forward and inverse problems. Forward modelling methods that rely on a volumetric discretization of the Earth can no longer be used unless an intermediate volumetric mesh is created that honours the contact surfaces. The solution of the inverse problem requires different computational optimization methods. Despite the computational challenges involved, common methods for parallelization, decomposition and mesh adaptation can be applied to significantly limit computation times and memory usage. This provides computationally feasible approaches for working with novel subsurface parameterizations that can efficiently and flexibly emphasize distinct rock units.