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Abstract of Doctoral Dissertation

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Title of Doctoral Dissertation

Petrological and Geochemical Study of Sundoro Volcano, Central Java, Indonesia: Temporal Variation in Differentiation and Source Processes in the Growth of an Individual Volcano

(インドネシア中部ジャワ、スンドロ火山の岩石学および地球化学的研究：単一火山の成長におけるマグマ発生源プロセスおよび分化作用の時間変遷)

Subduction zone resembles site of arc crustal building through complex magmatic processes involving subduction components such as mantle wedge, subducting slab, and overriding crustal in which all of them might chemically and/or physically change through time. Thorough understanding of volcanic arc must include careful examinations of the magmatism of individual volcanoes including reconstruction of its magma supply systems through recorded past activities. These highlight the importance of study on temporal variation of differentiation and source process in an individual arc volcano. During their lifetime, many individual volcanoes experienced magmatic compositional change including their isotopic compositions and incompatible elements related to the slab contribution. This compositional change might occur within the same magma series, with similar mineral assemblages, through time reflecting various processes both in the intra-crustal level and deep magma source level. However temporal variations of these processes are not well understood yet, mainly due to lack of detailed petrological and geochemical study which is combined with thorough field observation and dense resolution of the precise age determination data. This is mainly the case in Sunda arc despite of the well-known strong signature of sediments and wide range isotopic compositions of the volcanic products.

This study reported new Sr-Nd-Pb radiogenic isotope ratios in addition to the complementing whole rock geochemistry and trace elements combined with mineral chemistry of representative rocks of Sundoro volcano, approximately 50 km west of Merapi volcano, in the central Java sector of Sunda arc. Collected samples cover stratigraphically well-constrained volcanic products from the past 34 ka activities ensuring useful information to our understanding in the temporal variations of differentiation and source process of magmatism in an arc volcano.

The rocks of the volcano span from basalt (SiO₂ 51.5 wt. %) to andesite (62.9 wt.%)

and are dominated by basaltic andesite. Least evolved samples contains MgO less than 6 wt.% and is considered as evolved basalt. Samples can be divided into three magma types A, B, and C on the basis of isotopic compositions. Relative to each other, A-type has low $^{87}\text{Sr}/^{86}\text{Sr}$ and Pb-isotopic ratios. B-type has medium $^{87}\text{Sr}/^{86}\text{Sr}$ and Pb-isotopic ratios. C-type has high $^{87}\text{Sr}/^{86}\text{Sr}$ and Pb-isotopic compositions.

Crustal contaminations were recorded in the Pb isotopic compositions change through progressive differentiation indices. Shifting of wide range bimodal plagioclase core compositions from mafic rich in the basaltic samples to felsic rich in the andesitic one suggests for crustal contamination through magma mixing process. Distinct trends of the isotopic compositions of the three magma types are reflected in the ratios of incompatible elements such as Ba/Zr, La/Yb, Th/Zr, and Ba/La against differentiation indices and suggesting the existence of three mafic and felsic end-member magmas. Felsic end-member magmas cannot be produced by simple fractional crystallization of respected mafic end-member magmas and probably are derived from partial melting of crustal materials. However, $^{87}\text{Sr}/^{86}\text{Sr}$ and $^{143}\text{Nd}/^{144}\text{Nd}$ isotopic ratios that remain unchanged through differentiation process and discrete variations of each magma types in the isotopic compositions and ratio of incompatible elements allow us to further discuss the significance of differentiation in the deep magma source to the genesis of Sundoro magma. $^{87}\text{Sr}/^{86}\text{Sr}$ and Pb-isotopic ratios show positive correlation to the proxies of subducted slab contributions and suggest for significance of subducted slab materials to the petrological and geochemical variation of Sundoro rocks. We have identified the existence of three distinct slab-derived materials containing various sediment contributions approximately 50%, 55%, and 60% which correspond to generation of magma A-, B-, and C-type, respectively. These slab-derived materials were added to mantle wedge in various rates within the range of 1-2%.

Temporal change of magma type shows the existence of A-type in 20-9 ka and remarks co-existence of A- and B-type in the period of 14-17 ka before the abrupt change to C-type since 9 ka. Supply of mafic magma shows decreasing-trend in the active period of A-type magma and relatively constant for C-type magma. Genesis of the three magma types in the source level is controlled by continuous dehydration and partial melting generating three distinct slab-derived fluxes. Time interval between these three fluxes is about 3-8 ky and shows increasing portion of sediment contribution through time. Through combination of detailed field observation and high quality petrological and geochemical data of stratigraphically well-controlled volcanic products, this study has successfully identified three distinct slab-derived fluxes beneath an individual arc volcano with certain time interval between their occurrences.