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Extra-thick plates: basis of a versatile mode of mantle magmagenesis, also possessing isotopic selectivity relevant to planetary differences

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Simple, geologically supported, plate dynamical arguments (Osmaston 2005, 2006, 2007, 2008a,b, 2009a,b, eg.[1]) show that tectonic plates are very thick, with cratons having tectospheric keels to near 660km, and that Earth has had a 2-layer mantle since ~2.3Ga. These, which I will begin by outlining, have proved remarkably persuasive, even to seismologists. This finding opens a new door to understanding many features of magmagenesis in the mantle and perhaps in other terrestrial planets.

The splitting of plates that are thin has insufficient temperature potential for inducing magmagenesis but with thick plates, inherently possessing super-adiabatic thermal gradient, it does. That successive OIB compositions rather precisely prescribe a sequence of depths of segregation, often 50km or more, presents persistent problems for mantle magmagenesis. How is such segregation achieved and how do such magmas reach surface without being overprinted by reaction with mantle on the way? The low density of melt renders magma chambers in the mantle untenable; How do you establish one? How do you prevent it collapsing as soon as a vent occurs? And sequences of trace elements are seldom consistent with fractionation from a ‘pool’.

We will study the evolution of an induced mantle diapir as it ascends a narrow basal split in a thick plate, and extends it to the surface if that is not already the case. We present three simple variants of this model, adapted to each of OIB, CFB and kimberlite. Source compositions are still important but processing is central and (variably) thick plates provide the column-space to do it in, with a varying result. Among the notable features [2] are:-

(a) Pressure-relief melting in the diapir decreases again as wall cooling asserts control. Enlarged by cumulate intergrowths, the solids form a ‘log-jam’ in the crack (familiar to grouting engineers), and melt is forced through it (primary segregation). So this depth varies with current parameters (wall temperature, splitting rate), the jam providing xenoliths when ruptured. The pressure-differential to do so and ability to extract melt increases with jam depth - column density above it is lower (kimberlite).

(b) Reduced pressure at the foot of the diapir causes incipient melting of mantle accessories, trace element contents being drawn, and gases diffuse, along melt pathways, resulting in light-isotope enhancement (OIB). This effect (eg. He3/4) increases with column height, and likely affected the isotopic evolution of planetary atmospheres, exemplified in Earth-Mars comparisons like H/D and Ar36/40.

(c) Heated by an eruption, the big volume increase (per joule) at the gt-sp peridotite phase change at ~50km in the walls may close the crack, prising it apart elsewhere, extending island chains. It may also control eruptivity and, by alternating thermally, prolong it, as in the lunar maria sequences.

References

[1] Osmaston, M. F., 2009, Deep cratonic keels and a 2-layer mantle? Tectonic basis for some far-reaching new insights on the dynamical properties of the Earth's mantle: example motions from Mediterranean, Atlantic-Arctic and India. Geophys. Res. Abstr, **11**, EGU2009-6359-6. (solicited)

[2] Osmaston, M. F., 2008, Extra-thick plates: basis for a single model of mantle magmagenesis, all the way from MORB to kimberlite: GCA **72** (12S) A711. (Goldschmidt 2008)