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Petrology of Rinjani volcano, Indonesia: The magmatic processes before and during AD 1257 caldera-forming eruption

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In order to compare distinct types of caldera volcanoes, we start to study the AD 1257 caldera-forming eruption of Rinjani volcano, Indonesia, which occurred at the summit of a large startovolcanoto. On the other hand, there exist no a large preceding stratovolcano in Japan. Thus, the volcano must be different type. The volcano started its activity ca. 0.10 Ma. The activity can be divided into four major stages, stratovolcano-building, low activity (pre-caldera), caldera-forming and post-caldera stages. Eruption rate had decreased since the low activity stage from 0.6 km^3/ky to 0.15km^3/ky. The caldera-forming stage occurred in AD 1257. The total eruptive volume during the stage is estimated to be more than 10 km^3 DRE. Activity of the post-caldera stage has continued within the caldera. The rocks of the stratovolcano-building stage, ranging from SiO_2=44.8 to 63.7%, are mainly basaltic andesite. Type of rocks has clearly changed since the low-activity stage and are amphibole dacite. The rocks of the caldera-forming one are less silicic compared with those of the low activity one. The rocks of the post-caldera stage are olivine-pyroxene andesite (SiO_2~55). Based on whole-rock chemistry, the rocks of the volcano can be grouped into two, stratovolcano-building and post-caldera stages, and low activity and caldera-forming ones. The two groups can be easily distinguished according to two distinct chemical trends in many SiO_2 variation diagrams for major (Al_2O_3, MgO, FeO, CaO and K_2O) and trace (V, Rb, Y, Zr, Ba and Th) elements. Ratios of incompatible elements and Sr isotope ratios of the rocks from two groups are also distinct. These suggest that the dacitic magmas from the low activity and caldera-forming stages could be produced not by crystallization differentiation of the basaltic magma but by additional processes, such as crustal melting and/or AFC process. Although the rocks from low activity and caldera-forming stages are similar amphibole dacite, these rocks can be distinguished in terms of two distinct trends in many SiO_2 variation diagrams. Contents of LIL elements, such as K_2O, Rb and Ba, of the rocks from each stage increase with increasing of whole-rock SiO_2. Thus, nearly parallel, positive trends are formed in such SiO2 variation diagrams. Contents of LIL elements of the rocks from caldera-forming stage are lower contents than those from low activity one at the same SiO_2 content. On the other hand, HFS elements, such as Nb, Zr and Y, show different variations of the rocks between two stages with increasing of whole-rock SiO_2 contents. Although the elements of the rocks from the caldera-forming stage show positive correlation with SiO_2 in SiO_2 variation diagrams, those from the low activity stage show negative one. Thus, the contents of LIL elements from two stages are similar in silicic dacite, whereas those are largely different in andesitic dacite. The andesitic dacite of the low activity stage is characterized by high contents of HFS elements. Considering these chemical difference in dacites between low activity and caldera-forming stages, these rocks cannot be formed by simple crystallization differentiation and/or contamination from the same primary magma. According to the temporal change of volcanic activity and erupted magma since late Pleistocene, it would be possible to consider the low activity stage as preceding stage for caldera-forming eruption. During the stage, eruption rate had rapidly decreased and magma type has also changed to be dacitic one, which is similar to the magma of the caldera-forming stage. Thus, it seems that caldera-forming, voluminous dacitic magma had been formed and accumulated during the low activity stage. However, our study revealed that the dacitic magma from these two stages are different. Thus, this would not be the case that the same dacitic magma had been continuously formed and accumulated until the caldera-forming stage.

Keywords: caldera, caldera-forming eruption, magma process, silicic magma, Rinjani volcano