The Petrogenesis of Plagioclase Ultraphyric MORB

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The petrogenesis of plagioclase ultraphyric lavas (PUB) represents one of the oldest open questions in petrology. The central issues relate to a number of their characteristics. 1) Plagioclase megacrysts are too anorthitic to be in equilibrium with their hosts. 2) The host lavas fall on an olivine/plag liquid line of descent. However, the ratio of plagioclase to olivine is usually on the order of 10 or more – not the proportions one would expect of lavas crystallizing on the olivine–plagioclase cotectic. 3) Both plagioclase megacrysts and the melt inclusions in them exhibit a wide range of minor and trace element and isotopic compositions. 4) PUB lavas occur along ridges with slow to intermediate spreading rates or off axis at fast spreading ridges – environments that generally have no long term axial magma chamber (AMC).

Based on detailed analysis of a globally distributed set of PUB lavas, we present a new model for their petrogensis. Based on estimates of the density of the PUB host lavas and their crystal cargo, PUB lavas do not originate by crystal flotation because in the vast majority of cases, the plagioclase megacrysts are more dense than their host. If plagioclase flotation was the primary mechanism for their origin, PUB lavas should be found predominantly in areas with AMCs.

PUB lavas only occur at ridges without an AMC because such a body would act as a density filter, preventing the megacrysts from being carried upward. Only with magma ascent rates on the order of 1 cm/sec will the upward mobility of crystals exceed the rate of settling. This model also explains how crystal sorting might enhance the relative proportion of plagioclase in PUB.

The diverse compositional signal, and modal proportions are consistent with a petrogenetic model wherein the PUB crystal cargo represents a sampling of megacrysts formed near the base of the crust prior to magma homogenization. The relatively homogeneous composition of some elements in plagioclase megacrysts (e.g. Sr) is attributable to diffusive re-equilibration post crystallization but prior to being swept up and transported to the surface.

The geochemical signal represented in the megacrysts represents a long term sampling of the range of primitive (as indicated by the high An content) compositions present at that ridge segment – modified by varying amounts of diffusive equilibration.