Barium isotopes reveal pervasive recycling of oceanic crust in the source of mid-ocean ridge basalts

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Mid-ocean ridge basalts (MORBs) provide useful information for unraveling the composition and heterogeneity of the upper mantle. However, it is still not clear to what extent the enriched MORB (E-MORB) results from recycling of subducted crustal materials or intra-mantle differentiation [1,2,3]. Here we show that Ba isotope compositions in MORBs can be used to decipher these processes because of the high crust/mantle ratios of Ba contents [4,5] and large fractionation of Ba isotopes in crustal materials [6].

We measured Ba isotope compositions of ~ 25 MORB samples from East Pacific Rise, Mid-Atlantic Ridge, Gakkel Ridge, and South East Indian Ridge. The precision for $\delta^{137/134}Ba_{SRM3104a}$ is better than 0.04‰ (2SD) based on analyses of standards and duplicated samples. The $\delta^{137/134}Ba_{SRM3104a}$ of these MORBs range from -0.05‰ to 0.08‰, slightly different from the data in previous study ($\delta^{137/134}Ba_{SRM3104a}$ of 0.01‰ to 0.11‰) [7]. Nielsen et al. (2018) suggested that Ba isotope variation in MORBs is controlled by sediment addition in the depleted mantle. However, we find that MORBs have larger variations of $\delta^{137/134}Ba$ with increasing Ba/Th and radiogenic Sr isotopes, not consistent with a simple mixing model between the upper mantle and oceanic sediments.

Because Ba isotopes are unlikely significantly fractionated during mantle melting and basaltic magma differentiation, our observation supports the involvement of recycled oceanic crust with $\delta^{137/134}Ba_{SRM3104a}$ ranging from -0.17‰ to 0.30‰ in the mantle sources of the E-MORBs. A mixing model suggests that addition of a few per cent of the recycled altered oceanic crust can account for the Ba isotopic signature of the MORBs.

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