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Volcanological constraints on the post-emplacement zeolitisation of ignimbrites and geoarchaeological implications for Etruscan tomb construction (6th–3rd century B.C) in the Tufo Rosso a Scorie Nere, Vico Caldera, Central Italy

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ABSTRACT

We examine the role of physical volcanological processes including eruption style (magmatic versus phreatomagmatic) as well as transport and depositional processes (pyroclastic fall versus pyroclastic flow) in promoting the ideal hydrologic conditions necessary for large scale, homogeneous, post-emplacement zeolitisation of ignimbrites, associated with caldera forming eruptions. We consider the Tufo Rosso a Scorie Nere (TRSN) of Vico Caldera (151 ka), in central Italy. The TRSN exhibits pervasive, homogenous alteration of high alkali tephriphonolitic and phonolitic glass to zeolite minerals (chabazite and phillipsite) in all regions of the study area and at all stratigraphic levels with the exception of the basal 1 m.

Based on detailed lithological studies, we propose that a large geothermal field around the vent area was destroyed during the closing stages of the Sutri eruption. Subsequent incorporation and entrapment of superheated geothermal fluids into the ensuing pyroclastic flow during eruption column collapse greatly influenced the emplacement temperature and provided the necessary water required for post-emplacement zeolitisation of the TRSN. We suggest that the absence of zeolitisation at the base of the ignimbrite is directly related to transport conditions reflecting cooler regions in the lower portions of the deposit where the flow came into contact with the underlying substrate.

We also consider the geoarchaeological implications of enhanced strength and cohesiveness provided by the zeolite rock framework on Etruscan tomb location and burial architecture in the Vico region. The TRSN contains literally hundreds of hypogeum-style Etruscan tombs at a number of sites across the study area. This study focuses on two sites in particular, the Norchia Necropoli and the San Guiliano Necropoli. Considering the enhanced mechanical properties of zeolitised ignimbrites we infer that physically the TRSN would still have been a relatively soft rock, suitable for the carving of tombs. However, we infer the increased strength and cohesiveness provided by the zeolite framework enhanced the conservation potential of these tombs, preserving them for over two thousand years.

1. Introduction

The study of physical and chemical factors influencing the post-emplacement lithification of ignimbrite deposits helps to further our understanding of the eruptive conditions associated with the generation of pyroclastic flows. One such process, the post-eruptive alteration of volcanic glass to zeolites, can provide valuable insight into the internal properties of an ignimbrite following deposition such as water content, temperature (both emplacement and rate of cooling) and glass chemistry (zeolites favour high-alkali compositions). Zeolitisation is commonly described as the diagenetic alteration of volcanic glass to zeolite under ideal hydrologic conditions (Hall, 1998). The zeolitisation process gradually replaces the pre-existing glassy matrix of an ignimbrite/volcaniclastic deposit, increasing the stability of the rock framework and enhancing lithification (Langella et al., 2002). However conditions are not always suitable for zeolitisation to occur. A number of studies have considered the physical–chemical conditions favourable for the zeolitisation of volcanic glass both in primary pyroclastic deposits and secondary volcaniclastic deposits (de'Gennaro and Langella, 1996; Hall, 1998; de'Gennaro et al., 2000; Cappelletti et al., 2003).

Several models have been proposed to account for the large-scale zeolitisation of thick ignimbrite deposits typically using examples from central and southern Italy where this type of post-emplacement alteration is common at a number of volcanic centres. (eg. Campanian Ignimbrite, Neapolitan Yellow Tuff, Campi Flegrei; de'Gennaro et al., 1995; de'Gennaro and Langella, 1996; Hall, 1998; de'Gennaro et al.,

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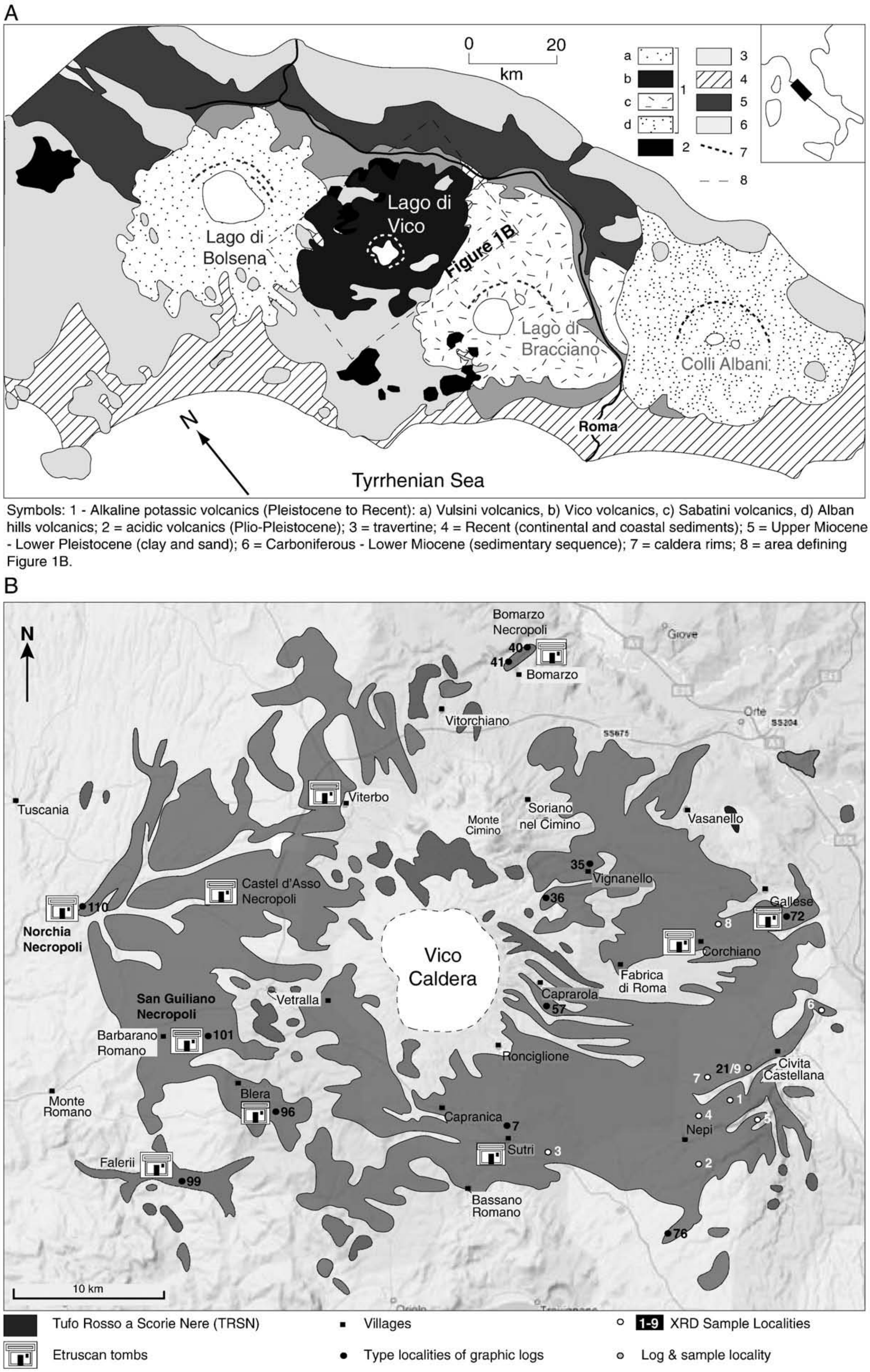
A
0 20
km
a b c d 1
2
3 4 5 6 7 8
Lago di Bolsena
Lago di Vico
Figure 1B
Lago di Bracciano
Colli Albani
Roma
N
Tyrrhenian Sea
Symbols: 1 - Alkaline potassic volcanics (Pleistocene to Recent): a) Vulsini volcanics, b) Vico volcanics, c) Sabatini volcanics, d) Alban hills volcanics; 2 = acidic volcanics (Plio-Pleistocene); 3 = travertine; 4 = Recent (continental and coastal sediments); 5 = Upper Miocene - Lower Pleistocene (clay and sand); 6 = Carboniferous - Lower Miocene (sedimentary sequence); 7 = caldera rims; 8 = area defining Figure 1B.
B
N
Bomarzo Necropoli
40
41
Bomarzo
Giove
Vitorchiano
Orte
Viterbo
Tuscania
Monte Cimino
Soriano nel Cimino
Vasanello
35
Vignanello
36
Castel d'Asso Necropoli
110
Norchia Necropoli
Gallese
72
8
Corchiano
Vico Caldera
Fabrica di Roma
Caprarola
57
San Guiliano Necropoli
Vetralla
6
Barbarano Romano
101
Ronciglione
21/9
Civita Castellana
7
1
Monte Romano
Blera
96
4
5
Capranica
7
Nepi
Sutri
3
Falerii
99
2
Bassano Romano
76
10 km
Tufo Rosso a Scorie Nere (TRSN)
Villages
1-9 XRD Sample Localities
Etruscan tombs
Type localities of graphic logs
Log & sample locality