Main Session Talk

Translating Compositional Earth Models into Realistic Computational Models with Consideration to the Complexity of Geological Constraints

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There are two main Earth models we use to consider the subsurface structure, that is compositional and rheological. In geophysics, we utilize residual anomalies to bear some semblance to the structural changes in the subsurface that can be constrained by other independent observations. Geophysical modelling may be 1D (a series), 2D (profile or plan), or 3D (parameterized, hybrid, or regularized mesh). Sometimes we classify a forward or reverse (inversion) model dependent on the purpose. Forward models are generally used to test geophysical responses, for example, in survey design. Reverse, or inversion models attempt to fit observed geophysical measurements to a model of equivalent geophysical properties constrained by known hard data, whilst minimizing the mis-fit error, to solve a geological question.

In order to acquire measured data meaningful to the long wavelength structure in the crust and mantle layers of the Earth our measurements are limited to those that can achieve global coverage. We are therefore limited to satellite gravity and magnetics, and the networks of permanent seismometers such as published by IRIS, and regional survey networks, for example, the West African and SAMTEX MT, and the legacy Kenyan Rift International Seismic Project (K.R.I.S.P.). Deeper structure relies on seismic tomographic models of p and s-wave velocities. There exist other hybrid mantle composition models based on density conversions, but all the tomographic models rely on some form of regularized 3D cell inversion of spatially under-sampled 1D vertical profiles of velocity structure.

In order to achieve better unifying theories of the Earth's structure, we must also consider qualitative methods of understanding the structure. Therefore our geophysical models should conform to the geological surface exposure and geological inference of bedrock subcrop structure. If we abide by the compositional model of the Earth, then the structure we see from the measurement of geophysical properties and their anomalies should bear good correlation to the mapped surface geological expression and rock exposure.

Here we present several examples of the correlations that can be made from different geophysical methods employing different quantitative and qualitative methods that help us understand the longer wavelength structure and its impact on regional stress fields, using satellite potential fields data, seismic tomography, seismic refraction and MT station networks. We will explore the correlation with geology at a variety of scales (from continental to prospect level) and how this helps us understand the fourth dimension, time, that defines the evolution of geological processes. Utilizing data from the African continent, consideration will also be given to different theories we commercially use and their influence on our present day soft and hard rock 3D models in basin exploration, and mineral ore modelling respectively.