Magma source evolution after subduction initiation implied by oxygen and hydrogen isotopes in IODP Expedition 352 glasses

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IODP Expedition 352 cored the volcanic section of oceanic crust generated in the aftermath of subduction initiation in the western Pacific at 52-52.5 Ma [1]. Fresh glasses recovered from those cores were analyzed for $\delta^{18}O$ and δD values to chart the evolution of magma sources and differentiation processes over the first c.2 Myr of subduction. The oldest glasses are fore-arc basalts (FAB) from trenchward Site U1440 with overall compositions similar to highly depleted MORB[2]. These glasses have $\delta^{18}O$ of 5.65-5.12‰, δD of -66‰- -71‰, and 0.29-0.75 wt% H_2O. Andesite glass fragments found interbedded with FAB have variable $\delta^{18}O$ values, from 4.7‰-3.8‰, and one δD measurement of -61‰. Correlations between these values and other geochemical parameters such as Cl/K ratios suggest that primitive FAB have MORB-like $\delta^{18}O$ and δD whereas differentiated FAB glasses have compositions affected by assimilation of high-T altered crust. The earliest involement of subducted fluids in magma genesis is recorded in one relatively trace-element enriched FAB (E-FAB; [2]) glass from deep in the core. This sample has 5.7‰ $\delta^{18}O$ and -55‰ δD, along with elevated concentrations of water (1.76 wt%) and some fluid mobile elements. Boninite glasses erupted c. 50-51 Ma at upslope sites U1439 and U1442 have higher H_2O concentrations (1.32-2.65 wt%), and higher $\delta^{18}O$ (5.6 to 6.2‰) and δD values (-63 to -51‰) than most FAB, which together with high H_2O/Ce and low Cl/K, reflects the invovement of relatively fresh water from ^{18}O-enriched sources involved in their genesis. Two boninites have markedly lower δD values than others (-77 & -78‰) suggesting a separate fluid source. We infer that first melting of mantle after subduction initiation was solely by decompression associated during seafloor spreading, with rare incursions of subducted fluids. Later flux melting to generate boninites involved fluids produced by dewatering of hydrous minerals from the upper subducting plate.

[1] Reagan et al. (2019) EPSL, v. 506. p. 520-529; [2] Shervais et al. (2019) G³, 10.1029/2018GC007731.