Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

SVC53-04 Room:301A Time:May 21 09:45-10:00

Magma series and their source materials at Akita-Komagatake volcano, Northeast Japan arc

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Geologic background: Akita-Komagatake volcano has been erupted mainly tholeiitic magmas with subordinate amount of calc-alkaline magmas to develop a composite volcanic edifice in the recent 100,000 years. It consists of the main strato cone with a caldera in the southern area and several parasitic cones involving central cones were formed in the caldera floor. About 13 ka, an explosion event involving major pyroclastic flow with huge amount of air-fall ash resulted in the caldera collapse, which accompanied drastic change of the magma plumbing system beneath the volcano. Magmatic eruption history in the post-caldera stage can be further divided into two sub-stages by the presence of about 3,000 years of dormancy from 7 ka to 4ka. Parasitic cones in northern area had been built predominantly in the early sub-stage, whereas central cones in the southern area have been developed during the later sub-stage. Episodic explosive eruption occurred immediately after the dormancy (ca. 4 ka), resulting in the last cinder cone in the northern area.

Aim of this study: In the present study, the erupted magma series and their temporal compositional variations were revealed by correlating the frequency of magmas with their localities of the eruption centers to their bulk chemical compositions. The temporal and spatial compositional variations of the magmas further examined to the chemical characteristics including isotopic compositions, so as to investigate the genetic relationship among a variety of the magmas erupted in the post-caldera stage of the volcano.

Results: Low-K tholeiitic magmas showing high FeO/MgO have been the dominant type throughout the post-caldera stage. Calc-alkaline andesitic magma erupted episodically at the beginning of the late sub-stage. The early sub-stage began with eruptions of the tholeiitic andesite magmas, followed by effusions of the basaltic to basaltic andesite magmas of the same magma series. After the dormancy, calc-alkaline andesitic magma erupted in the northern vent, which was succeeded to the magmatic eruptions in the caldera floor in the southern area. Tholeiitic andesite magmas erupted first in the caldera floor, but superseded soon by the tholeiitic basalt to basaltic andesite magmas. The latest magmatic eruption occurred in 1970, and produced a lava flow of andesitic in composition.

The calc-alkaline magma is distinctive to the tholeiitic basaltic magma in terms of the chemical characteristics including isotopic compositions; the former strongly suggests incorporation of (smaller degree of) partial melt of crustal materials into the magma, whereas the latter more likely derived from depleted MORB source mantle (DMM) with slab-derived components. These are indeed compatible with the traditional hypothesis on the genesis of tholeiitic vs. calc-alkaline magmas.

At least two kinds of tholeiitic andesitic magmas can be recognizable with respect to the chemical characteristics. One is that erupted about 3 ka, showing characteristics reflecting dominant involvement of crustal materials, even when compared with the calc-alkaline andesite magma. The other is that erupted in 1970, showing similar characteristics to those for the MORB, relative to the co-existing tholeiitic basalts.

Discussion and conclusion: From the above mentioned data, we can infer the genetic relations among the co-existing magma series in the post-caldera stage as follows: (1) Tholeiitic basaltic magma was generated by partial melting of the DMM, and derived andesitic members of the same series through fractional crystallization with or without assimilation. (2) Calc-alkaline andesitic magma was to be the product of mixing between the tholeiitic basalt magma and felsic magma enriched in crust-derived materials. (3) Some of the tholeiitic andesite magma might be generated from (lower) crust by considerable degrees of partial melting, which is similar to those preferable for the tholeiites in the middle area of the Northeast Japan arc.

Keywords: Island-arc volcanism, Tholeiite magma, Calc-alkaline magma, magma source materials, Isotopic compositions of magmas