

Magma genesis and differentiation at Merapi volcano, Sunda arc, Indonesia

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Merapi, a large Quaternary volcanic complex situated within the active volcanic front of the Sunda arc in Central Java, is one of the most active volcanoes in Indonesia. Its recent activity is characterized by the extrusion of high-K basaltic andesite lavas forming lava domes in the summit area and intermittent gravitational or explosive dome failures generating small-volume pyroclastic flows that are a permanent threat to life within the densely populated areas on the flanks of the volcano.

During the Holocene, Merapi erupted basalts and basaltic andesites of medium-K affinity in the earlier stages of activity and high-K compositions from ~1900 years BP to the present. This increase in K₂O is accompanied by a marked increase in whole-rock ⁸⁷Sr/⁸⁶Sr ratios, but not by systematic variations in δ¹⁸O values, which are relatively constant and slightly elevated compared with mantle values. Whole-rock trace element and isotopic characteristics suggest that mantle source contamination played a significant role in determining the geochemical characteristics of the parental magmas of the two magmatic series. Subsequent differentiation of these magmas during ascent and storage in the arc crust involved a complex interplay of fractional crystallisation, recharge, magma mixing and assimilation of carbonates from the subvolcanic basement. Whole-rock analysis of the crystal-rich Merapi rocks can only provide a blurred picture of these processes and open-system processes, such as crustal contamination, are often masked in the whole rock isotope ratios. Therefore, a more complete picture of these processes has been assembled by combining crystal isotope stratigraphy, petrological analysis of magmatic and crustal xenoliths hosted in recent Merapi deposits and stable isotope analysis of fumarole gases. These studies indicate that magma-crust interaction and late-stage crustal contamination are volumetrically significant and have important implications for magma evolution and, potentially, the eruptive behaviour at this high-risk volcano.