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The origin of a zoned ignimbrite: insights into the Campanian Ignimbrite magma chamber (Campi Flegrei, Italy)

Francesca Forni (1), Olivier Bachmann (1), Silvio Mollo (2), and Gianfilippo De Astis (2)

(1) Institute of Geochemistry and Petrology, ETH Zürich, Zürich, Switzerland, (2) Istituto Nazionale di Geofisica e Vulcanologia, Roma, Italy

The Campanian Ignimbrite (CI; Campi Flegrei, Italy), dated at 39 ka, is a widespread pyroclastic sequence emplaced during a cataclysmic caldera-forming eruption fed by trachytic to phonolitic magmas. The CI pyroclastic sequence is famous for its remarkable geochemical gradients,attributed to the presence of a vertically zoned magma chamber. Combining bulk-rock data with detailed phenocrysts and matrix glass analyses from well characterized stratigraphic units, we investigate the relatioships between such chemical zoning and the crystallinity variations observed along the CI pyroclastic sequence. Using geothermometers and hygrometers specifically calibrated for alkaline magmas, we reconstruct the reservoir storage conditions, revealing the presence of gradients in temperature and magma water content. In particular, we observe an increase in crystallinity and temperature and a decrease in magma evolution and water content from the bottom to the top of the sequence. We interpret these features as the result of protracted fractional crystallization leading to the formation of a cumulate crystal mush at the base of the eruptible reservoir, from which highly evolved, crystal-poor, water-rich and relatively cold melts were separated. The extracted melts, forming a buoyant, easily eruptible cap at the top of the magma chamber, fed the initial phases of the eruption, until caldera collapse and eruption of the deeper, more crystalline part of the system. This late-erupted, crystal-rich material, represents remobilized portions of the cumulate crystal mush, rejuvenated after mafic recharge. Our interpretation is supported by: 1) the bulk-rock positive Eu anomalies and the high Ba and Sr contents observed in the crystal-rich units, implying feldspar accumulation; 2) the positive Eu anomalies in the matrix glass of the crystal-rich units, testifying to the presence of liquid derived from partial melting of low temperature mineral phases within the crystal mush (feldspars and biotite); 3) the Ba and Sr-rich rims in the feldspars and positive Eu anomalies in clinopyroxene rims, suggesting late crystal-growth from a locally enriched melt; 4) the An-rich plagioclase making the mafic recharge, conductive to cumulate mush remelting.