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Evolution of the magma feeding system during a Plinian eruption: the case of Pomici di Avellino eruption of Somma-Vesuvius, Italy

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Numerical simulations of magma flow in a conduit combined with volcanological and geological data, allow for the first description of a physics-based model of the feeding system evolution during a sustained phase of an explosive eruption. The method was applied to the Plinian phase of the Pomici di Avellino eruption from Somma–Vesuvius (Italy). Information available from volcanology, petrology, and lithology studies was used as input data and as constraints for the model. In particular, Mass Discharge Rates (MDRs) assessed were used as target values for numerical simulations. The model solutions were constrained using geological and volcanological data. Three geometric configurations of the feeding system were assessed for the Eruptive Units 2 and 3 (EU2, EU3), which form the magmatic Plinian phase of PdA eruption. They describe the conduit system geometry at time of deposition of EU2 base, EU2 top, and EU3. A 7-km deep dyke (length 2a = 200–400 m, width 2b = 10–12 m), connecting the magma chamber to the surface, characterised the feeding system at the onset of the Plinian phase (EU2 base). The feeding system evolved into hybrid geometric configuration, with a deeper dyke (length 2a = 600–800 m, width 2b = 50 m) and a shallower cylindrical conduit (diameter D = 50 m, dyke-to-cylinder transition depth $\sim$ 2100 m), during the EU2 top. The deeper dyke reached the dimensions of 2a = 2000 m and 2b = 60 m at EU3 peak MDR, when the shallower cylinder had enlarged (D = 60 m) with a transition depth of 3000 m.

The changes in geometry indicate a partitioning of the driving pressure of the eruption, which affected both magma movement to the surface and dyke growth. This implies that a significant portion of the magma injected from the magma chamber filled the enlarging dyke before it erupted to the surface. In this model, the lower dyke acted as a sort of magma “capacitor” in which the magma was stored briefly before accelerating to the cylindrical conduit and erupting. The capacitor effect of the lower dyke implies longer times of transit for the erupting magma, which also underwent several steps of decompression. On the other hand, the decompression of magma within the capacitor provided the driving pressure to maintain the flow into the upper cylindrical conduit, even as the base of the dyke started to close due to the drop in driving pressure from progressive emptying of the magma chamber. The shallower cylinder was shaped through the erosion of conduit wall rocks at and above the fragmentation level. Using the lithic volume and duration of EU3, the erosion rate of the cylinder was calculated at $\sim 5 \times 10^3$ m3/s.