Why Does The Earth Have Lithosphere Of Around 90 Km Thickness In Oceanic And Many Continental Intraplate Settings?

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The concepts of lithosphere and asthenosphere derive from inferred rheological properties of the uppermost part of the upper mantle and the overlying crust (the lithosphere), and the underlying mantle with lower viscosity at depths usually between 100 and 200 km approximately (the asthenosphere). In plate-tectonics the concepts correlate with the 'rigid plate' overlying the asthenosphere, a detachment layer with respect to underlying mantle. Observed and inferred seismological and rheological differences between lithosphere and asthenosphere have been attributed to temperature (geothermal gradient), presence or absence of fluid ('water-weakening' of olivine) or presence or absence of melting. These possible causes are interdependent.

Experimental petrology has defined the conditions for melting of upper mantle peridotite and in particular has demonstrated the important role for carbon and hydrogen (C, H,O species) in causing incipient or small degree melting at temperatures of 400-500°C below the C,H-free peridotite solidus, at ~100 km depth. The roles of carbonatite and silicate melting have been demonstrated by studies of magmas and xenoliths, including experimental studies. In intraplate settings consideration of carbon, hydrogen and fO_2 characteristics of intraplate magmas and of mantle xenoliths leads to a specific model in which *the lithosphere/asthenosphere boundary is identified with the high pressure stability-limit of pargasitic amphibole.* At depths >90 km, carbon and hydrogen, even at levels ~100 ppm H_2O, and lower C (CO_2, CH_4) contents, initiate melting. Small fractions (<1-2% melt) have low permeability and additionally cannot rise above 90 km without crystallising as pargasite±carbonatite melt.

Within the asthenosphere, slow migration of the incipient melt fraction produces chemical inhomogeneity with enrichment in the upper asthenosphere and lower lithosphere in incompatible elements and corresponding depletion in the underlying mantle. A second major cause of chemical heterogeneity in the mantle is subduction of crust/lithosphere and further history of reaction and re-fertilisation during mantle residence. The interface between subducted crust/lithosphere and fertile(MORB-source) mantle is a favourable location for melting and initiation of upwelling. The lack of predicted differences in temperatures and depths of origin of primitive magmas from 'hot spot' sources and MORB sources argues for compositional buoyancies rather than deep-origin thermal plumes as the cause of 'fixed hot spot' volcanism.

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