



Eocene volcanism during the incipient stage of Izu-Ogasawara arc: Geology and petrology of the Mukojima Island Group, the Ogasawara Islands

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The Ogasawara Islands mainly comprise Eocene volcanic strata formed during the establishment of the Izu-Ogasawara-Mariana arc. We present the first detailed volcanic geology, petrography and geochemistry of the Mukojima Island Group, northernmost of the Ogasawara Islands, and show the stratigraphic relationships of the volcanic strata among the islands which are correlatable to the Maruberiwan, Asahiyama and Mikazukiyama Formations in Chichijima Island Group. Altered tholeiitic strata in the northern Mukojima Island Group are correlatable to the John Beach Volcanics in Chichijima which represents the lowermost Maruberiwan Formation. Boninite and its differentiates with the most depleted REEs among the Mukojima volcanic rocks are correlatable to the main portion of the Maruberiwan and Asahiyama Formations. Relatively fertile bronzite andesite and the uppermost andesite of Yomejima are correlatable to the Mikazukiyama Formation. A short quiescent period is identified between the Maruberiwan Formation composed of boninite, bronzite andesite and dacite and the Asahiyama Formation composed of quartz dacite and rhyolite. However, bronzite andesite, dacite and quartz rhyolite flows are alternating with each other in Nakodojima, indicating that these magma types were simultaneously active. Stratigraphically lower portion of the Mukojima Island is mainly composed of pillow lava, which is overlain by the middle portion comprising reworked volcanoclastic materials, whereas the upper portion is dominated by pyroclastic deposits. This suggests that volcanic activity of the Mukojima Island Group began with quiet extrusion of lava under deep water followed by a quiescence period as represented by the volcanoclastic strata, and then changed into moderately explosive eruptions that took place under shallow water or above sea level as the volcanic edifice grew. The shallowing water depth of the Mukojima Island Group is consistent with the uplift of the entire Ogasawara Ridge during the Eocene. Boninites from the Mukojima Island Group are divided into three types on the basis of geochemistry. Type 1 boninites have high SiO_2 (>58.5 wt%) and Zr/Ti (>0.022), which are the most abundant type in both Mukojima and Chichijima Island Groups. Type 2 boninites have low SiO_2 (<57.1 wt%) and Zr/Ti (<0.010). Type 3 boninites have remarkably high $\text{CaO/Al}_2\text{O}_3$ values (0.9-1.1). Type 2 and 3 boninites are common in Mukojima, however, both types are rare in amount in Chichijima Island Group. Trace element modeling indicates that the source mantles for both type 1 and 2 boninites are highly depleted harzburgite that experienced 12% to 18% melt extraction from DMM-like source. The difference in Zr/Ti ratio between type 1 and 2 can be explained by higher degrees of amphibolitic slab-melt contribution for the former. Chemical compositions of type 3 boninite does not represent primary liquids but are resulted from contamination of xenocrysts of evolved augite, hypersthene and plagioclase in type 1 and/or 2 boninite.