Boron isotopic systematics in primitive volcanic arcs

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Boron concentrations and isotopic compositions were determined in representative lavas from the Cascades, Aleutian, Mariana, Tonga-Kermadec, and South Sandwich volcanic arcs. These arcs were selected because of the primitive nature of the underlying crust, the presence of basaltic lavas, and a wide spectrum of subduction zone characteristics (convergence rates, slab lengths, age of subducted plate, etc.) corresponding to a range of thermal structures (warmest = Cascades, coldest = Tonga?). Boron isotopic analyses were performed at IGGI (Pisa). The analitycal uncertainty is $\pm$ 0.45‰ (2σ) as reported by Tonarini *et al.* (1997).

Young Cascades (S. Washington) basalts exhibit the least B-enrichment, ranging from slight at the arc front to negligible in the backarc (B/Nb: 4.3 to 0.04; B/La: 1.2 to 0.05); β isotopic ratios also are low and decrease to the east ($\delta^{11}B$: −0.35 to −9.8‰). There is no significant correlation between $\delta^{11}B$ and B/fluid immobile elements (FIE); in contrast, positive correlations between $\delta^{11}B$ and B/FIE in old (25−10 Ma) Cascades basalts suggest small subduction contributions to their mantle sources.

Aleutian basalts show relatively small variation in $\delta^{11}B$ (from −0.35 to +3.5‰) despite significant variation in B/Nb (4.4 to 32.5) and La/Nb (0.94 to 7.1). Seguam, Okmok and Kanaga basalts display positive correlation between $\delta^{11}B$ and Nb/B (r^2 = 0.91; $\delta^{11}B$ intercept = +3.7‰) suggesting simple mixing in the magma source between two isotopi-

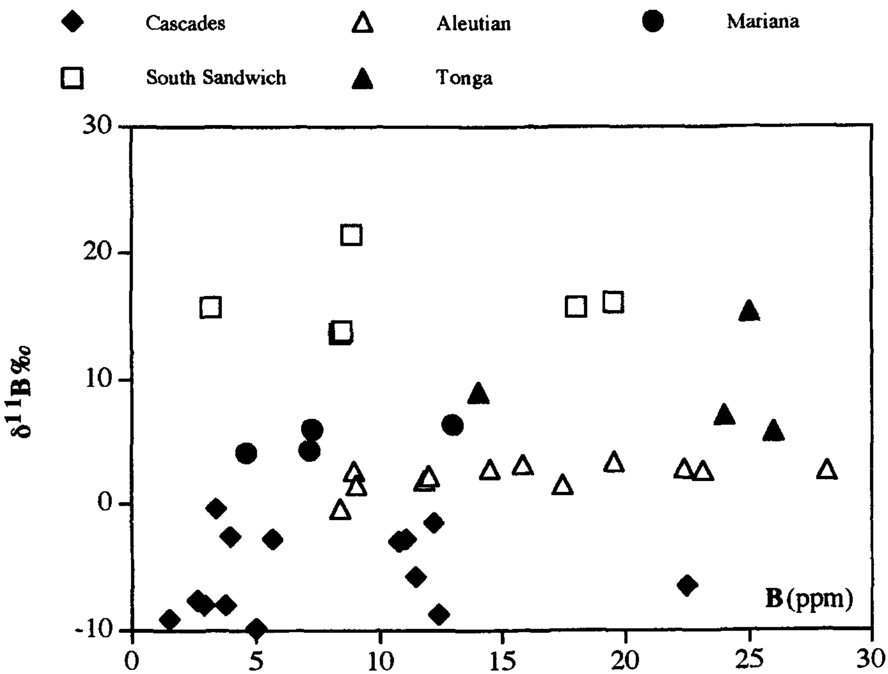

FIG. 1. $\delta^{11}B$ and boron concentration for lavas from Pacific arcs.

cally homogeneous end members: (1) a slab-derived component and (2) the mantle wedge. Basalts from Shishaldin and Semisipochnoi fall off this trend, possibly reflecting variable along-strike mantle sources and/or subduction contributions.

The Mariana ($\delta^{11}B$: 4.1–6.5‰; B/Nb: 4.6–26; B/La: 0.8–3.5) and Tonga-Kermadec ($\delta^{11}B$: 5.8–8.9‰ [excl. Hunga Ha'apai andesite with $\delta^{11}B$ = +15.3‰]; B/Nb: 19–58; B/La: 6.7–14) lavas generally have B isotopic compositions in the range reported for the Japan (Ishikawa and Nakamura, 1994) and Kurile (Ishikawa and Tera, 1997) arcs. In general, the available global boron database ($\delta^{11}B$ and B/FIE) seemingly is consistent with metasomatization of nearly uniform mantle sources by subduction-derived component (fluid?) of remarkably similar composition world-wide. The extent of source modification seems to be greater for Tonga than in the western Pacific or Aleutian arcs.

South Sandwich arc basalts show variable B enrichment (B/Nb: 4.0 to 36; B/La: 2.8 to 9.1) similar to that in Mariana and Tonga lavas, but with significantly higher $\delta^{11}B$ (13.6 to 16.1‰, with one value of +21.4‰). Poor correlation between $\delta^{11}B$ and B content (3.9 to 20 ppm; Fig. 1) suggests that processes like seawater interaction are improbable. Considering the low LILE contents of South Sandwich lavas (Pearce *et al.*, 1995), their source may be (originally) highly-depleted mantle that is dominated by slab-derived fluid contributions; however, the additive must have unusually high $\delta^{11}B$ compared to average altered oceanic crust.

With the exception of the South Sandwich arc, B/Nb-$\delta^{11}B$ systematics together with previously reported trace element and Sr and Nd isotope data strongly suggest that arc magma sources are formed by variable addition of a near constant subduction component to variably-depleted mantle wedge.

References

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