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More evidence that a plume-fed asthenosphere underlies all but thick cratonic lithosphere

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The hypothesis that a weaker asthenosphere underlies the strong surface plates was first proposed a century before the advent of plate tectonics – even its name (“asthenos” is greek for weak; “sphere” greek for spherical shell) presupposes the earth to have a simple spherically layered structure instead of the heterogeneous mosaic of quasi-rigid plates that make up the strong near-surface region. However, there is increasing observational evidence which indicates we need to redefine our concept of asthenosphere. While a well-developed and extremely weak asthenosphere exists between ˜80-250 km depths beneath the relatively thin lithosphere found in the ocean basins and younger continental regions, a significantly deeper (˜100 km deeper) and more-viscous ‘asthenosphere’ (if we want to use the same term) is found beneath ˜200+km-thick continental cratons. Recent seismic wavespeed and attenuation observations imply that beneath oceanic lithosphere, the potential temperature reaches a maximum ˜1425°C at ˜175 km beneath oceanic lithosphere, beneath craton roots the maximum potential temperature of 1125-1225°C is reached at ˜250 km depths (consistent with downward extrapolation of the 80-160 km segment of Boyd’s kimberlite geotherm), and the potential temperature beneath both cratons and oceanic lithosphere is ˜1125-1225°C at 300km depths. Recently observed underside reflections from the base of subducting slabs and shear-wave splitting at subduction zones also maps structures that would form in a plume-fed asthenosphere. If a plume-fed asthenosphere indeed exists, it has several important consequences for mantle convection: (1) The asthenosphere is fed from below by hotter-than-average mantle temperature plumes;

(2) The hot, weak, and buoyant asthenosphere acts as a barrier to upwelling of underlying colder and denser mantle, which in turn implies that ridge upwelling and the accretion of oceanic lithosphere reuse asthenosphere originally fed by plumes; (3) The base of thick cratons and Proterozoic terrains is the only part of the surface plates strongly coupled to underlying sub-asthenospheric mantle flow, and also has a time-averaged lower potential temperature than the base of oceanic lithosphere; (4) Plume material 'drains' sideways from beneath cratons towards neighboring regions of thinner lithosphere.