Meetabst\GordonRC.sam/doc/pdf
Gordon Research Conference on 'Interior of the Earth'. Mt Holyoke College, Mass, 10-15 Jun 2001
Convened by John E, Vidale & Jerry X. Mitrovica

Two-layer convection of the mantle. How is it possible? When did it change? What are its geochemical and plate tectonic Implications?

Miles F. Osmaston *miles@osmaston.demon.co.uk*
The White Cottage, Sendmarsh, Ripley, Woking, Surrey GU23 6JT, UK.

Based on elemental abundances in meteorites, geochemists recognize a need for a major enriched reservoir, commonly identified as the lower mantle; recent developments of the plume concept make use of this view. Yet seismologists claim to observe the traces of large-volume subducting 'slabs' penetrating far into the lower mantle, making dubious the long-term retention of a lower mantle reservoir. But the 'Dupal' isotopic signature in magmas (named after its discoverers, Dupré & Allègre), widely observed as streaks crossing the Indian and South Atlantic oceans and in the Western Pacific-East Asia areas, records the effective isolation of the source from depletion and mixing processes since 2.5-3.0 Ga. Where has that material resided until its involvement in magmatic processes during the past 100Ma?

To resolve this conflict, we reconsider the subduction process and what is actually being subducted. To achieve tectonic undercutting and development of 'flat-slab' profiles (Osmaston, 1995; 1999a), subducting plates must possess thermal buoyancy (Osmaston, 1999b); so a new model of the MOR process has been devised which treats LVZ material as integral with the plate and provides much more ridge-push to drive subduction (Osmaston, 2000a). During subductive descent the LVZ interstitial melt solidifies, restoring good thermal conductivity, and LVZ heat starts to conduct towards the interface. This seems to be supported by two kinds of seismological evidence. Firstly, the well-defined double seismic zone beneath Japan converges between 50 and 200km depth before it peters out. Secondly, subduction tomographic profiles kindly made available to me by E.R. Engdahl show a marked attenuation of the 'cold-slab' signature in the 250-400km depth interval, beyond which a high-velocity signature reappears. This seems inconsistent with the cold-slab imagery offered by modellers.

The high energy-release of deep (350-660km) earthquakes is a problem which near-melting interface conditions may resolve; melts there are denser than the solid from which they derive, so imply input of overburden adiabatic compressional energy which propagates the melting. Regardless of whether this is a valid resolution of the deep earthquake problem, this partial melting of the subducted crust will (at these depths) produce low-silica melt very rich in Fe, with a probably stishovite-rich residue, so that *both* components could be denser than the original, creating lumps with a high-velocity signature in the TZ and showering slowly as dense high-seismic-velocity lumps into the lower mantle, with stishovite thought to match the properties of D".

Tomographic traces will be interpreted in these terms; sloping traces imply westward motion of the Americas; significantly, these traces greatly widen vertically with increasing depth, consistent with different sinkage velocities for different-sized lumps. Meanwhile the mantle part of the subducted plate recycles within the upper mantle. High heat generation in the early Earth made whole-mantle convection inevitable, so when did it change?

Huge changes in geological processes during the 2.5-2.2Ga interval (marked by an absence of greenstone and orogenic granitoid dates in the 2.45-2.22 Ga interval, and during which much tightly-interlocking evidence supports that plate tectonic processes were temporarily halted) suggest this was the time of changeover to separate upper mantle convection. Since then, depletion has been confined to the upper mantle, much of its differentiates being dumped into the lower mantle, although some have formed additions to the continental crust. The major reduction in the volume of mantle being depleted is evident in the much-accelerated rise in mantle depletion indicators like epsilon Nd since that time (Osmaston, 2000b). Studies have shown that even after it has passed the subarc point, subducted oceanic crust still contains significant water, so the loss of this material into the lower mantle constitutes a mechanism for drying out the upper mantle from the much wetter state in the Archaean favoured by studies of komatiites.

Beneath Archaean cratons, the 410km and 520km discontinuities are reported to appear weak or absent, suggesting that less-depleted tectospheres extend to beyond that. This interpretation is

rendered tenable if this material is wet (and perhaps CO2-rich) Archaean mantle; the hydrous/CO2 component would counteract the high density which would otherwise prevent its continued adherence below the craton. This interpretation is supported by the metasomatism widely seen in mantle xenoliths of deep origin.

If cratons have keels extending almost to the base of the upper mantle there are interesting consequences for plate tectonics. As the Atlantic opened, where did the mantle below it come from if it cannot come from the lower mantle? Are the eastward motions of the Caribbean and Scotia areas the result? Likewise, did the Cenozoic opening of the Arctic Ocean drag Greenland's keel northwards, causing the widespread folding at that time along its northern margin, in Ellesmere Island and in western Svalbard? These motions have hitherto lacked a cause.

Osmaston MF (1995) Comparability of the flat-slab sectors of the Andes and Sevier-Laramide USA: consequences of tectonic erosion and coupling at the subducting plate downbend Int.Union Geod.Geophys. XXI Gen.Assy., Boulder, Colorado. Abstr.A, A441.

Osmaston MF (1999a) Seismic coupling at subduction zones; its mechanical cause and far-reaching geological consequences. IUGG99, Birmingham, UK. , Abstr.A A.157 (A.159 in Abstr.Update CD-ROM).

Osmaston MF (1999b) Phanerozoic subduction and the TTG-magmatic construction of Archaean continental crust. IUGG99, Birmingham, UK. Abstr.B B.74 (B.75 in Abst.Update CD).

Osmaston MF (2000a) What goes on beneath MORs? A reassessment. 31st Int.Geol.Congr., Rio de Janeiro. Abstracts CD-ROM: Gen.Symp. 4-1.

Osmaston MF (2000b) An upper mantle source for plumes and Dupal; result of processes and history that have shaped the Earth's interior from core to crust. Goldschmidt 2000, Oxford, UK. J.Conf.Abs. (CD-ROM) 5 (2): 763.