Geophysical Research Abstracts, Vol. 9, 10081, 2007
SRef-ID: 1607-7962/gra/EGU2007-A-10081

Structures and geometries in the continental lithosphere: Insights from joint inversion and co-operative interpretation of seismic and electromagnetic data

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Our understanding of how the Earth operates, particularly its tectonic history and secular variation of tectonic processes, is severely limited by both our lack of knowledge, and the intrinsic bias in knowledge, at depth. Whereas superb geological mapping yields plausible inferences about subsurface geometries, from which reasonable deductions can be made about likely tectonic histories, there are very few regions where such models have been tested, and then only to depths of 10 km in deep continental drilling programmes. Similarly, inferences based on geochemical, petrological and geochronological analyses of crustal and mantle xenoliths and xenocrysts, brought to the surface by volcanic or tectonic processes, also yield models of subsurface geometries and tectonic histories; however sampling is highly biased, with no material from many key locations, leading to valid questions about generic applicability of those inferences.

In-situ physical properties of the continental lithosphere and beyond, obtained through seismological and electromagnetic observations, yield geometrical information and have the advantage that all regions are sensed, albeit with varying resolution kernels. A particular feature of the continental lithosphere and underlying asthenosphere that has been used to guide interpretation over the last decade is the observation of seismic, and more recently electrical, anisotropy. Valid comparisons between different measures of anisotropy require both a thorough appreciation and understanding of the principles and limitations of the various techniques and the development of analysis and interpretation tools.

Results will be shown from two Archean cratons, the Slave craton of northern Canada and the Kaapvaal craton of southern Africa, where joint inversion and co-operative interpretation of seismic and electromagnetic data have been applied. Joint inversion of receiver function and MT data from a site on the Slave craton exhibits isotropic layering consistent with the two datasets, and that suggests a functional relationship between velocity and electrical resistivity not as a consequence of either thermal or fluid state. Co-operative interpretation of anisotropy directions deduced from SKS analyses of seismic arrivals and directionality analyses of MT data exhibit some similarities, but significant differences, suggestive of dominant conductive directions not being controlled by aligned mantle lattices.

These modern multi-discipline and multi-technique tools will form an essential component of TOPO-Europe in its quest to understand the driving mantle processes that result in the topography on which we live.