Thick plates and a two-layer mantle: basis for a single model of mantle magmagenesis, all the way from MORB to IOB to flood basalts to kimberlite

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

Magmagenesis within the mantle has long presented problems. These include:- Magma chambers would collapse: How can the depth of segregation change systematically? Percolation can be too slow: How are end-member compositions brought together, often from different segregation depths? How are deep xenoliths entrained? These arise in the context of heavy reliance upon mantle mobility, unconstrained heat sources and thermodynamic equilibration.

Consequently my recent IUGG2007 Perugia [1] demonstration to two successive audiences (seismologists and then (by invitation) to lithosphere specialists) that we have both a 2-layer mantle and that cratons have keels that nearly reach the 660, demands appraisal of how this radical change reflects upon the genesis and understanding of mantle-derived magmas. So that is the task here, bearing in mind that the thick-plate perpective extends (but not so deeply) all the way to MORs [2]. I will show that, contrary to traditional perspectives in which thin plates are thought necessary for magmas to reach surface, a thick-plate version of the plate tectonics paradigm leads to exciting illumination of mantle magmagenesis and its significance.

The basic model is that of an induced diapir in a deep, narrow, mantle crack, first presented at VMSG 1999 and recently at Goldschmidt 2005 [3], but needing thick plates to be truly applicable. This has three main features.

(a) Being an induced diapir (for which plate tectonic mechanisms exist), the degree of melting increases as it rises, but then decreases as wall cooling asserts an influence, the solids, enlarged by cumulate intergrowths, then forming a 'log-jam' in the crack (a phenomenon well-known to engineers), through which the melt is then forced. This not only controls the primary segregation depth, which thereby depends on thermal factors such as wall temperature and crack opening rate, but also constitutes a source of xenoliths when ruptured.

(b) Reduced pressure is characteristic of the bottom of any diapir. In this case, incipient melting of low-melting mantle accessories, provides a source not only of their often-rich trace element contents but also melt pathways along which gases will diffuse, with resulting light-isotope enhancement. At MORs, continuity promotes self-cancelling of this effect.

(c) Eruptivity control, and more, arises from the presence, at some level in the walls, of the sp-gt peridotite phase change. Upon heating by an eruption, this increases volume tens of times more than thermal expansivity, and may close the crack, prising it apart elsewhere. At MORs this now constitutes the main ridge-push force. In the IOB case, it may prolong volcanic chains.

The two mechanisms (a) and (b) provide, in effect, 2 different kinds of segregation, and at 2 different depths, thus offering an apparently 2-source-component final composition, there having been insufficient time (narrow crack, fast flow) for mutual equilibration at the log-jam level.

I will present four simple variants of this basic model, adapted to each of the four kinds of magmatism named in my title. Source compositions are still important but processing is central and thick plates provide the space to do it in. Local differences of mantle composition are smaller.

[1] See *http://osmaston.nmpc.co.uk.* The reasoning wholly escapes seismological matters, but concentrates on mantle dynamic consequences, well displayed by geologically recorded tectonic behaviour. Apparently this proved persuasive. The website is my response to IUGGs failure to provide any publicly accessible scientific record of the conference (6990 abstracts).

[2] Osmaston, M. F. 2006 In *ICAM IV, Proceedings of the Fourth International Conference on Arctic Margins, 2003, Dartmouth, NS, Canada* (ed. R. Scott & D. Thurston), OCS Study MMS 2006-003, pp.105-124. Also published on: *http://www.mms.gov/alaska/icam*:. Also available (.pdf) on [1] above.
[3] Osmaston, M. F. 2005. Geochim Cosmochim Acta **69**, (10S) A439.