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Volcanic stratigraphy and magmatic differentiation in the northern Kita-Hakkoda volcanic group

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Stratigraphy of northern Kita-Hakkoda volcano, consisting of Mae-dake, Tamoyachi-dake, Narusawa-daichi cones, was established. Combined with the stratigraphy, differentiation process was investigated from whole-rock chemistry and mineralogy. Eruption products were divided into 9 units: the Hakkoda 2nd Stage Pyroclastic Flow deposit, Northern Kita-Hakkoda Basaltic Andesite Lavas, the Lower Kansuisawa Pumice Flow deposit, the Lower Tamoyachi-dake Andesite Lavas, the Upper Kansuisawa Pumice Flow deposit, the Upper Tamoyachi Andesite Lavas, Maedake lavas, Narusawadaichi Andesite Lavas and the Okuzuresawa Pyroclastic Flow deposit in stratigraphic order. Chemical analysis following the stratigraphy elucidated the temporal variation in magmatic compositions. The activity initiated with the effusion of differentiated tholeiitic basaltic magma around 0.4 Ma (Northern Kita-Hakkoda Basaltic Andesite Lavas). After a dormancy, the activity (deposition period of Tashirotai Lacustrine Deposit), the activity resumed around 0.2 Ma with effusion of andesitic magma (60 wt% SiO_2)(Lower Tamoyachi-dake Andesite Lavas, Upper Tamoyachi Andesite Lavas, and lower Maedake Lavas), followed by a series of activity of low-silica calc-alkaline andesite (middle Maedake Lavas) and tholeiitic basalt magmas (upper Maedake Lavas). Then, the magma composition jumped to high silica (60 wt% SiO_2) calc-alkaline andesite (Narusawadaichi Andesite Lavas). Each rock from the all units contains plagioclase, augite, orthopyroxene, olivine, and magnetite as phenocrysts. Some calcalkaline andesite (Upper Tamoyachidake Andesite Lavas) contain embayed quartz phenocrysts. No evidence for open system process is recorded in phenocrysts in the tholeiitic rocks. Previous studies accounted for the chemical variation of tholeiitic magma by crystallization differentiation, and our new data is consistent with the model. Disequilibrium mineral assemblages in calc-alkaline rocks, e.g., coexistences of magnesian olivine and embayed quartz, and of reversely zoned pyroxenes and normally zoned pyroxenes, imply open system processes. As indicated by the linear trend between tholeiitic basalt and the high-silica andesite, magma mixing is a plausible process to produce the series. Stratigraphic chemical variation might be caused by temporal variation in mixing ratios. Focused on the magmatic activity after the dormancy, initial stage was dominated by felsic end-member to produce high-silica andesite (60 wt% SiO_2). Then, contribution of the mafic end-member increased and chemical composition gradually shifted to basic. The composition of erupted magma finally achieved to the pure mafic endmember magma composition which is a tholeiitic basalt. Then mixed magma with a high silica content (60 wt% SiO_2) erupted again.

Keywords: Kita Hakkoda Volcanic Group, calc-alkaline series, magma-mixing