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The 2010 Eruption of Merapi Volcano, Java, Indonesia: Petrological Insights into Magma Dynamics and Eruptive Behaviour

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The violent eruption of Merapi volcano (Central Java) that started on 26 October 2010 was the volcano's largest since 1872 and the deadliest event since 1930. Before 2010, Merapi's more recent (historical) eruptive activity was repeatedly characterised by periods of slow lava dome extrusion punctuated by gravitational dome failures, generating small-volume pyroclastic density currents (PDCs) with runout distances of typically less than 10 km.

The unforeseen, large-magnitude events in 2010 were unusual in many respects: (1) the eruption was short-lived and started with an explosive phase that was not preceded by a lava dome at the surface; (2) between 31 October and 4 November, a lava dome appeared and grew rapidly within the summit crater, exceeding growth rates observed at the peak of the penultimate eruption in 2006 by a factor of $\sim$ 22; (3) during the most vigorous eruptive phase on 5 November, at least one PDC travelled more than 15 km (more than twice the distance of the largest flows in 2006) beyond the summit along the Gendol river valley, causing widespread devastation on Merapi's south flank; (4) in a late phase of the eruption, pumice-rich PDCs were produced, forming a thin veneer on top of the deposits of the largest PDCs from 5 November; (5) ash emissions from sustained eruption columns resulted in ash fall tens of kilometres from the volcano, affecting, amongst other areas, the volcano's western slopes and the city of Yogyakarta $\sim$ 25 km to the south; and (6) the total deposited volume in 2010, based on provisional estimates, may have been $\sim$ 10 times higher than that of other recent eruptions.

Here we report and present new geochemical, Sr-Nd-O isotope and U-series data for the volcanic products (lava dome fragments, magmatic inclusions, scoria, pumice and ash) from various stages of the 2010 eruption of Merapi. These data are discussed in the context of other recent to historical, typically less explosive, dome-forming eruptions to elucidate the driving forces behind the unusual explosive behaviour in 2010 and their timescales. The 2010 events highlight that dome extrusion and relatively small, prolonged dome-forming eruptions at Merapi can be interrupted at relatively short notice by larger and more vigorous eruption phases or eruptions, which appear more common in the geological record. An improved knowledge of these processes and of changes in the pre-eruptive magma system has important implications for the assessment of hazards and risks from future eruptive activity at Merapi.