

Precise determination of carbon dioxide contents in melt inclusions

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Volatile composition in magmas can be estimated using melt inclusions encapsulated in phenocrysts. Because of the low solubility of CO₂ in melts, CO₂ is partitioned in both solid phases and shrinkage vapor bubbles in melt inclusions. We present a novel method to determine the total CO₂ in melt inclusions by summing CO₂ in solid phases and vapor bubbles. First, doubly polished olivine containing crystalline melt inclusions was heated and quenched on a heating stage to rehomogenize it. Second, a micro Raman spectrometry was applied to measure the density of CO₂ in vapor bubbles. Third, the volume of glasses (former solid phases) and vapor bubbles was determined using a micro X-ray CT technique. Finally, CO₂ concentration of the glasses was measured with secondary ion mass spectrometry after exposing the melt inclusions by polishing. In the previous studies, the volume proportion of the glasses and vapor bubbles was calculated by measuring their dimensions on a horizontal plane under microscope and assuming a spheroidal shape. The imaging of melt inclusions with the micro X-ray CT provides a quantitative way to determine the volume ratio that is required to sum up CO₂ in the glasses and vapor bubbles.

This method was applied to olivine-hosted melt inclusions in ocean island basalts from Raivavae in South Pacific. Carbon dioxide dissolved in glasses in homogenized melt inclusions ranges from nearly null to ~7000 ppm. The CO₂ content in vapor bubbles is generally greater than that in glasses. The highest total CO₂ from glasses and vapor bubbles in the studied melt inclusions is ~20000 ppm. However, the total CO₂ is positively correlated with the volume proportion of vapor bubbles in melt inclusions (up to ~20 volume %). We suggest that such unusually high total CO₂ and bubble volume proportion is ascribed to the simultaneous entrapment of melts and fluids by host olivine. This theory is supported by the presence of CO₂-rich fluid inclusions in some studied olivine phenocrysts.

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