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Are plumes really necessary? A new mechanism for intraplate volcanism: melting, melt segregation and petrogenetic variation.

Miles F.Osmaston, The White Cottage, Sendmarsh, Ripley, Woking, Surrey GU23 6JT, UK;
E:- miles@osmaston.demon.co.uk T:- +44-1438-224138.

Plumes of lower mantle origin have been invoked, perhaps unnecessarily, for (1) extraction of early-Earth heat production, (2) causing the major dyke-swarms of the early Proterozoic, and (3) explaining trace-element features of intraplate volcanism. I discuss each in turn.

(1) Archaean heat extraction is only a problem if one assumes a mantle as dry as the present upper mantle. The constant association of felsics with komatiites, occurrences of komatiitic tuffs, Nb anomalies and rich H2O-borne mineralizations all suggest a much wetter mantle. That could lower mantle viscosity by 1-2 orders of magnitude, giving more than ample ability to extract the heat produced.

(2) The 2.45-2.20Ga interval saw three major 'events': (a) a clear hiatus in orogenic granitoid production, (b) dyke swarms and extension features on every craton, (c) unparalleled BIF deposition. All appear consistent with a hiatus in mantle overturn; a heat budget crisis precipitated by accelerated advective heat loss during late Archaean TTG intrusion. The dyke swarms represent thermal shrinkage of the global lithosphere with no MORs to accommodate it. See (3) below for magmatic mechanism.

(3) Intraplate volcanism. Mantle viscosity is highly non-Newtonian, is temperature sensitive and dependent on local composition. If the base of a plate is put into extension these properties may result in rapidly concentrated upward-necking of the plate. Sub-plate material thus drawn upward will undergo pressure-relief melting and eventually endow the column with net buoyancy to extend the narrow split up to the surface. Melt segregation will occur by a log-jam filter mechanism, well-known to grouting engineers and in other fields, in which the solids invariably jam in the crack if they are bigger than 20-25% of the crack width.

This basic mechanism could provide many features present in intraplate magmatism. In our diapiric-intrusive column the jam will form when the solids grow again at shallower levels where wall cooling becomes important. The diapiric column will force melt through the jam. If further opening of the crack is offset by wall accretion, a succession of jams will form at depths that can vary with time. I show that this leads directly to the OIB characteristic sequence (low-volume-alkaline to high-volume-tholeiitic to low-volume-alkaline), based simply on a (plate-shrinkage?) crack that opens rapidly and then slows. Rupturing of jams provides a source of xenoliths. The self-generated diapiric capability of the column in the crack results in pressure around its base being sub-lithostatic, so low-melting and diffusible-gas mantle constituents will be drawn from a wider zone than the main melting. This could provide isotopic enrichments (e.g. ^{87}Sr, ^{40}Ar (both from phlogopite), ^{3}He) hitherto interpreted in OIB as of lower mantle plume origin. Effects of plate thickness and crack opening rate could yield a full eruptive range from intermittent to flood basalts.