RAS Specialist discn mtg 11Nov2011 'UKSEDI: Study of the Earth's Deep Interior' : Kathy Whaler, Richard Holme & James Wookey', organizers.

A new starting-point for the deep-Earth paradigm, leading to wider insights on today's behaviour

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

Our attempts to understand the internal behaviour of our planet are necessarily underlain by what we think we know about its origin and the evolution of what is going on inside it. So this contribution outlines the big changes in this that are already well in train, even bearing upon major features of our everyday lives - water, oxygen, big earthquakes. Obviously, changes in the deep-Earth paradigm could also affect our views on the other terrestrial planets (TPs) and influence exploration missions to them.

Our starting point, for all four TPs, is their planetary construction and the formation of their iron cores. To achieve their individually very high orbital specific angular momenta, relative to solar material (>5000-fold for Earth), the nebula must be present and do it for their feedstock throughout their growth [1]. This short timescale (<5 Ma?) completely rules out the >30 Ma timescales inferred for cores-by-percolation models and necessitates reversion to the Ringwood model, with the further great benefit of forming the solar planetary system's water by chemical reaction of nebular H with erupted FeO [1]. The resulting Fe is then 'subducted' in non-reacting lumps, to build the core. This mechanism also has potential to carry lithophiles (U,Th) into the core.

It turns out that the inevitable incorporation of a lot of this water in the mineral structure of the mantle has dominated the magmagenetic and (via its rheological effect) the dynamical evolution of the Earth [1,2]. Prior to 2.5 Ga this permitted convective extraction of early heating and genesis of komatiite, the predominant high-melting magmatic effusive, all without a need for mantle plumes.

After that, its non-linear effect upon rheology [3] as the ocean emerged resulted in a complete hiatus in plate tectonics ~2.45-2.2 Ga [2,4,5], during which oxygenic life in shallow water was able to win its battle against acidic (mainly CO_2) volcanic exhalations at MORs, marking the initiation of our oxygen-bearing atmosphere, to which we owe our very existence. Concomitantly, it also oxidized the previously low-pH deeper ocean water, bringing deposition from it of most of the world's iron ore reserves (BIF). MOR collapse greatly lowered (>3km) sea-level and the resultant erosion of cratons lowered atmospheric CO_2 by weathering to the point that Earth's first global glaciations (Huronian) occurred during the hiatus.

Since that time, and globally explicit in the dynamics of plate motions for the past 150 Ma [5], this rheologically 'stiffened' mantle has (despite seismological interpretation to the contrary, on account the low *Vs* of its persisting late-Archaean content of interstitial fluid) remained attached to the undersides of craton lithospheres as 'deep keels' reaching to or near the base of the Upper Mantle [2,5]. That fluid apparently sources the metasomatism in kimberlite xenoliths erupted through cratons.

The '2-layer mantle' implied by these dynamics arises from convective separation precipitated by the hiatus and is seen in the subsequent 3-fold steeper rise in the UM depletion parameter εNd. Interpretation that high-*Vp* 'slabs' penetrate far into the Lower Mantle requires fundamental revision in the light of the thick-plate (including LVZ [ref 3]) and heat-retaining view for oceanic plate. So the LM 'slabs' are actually showers of high-density, high-*Vp* stishovitic crustal residues, more being produced, the younger the plate. This resolves the paradox that the biggest LM 'slab' signature relates to the world's youngest-plate subduction zone, and the smallest signature to the oldest.

Another group of mantle-constitution factors - phase changes - needs attention by geophysical modellers, on account of the very large volume changes, per joule in or out, exhibited by most of them, relative to pure thermal expansivity. As thermally induced volume changes these can have big effects upon topography. In particular [2], that of spinel peridotite to garnet peridotite, whose volume change/joule multiple is around 50-fold, is typically present at somewhere between 50-90km below our ocean floor. The volume change is confused, using pure expansivity, with the convective injection of very large volume of hot magma to that sort of depth, whereas the heat from quite a narrow volcanic duct - in much thicker plate - may readily do the job. An important consequence of this solid-state volume increase is that its horizontal expression may split the plate further. Moreover, if you have a planet with no plate tectonics, as was the Earth during the hiatus, on which the global lithosphere is cooling and shrinking horizontally, this will produce limited-extension rifts, such as are widely evident on cratons in this interval.

Another feature of thick plates is that narrowly splitting them is a fertile mechanism for mantle magmagenesis and its segregation at different depths to yield different volcanic compositions [6].

References

[1] Osmaston M. F.: Providing solar system water and high planetary angular momentum, using a return to Ringwood's core formation model, supported by the behavioural evolution of the mantle. *Geochimica et Cosmochimica Acta,* v.**74**(S1), A 779. 2010.

[2] Osmaston M. F.: On the actual variety of plate dynamical mechanisms and how mantle evolution affected them through time, from core formation to the Indian collision. *Geophysical Research Abstracts* **12**, EGU2010-6101, 2010.

[3] Hirth G. and Kohlstedt D. L.: Water in the oceanic upper mantle: implication for rheology, melt extraction, and the evolution of the lithosphere. *Earth and Planetary Science Letters* v.**144**, 93-108. 1996.

[4] Condie K. C., O'Neill C., and Aster R.: Did plate tectonics shut down for 200 to 300 My during the Early Proterozoic? *Geochimica et Cosmochimica Acta,* v.**72**(12S) A175. 2008.

[5] Osmaston M. F.: Deep cratonic keels and a 2-layer mantle? Tectonic basis for some far-reaching new insights on the dynamical behaviour and properties of the Earth's mantle; with major plate motion examples. *Geophysical Research Abstracts,* v.**11**, EGU2009-12537-1. 2009.

[6] Osmaston M. F.: Extra-thick plates: basis for a single model of mantle magmagenesis, all the way from MORB to kimberlite. *Geochimica et Cosmochimica Acta* v.**72**(12S), A711, 2008.