A petrological study on the magma plumbing systems in the Niijima and Shikinejima volcanoes, Izu Islands

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The Niijima and Shikinejima volcanoes have been active for tens of thousands of years, forming 12 rhyolitic, 1-3 andesitic, and a basaltic units. The assemblages of hydrous ferromagnesian phenocrysts in the rhyolites systematically change with eruption sequence; from the cummingtonite (Cum) group via the cummingotnite and biotite (Cum+Bt) group to the biotite (Bt) group. The phase equilibria of the Cum and Bt bearing rhyolities has not been established. In order to understand the petrogenesis of these rhyolites and magma plumbing systems, we carried out a petrological study of the erupted materials, following up Yoshiki et al. (2006, Master thesis and JGU Meeting).

In the SiO_2variation diagrams, whole rock compositions of the Shikinejima group show a trend different from those of the Niijima uinits. The SiO_2 contents of the Cum, Cum+Bt and Bt groups in the Niijima volcano increase in this order, showing continuous trends. The variations of the whole rock compositions within the Cum and Bt groups can be reporduced by fractional crystallization of the present pehenocrysts, whereas the three groups cannot be derived from each other through fractional crystallization of the present phenocrysts. This is consistent with an observation that reaction relation (reaction rim) was not observed between the present Cum and Bt phenocrysts. The phenocryst core compositions (Mg-values of Cum and Bt and An content of plagioclase) have wide ranges covering those of the Cum and Bt groups. These petrographical characteristics show that Cum+Bt group was formed by mixing between the magmas of Cum and Bt groups. Considering that the phenocryst assemblage of the Niijima volcano systematically changes from Cum to Bt and that the whole rock compositions form generally continuous but not strict differentiation trends, parental magma of the Bt group (proto Bt magma) was possibly formed from the parental magma of the Cum group (proto Cum magma) through the reaction relation shown by Evans and Ghiorso (1995) at a deeper magma chamber than that at which present phenocrysts crystallized. The magma temperature was estimated from the coexisting Fe-Ti oxide phenocrysts to be 780-750 (Cum group), 720-700 (Bt group of Niijima). This temperature difference is consistent with the above interpretation of petrogenetic relationship between the Cum and Bt groups.In the Ab-Or-Qtz-An ternary diagram, the whole rock compositions of the Cum- and Bt- rhyolites, not their groundmass glass compositions, were plotted on the cotectic crystallization lines at 0.5-1.5 kbar.Tonalite xenoliths collected at Mamashita-ura, Niijima, have whole rock compositions corresponding to the most undifferentiated Niijima rhyolites and a silicic end-member of a mixing line formed by the basaltic units and enclaves.

On the basis of these observations, we propose a following model of magma plumbing ststem. In a deeper magma chamber, fractional crystallization from the proto Cum rhyolite to the proto Bt rhyolite occurred via reaction relation. The tonalite may represent the parental magma of the proto Cum rhyolite. The present Cum and Bt groups were formed by fractional crystallization from nearly aphyric rhyolite magmas segregated from the parental magma of the proto Cum magma. The Cum+Bt magma was formed by mixing between the Cum and Bt magmas. The basaltic magma should have existed beneath the rhyolite magma chambers throughout the rhyolite activity. The Shikinejima Bt rhyolite was derived from a different magma chamber from those of Niijima.