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Volatile flushing controlling the eruptive styles at Mount Etna volcano (Italy)

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At Mount Etna volcano (Italy), the massive release of magmatic gases (especially H_2O, CO_2 and SO_2) during explosive eruptions and throughout the persistent gas plume raises important issues: i) the volume of magma erupted at given period is not sufficient to feed the gas plume released during the same period; ii) gas-dominated explosive eruptions do not emit differentiated products but relatively high-Mg magmas; iii) H_2O measured in melt inclusions ($\sim$3.5 wt.% at about 0.4 GPa) exceeds what is expected from intraplate mantle-derived melts considering a "normal" amphibole- and/or phlogopite-bearing peridotite (<1.4 wt%; see also Kovalenko et al., 2007). In its recent history the Etnean volcano has been characterized by four main eruptive styles: i) constant massive degassing at the summit craters, ii) long-lasting (months to years) quiet lava effusions from sub-terminal or lateral vents, iii) violent and short-lasting outburst from the sub-terminal craters (especially the New? South East Crater), iv) explosive and effusive eruptions through fractures opened along the flanks of the volcanic edifice. In this study, we proposed an idea that, gathering literature data on melt inclusions and observations on plagioclase textures and compositions, constrained by phase stability MELTs calculation, is able to figure out the processes responsible for the great amount of H_2O in the Etnean magmas and its movement along the feeding system. The H_2O enrichment is in fact the main factor influencing the eruptive style, which shifts from purely effusive to violent explosive paroxysms. We propose that in open conduit conditions the continuous loss of gas from the free surface of magma promotes an almost steady stream of H_2O-rich fluid extending well below the gas saturation depth, in this way the H_2O undersaturated primitive magma, residing along the plumbing system, will undergo an intense volatiles "flushing". This process, which could be enhanced also by CO_2 migration, is fundamental to increase the low H_2O content in basic magma (<1.4 wt%) allowing it to overcome the saturation threshold, exsolve as gaseous phase and promote also violent strombolian eruption of Mg-rich lavas. Such mechanism would also account for the unexpectedly high amount of magmatic water released during non-eruptive periods. The distinct eruptive styles can therefore be considered as the evidence of a unique process in which the magma, residing at different levels along the feeding system, is charged with volatiles (especially H_2O) up to the saturation point. The interplay between the amount of volatiles acquired by the magma at depth and the increase in the viscosity due to degassing at shallower level can drive the volcano behavior from effusive activity to violent strombolian short-lasting events.

Kovalenko et al. (2007). Petrology. Vol. 15, No, 4, pp. 335-368