Distal Pyroclastic Current Deposits of the 79 AD Vesuvius Eruption on the Mountains Adjacent to the Campanian Plain

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Abstract

Literature data show that the two most widespread Vesuvius 79 AD pyroclastic density currents (PDCs) have been traced over a large area around the volcano throughout the Campanian plain. Here, we present stratigraphic and volcanological evidence for 79 AD PDC deposits on higher elevated areas bordering the Campanian plain. More specifically, a sequence of ash deposits, with erosive basal contacts, interstratified with lithic-rich lapilli fall layers (D, G1, G3, I, and X2), has been observed above a thick pumice blanket that has been associated with the Plinian phase on the Lattari mountains between 50 and 300 m asl. We use fall layers as guide levels that allow the correlation of the distal ash deposits with the proximal/medial stratigraphic sequences. The ash PDC sequence ranges in thickness from 22 cm (where local debris flows partially erode it) to 150 cm (where it thickens against anthropic structures). This study demonstrates that most PDC units recognized in medial areas, including the final phreatomagmatic events, are traceable on mountain slopes about 20 km from the vent. The discovery of PDC units at altitudes as high as 300 m asl adjacent to the Campanian plain suggests an inflated and turbulent nature of the parental pyroclastic currents and a limited shielding effect of the mountains to the spread of the PDCs.

Keywords

AD 79 vesuvius eruption • Distal pyroclastic current deposits • Post-plinian phase

1 Introduction

Plinian eruptions are characterized by buoyant plumes, widespread fall deposits, and total or partial collapse regimes emplacing pyroclastic density currents (PDCs) (Cioni et al., 2015). Although, most of the volume of magma emitted is usually associated with a sustained column phase, the generation and propagation of PDCs cause the greatest damage to the territory and the resident populations (Neri, 2015). One of the most important examples in this sense is represented by the 79 AD Plinian eruption of Vesuvius, during which several PDCs destroyed and buried the Roman cities of Pompeii and Herculaneum and many suburban villas (Cioni et al., 2004; Luongo et al., 2003; Sigurdsson et al., 1985). The destructive impact is mostly observed 10 km from the vent, even if a PDC probably killed the famous Pliny the Elder near Stabiae, ca. 15 km south of Vesuvius (Sigurdsson et al., 1985). PDCs were generated during and after the Plinian phase by a partial to entirely collapsing plume (Shea et al., 2011). The two most energetic PDCs inundated the Campanian Plain south of Vesuvius (Tadini et al., 2021).

Here, we present stratigraphic and volcanological evidence for 79 AD PDC deposits on the mountains bordering the Campanian plain.

2 Methods

The composite stratigraphy of the 79 AD Vesuvius eruption deposits, illustrated here, follows the naming scheme proposed by Scarpati et al. (2020). The relationship between this stratigraphy and previously published data is described in Scarpati et al. (2020). Lithofacies were described using non-genetic terms based on the lithological characteristics of the deposits (e.g., internal structures, grain size, sorting, component variations, and welding intensity).

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3 Results

3.1 Stratigraphy

In distal areas, beyond 15 km from the vent, ash deposits are observed at altitudes between 50 and 300 m asl on the Lattari mountains (Fig. 1). They are not interbedded with the Plinian pumice fall deposit but lie above it (Fig. 1). The lowermost ash deposit, unit E, which is poorly sorted ($\sigma\phi$ = 2.15–2.73), exhibits a massive structure with gray pumice clasts at the base and rare armored lapilli. It thickens toward obstacles. Unit F is poorly sorted ($\sigma\phi$ = 2.18–3.02), stratified, and shows diffuse accretionary lapilli. Unit H is a massive ash deposit with accretionary lapilli. Locally, it thickens in small depressions, and accretionary lapilli concentrate at the top. Unit L is an accretionary lapilli-bearing horizon. Unit N is a thin, very fine ash deposit. It is overlain by unit X1, a poorly sorted, lithic-rich, coarse ash deposit documented here for the first time. Finally, above the uppermost lithic-rich fall deposit (X2), a stratified ash deposit, unit O, is observed. Accretionary lapilli are diffused in the whole unit and concentrates at the base and in the middle. Lithic clast content increases from 14 to 40 wt% from E to X1, while the overlying unit O has 5–15 wt%.

3.2 Lithofacies

Lithofacies recognized in the distal 79 AD PDC deposits are described, and their emplacement mechanisms are discussed in Table 1. Facies description indicates that the depositional system shows spatial and temporal variability in many parameters (e.g., concentration and components). Massive facies are generally overlain by accretionary lapilli-bearing tuff, indicating an increasing involvement of external water in the eruptive dynamics. Large-scale lateral facies variation, from proximal to distal locations, shows a substantial decrease in grain size and lithic content and few types of facies in distal areas. These sedimentological variations generally reflect a depletive competence and nonuniform behavior of all post-Plinian AD 79 PDCs.

4 Conclusions

Most of the 79 AD PDC units recognized in medial locations above the pumice lapilli Plinian deposit are recognized on the elevated areas bordering the Campanian plain, interstratified with lithic-rich lapilli fall layers. The presence of PDC units at 300 m asl in distal locations suggests the

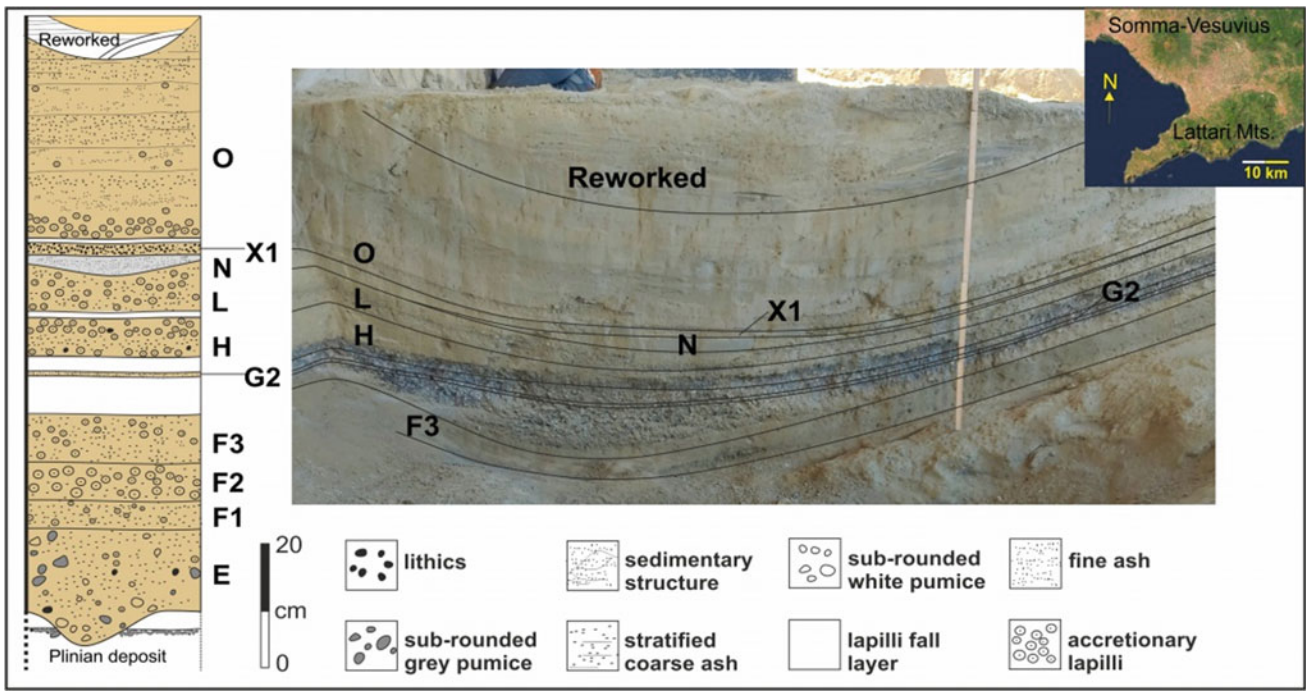

Fig. 1 Stratigraphic column showing the AD 79 distal deposits. On the right is a field photograph of AD 79 PDC layers. Inset shows the location of the PDCs facies on the Mts. Lattari

Table 1 Summary description and interpretation of AD 79 PDC lithofacies

Lithofacies	Description	Unit	Interpretation
Massive tuff or massive lapilli tuff (mLT)	Massive, coarse ash matrix-supported, and very poorly sorted deposits containing rounded pumice lapilli, white and gray (up to 20 mm in diameter) with subordinate sub-centimeter lithic fragments (mainly lava and rare limestone) and rare accretionary lapilli set into the matrix. The basal contact is strongly erosive Sorting: $2.96 < \sigma\varphi < 3.43$; Thickness: 6 to 124 cm	E, G2, N	Aggradation from highly concentrated, fluid-escape dominated flow-boundary zone without directional grain fabric
Accretionary lapilli-bearing tuff (accT)	Poorly-sorted coarse ash beds are rich in accretionary lapilli (between 4 and 30%) with concentric layers or an armored structure around a lithic or pumice clast. Accretionary lapilli are up to 10 mm in diameter and are randomly distributed in the deposits or arranged in layers Sorting: $2.49 < \sigma\varphi < 3.02$; Thickness: 4–21 cm	F, H, L	Explosive phase involving external water consistent with a phreatomagmatic origin
Lithic-rich massive tuff (lmT)	Massive, poorly-sorted, fine ash matrix-supported deposit with abundant rounded mm-sized lithic clasts predominantly composed of lava fragments. Very rare limestone and tuff clasts are found Sorting: 2.31; Thickness: 2 cm	X1	Lithic-rich deposits are related to the segregation of heavy components
Stratified tuff (sT)	Stratified deposits with sub-parallel millimeter to centimeter scale stratifications are defined by sharp changes in matrix grain size, from fine to coarse ash. Most individual layers are laterally impersistent, and low-angle erosional truncations are observed. Locally, massive and clast-supported lenses composed of very fine lithic fragments occur between the layers Sorting: $2.24 < \sigma\varphi < 2.76$; Thickness: 25–37.5 cm	O	Low-concentrated, traction-dominated flow-boundary zone in a highly unsteady current

turbulent behavior of the parental pyroclastic currents and the limited shielding effect of the mountains on the spread of the PDCs.

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