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Partial melting at 410- and 70-km and the origin of the asthenosphere

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The asthenosphere of Earth is a mechanically weak layer that helps plate tectonics to operate and is also a region from which mid-ocean-ridge basalt is formed. However, all previously published models of the asthenosphere fail to explain some of the key observations. It is proposed that the asthenosphere is formed as a residue of a small degree of partial melting at 410 km and the lithosphere-asthenosphere boundary is defined by the partial melting at 70 km below the mid-ocean ridges that re-distributes hydrogen. Combined with mineral physics observations on non-elastic deformation and wetting behavior of upper mantle materials, this model provides a unified explanation of observations including a sharp and large velocity drop at the lithosphere-asthenosphere boundary, mostly plate velocity parallel but plate velocity normal anisotropy below some subducting slabs, a thick low velocity region above the 410-km discontinuity, and the modestly depleted and nearly homogenous composition of the asthenosphere.