ORIGIN AND EVOLUTION OF CONTINENTAL LITHOSPHERIC MANTLE: BUOYANT BLOBS, INTRACRATONIC EDDIES AND FERTILE UPWELLINGS?

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Samples of the deep lithosphere occur at the surface as small xenoliths in lavas with restricted petrological context, and as tectonic slivers on the scale of km^2 but commonly with metamorphic petrological overprints. Geophysical data (especially tomography) allow us to extrapolate mantle rock-type domains between magmatic virtual drill holes and to build up 3-D images of lithosphere composition, sometimes in time-slices (4-D). Xenolith data reveal significant differences in composition and physical properties of Archean and Phanerozoic mantle; much intermediate "Proterozoic" mantle may represent reworked Archean material. Truly pristine Archean mantle may be very rare as these buoyant blobs undergo repetitive geochemical transformation to varying degrees.

Refined seismic tomography inversions image low density regions, persisting in some cases down to the transition zone, beneath both cratons and the oceans. Old Re-Os ages for some depleted mantle rock types beneath rift zones and oceanic areas suggest that these low-density blobs represent relict Archean SCLM, which has been mechanically disrupted and thinned. This implies that old lithospheric mantle is much more extensive, laterally and vertically, than previously considered and proposed processes for the formation of Archean lithosphere have to consider this.

If coherent old SCLM persists at depth, this has important implications for the nature of global convection. Models involving large-scale horizontal components are difficult to reconcile with these observations. Instead, convection may be dominantly in the form of upwelling vertical conduits with shallow horizontal flow (eg a modified lava lamp model of Kellogg and van der Hilst). The locus of these conduits may be controlled by the geometry of the margins and the coherence of the buoyant lithospheric blobs. Convective plate motions are "eddies" between these buoyant blobs and can be preserved in the observed plate stress directions and anisotropy (eg Simons and van der Hilst). Mobile belts represent lithosphere accretion between blobs.

Persistence of ancient SCLM beneath younger mobile belts and oceans also provides a logical explanation for the alphabet soup of mantle sources created by geochemists (eg EM1, HIMU). These geochemical fingerprints are all found in lithospheric material (xenoliths). If lithospheric volumes persist to very deep mantle levels (eg 400km) then interaction with upwelling mantle can "contaminate" these plumes andMantle tomographyMantle composition fluids.