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Cl Isotope Compositions of Fumarolic Gas from a Japanese Volcanic Island

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As chlorine is known as an excess volatile element recycling from the earth's interior to the surface reservoir, chlorine stable isotope compositions (δ^{37}Cl ‰ vs. SMOC) have been suggested as a potential index for circulation of mantle material (Ito et al., 1983). At a mid-ocean ridge, δ^{37}Cl values of Cl bearing-secondary minerals in MORB basalts were reported remarkably large; values up to +7.5 ‰ were found (Magenheim et al., 1995). On the other hand, at the Barbados and Nankai subduction zones, δ^{37}Cl values of marine pore waters were very low (down to -8 ‰, Ramson et al., 1995). Both reports suggested that the heavier isotope (^{37}Cl) would be preferentially built into the solid phase. δ^{37}Cl was also applied to investigate the role of mantle derivatives during rock formation (Eggenkamp and Koster van Groos, 1997; Markl et al., 1997). In this study, with the purpose to trace recycling of volatile components through the subduction process, we studied the Cl stable isotope compositions in gas condensates from a volcanic island.

Gas condensates are from the island Satsuma-Iwo Jima, which locates in the southwestern part of the Japanese island arc. This arc is along the Nansei-Shoto trench where the Philippine Sea plate subducts underneath the Eurasian continental plate. The island has tens of the fumarolic vents, of which temperatures range from 97 to 890 °C. For this study we used gas condensate samples collected and described by Kanzaki et al. (1979). For Cl isotope analysis, Cl was extracted as AgCl from the condensate and was subsequently converted to CH_3Cl. The δ^{37}Cl value was measured on a VG SIRA 24 mass-spectrometer with a precision of 0.06 ‰ (1σ).

We measured nine samples, which were selected from twenty-eight different vents with temperatures varying from 126 to 890°C. The Cl content of the samples ranged from 12.4 to 28.9 g/l and the atomic Cl/F ratio from 7.3 to 17.5. δ^{37}Cl values of these samples was between 0.61 ‰ and +0.29 ‰. No correlation between δ^{37}Cl values and either Cl contents or Cl/F ratios was found. However, a positive correlation between the temperature and δ^{37}Cl value was found (Fig. 1). This correlation suggests that δ^{37}Cl value would increase with increasing temperature.

In the previous study by Kanzaki et a1. (1979), Cl/B (x100) atomic ratios of the lower temperature (<400 °C) samples varied much more (between 10 and 630) than those of the higher temperature samples (>400 °C) which had almost constant Cl/B ratios (close to 250). They concluded that the colder samples experienced more interaction with subsurface water, lowering their temperature, than the hotter samples. A different degree of mixing between original gas and the subsurface water would cause the variation in Cl/B ratios of the lower temperature gases. In this study, the lowest temperature gas showed the lowest δ^{37}Cl value, which is close to the value of marine pore water in the Nankai subduction zone (Ransom et al., 1995). If a higher temperature gas is less contaminated with subsurface water than a lower temperature gas, the former could preserve the isotopic composition of original Cl better than the latter. Therefore, the hottest gas with the highest δ^{37}Cl value (+0.29 ‰) in this study would be the closest to that of the Cl reservoir of this volcano. If this is the case, the island arc magma may be preferentially enriched in ^{37}Cl.

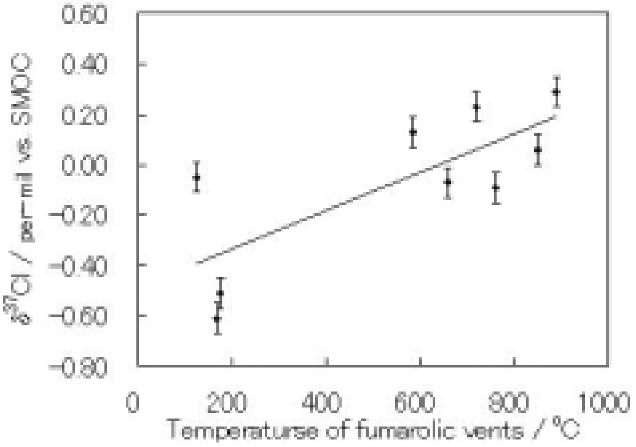

Figure 1: Correlation between δ^{37}Cl values and the temperatures of the gas condensates taken from Satsuma-iwo Jima, Japan. The error bar is equal to analytical precision of 0.06 ‰ (1). The least squares-fitting line ($r^2 = 0.58$) is shown diagonally.

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