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Seismic evidence for the layered mantle lithosphere: a comparsion between Zagros and South Africa

Forough Sodoudi (1) and Rainer Kind (1,2)

(1) Deutsches GeoForschungsZentrum GFZ, Potsdam, Germany (foroug@gfz-potsdam.de, 0049 331 2881277), (2) Freie Universität Berlin, Germany

Recent S receiver function studies present evidence for the existence of the layered mantle lithosphere beneath ancient cratons. However, the nature of these layers is still unclear. They can be attributed to the presence of accumulated melts, remnants of subduction interfaces, changes in anisotropic properties or fluids. Further characterization of these layers is needed to provide more insights into the assembly and evolution of cratons. Here we compare the mantle lithosphere of the ancient Kalahari craton with the relatively young mantle lithosphere of Zagros, which is assumed as the location of the future craton. We applied the S receiver function method to map the internal layering of the lithosphere and to image its lower limit. For this aim, we used teleseismic events recorded at 97 seismic stations within the Kalahari craton and those recorded at 61 permanent seismic stations in Iran. Our results reveal a thick and stratified mantle lithosphere beneath the Kalahari craton containing three significant negative velocity contrasts at 85, 150-200, and 260-280 km depth. Moreover, they imply that frozen-in anisotropy as well as notable compositional variations can lead to sharp Mid-Lithospheric Discontinuities (MLD) that can be clearly observed in the SRF data. We show that a 50 km thick anisotropic layer just below the Moho boundary with 3% S wave anisotropy may be responsible for producing a MLD at 85 km depth. The horizontal anisotropy in the upper lithosphere may be attributed to processes during the formation of the Kalahari Craton. Furthermore, significant correlation between the depths of an apparent boundary separating the depleted and metasomatised lithosphere, as inferred from chemical tomography, and those of our second layer led us to characterize it as a compositional boundary, most likely due to the modification of the cratonic mantle lithosphere by magma infiltration. The largest velocity contrast (3.6-4.7%) is observed at a boundary located at depths of 260-280 km, which most likely represents the lithosphere-asthenosphere boundary. Based on our result, the Kalahari lithosphere may have survived multiple episodes of intense magmatism and collisional rifting during the billions of years of its history, which left their imprint in its internal layering. Beneath the Zagros collision zone we find a 200 km thick lithosphere, which most likely represents the Arabian lithosphere that has been strongly deformed, thickened and depleted. Thus, similar processes such as those that occurred beneath shields may have taken place beneath the Zagros. In contrast, we observe a thin lithosphere of about 80-90 km beneath Central Iran and Alborz. Our results also suggest the presence of remnants of the fossil Neo-Tethys subduction at depths ranging between 80-150 km within the Arabian lithosphere. This dipping structure can be seen beneath the Zagros collision zone and disappear towards the northeast beneath Central Iran and Alborz. These findings may support the idea of a breakoff of the oceanic Neo-Tethyan slab beneath Central Iran, which results in an asthenospheric upwelling and thinning of the Iranian lithosphere beneath Central Iran and Alborz.