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Geochemical properties and environmental impacts of seven Campanian tephra layers deposited between 40 and 38 ka BP in the varved lake sediments of Lago Grande di Monticchio, southern Italy

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ABSTRACT

We present the results of new tephrostratigraphical and environmental impact studies of the 40–38 ka varved sediment section of Lago Grande di Monticchio (southern Italy). The sediments in this time zone are correlated with the Heinrich H4-stadial that occurred between Greenland Interstadials GI-9 and GI-8, and include the widespread Campanian Ignimbrite (CI, 39.3 ka) as a thick tephra layer in the middle of the H4 stadial. The CI in the Monticchio record is overlain by the Schiava tephra from Vesuvius, c. 1240 varve-years younger than the CI, and preceded by four tephras from small-scale eruptions of the Phlegrean Fields and by an Ischia-derived tephra. The four Phlegrean Field-derived tephras were deposited 600 varve-years or fewer prior to the deposition of the CI and show very similar major, minor, and trace element glass compositions to those of the CI. This close similarity in composition and age could compromise the accurate linking and synchronisation of palaeoenvironmental records in the central Mediterranean area. Microfacies analyses and μ-XRF core scanning were used to characterise primary and secondary depositional features of all seven tephra layers and to evaluate environmental and ecological responses after tephra deposition. Higher concentrations of tephra-derived material (mainly glass shards and pumices) in primary and reworked layers were detected by elevated K-counts in μ-XRF elemental core scans. Reworked tephra derives mainly from in-washing from the littoral zone and the catchment and occurs within five to 30 years, and up to 1240 varve years, after the deposition of thinner (1–5 mm) and thicker (5–230 mm) tephra fallout deposits, respectively. An obvious response of diatom population growth directly after the primary tephra deposition was observed for the thicker tephra layers (>1 mm) during the first 1–8 years after deposition of the primary deposit indicating that the additional input of potential nutrients (glass shards) temporarily affected the ecological lake system.
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1. Introduction

The Mediterranean region is of special interest in terms of tephrostratigraphical study because of its long history of explosive volcanic activity (e.g. Keller et al., 1978; Druitt et al., 1999; Narcisi and Vezzoli, 1999; Peccerillo, 2005). Frequent explosive volcanic activity affected the Campanian volcanic arc of the Roman Co-magmatic Province, southern Italy, during the late Quaternary, generating numerous widespread tephra layers, often preserved as primary fall deposits in terrestrial and marine sediments (e.g. Keller et al., 1978; Paterne et al., 1986, 1988; Narcisi, 1996; Narcisi and Vezzoli, 1999; Siani et al., 2004; Wulf et al., 2004, 2012; Munno and Petrosini, 2007). Over the last decade, the detection of cryptotephra layers has added to the tephrostratigraphic record of

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volcanism in southern Italy during the last 300 ka (e.g. Lowe et al., 2007; Wulf et al., 2008; Bourne et al., 2010; Sulpizio et al., 2010). A key tephrostratigraphical archive is preserved in the annually-laminated lacustrine sediment repository of Lago Grande di Monticchio in southern Italy. This Maar lake, located within 100–140 km and downwind of the Campanian volcanoes (Fig. 1), documents the majority of explosive events derived from the Campanian volcanoes during the last 133 ka (Narcisi, 1996; Wulf et al., 2004, 2008, 2012). A total of 345 primary tephra layers have been recorded for the Monticchio sequence, for which a detailed chronology and palaeoenvironmental context has been established (e.g. Allen et al., 1999; Brauer et al., 2000, 2007). So far, more than 30 tephra layers have been precisely correlated with dated volcanic events and therefore provide important marker layers for independently dating and correlating the Monticchio record with other terrestrial and marine palaeoclimate records in the Mediterranean area (Wulf et al., 2004, 2008, 2012). One of these marker layers is the tephra labelled as TM-18 in the Monticchio record, a correlative of the basal fall unit of the Campanian Ignimbrite (CI), which erupted from the Campi Flegrei Caldera at 39.28 ± 0.11 ka BP (^{40}Ar/^{39}Ar; De Vivo et al., 2001). The CI eruption was one of the most powerful inferred for the Mediterranean region for the last 200,000 years (Barberi et al., 1978), and distal deposits – correlated with the marine Y-5 tephra – are distributed mainly towards the east as far as Russia (e.g. Keller et al., 1978; Thunell et al., 1979; Paterne et al., 1988; Vezzoli, 1991; Pyle et al., 2006; Giaccio et al., 2008). The main eruption occurred during marine isotope stage (MIS) 3, ca 1600 years after the Laschamp geomagnetic excursion (41 ka; Nowaczyk et al., 2012) and between Greenland Interstadials (GIS) 9 and 8. The volumetrically large CI eruption was considered to have strongly affected the climatic system during the Last Glacial period and to have triggered the Heinrich 4 (H4) cold episode (40–39 cal ka BP) that may have prompted human cultural and migration responses in this region (Fedele et al., 2002, 2008; Giaccio et al., 2008). This hypothesis, however, has been questioned recently by Lowe et al. (2012) who used the CI tephra to show that the onset of the H4 cold period predates the CI eruption. The CI tephra therefore forms an important stratigraphic marker in eastern Mediterranean palaeoclimatic and environmental records that requires an unambiguous identification. These requirements can be satisfied by the Monticchio tephra record, in which the CI is preceded and succeeded by a total of six other tephra layers of Campanian origin within a 2000 year period. One goal of our study is to clearly distinguish these six tephra deposits from the CI on the basis of their glass chemistry and mineral/lithic contents and to determine their specific sources. A second aim is the assessment of the environmental impacts of tephra layers of different thickness on the lake system, as reflected in u-XRF elemental data obtained from the varved host sediments. This information will not only help to detect and discriminate between primary and secondary (re-worked) tephra layers, but contributes to a better understanding of their environmental and geomorphological impacts.

2. Regional setting

Lago Grande di Monticchio in Basilicata, southern Italy (40°56′N, 16°35′E), is the larger of two adjoining crater lakes that formed during the final stage of volcanic activities at 132 ± 12 ka (Laurenzi et al., 1993; Brocchini et al., 1994), on the western slopes of the Monte Vúlture volcanic complex (Fig. 1). The lake surface of Lago Grande di Monticchio is situated at an altitude of 656 m a.s.l. and encompasses an area of ca 0.4 km^2. The basin features a maximum depth of 36 m and a shallow water area with an average depth of 8.7 m in the southeast of the basin (Zolitschka and Negendank, 1996). The lake has a restricted hydrological catchment of 2,370,000 m^2 with a maximum elevation of 956 m a.s.l. (Zolitschka and Negendank, 1996). The trophic state of the present lake is eutrophic to hypertrophic which promotes the preservation of annual laminations of its sedimentary deposits.

Situated approximately 120 km east of Naples and in a favourable downwind position to high-explosive Campanian volcanoes, Lago Grande di Monticchio has formed a unique sedimentary trap for fallout tephras (e.g. Narcisi, 1996; Wulf et al., 2004, 2008, 2012).

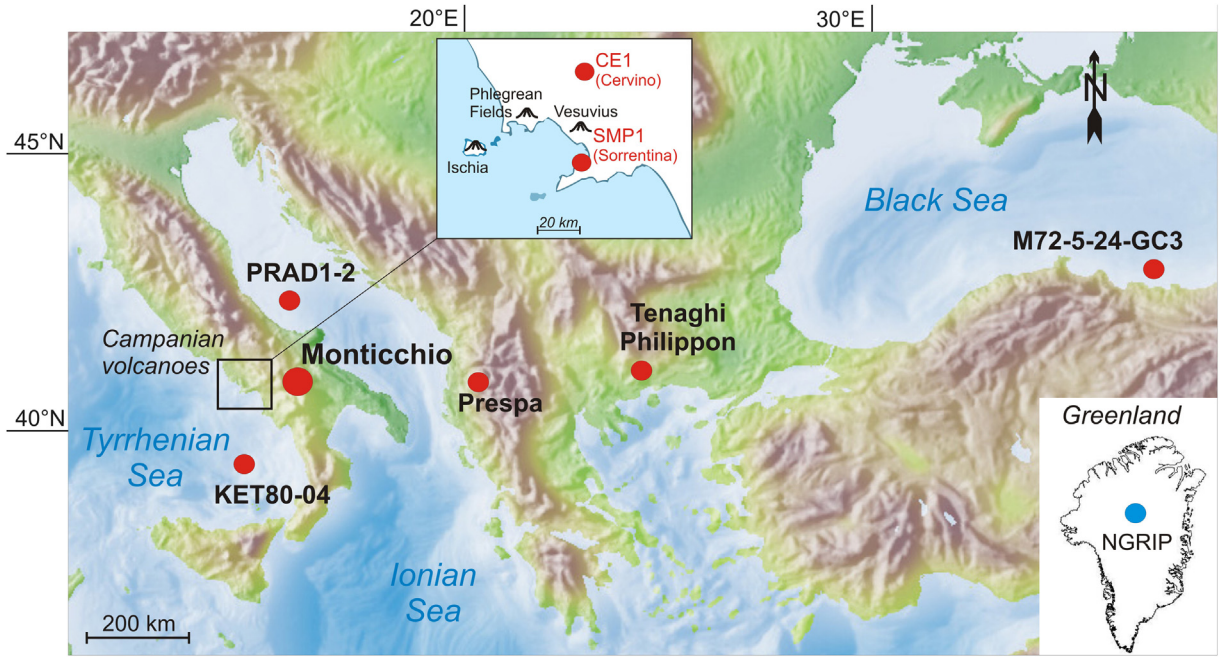

Fig. 1. Location of Lago Grande di Monticchio, Italian volcanic centres and sites mentioned in the text with correlatives of the tephra layers considered here.

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