On the shallow origin of hotspots and the westward drift of the lithosphere

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ABSTRACT

Intraplate migrating hotspots, which are unrelated to rifts or plate margins in general, regardless of their origin in the mantle column, indicate relative motion between the lithosphere and the underlying mantle in which the hotspot source is located. Pacific plate hotspots are sufficiently fixed relative to one another to represent an independent reference frame to compute plate motions. However, the interpretation of the middle asthenosphere rather than the deep lower mantle as the source for intraplate Pacific hotspots has several implications. First, decoupling between the lithosphere and subasthenospheric mantle is greater than recorded by hotspot volcanic tracks (>100 mm/yr) due to undetectable shear in the lower asthenosphere below the magmatic source. The shallower the source, the larger the décollement.

Second, computation of the westward drift is linked to the Pacific plate and assumes that the deep lower mantle, below the decoupling zone, sources the hotspots above. The Pacific plate is the fastest plate in the hotspot reference frame and dominates the net rotation of the lithosphere. Therefore, if decoupling with the subasthenospheric mantle is larger, the global westward drift of the lithosphere must be faster than present estimates, and may possibly vary between 50 and 90 mm/yr. In this case, all plates, albeit moving at different velocities, move westward relative to the subasthenospheric mantle.

Finally, faster decoupling can generate more shear heating in the asthenosphere (even >100 °C). This amount of heating, in an undepleted mantle, could trigger scattered intraplate Pacific volcanism itself if the viscosity of the asthenosphere is locally higher than normal. The Emperor-Hawaiian bend can be reproduced when bent viscosity anisotropy in the asthenosphere is included. Variations in depth and geometry in the asthenosphere of these regions of higher viscosity could account for the irregular migration and velocities of surface volcanic tracks. This type of volcanic chain has different kinematic and magmatic origins from the Atlantic hotspots or wetspots, which migrate with or close to the oceanic spreading center and are therefore plate-margin related.