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Seismic Evidence for Partial Melt Below Tectonic Plates

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The seismic low-velocity zone (LVZ) of the upper mantle is generally associated with a low-viscosity asthenosphere that has a key role in decoupling tectonic plates from the mantle. However, the origin of the LVZ remains unclear. Some studies attribute its low seismic velocities to a small amount of partial melt of minerals in the mantle, whereas others attribute them to solid-state mechanisms near the solidus or the effect of its volatile contents. Observations of shear attenuation provide additional constraints on the origin of the LVZ. On the basis of the interpretation of global three-dimensional shear attenuation and velocity models, here we report partial melt occurring within the LVZ. We observe that partial melting down to 150–200 kilometres beneath mid-ocean ridges, major hotspots and back-arc regions feeds the asthenosphere. A small part of this melt (less than 0.3 per cent) remains trapped within the oceanic LVZ. Melt is mostly absent under continental regions. The amount of melt increases with plate velocity, increasing substantially for plate velocities of between 3 centimetres per year and 5 centimetres per year. This finding is consistent with previous observations of mantle crystal alignment underneath tectonic plates. Our observations suggest that by reducing viscosity melt facilitates plate motion and large-scale crystal alignment in the asthenosphere.