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Conduit evolution during the Avellinio Plinian eruption (Vesuvius): insights from fieldwork, lithic grain size distributions and modelling

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Large-scale explosive eruptions are modulated by a combination of magmatic and conduit processes, including changes in the geometry of the conduit as host rocks are eroded from the conduit walls and vent region. This study of deposits 1-45 km from source of the main, quasi-steady Plinian phases of the 3949 $\pm$ 10 yBP Avellino eruption of Vesuvius (EU2 and EU3) demonstrates the potential for measurements of lithics and xenoliths to constrain subsurface eruption processes. The lithics comprise volcanic rocks derived from the upper $\sim$2700 m of the conduit, carbonates from the lower conduit and magma reservoir wall rocks.

The lithics (free clasts) are thought to be incorporated into the erupting mixture by conduit wall implosion around and above the fragmentation depth as well as shallow vent spalling, whilst xenoliths are interpreted to result from viscous shear stresses applied to the conduit walls pre-fragmentation. The lithology of xenoliths indicates that they are sourced from relatively deep in the conduit, and their scarcity indicates that there is only minor conduit erosion below magma fragmentation during the Plinian eruptions. In contrast total lithic volumes calculated for EU2 and EU3 are 0.002 and 0.02 km^3, respectively, which corresponds to 8 % and 18 % of the total erupted volume. Lava lithics dominate, making up 69 and 74 % of the total lithic volume for EU2 and EU3, respectively. The majority of conduit erosion occurred above the fragmentation depth, in the upper few kilometers of the conduit, and scales approximately with the increase in mass discharge rate between the two phases. Individual component (total lithic, carbonate, lava) Lithic Total Grain Size Distributions (L-TGSDs) provide insights into rock failure mechanisms. The fractal dimensions of the majority of the L-TGSDs are approximately 2 (grain size in ϕ against $\log_2$ no. of grains), inferred to be the result of conduit implosion modified by initial rock characteristics. The lava lithics from EU3, however, show a markedly different distribution at the coarse end (fractal dimension of $\sim$1.4), indicative of significant vent spalling producing large shallow lithics.

Steady-state numerical models of conduit dynamics predict large conduit underpressures (with respect to lithostatic) at the magmatic fragmentation level. These underpressures are far in excess of reasonable tensile rock strength values, and highlight the importance of conduit implosion for lithic generation. Discrepancies between cylindrical conduit models for the Avellino case and the field results arise resulting from model assumptions (notably conduit geometry), and together the two approaches are combined to elucidate the general conduit evolution of the Avellino Plinian eruption.