Formation and evolution of a zoned magma chamber of Tarumai volcano: implications for a long term prediction of volcanic activity

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Tarumai volcano began series of eruptive activity in AD 1667 after several thousands years' dormancy. The 1667 and 1739 plinian eruptions produced a large amount of air-fall pumice and pyroclastic flow deposits (total=1.0 and 0.7 km3DRE, respectively). Since then, although magmatic eruptions had occurred frequently from 1804 to 1909, scale of each eruption suddenly decreased (0.006 - 0.02 km3DRE). No magmatic eruption has occurred after the dome-forming eruption in 1909. Historic pyroclastics and lavas are mostly augite (aug)-orthopyroxene (opx) andesites associated with olivine-bearing aug-opx andesites. These rocks show considerable variations, SiO2=55-63. Variations of Mg-value of phenocrystic aug and opx and An contents of plagioclase phenocrysts are similar irrespective of whole-rock compositions. However, different types of pyroxenes, plagioclase and magnatite phenocrysts have occurred since 1739. Based on Wo contents of pyroxenes, FeO and MgO contents of plagioclase, and Mg/Mn ratios of magnetite, these phenocrysts can be divided into two types, type 1 and type 2. The type 1 phenocrysts are low Wo aug, high Wo opx, low FeO plagioclase, low Mg/Mn magnetite and ilmenite. These would be contained in the silicic andesite magma (type 1 magma) which temperature is about 900-950 C. On the other hand, type 2 phenocrysts are high Wo aug, low Wo opx, high FeO plagioclase and high Mg/Mn magnetite with no ilmenite. These would be derived from intermediate andesitic magma (type 2 magma) with temperature of about 1000 C. Olivine must not equilibrate with the above minerals in the same magma, and would crystallize in basaltic magma. Although this and the presence of banded pumice suggest that the rocks of each activity are formed by magma mixing, there exist three types of end-member magmas. Considering the assemblage of the above types of phenocrysts, the basaltic magma mixed with the type 1 magma in 1667, whereas the above three magma mixed in 1739 and latest. The type 2 magma always mixed with the type 1 magma. In addition, the rocks of each eruptive activity form linear trends in oxide-oxide diagram, suggesting that mixing of two end-member magmas occurred in each activity. Thus, it could be concluded that type 2 magma was formed by mixing between the basaltic and type 1 magmas. It could be concluded that both type 1 and type 2 magmas form a zoned magma chamber by injection of the basaltic magma into the type 1 magma during 1667 activity. Considering the density, the type 2 magma has been underplated beneath the type 1 magma. Compositions of olivine phenocrysts differ among each activity: Fo=74~76 in 1667, 71~74 in 1739, and 73~74.5 in latest. This is consistent with three distinct trends in SiO2-P2O5, -Sr diagrams. These suggest that end-member basaltic magmas have differed among each activity. In conclusion, the magma plumbing system has been composed of shallower zoned magma chamber formed during 1667 eruption and deeper several batches of basaltic magma.

The ratio of type 2 magma in latest activity is much larger than that in 1739, suggesting that considerable amount of the lower part of the zoned magma chamber has been withdrawn in the latest activity. Tapping depth in a magma chamber strongly depends on eruption rates. Considering eruptive volume and recorded eruption duration, eruption rate was much larger in 1667 and 1739 compared to those in the latest activity. Withdrawal depth should be much shallower in the latest activity compared to 1667 and 1739 ones. Thus, thickness of type 1 magma in the zoned magma chamber would be thin in the latest activity. Most of type 1 magma in the upper part of the zoned magma chamber could be withdrawn in 1667 and 1739 eruptions. Considering the temporal variations in both the ratios of type 1 and type 2 magmas in eruptives and eruptive volume, it could be assumed that considerable scale of plinian eruptions such as 1667 and 1739 ones might not occur in near future.