

Geochemical variations between the 79 AD and 1944 AD Somma–Vesuvius volcanic products: Constraints on the evolution of the hydrothermal system based on fluid and melt inclusions

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Abstract

A variety of metamorphic and metasomatized sedimentary nodules and cumulate ejecta are commonly present in Somma–Vesuvius pyroclastic products. In this paper we present compositional data for homogenized silicate melt inclusions (HMI) in olivine and clinopyroxene from cumulate nodules ejected by the 79 AD plinian and the 1944 AD interplinian eruptions. Variation diagrams of element ratios as a function of host crystal Mg# serve to constrain magma compositional variations. In addition HMI compositions in olivines and clinopyroxenes from nodules and volcanic rocks are compared with bulk rock compositions to examine the difference between “closed system” (MI) and “open-system” (bulk rocks) behaviour. Geochemical variations between 79 AD and 1944 AD samples are interpreted to represent the effects of hydrothermal processes active in the upper parts of the shallow magma chamber, before and during explosive plinian eruption. During 1944 AD interplinian activity, magmas continuously ascended through the system, undergoing simultaneous degassing and fractionation. The loosely cemented volcanic conduit does not allow significant build up of volatile pressure, leading to frequent, non-violent interplinian eruptions. The combination of ongoing magma supply and frequent eruptions results in near steady-state conditions under the volcano, which explains why there is such a small variation in the composition of the 1944 AD melt. A self-sealing process (as a result of precipitation of newly formed hydrothermal minerals) contributes to closing of the system at the end of the interplinian activity. Plinian explosive eruptions (e.g. 79 AD) occur after a long repose time under closed-conduit condition. This means that a carapace, surrounded by an impermeable rind, forms beneath the Somma–Vesuvius volcanic complex and around the upper portion of the shallow magma chamber, and is the interface between brittle and plastic rocks. Several different mechanisms may play a role in triggering major breaches of the sealed zone (e.g. the activation of a fault system after the 62 AD earthquake in the Somma–Vesuvius area). In 79 AD the local strain rate increased due to an upward surge of new magma to such a degree that previously plastic material underwent shear failure in response to a stress difference, causing an explosive eruption.

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1. Introduction

Somma–Vesuvius is a Quaternary, silica-undersaturated, potassic to ultrapotassic eruptive center intruded into Meso- to Cenozoic carbonate sequences.

The volcano is intensely investigated by many research groups because it is one of the most potentially hazardous volcanoes in the world. Nevertheless although much is now known about the volcano and its magmatic processes, a comprehensive understanding of its complex magmatic system has not yet been achieved.

Somma–Vesuvius is a composite volcano located on the southwestern coast of the Campanian Plain (Fig. 1). The Campanian margin is a Middle Pleistocene half graben filled by depositional sequences that are ar-

ranged in succession sets that display long-term aggradational–progradational stacking patterns (Milia, 1999; Milia and Torrente, 1999). The Mesozoic–Cenozoic carbonate substrate, cropping out on the Sorrento Peninsula, dips towards the NW and is overlain by Quaternary sediments and volcanic products. The volcano lies above NW–SE normal faults that in the submarine counterpart control the cryptodome emplacement and gas emission (Milia et al., 1998; Bellucci et al., 2006).

Mt. Somma began its eruptive activity at least 35 ka BP (Scandone et al., 1993), but the first episode of volcanic activity within the Somma–Vesuvius area has been dated at 400 ka BP and occurred in a marine environment (Brocchini et al., 2001). According to

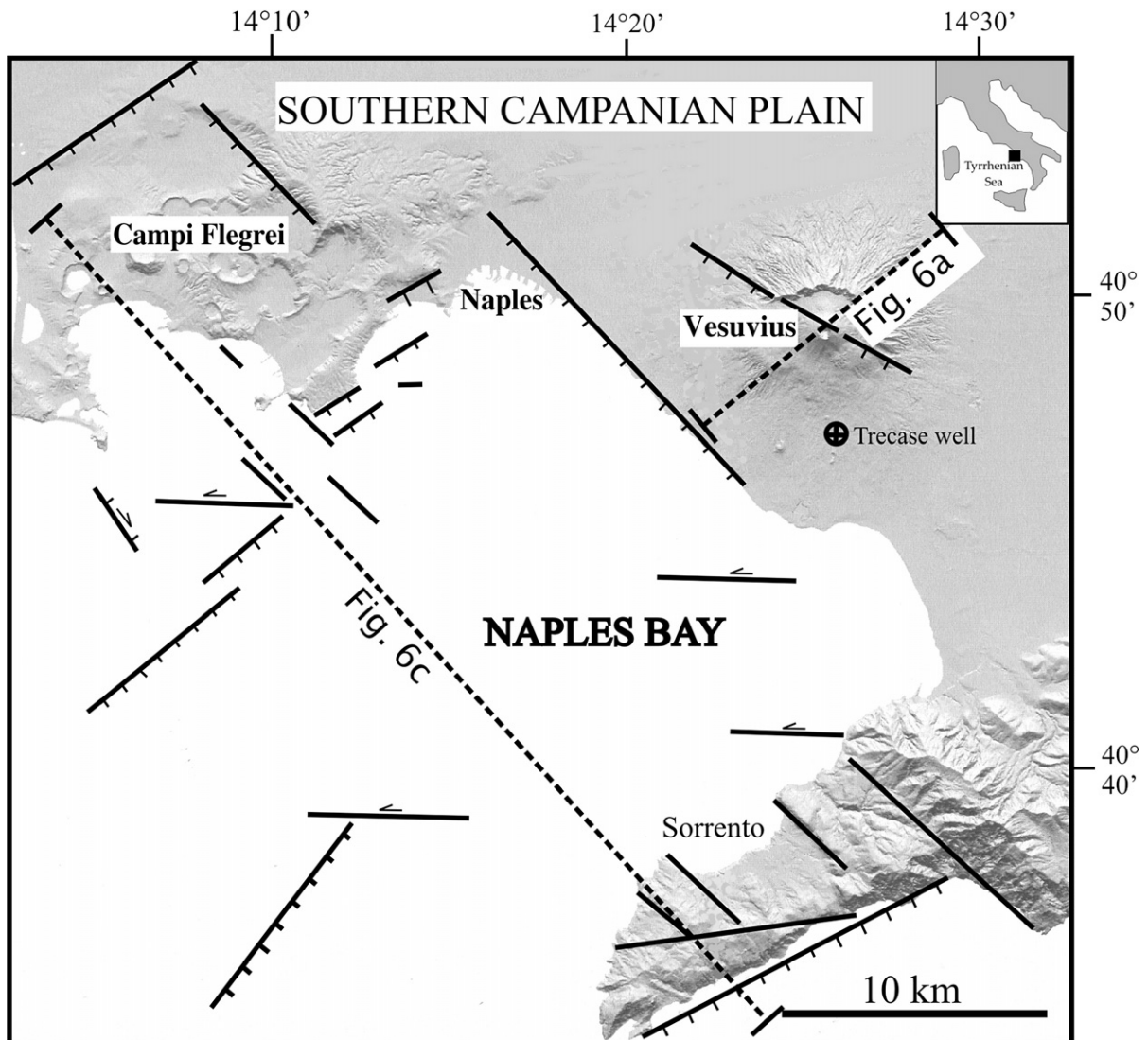


Fig. 1. Structural map of the Southern Campanian plain (from Milia and Torrente, 1999), also shown are the sections of Fig. 6.

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