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Quaternary Science Reviews 25 (2006) 2713–2728

QSR

Wide dispersal and deposition of distal tephra during the Pleistocene 'Campanian Ignimbrite/Y5' eruption, Italy

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Received 10 June 2005; accepted 28 June 2006

Abstract

A trachytic volcanic ash layer is widely distributed across south-western Russia, where it is found both in well-characterised archaeological contexts close to the Don River (the Paleolithic sites of Kostenki-Borschevo (51.4°N, 39.0°E), and in undisturbed geological contexts. This ash layer has all of the characteristics of a distal tephra fall deposit: it is fine grained and unimodal with a grain size of 60–170 μm, dominated by strongly elongate glass shard fragments.

Chemical analysis confirms that this ash layer is a distal equivalent of the deposits of the ca 39.3 ka Campanian Ignimbrite eruption of the Phlegrean Fields, Italy, and correlates with the widely recognised Y5 ash layer in marine cores in the south-eastern Mediterranean. This work shows that ash particles can be dispersed over considerable distances (>2500 km) and areas (>1.5–3×10^6 km^2) during large-magnitude explosive eruptions. The volume of the products associated with this event (31–50 km^3 of magma erupted as fallout tephra, and a total volume of 105–210 km^3 of magma, or 2.5–5×10^{14} kg) confirms the Campanian Ignimbrite/Y5 eruption as the most significant known volcanic eruption in Europe of the past 100 ka. This correlation places tight constraints on the absolute ages of a number of important archaeological horizons in southern Russia.

1. Introduction

Quaternary tephra have been used extensively to develop a high-resolution stratigraphy for the late Pleistocene and Holocene across the eastern Mediterranean (e.g. Keller, 1971; Keller et al., 1978; Federman and Carey, 1980; Paterne et al., 1988; Vezzoli, 1991). While early work focussed mainly on samples from marine cores, recent work on terrestrial contexts (including Italian maars, Greek, Bulgarian and Italian cave sites, and Greek and Turkish lakes; e.g. St. Seymour and Christianis, 1995; Narcisi and Vezzoli, 1999; St. Seymour et al., 2004; Wulf et al., 2004; Margari et al., 2006) has considerably improved the prospects of developing a long, high-resolution tephra stratigraphy that will link marine and terrestrial records of Pleistocene age across eastern Europe.

The largest known European eruption of the last 100,000 yr was the Campanian Ignimbrite (Barberi et al., 1978) at ca 39–41 ka BP (De Vivo et al., 2001; Ton-That et al., 2001). The vent for this eruption is generally thought to have been located in the Campi Flegrei (Phlegrean Fields) region of southern Italy, close to the present day Bay of Naples (Fig. 1a), and the extensive proximal ignimbrite deposits from this event are correlated with a widespread ash horizon, Y5, that is recognised in cores across the eastern Mediterranean. While the axis of deposition for the distal tephra associated with this eruption was originally thought to trend to the southeast, away from the central Italian source region and along the axis of the Eastern Mediterranean (e.g. Keller et al., 1978; Federman and Carey, 1980; Cornell et al., 1983), this was

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doi:10.1016/j.quascirev.2006.06.008

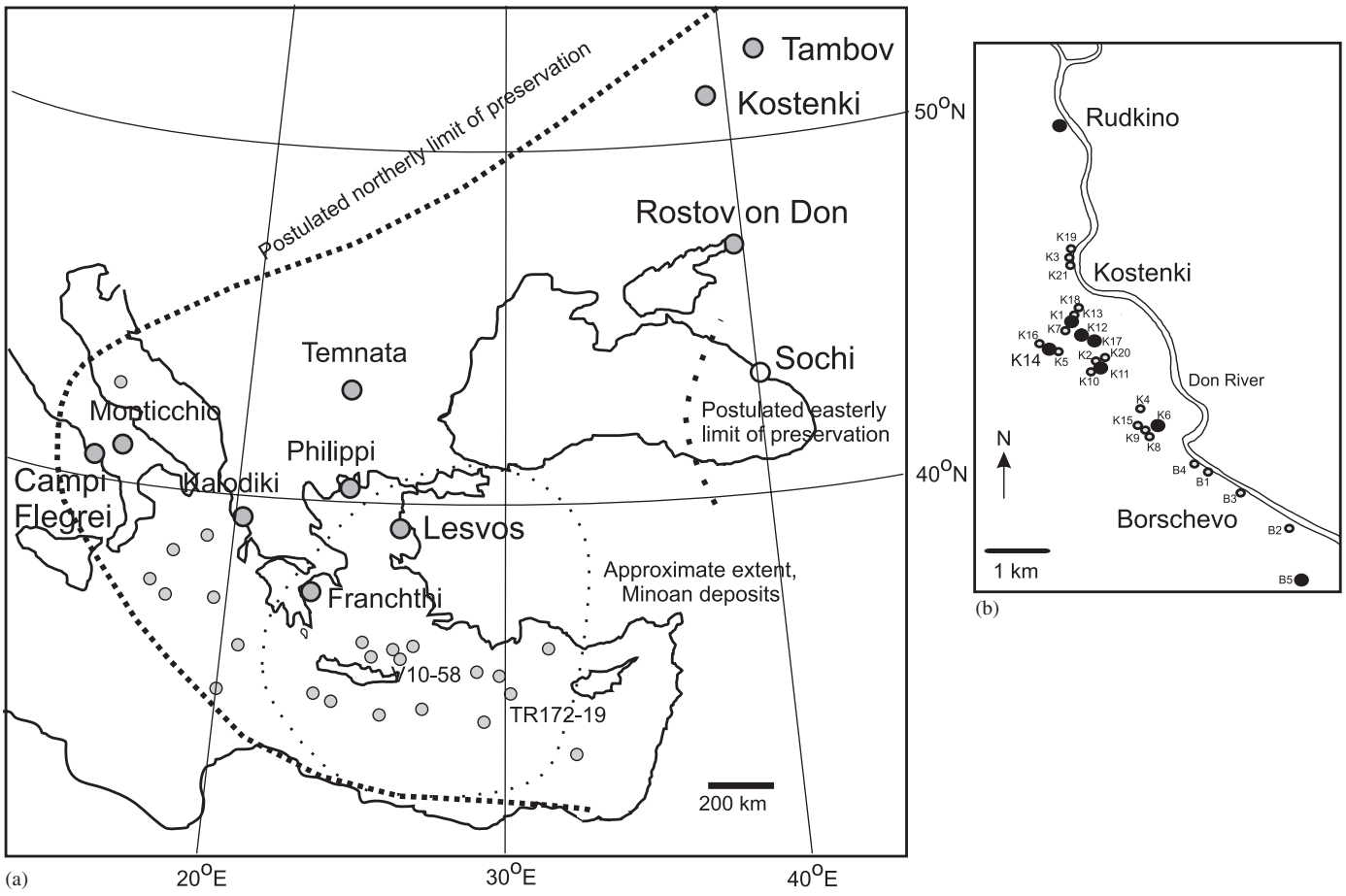

Fig. 1. (a) Map to show location of Kostenki and the general distribution of the Y5 tephra layer and correlated tephra horizons. The approximate southerly 1 cm isopach is based on marine core data (Cornell et al., 1983); the suggested northerly and easterly limits are discussed in the text. Grey-filled circles indicate selected localities where terrestrial deposits of Y5 tephra have been recognised: Kalodiki fen and Philippi peat bogs, Greece (St. Seymour and Christianis, 1995; St. Seymour et al., 2004); Paleolithic contexts in caves at Temnata (Bulgaria) and Franchthi (Greece; Pawlikowski, 1992; Paterne, 1992; Federman and Carey, 1980; Vitaliano et al., 1981). The approximate extent of deposition of a discrete tephra layer during the ca 3.7 ka BP Minoan eruption of Santorini is shown for comparison. (b) Location map showing the outline distribution of archaeological sites (Kostenki: *K* numbers; Borschevo: *B* numbers) in the Don river region between Rudkino and Borschevo. Filled circles indicate localities where tephra have been recognised (adapted from Sinitsyn, 2003). Kostenki lies at approximately 51.4°N, 39.0°E.

brought into question with the recognition of a trachytic ash layer with a composition similar to Y5 in southern Russia (Melekestsev et al., 1984; Fig. 1a). This Russian work and its implications have been overlooked until recently (e.g. Narcisi and Vezzoli, 1999; Fedele et al., 2003). Here, we present new descriptions and analyses of this Russian tephra unit; demonstrate that this can be correlated with the Y5/Campanian Ignimbrite eruption, and use this to draw some conclusions about the volume of the original eruption, and implications for the dating of Palaeolithic archaeological sequences across eastern Europe.

2. Tephra at Kostenki, Don river, Russia

The plains of southwestern Russia extend from the Ukraine to the Caucasus mountains, and contain abundant archaeological evidence for human occupation over the past 30–60,000 yr. One well-known cluster of Palaeolithic archaeological sites is at Kostenki, Voronezh (51.39°N, 39.04°E; Fig. 1b). Here, numerous archaeological sites have been investigated over the past 125 yr (Sinitsyn, 1996, 2002; Praslov and Sulerzhitskii, 1999; Anikovich and Platonova, 2004). During the 1970s and 1980s, a tephra layer was found in a number of locations, both within archaeological contexts and elsewhere, extending from Kostenki as far south as Rostov on Don (47.1°N 39.5°E; Kholmovoy, 1989; Tsekhovskii et al., 1998), and as far north as Tambov (52.5°N, 41.5°E) (Melekestsev et al., 1984).

In the site Kostenki 14 (Markina Gora), the tephra layer forms a key stratigraphic horizon (Fig. 2). Here, the tephra layer lies above a palaeosol, which contains evidence for the Laschamp magnetic excursion (Gernik and Guskova, 2002; locally recognised as the Kargapolovo excursion, Pospelova et al., 1998), which is currently dated (elsewhere) to 40.3–41.7 ka Cal BP (Voelker et al., 2000). The tephra