CORRELATING THE CAMPANIAN IGNIMBRITE USING MATRIX GLASS GEOCHEMISTRY AND MORPHOLOGY

Poster #0222

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The Campanian Ignimbrite

The Campanian Ignimbrite was emplaced during the 39-ka caldera-forming eruption of Campi Flegrei near Naples, Italy. This eruption deposited a trachytic ignimbrite up to 80 km from the caldera and co-ignimbrite fallout more than 2300 km to the northeast. The pyroclastic density current (PDC) was dilute and mobile, overtopping kilometer-high mountains up to 60 km from the vent. Stratigraphic units within the proximal and distal deposits of the Campanian Ignimbrite have never been definitively correlated due to an absence of medial exposures and significant differences in the appearance of the proximal and distal deposits. The proximal deposits are coarse grained (some clast-supported), and rich in pumice, lithic and obsidian clasts, while the distal ignimbrite is a fine-ash dominated ignimbrite. Knowing which proximal units formed simultaneously with the distal deposits will better define the events that formed this dilute current.

The proximal and distal deposits have distinct stratigraphic sequences (Fedele et al., 2016). The Plinian fall deposits that preceded the ignimbrite are called the **Plinian Pumice Fall (PPF)**.

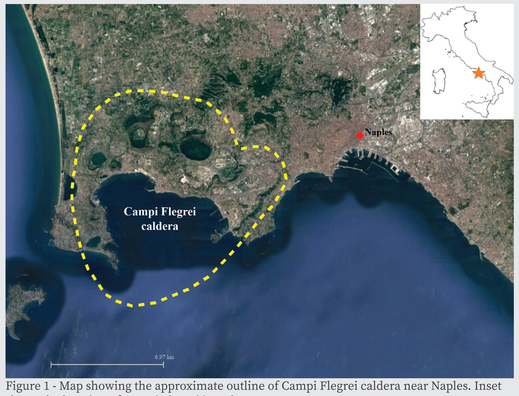

Figure 1 - Map showing the approximate outline of Campi Flegrei caldera near Naples. Inset shows the location of Campi Flegrei in Italy.

The distal ignimbrite is divided into:

- **Ground Layer (GL)**: thin, discontinuous lithic and crystal-rich horizon at ignimbrite base.
- **Unconsolidated Stratified Ash Flow (USAF)**: thin, unconsolidated, stratified layer of ash and pumice lapilli.
- **Welded Grey Ignimbrite (WGI)**: gray massive ignimbrite.
- **Lithified Yellow Tuff (LYT)**: possibly same flow unit as WGI, but with extensive post-emplacement zeolitization.

The proximal deposits are divided into:

- **Piperno**: high-grade ignimbrite with alternating beds of coarse monomict breccia and fiamme-rich ignimbrite.
- **Lower Pumice Flow Unit (LPFU)**: pumice-rich layer with variable sorting, grading and consolidation.
- **Breccia Unit (BU)**: Coarse lithic-rich, clast-supported breccia containing lesser amounts of pumice and obsidian; may represent caldera-collapse phase.
- **Spatter Unit (SU)**: spatter-rich horizons interbedded within Breccia Unit.
- **Upper Pumice Flow Unit (UPFU)**: pumice-rich, non-lithified, poorly sorted and massive or slightly normally graded.

The morphology and chemistry of the matrix glass shards provide a means to correlate the proximal and distal deposits. The morphology is assessed qualitatively and by quantitative shape parameterization of scanning electron microscope images (Liu et al. (2015). The major element geochemistry from electron microprobe analysis is compared between samples from different distances and azimuths from the caldera and stratigraphic heights.

Shard Morphology

Juvenile matrix material includes pumice, scoria, blocky and bubble-wall shards. Pumice fragments can be divided into three morphological types: tube pumice and two types of irregular pumice that differ in vesicle density (Fig. 2).

Tube pumice fragments occur in all units and are the only pumice type in the PPF, GL, USAF and LPFU. Low-density irregular pumice is found in the WGI and Piperno only. Higher density irregular pumice is found in the Piperno, UPFU and LYT.

Pumice fragments are the dominant or only glass shard type at most outcrops. However, the two sampled high-elevation distal WGI outcrops, at 560 m and 970 m asl, are dominated by bubble-wall shards. USAF is also observed at these locations. These high-elevation deposits are proposed to be derived from the top and/or leading edge of the PDC, where there was less abrasion of tube pumice lapilli.

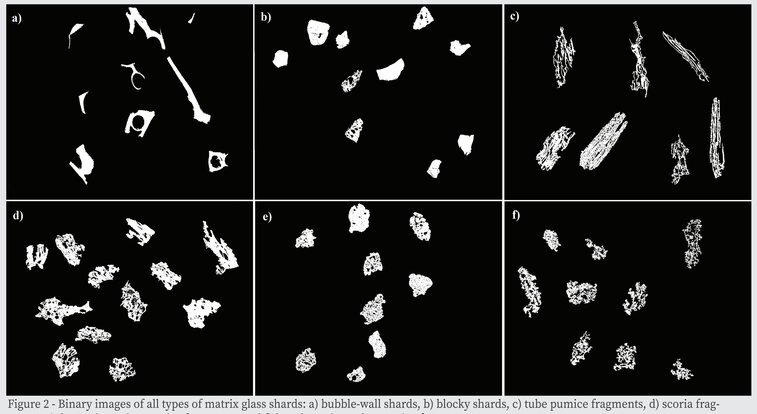

Figure 2 - Binary images of all types of matrix glass shards: a) bubble-wall shards, b) blocky shards, c) tube pumice fragments, d) scoria fragments, e) denser irregular pumice fragments, and f) less dense irregular pumice fragments.

Shape Parameters

Pumice shards are the only category of glass shards that displays variability in shape parameters between different units of the ignimbrite. These differences are best observed through comparison of three parameters: convexity, solidity and rectangularity.

Figure 3- Values for solidity, convexity and rectangularity of pumice fragments are displayed for distal units, left, and proximal units, right. Pastel zones delineate the ranges of the point clusters of matching color.

The WGI, Piperno and BU have similar ranges for solidity, and have a broader distribution than the other units for all parameters. The LYT is simiar to the WGI in rectangularity and convexity, but has only high solidity values due to alteration (vesicles are filled). This may indicate a similar fragmentation process for these four units, perhaps related to higher energy or to vent characteristics.

The WGI has the highest values and broadest range for convexity. The BU and Piperno have the highest values and broadest range for rectangularity. These trends reflect abrasion in the WGI and its lack in the BU and Piperno.

Major Element Geochemistry

The PPF, GL and USAF have a very restricted compositional range. The UPFU has the broadest range and follows a different trend than other units.

The compositional range of the WGI is equivalent to the Piperno and the BU combined; the most evolved compositions are found in the Piperno and WGI. The range of the LYT is similar to the BU.

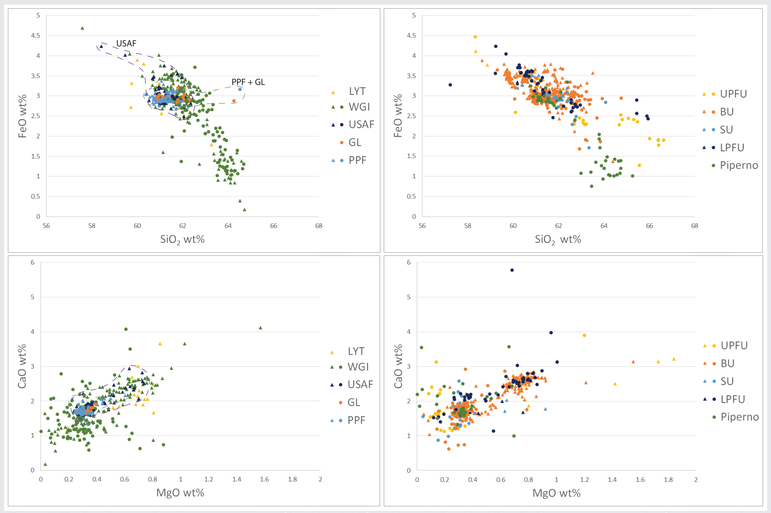

Figure 4- Harker diagrams showing compositions of distal units, left, and proximal units, right. Circles represent new data from matrix glass and triangles represent data from pumice clasts taken from Fedele et al. (2016, 2008), Forni et al. (2016), Fulignati et al. (2004), Melluso et al. (1995), Smith et al. (2016), and Sparice (2015).

Stratigraphic Model

The data presented support a stratigraphic model that correlates the bulk of the distal deposits (WGI and LYT) with the Piperno and BU. The compositional and morphological range of the WGI corresponds to the combined ranges of the Piperno and BU, while the range of the LYT most closely corresponds to that of the BU.

The LPFU and UPFU are proposed to represent low-energy phases with little runout. These units are finer grained and pumice-rich and lithic-poor compared to other proximal units.

Four proximal stratigraphic sequences, in which any or all of the USAF, Piperno and LPFU may be absent, show that these units are not laterally continuous and may not be true time-stratigraphic units. Figure 5 shows our proposed stratigraphic correlation of the proximal and distal units.

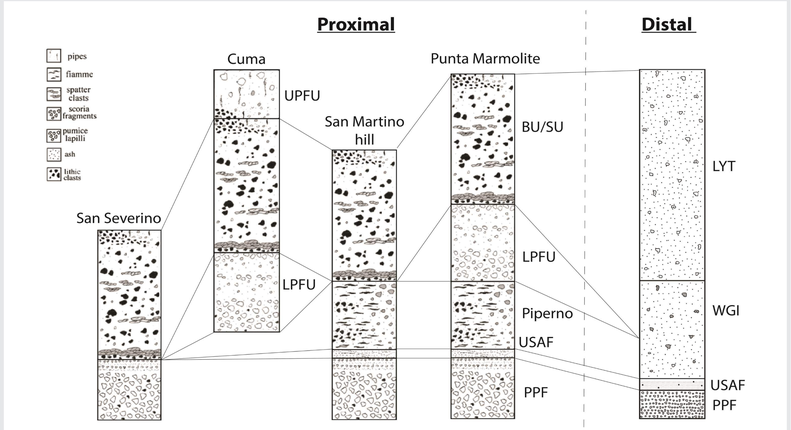

Figure 5 - Schematic stratigraphic sections of the proximal deposits and how they might correlate with the distal units. Modified from Fedele et al. (2008) and Cappelletti et al. (2003).

Previous studies proposed a large zoned magma chamber as the source for the Campanian Ignimbrite (Civetta et al., 1997; Fedele et al., 2016; Forni et al., 2016). However, the major element compositions of the deposits do not become less evolved upward as would be expected. The most evolved compositions of the eruption are not in the basal PPF and USAF, but in the Piperno, the first major ignimbrite-forming stage. Compositions appear to become less evolved in the LPFU but then return to compositions more similar to the basal units in the BU and SU. The UPFU has a broad range of compositions only partially overlapping with the trend of the other units.

These trends are more easily accounted for by eruption from a series of related magma bodies of slightly different compositions. Migration of the primary vent sites during the eruption could tap different magma bodies beneath and adjacent to the caldera. The UPFU may record the evacuation of several magma bodies as the caldera roof came to rest.

Summary

- The matrix ash shards of the Campanian Ignimbrite include fragments of pumice and scoria as well as blocky and bubble-wall shards. Pumice fragments, especially tube pumice, dominate except in high-elevation distal deposits. These may record deposition from the low-concentration, low-abrasion top of the PDC whereas most deposits came from more particle-rich lower parts.
- The WGI, Piperno and BU have similar shard shapes, consistent with shared fragmentation processes.
- Major element geochemistry of matrix and pumice glass links the major distal ignimbrite units with a combination of the Piperno and BU. The LPFU and UPFU are limited in distribution.
- Stratigraphic geochemical trends do not reflect progressive tapping of a zoned magma chamber. Instead a magmatic system of several closely related intrusions beneath the caldera is proposed.

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