Stratigraphy and evolutionary mechanism for the low-K tholeiitic magmas at Kotakakura volcano in the Sengan geothermal field, Northeast Japan arc

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Background and purpose

Kotakakura volcano is a Quaternary stratovolcano located in the Sengan geothermal field, Northeast Japan arc. It consists of low-K tholeiitic series, and has a K-Ar age of 1.2 to 2.3 Ma (Suto and Ishii, 1987). In order to elucidate the mechanisms that cause the compositional variations of low-K tholeiitic magmas in Northeast Japan arc, geology and stratigraphy along with petrology and petrography on the Kotakakura ejecta are revealed with high resolution. The crystallization differentiation of phenocrysts has been considered as the chi of mechanism to create the characteristic tholeiitic variation trend. It is basically true for the case with the Kotakakura ejecta, either crustal assimilation or mixing of felsic magma has considerable role acted effort in several lava flows in the early stage of development.

Geology

Kotakakura volcano consist mainly of lava flows. On the basis of presumed eruption center deducted from flow directions, the ejecta is roughly divided into Kotakakura East lava group (KTE) and Kotakakura North lava group (KTN). The KTE and KTN are subdivided into 16 and 7 lava flows, on the bases of the topography of the individual lava robe, stratigraphic relations, and lithofacies, as well as petrological features, petrography and bulk chemical compositions. Although we can not confirm the direct covering relationship, we infer that KTN is covered by KTE from the remaining state of the terrain at the boundary. In addition, the KTN suffered weathering erosion of outcrops heavily compared with KTE, so that the KTN is considered to be effused earlier than KTE.

Petrological data

Petrography

The KTE lavas commonly contain Plagioclase, Orthopyroxene, Clinopyroxene, opaque mineral, as phenocryst phases. Olivine are found only in KTE1 to 3. The amount of phenocrysts varies from 16.9 to 48.5.

The KTN lavas commonly contain Plagioclase, Orthopyroxene, Clinopyroxene, Opaque mineral, as phenocryst phases. Phenocryst-sized quartz grains are found only in KTN1, 1'. The amount of phenocrysts varies from 19.8 to 41.5.

Major elements

The SiO2 content varies from 49.1 to 60.9, and almost all the ejecta come within the low-K basalt to andesite clan on the Harker diagram. Both the KTE and KTN lava samples come within the range for the tholeiitic series in the northern subzone of the Nasu (frontal) volcanic zone in the NEJ (Kawano et al., 1961), with slightly high Al2O3 and CaO, and low FeO*, MgO, and Na2O levels compared with the average TH trend in the NEJ.

Almost all the Kotakakura samples are plotted in the area for the tholeiite (TH) series on the Miyashiro's diagram. The exceptional two samples also come low-SiO2 extension of the trend for the Kotakakura TH series. The KTE samples show typical variation trend for the low-K tholeiite series in the Northeast Japan arc (NEJ). The KTN samples, on the other hand, show somewhat peculiar trend; the FeO*/MgO decreases slightly with increasing SiO2.

Trace elements

The KTE samples show virtually the same incompatible element characteristics as those typical for the TH in NEJ. The KTN samples basically share the characteristics with the coexisting KTE, but only Y kept almost constant through the whole SiO2 range of the KTN variation.

Discussion

Because the KTE shows the typical tholeiitic variation trend which share the TH series in NEJ, a crystallization differentiation modeling was examined using mass balance calculation by employing phenocrysts as the fractionated phases. The results successfully reproduce the actual variation trends for the KTE. The KTE did not become more evolved composition with descending order of eruption, suggesting that either intermittent supply of primitive tholeiitic magma into the differentiating chamber, or liquid differentiation caused by boundary-layer convection at the chamber wall acted as the additional role in the compositional variation process of the KTE.

As for the KTN peculiar trend, it may be due to incorporation of some quartz-bearing silicic component into the differentiating tholeiitic magma. Such silicic component might be either the Tamagawa dacitic welded tuff that lies under the Kotakakura volcanic edifice, or rhyolitic partial melt of crustal origin.

Keywords: stratigraphy, tholeiitic magmas, crystallization differentiation, magma mixing