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The elusive lithosphere-asthenosphere boundary (LAB)

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The lithosphere-asthenosphere boundary (LAB) is a first-order structural discontinuity that accommodates differential motion between tectonic plates and the underlying mantle. Although it is the most extensive type of plate boundary on the planet, its definitive detection, especially beneath cratons, is proving elusive. Different proxies are used to demarcate the LAB, depending on the nature of the measurement. Here we compare interpretations of the LAB beneath three well studied Archean regions: the Kaapvaal craton, the Slave craton and the Fennoscandian Shield. For each craton, xenolith and xenocryst thermobarometry define a mantle stratigraphy, as well as a steady-state conductive geotherm that constrains the minimum pressure (depth) of the base of the thermal boundary layer (TBL) to 45-65 kbar (170-245 km). High-temperature xenoliths from northern Lesotho record Fe-, Ca- and Ti-enrichment, grain-size reduction and globally unique supra-adiabatic temperatures at 53-61 kbar (200-230 km depth), all interpreted to result from efficient advection of asthenosphere-derived melts and heat into the TBL. Using a recently compiled suite of olivine creep parameters together with published geotherms, we show that the probable deformation mechanism near the LAB is dislocation creep, consistent with widely observed seismic and electrical anisotropy fabrics. If the LAB is dry, it is probably diffuse ($>$50 km thick), and high levels of shear stress ($>$ 2 MPa or $>$ 20 bar) are required to accom-

modate plate motion. If the LAB is wet, lower shear stress is required to accommodate plate motion and the boundary may be relatively sharp ($>$ 20 km thick).

The seismic LAB beneath cratons is typically regarded as the base of a high-velocity mantle lid, although some workers infer its location based on a distinct change in seismic anisotropy. Surface-wave inversion studies provide depth-constrained velocity models, but are relatively insensitive to the sharpness of the LAB. The S-receiver function method is a promising new seismic technique with complementary characteristics to surface-wave studies, since it is sensitive to sharpness of the LAB but requires independent velocity information for accurate depth estimation. Magnetotelluric (MT) observations have, for many decades, imaged an "electrical asthenosphere" layer at depths beneath the continents consistent with seismic low-velocity zones. This feature is most easily explained by the presence of a small amount of water in the asthenosphere, possibly inducing partial melt. Depth estimates based on various proxies considered here are similar, lending confidence that existing geophysical tools are effective for mapping the LAB beneath cratons.