Chemical variations of the A.D. 79 pumice deposits of Vesuvius

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Abstract: The pumice-fall deposits of the A.D. 79 Vesuvius eruption are subdivided into a lower white and an upper grey pumice. Major and trace element variations show significant differences between them. The more evolved phonolitic white pumice exhibits well-developed, stratigraphically controlled chemical gradients in all major and trace elements whereas the tephriphonolitic grey pumice is compositionally less variable and lacks such gradients. Incompatible elements are mostly enriched in the white pumice, whereas the grey pumice shows higher contents of compatible elements such as Ti and Mg. The difference in chemical composition between white and grey pumice is interpreted in terms of fractional crystallization of clinopyroxene, sanidine and leucite. The well-developed gradients of the white pumice indicate a stable layering within the upper phonolitic magma body, which is thought to originate from diffusion processes of highly incompatible elements. The lack of a similar stratigraphy-related zonation within the grey pumice indicates a more homogeneous tephriphonolitic magma resulting from continuous convective mixing within the lower part of the magma chamber. The transition from white to grey pumice is characterized by a boundary zone containing, besides white and grey pumice clasts, a third type of pumice, "the boundary pumice", which is light grey in color; this pumice is internally homogeneous, without evidence of physical mingling between "white" and "grey" glass, and is typically characterized by intermediate MgO, K2O and Ba contents. It is interpreted to represent a third magma component in the magma chamber, the interface magma layer, resulting from mixing and diffusion processes across the phonolitic/tephriphonolitic magma boundary.

Key-words: zoned pyroclastic deposits, Vesuvius, magma chamber.

Introduction

The A.D. 79 Plinian eruption of Vesuvius is one of the most famous historical eruptions that buried the Roman cities of Pompei, Stabiae, Oplontis and Herculaneum under several meters of pumice-fall, ash-flow and surge deposits. The eruption produced at least 4 km³ DRE (dense rock equivalent) of magma, including 1 km³ DRE of phonolitic white pumice-fall and 2.6 km³ DRE of tephriphonolitic grey pumice-fall deposit (Sigurdsson et al., 1985). Based on Pliny the Younger’s record (Epistolae, 4, 16, 20) and volcanological data, Sigurdsson et al. (1982, 1985) reconstructed the course of the eruption. The Plinian fall phase lasted from August 24, at about 1 p.m., till 8 a.m. on August 25. The eruption column rose up to 27 km into the atmosphere during the deposition of white phonolitic pumice; after seven hours, the composition of the erupted magma changed and grey tephriphonolitic pumice was deposited for the next 12 hours out of an eruption column towering up to a maximum height of about 33 km shortly after the beginning of the grey pumice fallout (Carey & Sigurdsson, 1987; Sigurdsson et al., 1990). The pumice fallout dispersed almost invariably to the southeast (Lirer et al., 1973; Sigurdsson et al., 1985).