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Insights into Magmatic Degassing at Merapi Volcano, Indonesia from Uranium-Series Disequilibria in Recently Erupted Volcanic Rocks

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We present new uranium-series isotopic data for the volcanic products of the 2006 and 2010 eruptions at Merapi to investigate magmatic degassing and the driving forces behind the recent unusual explosive behavior in 2010. The 2006 and 2010 Merapi whole-rock samples and plagioclase separates have U excesses ((^{238}U/^{230}Th) activity ratios > 1) and excess Ra ((^{226}Ra//^{230}Th) > 1) with no significant difference between the 2006 and 2010 whole-rock samples. Two samples, one from 2006 and one from 2010 have apparent (^{228}Ra/^{232}Th) values in excess of secular equilibrium, suggesting that the process causing the ^{226}Ra enrichments over ^{230}Th (possibly the interaction of magma with carbonate material in the crust) might have continued to shortly before eruption at least for some magmas. The 2010 Merapi rocks were variably degassed of ^{210}Po upon eruption, showing no systematic temporal evolution. The variation observed in (^{210}Pb/^{226}Ra)$_0$ for the 2006 and 2010 eruptions is comparable to the full range of ratios measured in the time period from 1981 to 1995, previously reported for the volcano. The 2006 and 2010 samples are largely characterised by ^{210}Pb deficits ((^{210}Pb/^{226}Ra)$_0$ < 1), though four of the samples lie within error of secular equilibrium. The observed variability in (^{210}Pb/^{226}Ra)$_0$ is attributed to variations in magmatic source depth as well as potential variable speed of ascent. The range of ^{210}Pb deficits observed in the 2006 Merapi samples imply approximately 2-4 years of degassing prior to eruption. In the main 2010 dome-building phase, the three samples analysed show small ^{210}Pb deficits to a small ^{210}Pb excess and lie within error of secular equilibrium. This likely represents the arrival of fast moving magma that did not stall and degas for any significant amount of time since its last stagnation point. The higher (^{210}Pb/^{226}Ra)$_0$ in samples erupted between 1 to 4 Nov 2010, compared to 2006, supports the previous model that periods of magmatic recharge are linked to rapid dome extrusion and, ultimately, more explosive eruptions at Merapi and the low/zero initial Po activities in these samples suggest that open-system degassing must have occurred very shortly (weeks to months) before eruption.