Multiple microanalysis of melt inclusions from the Pitcairn basalts and its implications for melting source region

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We have developed a systematic analytical procedure to determine 44 major-trace-volatile element concentrations and lead isotopic ratios for melt inclusions with a few tens- to hundred-micrometer in diameter. This was accomplished by using multiple microanalytical instruments including SIMS, EPMA, and LA-ICP-MS. We analyzed olivine-hosted melt inclusions in basalt lavas and a pyroclastic rock from Tedside Volcanics, Pitcairn Island. Tedside Volcanics represents the shielding phase of island (0.95-0.76Ma) and shows lower lead isotopic ratios than basalts from other geological formations of the post-erosional phase between 0.67 and 0.45 Ma (Pulawana Volcanics, Christians Cave Formation and Adamstown Volcanics) which show MORB-like lead isotopic ratios.

Melt inclusions in the lavas contain pargasite, ilmenite, garnet, and pyrite of up to 63 modal %. Some of the crystals could have crystallized before the melt inclusions were entrapped in the host olivine. Two groups of the melt inclusion samples were prepared for the instrumental analysis; (1) original samples, and (2) homogenized samples that were reheated at the liquidus temperature, which was carefully determined by the melting experiments, and were then quenched to produce a uniform glass. By analyzing the two suites, compositional modification during the homogenization procedure, which is commonly used in melt inclusion studies, can be discussed by comparing the analytical results of the two groups. The melt inclusions in the pyroclastic rock are naturally homogenous, with which homogenized samples were also prepared for the comparison.

Major and trace element compositions of the original and the homogenized samples overlap with the bulk compositions of their host rocks. Volatile elements are affected by the homogenization. The F contents in the homogenized samples show two trends; one exhibits a broadly constant concentration (584-842 ppm) irrespective of their various H_2O contents, whereas another shows a positive correlation with H_2O. The homogenization affects H_2O contents in the melt inclusions in several ways; increase by melting of hydrous minerals in the melt inclusions, decrease by diffusion into bubbles formed in the melt inclusions, and decrease by diffusional escape to the outside of melt inclusions. CO_2 in the melt inclusions also re-equilibrated with the bubbles formed during homogenization. The range of lead isotope ratio of melt inclusions is larger than bulk of basalt in Tedside Volcanics. Low lead isotope ratio ($^{207}Pb/^{206}Pb$ and $^{208}Pb/^{206}Pb$) is consistent with the post-erosional phase in Pitcairn Island. The heterogeneity in Pitcairn Island is classified four major clusters based on the k-means cluster analysis. The main cluster is broadly distributed around the average lead isotopic ratios of Tedside Volcanics. This cluster involves melt inclusions from both the basalt lavas and the pyroclastic rock. Melt inclusions from the pyroclastic rock are all glassy and appear uniform under the microscopes, yet classified into two distinct clusters; the main cluster and another cluster with a highly enriched signature. It is suggested that an enriched source that has been metasomatized by either aqueous fluid or melt and a depleted MORB-source-like material coexisted in a very small spatial scale in melting source region of the Pitcairn basalts.

