Magmatic control on volcanic activity at Volcan de Colima, Mexico

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Volcan de Colima historical activity is characterized by periods of intermittent effusive and Vulcanian eruptions punctuated by major sub-Plinian to Plinian eruptions, the most recent of which occurred in 1913. The effusive-Vulcanian phases are dominated by andesitic lavas with 61 wt% SiO_2, when the Plinian eruptions involve more mafic andesites with 58 wt% SiO_2. The systematic shifts in compositions associated with the Plinan eruptions indicate a link between the eruptive cycles and the magmatic dynamics.

Detailed petrological and geochemical investigations of the magmas erupted during the effusive and Vulcanian activity between 1998 and 2010 enable us to constrain the storage conditions and pre-eruptive evolution of these magmas. The melt inclusions exhibit compositional trends consistent with up to 40% crystallization under vapour-statured conditions at pressures <1.5 kbar. Decompression induced dehydration is driving crystallisation in the sub-volcanic magmatic systems. Compositional zoning of phenocrysts indicates that, in addition to magma mingling in the ascending dacite melt of mafic crystals, magma mixing was important in the 1998-2010 magmatic system but involved predominantly dacitic magmas with limited compositional variability. The range of ($^{210}Pb/^{226}Ra$) activity ratios and the width of amphibole reaction rims indicate that the feeding magmatic system comprised several magma batches with residence and degassing times in the vapour-saturated section of the system ranging from several days to 7 years. No significant differences in petrology, volatile contents, degassing paths and time scales are observed between the Vulcanian and effusive eruptions, implying that these shifts in eruption style are principally related to conduit dynamics. The most vigorous effusive phases may, nonetheless, be related to influx of undegassed dacitic magmas.

The last major Plinian eruption, in 1913, erupted magmas clearly distinct from those of 1998-2010 in terms of storage conditions and pre-eruptive magmatic evolution. The most distinctive features of the 1913 magmas are the higher H_2O contents (and storage pressures) of the melt inclusions, the textural and chemical evidences for magma mixing with mafic melts shown by some phenocrysts, and the more mafic compositions of the groundmass glasses compared to the melt inclusions. Taken together this indicates that the Vulcanian-effusive activity characteristic of the 1998-2010 period and the 1913 Plinian eruption represent clearly distinct pre-eruptive scenarios rather than a continuum. Influx and mixing of mafic magmas in the dacitic subvolcanic reservoir was important prior to the 1913 eruption and most likely caused the shift in eruptive style. The rates and periodicity of replenishment of the subvolcanic system by, respectively, dacitic and mafic magmas appear to be key parameters controlling the eruptive cycles at Volcan de Colima.