

Quantifying parental MORB compositions from the eruptive products of realistic magma chambers

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In a series of classic papers in the 1960's Mike O'Hara demonstrated that MORB have major element compositions controlled largely by the position of low-pressure cotectics; i.e. crystallization in magma chambers plays an important role in controlling the observed compositions. From this time forward Mike expended significant effort in unraveling the effects of realistic magma chamber processes on the compositional evolution of parental melts. This is a widely overlooked pre-requisite for using measured MORB compositions to interpret mantle conditions (e.g. T, X) and processes (e.g. melt extraction mechanisms). Instead, common approaches include: (i) ignoring differentiation; (ii) (linear) regression to a constant melt MgO content or Mg#; and (iii) assuming perfect fractional crystallization. However, evidence for "complex" magma chamber processes abounds in the petrology of MORB, oceanic plutonic rocks and ophiolites. A more subtle approach is required to estimating parental melt compositions and the inherent uncertainties in these estimates.

Building on recent work with Mike [1] we have developed a simple stochastic numerical model of a replenished and tapped magma chamber in which some portion of the crystallization occurs in a boundary layer (*in situ* crystallization). The free parameters in this model are the parental melt composition and the average and standard deviations of: (i) the mass fraction replenished; (ii) the mass fraction tapped; (iii) the mass fraction crystallized; (iv) the mass fraction of melt involved in boundary layer crystallization, and (v) the mass fraction of melt trapped in the boundary layer. Stochastic modeling generates synthetic datasets that can be statistically compared with real data (MORB compositions from a limited geographical area) to determine the probability distributions for each parameter *including the parental melt composition*.

Simple models, that were fit to the data visually rather than quantitatively, show that parental MORB are more depleted than typically assumed [1]. Additionally, as repeated shown in Mike's theoretical work, and recently observed by O'Neill and Jenner [2] incompatible elements are likely to be fractionated from one another in magma chambers. For example, the Sm/Nd of MORB is lower than that of their parental melts complicating interpretation of the mantle's Nd-isotopic evolution.

[1] Coogan and O'Hara (2015) *GCA*
doi.org/10.1016/j.gca.2015.03.010 [2] O'Neill and Jenner (2012)
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