

Volatile behaviors at an immature stage of subduction zone inferred from volcanic glasses in the Bonin fore-arc (IODP Expedition 352)

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IODP Expedition 352 was targeted to drill the entire magmatic sequence comprising the outer Bonin fore-arc to elucidate early subduction dynamics. During the expedition, a total of 1.22 km of igneous basement related to subduction initiation was cored from four sites (U1439, U1440, U1441, U1442). Two sites (U1440 and U1441) located nearer to the trench (stratigraphically lower and older sequence than U1439 and U1442), recovered igneous rocks at the basement that are mostly fore-arc basalts (FABs). From other two sites (U1439 and U1442) located ~15 km west from U1440 and U1441, boninites were recovered.

From all sites, we recovered fresh volcanic glasses manifest as chilled margins of pillow lavas, massive lavas, hyaloclastites and pyroclastic deposits. In order to constrain behaviors of volatiles at an immature stage of subduction zone, we analyzed volatile (H_2O , CO_2 , F, Cl, S) and P_2O_5 concentrations of 100 volcanic glasses (31, 23, 1 and 45 samples from U1439, U1440, U1441 and U1442, respectively) using SIMS (CAMECA IMS 1280-HR) at JAMSTEC.

Glasses from the boninite sites (U1439 and U1442) are higher in H_2O (~1.9 wt%) at the lower parts of the holes and slightly lower in H_2O (~1.6 wt%) at the upper parts of the holes and are remarkably in low CO_2 (< several ppm: below detection limit, DL) and S (7-130 ppm). Their F and Cl contents are 66-166 ppm and 357-981 ppm, respectively.

On the other hand, most glasses from the FAB sites (U1440 and U1441) have various H_2O contents (0.11-0.57 wt%) and measurable CO_2 contents (67-151 ppm) with high S contents (776-1250 ppm). Their F and Cl contents are 62-111 ppm and 101-597 ppm, respectively. Three highly evolved glasses (MgO 3.3 wt%) probably from the same glassy layer from U1440 are high in H_2O (0.80 wt%), F (300 ppm) and Cl (2900 ppm). We also found a boninitic glass between FAB lavas from U1440, in terms of H_2O (1.95 wt%), CO_2 (below DL) and S (301 ppm).

F/P ratios of glasses, which reflect their original source mantle, are 0.49 ± 0.03 (1 standard deviation) for boninites and 0.28 ± 0.02 for FABs. Since the F/P ratio of the depleted upper mantle (DM) is 0.27 ± 0.11 , those of FABs have not been influenced by subducting materials. However, 10-50 times higher Cl/K (0.6-4) and 2-4 times higher H_2O/F (24-56) ratios of FABs than those of DM indicate influx of a small amount of Cl-rich fluid to the mantle wedge at the very beginning of subduction formation. Boninites are highly enriched in H_2O (H_2O/F : 110-298), but not in Cl (Cl/K: 0.1-0.4) relative to FABs, indicating that contribution and composition of subducting materials have changed with time.

キーワード：沈み込み帯、揮発性元素、IODP

Keywords: subduction zone, volatiles, IODP