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Lowermost mantle anisotropy beneath Africa imaged by SKS-SKKS differential splitting

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Seismic observations of the lowermost mantle show that this deep part of the earth's interior is highly heterogeneous. This includes the presence of two large low shear velocity provinces (LLSVPs), and the presence of seismic anisotropy, particularly at the margins of the LLSVPs. Here, we investigate the lowermost mantle in the vicinity of the African LLSVP using shear-wave splitting discrepancies of teleseismic SKS and SKKS phases for the same station-event pairs. Though these phases are traditionally used to study anisotropy in the upper mantle and infer past and present mantle flow processes, discrepancies in their splitting measurements can be exploited to resolve lowermost mantle anisotropy because of their divergent pathways in the lowermost mantle. To measure shear-wave splitting, we use the transverse energy minimization and multi-channel splitting intensity method (Silver & Chan, 1991; Chevrot, 2000). Overall, we present observations from 375 stations and ~900 SKS-SKKS pairs. This data set comprises all publicly available permanent stations in Africa and temporary experiments since 1990. This enables us to map the spatial distribution of the anisotropic and isotropic regions of the lowermost mantle with unprecedented resolution.

Of our observations, one third of the SKS-SKKS pairs is highly discrepant as defined by the difference in the splitting intensity. Discrepant pairs are roughly localized in three areas: at the northern and southeastern border of the LLSVP, inside the LLSVP beneath central Africa, and outside of the LLSVP atop and east of the Afar plume. To explain these observations, we invoke different mechanism for seismic anisotropy. Discrepant pairs located across the border of the LLSVP indicate that SKS-SKKS pairs pierce an isotropic LLSVP and an anisotropic cold/fast D" outside the LLSVP. As observations of strong discrepancies inside the LLSVP coincide with a previously mapped ULVZ, anisotropy is best explained by SPO inside the ULVZ due to martial melting, compositional heterogeneities or the highly anisotropic magnesiowüstite. Finally, observations of discrepant pairs in the cold/fast part of the D" are thought to elucidate a change in the flow geometry from horizontal to vertical. Considering all observations, our analyses suggest that LLSVPs are passive thermochemical piles in which subduction driven horizontal flow at the base of the mantle induces a vertical flow component at the LLSVP boundary. Inside the LLSVP, an ULVZ may slowly be swept towards the LLSVP boundary. In the center of both, the deep-rooted Afar plume impinges from the CMB. Accordingly, we present a significant contribution towards lower mantle dynamics and processes which also control the upper mantle.