Addressing an old question with a new model: What are the sources of garnet signatures in MORB?

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Presently, there is no straightforward method to determine if a major element, trace element, or isotopic garnet signature in ocean ridge basalts is either imparted during hot, deep mantle melting in the garnet stability field or by remelting of a non-lherzolitic source such as recycled oceanic crust. To solve this problem, we use the range of 'standard' lherzolitic mantle conditions as input to model the igneous origin and evolution processes of erupted basalts. Our forward petrologic – geochemical (major and trace element) – geodynamical model of mantle melting and subsequent melt modification is built upon [1] and [2]. Because our model is calibrated for melting in the plagioclase, spinel, and garnet fields with and without small amounts of water, we are now uniquely able to quantify the conditions that lead to the generation of garnet signatures. Using our model we quantitatively show the permissible range of mantle potential temperatures, mantle compositions, spreading rates, and mantle flow regimes that give rise to recognizable garnet-lherzolite field melting in erupted basalts and glasses. In so doing, we identify basalt compositions that are not reproduced using our model as potentially requiring exotic source lithologies.

We find that lherzolitic garnet field melting occurs at high mantle potential temperatures and/or under damp conditions. However, the fraction of melting that occurs in the garnet field is not sufficient to impart a recognizable garnet signature to the pooled melt composition. Thus, observed garnet signatures must then represent melts that are (1) rapidly isolated and avoid subsequent pooling, (2) sourced from exotic source lithologies (e.g., garnet pyroxenites), or (3) sourced from more standard peridotites lithologies with a preexisting garnet signature. We discuss methodologies to distinguish between these three different scenarios.

[1] Behn and Grove (2015) *JGR* **120**, 4863-4886. [2] Grove *et al*. (2013), *CMP* **166**, 887-910.