Evolution of magma feeding system during Plinian eruptions: The example of Pomici di Avellino eruption of Somma–Vesuvius, Italy

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Magma flow during explosive volcanic eruptions has been described assuming that magma erupts from a deep magma reservoir through a volcanic conduit, typically modelled with fixed rigid geometries such as cylinders or planar geometries. This simplistic view of a volcanic eruption does not account for the complex dynamics that usually characterise a large explosive event. Here we study the dynamics of explosive volcanic flows to take account of the role of elastic deformation of the conduit influenced by local magmatic pressure. Numerical simulations of magma flow in a conduit combined with volcanological and geological data, allow for reconstructing 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 (PdA, 3945 ±10 cal yr BP) 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 from volcanological methods were used as target values for numerical simulations. The model solutions, which are non-unique, were constrained using geological and volcanological data, such as volume estimates and types of lithic components in the fall deposits.

Three stable geometric configurations of the feeding system (described assuming elliptical cross-section of variable dimensions) were assessed for the Eruptive Unit 2 (EU2) and Eruptive Unit 3 (EU3), which form the magmatic Plinian phase of PdA eruption. These configurations 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). Our results indicate that 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 ~2100 m), during the eruption of 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 to a diameter of 60 m and a transition depth of 3000 m.

The changes in feeding system geometry indicate a partitioning of the driving pressure of the eruption, which affected both magma ascent to the surface and dyke growth. The enlargement of the dyke from EU2 base to EU3 indicates a dynamic, inter-dependent eruptive system composed of the magma chamber, a deeper dyke, and a shallower cylindrical conduit. In particular, the volume of magma within the lower dyke shows first-order relations with MDR and erupted volume. This indicates that the deeper dyke could act as a sort of capacitor for erupting magma, whose MDR was regulated by the development and growth of the upper cylindrical conduit. The capacitor effect of the lower dyke also guaranteed the continuous mass flux necessary for the sustained eruption even when the base of the feeding dyke started to close due to the lowering of driving pressure in the magma chamber. The shallower cylindrical conduit was shaped through the erosion of conduit wall rocks at and above the fragmentation level.

These results depict new ideas on how the feeding system evolves during a sustained explosive eruption, which may represent the baseline for developing new models of volcanic eruptions and for the comprehension of their driving processes and represent an important baseline for further petrologic and

geophysical studies devoted to the comprehension of processes driving volcanic eruptions. For further details, please see: Massaro et al (2018) Evolution of the magma feeding system during a Plinian eruption: the case of Pomici di Avellino eruption of Somma-Vesuvius, Italy, Earth Planet. Sci. Lett., doi:10.1016/j.epsl.2017.11.030

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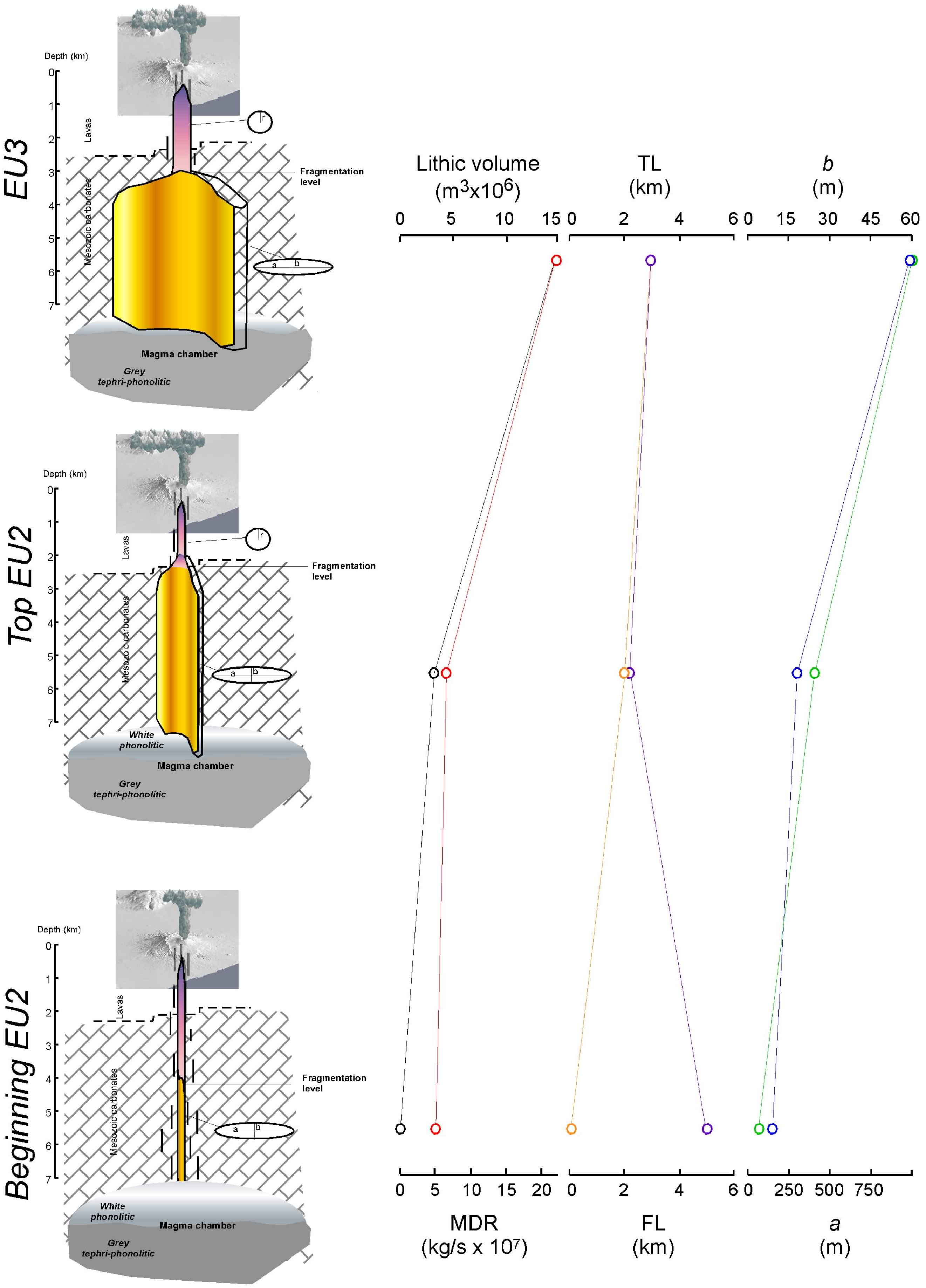
EU3
Top EU2
Beginning EU2
Depth (km)
Lavas
Mesozoic carbonates
Fragmentation level
Magma chamber
Grey tephri-phonolitic
White phonolitic
r
a
b
Lithic volume (m3x106)
TL (km)
b (m)
0 5 10 15
0 2 4 6
0 15 30 45 60
0 5 10 15 20
0 2 4 6
0 250 500 750
MDR (kg/s x 107)
FL (km)
a (m)