A new mechanism for intraplate magmagenesis and petrogenetic variation: the importance of process: significance for planetary volcanism and isotopic evolution

Miles F. Osmaston
miles@osmaston.demon.co.uk

The view that tectonic plates are thin denies the possibility of generating intraplate magmas by splitting them. Tectospheres actually extend far deeper [1] so a family of plate-splitting magmagenetic models is presented.

The base of a plate may be put into extension by epeirogenic flexure, by the penetration of cooling to the sp-to-gt peridotite phase-change rapid-contracting level, or by lithosphere shrinkage on a non-shrinking planetary interior, each resulting in rapidly self-concentrating upward-necking of the plate. Sub-plate material thus drawn upward undergoes pressure-relief melting, endowing the column with net buoyancy to extend the narrow split to the surface. Melt segregation then occurs by a log-jam mechanism, familiar to rock-grouting engineers; the solids inevitably form a jam if they are bigger than ~25% of the crack width. In our case, the jam forms when wall cooling makes the solids grow again at shallower levels. Melt is forced through the jam, this depth determining its major-element composition. Continued opening of the crack is offset by wall accretion and re-formation of the jam. Rupturing of jams provides a source of xenoliths; the rupturing force depends on the melt column (low density) height above the jam, so deeper jams (e.g. kimberlite) yield more xenoliths, and tholeiite hardly any.

The self-generated diapiric column in the crack produces a 'draw zone' at sub-lithostatic pressure around its base (a plume produces an increase there), so low-melting, trace-element rich and diffusible-gas mantle constituents are drawn from a wider zone than the material currently entering the crack, giving the magma a 'plume' signature (e.g. ^{3}He and ^{87}Sr) that is process-variable and not of lower mantle origin. The mechanism offers a direct account of the alk-thol-alk-neph OIB sequence in terms of a split that simply opens rapidly and then slows down.

Gaseous diffusion along the draw zone low-melt pathways results in light-isotope enhancement in the product (including H_2O) so will accumulate the more the planet's mantle has undergone the proposed magmagenetic process in its history. For the Earth, the atmosphere/hydrosphere ^{16}O/^{18}O has grown steadily over geologic time to SMOW, and its atmospheric ^{36}Ar/^{40}Ar is >25 times that in the mantle. Mars has undergone much less magmatism and evolution of water (wetter mantle). I will show that Mars-Earth isotopic comparisons for oxygen, H/D and Ar support this. So their original isotopic compositions may have been the same; it's processing that has made them different.

[1] M.F. Osmaston, Proc 4th Int Conf Arctic Margins, 2003 (R. A. Scott & D. K. Thurston, eds), US Dept. Interior, OCS Study MMS 2006-003, p.105-124. Also on: http://www.mms.gov/alaska/icam