Total carbon dioxide in melt inclusions with shrinkage bubbles

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Volatile composition in magmas can be estimated using melt inclusions encapsulated in phenocrysts. Because of the low solubility of CO_2 in melts, CO_2 is partitioned in both solid phases and shrinkage bubbles in melt inclusions. We determined the total CO_2 in melt inclusions by measuring (1) CO_2 concentration in glass with secondary ion mass spectrometry, (2) CO_2 density in bubbles with micro Raman spectrometry, and (3) bubble/glass volume ratio with micro X-ray CT technique on the rehomogenized melt inclusions. We applied this method to olivine-hosted melt inclusions in HIMU ocean island basalts from Raivavae in Austral Islands.

The shape of melt inclusions is broadly related with their size; larger melt inclusions tend to be more angular than smaller ones. The volume of large melt inclusions may be overestimated by the previous method in which the dimension of melt inclusions was measured under a microscope and the volume was calculated with the assumption of spheroidal shape. Carbon dioxide dissolved in glass in homogenized melt inclusions ranges up to ~7000 ppm. The glass with more alkalic composition shows greater CO_2 concentration than that with less alkalic composition in accordance with the composition-dependent CO_2 solubility. However, the total CO_2 content is less correlated with the composition of the glass because CO_2 in shrinkage bubbles is generally greater than that in glass. There found a few melt inclusions that have extremely high total CO_2 content (up to 25000 ppm). Because these melt inclusions have large volume proportion of bubbles in melt inclusions (>10 vol%), they likely formed by simultaneous entrapment of melts and fluids by host olivine. This theory is supported by the presence of CO_2-rich fluid inclusions in some olivine phenocrysts. Excluding those melt inclusions, the total CO_2 content and CO_2/Nb ratio in melt inclusions was up to 7000 ppm and 200. This study provides the lower bound of CO_2 concentration and CO_2/Nb of the HIMU basalts from Raivavae.