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Lithium Isotope Systematics of the Marianas Revisited

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Lithium abundances and isotope compositions were measured for a suite of well characterized Mariana arc lavas. These data are combined with existing Mariana forearc (Benton et al., 1999) and arc (Bouman and Elliott, 1999) data to examine the recycling of subducted Li in the Mariana volcanic arc. The samples analyzed were previously investigated by Ishikawa and Tera (1999) (B, Nb and $\delta^{11}B$) and Woodhead (1989) (e.g., major and trace elements and Sr, Pb and Nd isotopes) and are from the islands of Anatahan, Guguan, Alamagan, Pagan, Agrigan and Uracas.

Lithium isotopic compositions were determined using a VG Plasma 54-30 multi-collector ICP-MS, after HF-$HClO_4$ digestion and cation-exchange chromatography using methanol and nitric acid (Tomascak et al., 1999). Long term reproducibility at the laboratory has improved over time and is now estimated at better than 1‰ (2σ) based on repeat analysis of individual and multiple sample preparations. Lithium concentrations were determined by isotope dilution mass spectrometry, with a reproducibility of better than 1%. The δ^7Li ($^7Li/^6Li$ relative to the L-SVEC standard) of the JB-2 basalt standard analyzed during this study was +4.6‰, which compares favorably to published values (Tomascak et al., 1999). The Li concentration of our JB-2 split is 7.54 ppm.

Lithium concentrations of the suite range from 4.91 to 12.6 ppm (n=11) encompassing the values previously measured for Mariana lavas by Bouman and Elliott (1999). Lithium isotopic compositions measured in this study range from +0.7 to +7.6‰ (n=10) thus far with all but the highest and lowest values falling between +2.9 and +5.0‰ and within error of the range defined for MORB (Chan et al., 1992). These data almost double the range of δ^7Li values reported for Mariana lavas by Bouman and Elliott (1999). The combined data sets have δ^7Li values that range from +0.7 to +8.5‰.

The samples used in this study were chosen from the two groups defined by Ishikawa and Tera (1999) based on relationships between B/Nb and $\delta^{11}B$. The majority of samples come from Group I in which B/Nb and $\delta^{11}B$ strongly covary while in Group II they do not. For both groups, samples with high B/Nb and elevated $\delta^{11}B$ are interpreted to have the greatest additions of slab fluids to the region of arc magma genesis (Ishikawa and Tera, 1999). If Li is added to the mantle wedge by these fluids, the expectation is that similar trends would be exhibited on δ^7Li-Li/Yb or Li/Y plots. Although no such relationship is evident for our data set, the lowest δ^7Li value is associated with higher B/Nb and the highest δ^7Li value has a somewhat lower B/Nb for Group I samples. This suggests that slab-derived Li with relatively low δ^7Li may be transported to the mantle wedge along with B, but the relatively high Li content of the mantle wedge may make distinguishing slab additions difficult when using either Li concentrations or isotopic compositions. The presence of a slab component is also supported by $^{87}Sr/^{86}Sr$-δ^7Li plots in which the lowest δ^7Li value (+0.7‰) has the highest $^{87}Sr/^{86}Sr$ ratio (0.70362 [Woodhead, 1989]) and the highest δ^7Li (+7.6‰) has the lowest $^{87}Sr/^{86}Sr$ ratio (0.70334 [Woodhead, 1989]). Lithium isotopic data from the serpentine seamounts in the Mariana forearc indicate that the slab is losing fluids enriched in ^7Li early in the subduction cycle (Benton et al., 1999). Loss of an isotopically heavy fluid component would be expected to drive slab material to isotopically lighter values. As a result, a deeper-sourced subduction component that is relatively light seems reasonable.

Bouman and Elliott (1999) used Li/Yb and δ^7Li modeling to define two different subduction components: (1) an isotopically light sediment component (δ^7Li=+4‰) and (2) an isotopically heavier aqueous fluid flux possibly originating from altered oceanic crust. Our data may support the idea of a subduction component with low δ^7Li values, possibly in the form of an aqueous fluid that also transports B. However, the presence of an additional aqueous fluid with higher δ^7Li is less obvious when viewed in light of the existing B/Nb and B and Sr isotope data.

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