Systematics of volatile elements in melt inclusions from the proto-Izu-Bonin-Mariana arc (30-40 Ma)

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IODP Expedition 351 "Izu-Bonin-Mariana (IBM) Arc Origins" drilled at Site U1438 in the Amami Sankaku Basin, about 100 km west of the Kyushu-Palau Ridge, a remnant of the IBM arc. We recovered 1611-m-long cores composed of 150-m of igneous basement (Unit 1), which were formed when subduction initiated at ~52 Ma, and 1461-m of sediments (Units I, II, III and IV), which were deposited immediately after subduction initiation (Fig. **a**). We focused on Unit III (30-40 Ma) and have already analyzed the major elements and volatile elements (S and Cl) of more than 300 melt inclusions from Unit III with electron probe microanalyzers and have discussed the causes for temporal changes in volcanism of the proto-IBM arc (Brandl et al., 2017; Hamada et al., under review).

In order to extend our previous studies, we analyzed the concentrations of four volatile elements (H_2O, S, Cl, F) and P_2O_5 of a sub-set of 56 representative melt inclusions by Secondary Ion Mass Spectrometry (SIMS) at the Kochi Institute for Core Sample Research of JAMSTEC. Quantification of volatile elements was based on callibration lines and volatile standards by Shimizu et al. (2017). Generally, abundances of volatile elements increase from 40 Ma to 30 Ma (Figs. **b-e**), along with incompatible elements such as K_2O and P_2O_5 (Fig. **f**). As a result, the ratios of volatile elements to incompatible elements, such as F/K_2O and Cl/K_2O, are almost constant from 40 Ma to 30 Ma, irrespective of the rock series (low-K series or medium-K series) and chemical groups (clusters) of melt inclusions assigned by Hamada et al. (under review) (Figs. **g** and **h**). Because frontal-arc volcanoes and rear-arc volcanoes of the IBM arc are characterized by low-K series rocks and medium-K series rocks, respectively, these results suggest that (i) the volcaniclastics that accumulated at Site U1438 originate from both frontal-arc volcanism and rear-arc volcanism, and that (ii) volcanism around Site U1438 shifted from frontal-arc to rear-arc volcanism over time.

Volatiles in silicic (dacitic~rhyolitic) melt inclusions (Cluster 6 melt in Figs. **g** and **h**) seem to behave differently from those dissolved in mafic melts. Fluorine concentration of silicic melt inclusions (600-800 ppm) does not increase with increasing K_2O (Fig. **g**). Silicic melt inclusions mainly occur at ~30 Ma, the upper level of Unit III, which corresponds to the timing just before the arc rifting and back-arc opening of the IBM arc from ~25 Ma. These silicic melts may be a products of fractional crystallization or may be crustal anatexis (Ikeda and Yuasa, 1989). With respect to the occurences of extremely Cl-rich melt inclusions (Cluster 2 melt inclusions in Figs. **g** and **h**), we discuss two possibilities for their origin: one is that they are the "halogen-rich andesite melts" as proposed by Straub and Layne (2003) for the IBM arc; the other is brine assimilation in a submarine hydrothermal system. No F enrichment is observed for extremely Cl-rich (Cluster 2) melt inclusions, and they cannot be "halogen-rich andesite melts" (Straub and Layne, 2003). Therefore, brine assimilation likely explains the origin of extremely Cl-rich melt inclusions.

References
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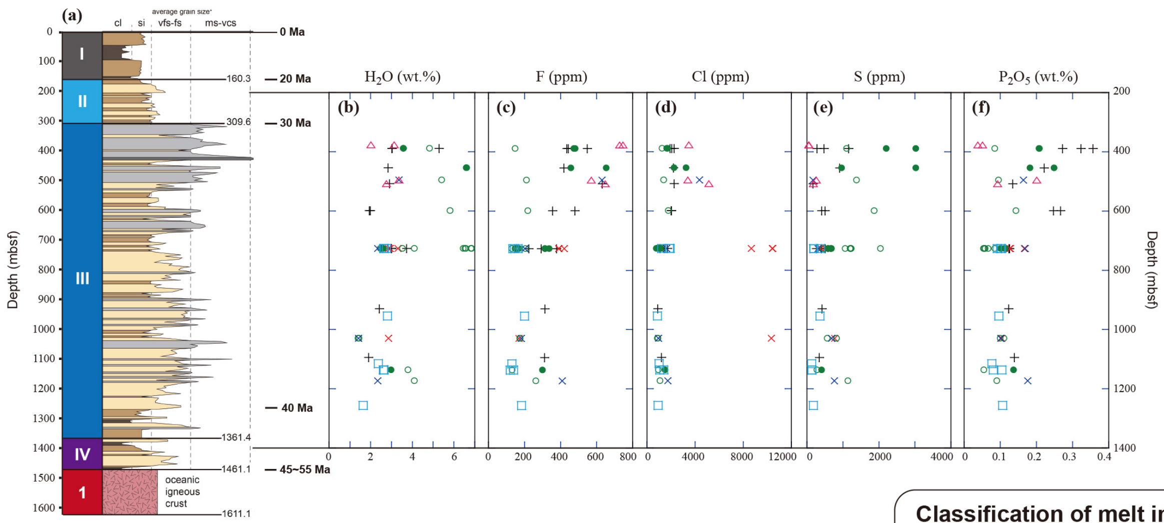

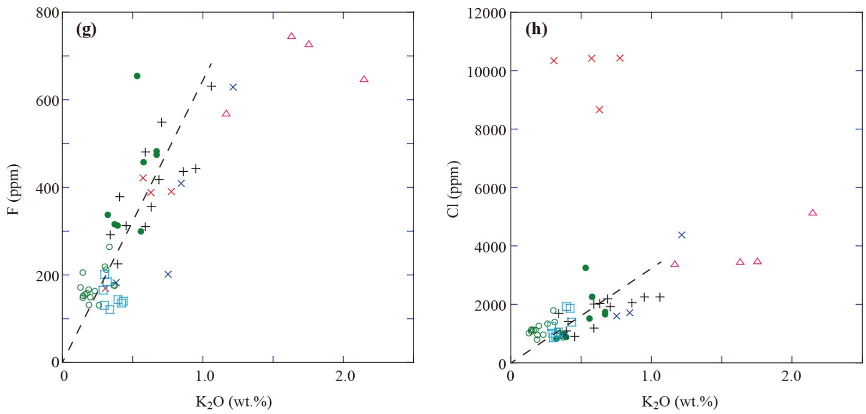

Classification of melt inclusions by Hamada *et al.* *(under review)*

- **Cluster 1 melt inclusions** (Medium-K tholeiitic series rocks)
- **Cluster 2 melt inclusions** (Extremely high-Cl melt inclusions)
- **Cluster 3 (low-K) melt inclusions** (High-S melt inclusions)
- **Cluster 3 (medium-K) melt inclusions** (High-S melt inclusions)
- **Cluster 4 melt inclusions** (High-Cl melt inclusions)
- **Cluster 5 melt inclusions** (High-Mg calc-alkaline andesites)
- **Cluster 6 melt inclusions** (Dacitic~rhyolitic melt inclusions)