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# A THEORETICAL APPROACH TO UNDERSTANDING THE ISOTOPIC HETEROGENEITY OF MID-OCEAN RIDGE BASALT

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We have developed an idealised mathematical model to understand the isotopic variability of the mantle and its relation to the observed variations in isotopic ratios $^{143}$Nd/$^{144}$Nd, $^{176}$Hf/$^{177}$Hf, $^{87}$Sr/$^{86}$Sr, $^{208}$Pb/$^{204}$Pb, and $^{206}$Pb/$^{204}$Pb measured in mid-ocean ridge basalt (MORB). The model is concerned with isotopic systems of long half-life, for example parent P=$^{147}$Sm, daughter D=$^{143}$Nd, D′=$^{144}$Nd. A single melt region produces a melt fraction $F$ of melt, and the average time between visits to this region following a fluid parcel in the mantle is given by the timescale $\tau_{\mathrm{melt}}$. The melt region fractionates P/D′ ratios. Over time this leads to variations in the mantle D/D′ ratios as the parent decays to the daughter. A key assumption is that the mantle has reached a statistical steady state, which enables us to neglect the specifics of the underlying flow.

The model predicts the probability distribution of isotopic ratios in MORB. Corresponding distributions have been obtained from measured isotopic ratios. The observed distributions are in good agreement with the model predictions. Fitting the MORB data to this model gives estimates of the model parameters $F$ and $\tau_{\mathrm{melt}}$. Notably the timescale $\tau_{\mathrm{melt}}$ is similar for a range of isotopic systems with a value of around 200Ma for Nd, Hf, and Sr systems, and 100Ma for the Pb systems.