



MANTLE HETEROGENEITY AND GEOCHEMICAL RESERVOIRS

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The heterogeneity of oceanic basalts have long indicated the presence of different source reservoirs and heterogeneity in the mantle. We have developed a model of mantle differentiation and recycling that explicitly includes heterogeneities created by differentiation and recycling. This allows us to model not only the mean isotopic ratios, but also the distribution of those ratios within the reservoirs. Owing to low chemical diffusion rates, subreservoirs that are created by mass transport into and out of the mantle effectively exist as distinct geochemical entities for all time. By tracking these subreservoirs, we obtain a model of the full range of isotopic values represented in the mantle. Using results from numerical calculations of mixing, we also parametrize and track the length scales associated with each subreservoir as it is deformed in a convecting mantle. Applying simple statistics, we obtain the distribution of expected measurements as a function of the stirring time, effective melt fraction, sampling volume, and mass transport history.

The model has been applied to the Nd and Sr isotopic systems. Observed data can be understood in terms of the initial length scale of melting (~ 100 km) and time scale for stirring (~ 500 My). We also apply it to investigate Pb isotope data in oceanic basalts. Much of the previous work on the Pb isotopic arrays has focused on intramantle differentiation (i.e. mid-ocean ridge generation and subduction) as the primary source of heterogeneity, neglecting the effects of continental extraction and recycling. Owing to the large concentration of U, Th, and Pb in the upper continental crust, we find that the effects of continental crustal recycling are very significant. Other processes we investigate include a layered continental crust, increased recycling of U in an oxidizing environment, uptake of U through hydrothermal exchange at mid-ocean ridges, and lower-crustal delamination. The model can also be applied to noble gases. The inclusion of small scale heterogeneity as well as larger reservoirs allows a

more meaningful quantitative comparison with geochemical observations, as well as removing precise geometric associations with regions in the mantle. The model can be applied to either a HAL model [L. Kellogg *et al.*, 1999] or a blob model [Becker *et al.*, 1999] as well as the more conventional upper/lower mantle model.