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Volatile and magma supply to standard eruptive activity at Merapi volcano, Indonesia.

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The standard eruptive activity of Merapi volcano consists in continuous degassing and extrusion of andesitic lava domes whose collapses generate block avalanches and gravitational pyroclastic flows. Gas release at Merapi occurs mostly during quiescent magma extrusion, since explosive eruptions, such as in November 2010, are episodic events. Here we summarize the results of repeated geochemical studies of high-temperature (600°-900°C) Merapi gas emissions during standard activity in the eighties and of volatiles dissolved in the magma [1], which provide important constraints upon the magma degassing behaviour and budget of this volcano. Chemical and isotopic analyses of gases emitted from Woro-Gendol fumarolic fields and from the lava dome itself demonstrate their feeding from a common source and a quite steady composition on the long term. Isotopic data point to a mantle-derived origin of most volatile species, with clear involvement of a subducted component in the case of water, sulfur and nitrogen. Carbon dioxide ([U+F064]13C = -3.9‰ and helium (3He/4He = 6.6 Ra) derive principally from the mantle, even though crustal contamination is allowed by the higher-than-MORB CO2/3He ratio and the presence of carbonate xenoliths in Merapi lavas [2].
The time-averaged gas fluxes, computed from SO2 plume flux measurements and the mean composition of high-temperature gases, point to a total gas output of about 6500 tons/d or 2.4 Mg/yr, which ranks Merapi as a typical medium arc volcanic source. Microprobe analysis of volatiles trapped in melt inclusions of pyroxene phenocrysts in the andesite indicate a minimal pre-eruptive sulphur content of 950 wt ppm. Normalizing the SO2 output to the degassed fraction of S leads to an average magma degassing rate of ≈0.05 km3/yr, which is 40 times greater than the lava extrusion rate averaged over the past hundred years (1.2E+06 m3/yr; [4]). Therefore, the Merapi gas discharge derives essentially from differential degassing of non-erupted magma. This implies, first, continuous gas percolation through molten andesite in the conduits or/and along conduit walls, second, the existence at greater depth of a magma feeding/storage system large enough to sustain the activity and to accomodate the amounts of unerupted degassed magma.
A key factor controlling the eruptive activity of Merapi may then be the ratio between the rates of gas supply and gas release (the latter being either equal to or lower than the former). Both rates are likely to equilibrate on the long-term, but may diverge on shorter time scale (months or weeks) depending on the aperture of the conduits or/and the recharge with deeper undegassed magma.

[1] Allard P., Carbonnelle J., Dajlevic D., Métrich N., Sabroux J.C. (1995) The volatile source and magma degassing budget of Merapi volcano, Indonesia: evidence from high temperature gas emissions and crystal melt inclusions. International Workshop Merapi Decade Volcano, Yogjakarta, Indonesia, extended abstract 16-18, Oct. 1995; [2] Deegan FM, Troll VR, Freda C, Misiti V., Chadwick JP, McLeod CL, Davidson JP (2010). J. Petrology 51, 1027-105; [3] Siswowidjoyo et al.., Bull. Volcanol., 57, 111-116 (1995).