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Preface to "Insights into the Earth's Deep Lithosphere"

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Dear Readers:

I am pleased to present a special issue of Tectonophysics entitled “Insights into the Earth’s Deep Lithosphere.” This compilation sought to capture the flavor of the increasing number of studies that are emerging to investigate the complex lithospheric structure of the earth. This issue evolved out of a Fall 2007 AGU special session entitled “Understanding the Earth’s Deep Lithosphere” that I organized with Irina Artemieva from the University of Copenhagen. For that session, we solicited talks that discussed the increasing number of methods that have surfaced to study various aspects of the earth’s deep lithosphere. These methods include seismic, gravity, thermal, geochemical, and various combinations of these methods. The quality of the presentations (2 oral sessions with 16 talks and 23 associated poster presentations) was such that we felt that the emerging topic deserved a dedicated forum to address these questions in greater detail.

The availability of new data sets has also improved the number and quality of lithospheric studies. With many new studies and methodologies, a better understanding of both continental and oceanic lithospheres is starting to emerge. Questions remain about the thickness and evolution of the lithosphere, the presence of lithospheric keels, the density and anisotropy of lithospheric roots, mechanisms of lithospheric thinning, and differences between mechanical, thermal and chemical boundary layers. While we did not get contributions on the full gamut of methods and regions, a lot of ground was covered in this issue’s manuscripts.

Like any collection of papers on the deep lithosphere, the topics are quite varied in methodology, geographic location, and what aspect of the lithosphere being studied. Still, the results highlight the rewarding aspects of earth structure, history, and evolution that can be gleaned. Here is a brief synopsis of the papers contained in this issue:

Forte et al. consider the dynamics of North America using constraints from seismic and mantle convections datasets. Main conclusions from the study are that viscous flow in the mantle may be associated with the descent of the Kula-Farallon plate system, and an active mantle upwelling below the Pacific margin of North America. They also find that large-scale heterogeneities give rise to regional scale flow and stress patterns.

Wüstefeld et al. use shear-wave splitting to examine ancient deformation in the East European Craton. Splitting magnitude and direction is used to determine the seismic anisotropy in the upper mantle. Lithospheric anisotropy in the region is supported by evidence of large-scale coherence within constitutive blocks, weak correlations with plate motions, and good correspondence with crustal magmatism.

The study of Forster et al. uses lithospheric thermal modeling to examine properties of the Arabian Shield in Jordan. They find that the thickness, composition, and petrophysical properties of the shield are not consistent with the suspected anomalously cold terrane.

Pasyanos uses long-period surface waves to estimate lithospheric thickness and compare the resulting maps to other estimates of this parameter in the broad Eurasia and Africa region. He concludes that the simple modeling employed in the study works well, and that estimates made using this method compare favorably with other estimates (lithospheric cooling, thermal, other seismic).

Martinez et al. look at the shear-wave attenuation structure of the lithospheric-asthenospheric system beneath the Mediterranean down to 160 km depth. The attenuation tomography finds high attenuation in a region from Corsica-Sardinia to Italy down to 75 km that is due to the presence of asthenospheric material at shallow depths.

Fernandez et al. combine petrological, mineral physics, and geophysics observables to study the structure of the Namibian volcanic margin. They calculated mantle temperature and density distribution along a 500-km long transect down to 400 km. They find a thermal lithospheric thickness of about 100 km under old oceanic lithospheric, increasing slowly to about 125 km under the ocean-continent transition, then rapidly to about 175 km under the continent.

Karato examines the longevity of deep crustal roots. In particular, he examines the rheology of mantle materials under “dry” (water-free) and “wet” (water-rich) conditions. The influence of water is large (change in viscosity up to 4 orders of magnitude). He concludes that high degree of water removal that occurred in the Archean is responsible for long-lasting continental roots.

Gregersen et al. look at a number of studies examining the deep earth under the Tornquist Zone to examine the uncertainty of lithospheric-asthenospheric structure down to 300 km depth. Stability of results is examined by pulling together the results of many studies using various techniques (P-wave travel times, surface waves, receiver functions, anisotropy, scattering) using data from Project Tor. What they find consistent among the studies are 3 different lithospheric structures across the Tornquist zone stepping from 120 km thick lithosphere in the west down to a depth of 200 km to the east.

The study of Wilde-Piorko et al. considers the transition from Precambrian craton to Phanerozic terranes along the Trans European Suture Zone (TESZ) in Central Europe using a number of mostly seismic techniques. They examine a number of aspects down to 900 km depth including sedimentary basins, the crust, lithosphere-asthenosphere boundary (LAB), and mantle transition zone. Besides shallow basins, a steady increase in crustal thickness, and several abrupt changes in LAB depth (mentioned above), they also find an increased mantle transition zone between the 410 and 660 km discontinuities under the East European Craton.

Saygin and Kennett use ambient noise tomography to look at shallow lithospheric structure across Australia. What they find from the surface wave dispersion is that short period sensitivity is mainly due to sedimentary basins. At long periods, reduced wavespeeds are due to elevated temperatures in agreement with estimates of crustal heat flow, while cratonic blocks are fast.

We hope that this series of papers can serve as a first effort to synthesize our understanding of lithospheric structure and processes behind its formation and evolution. We also look forward to how our knowledge of the lithosphere will continue to improve with focused studies on this aspect of our earth's structure.

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Best Regards,
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