Precise determination of carbon dioxide contents in melt inclusions

*羽生 毅[1]、山本 順司[2]、木元 克典[3]、中村 由里子[3]、清水 健二[4]、牛久保 孝行[4]
*Takeshi Hanyu[1], Junji Yamamoto[2], Katsunori Kimoto[3], Yuriko Nakamura[3], Kenji Shimizu[4], Takayuki Ushikubo[4]

1. 海洋研究開発機構 地球内部物質循環研究分野、2. 北海道大学　総合博物館、3. 海洋研究開発機構　地球環境観測研究開発センター、4. 海洋研究開発機構　高知コア研究所
1. Japan Agency for Marine-Earth Science and Technology, Department of Solid Earth Geochemistry, 2. The Hokkaido University Museum, 3. Japan Agency for Marine-Earth Science and Technology, Research and Development Center for Global Change, 4. Japan Agency for Marine-Earth Science and Technology, Kochi Institute for Core Sample Research

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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