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A 90,000–200,000 yrs marine tephra record of Italian volcanic activity in the Central Mediterranean Sea

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ABSTRACT

A detailed tephrochronological study was undertaken in three deep-sea cores collected in the Tyrrhenian and Ionian Seas. The age and the origin of the marine tephra were inferred from oxygen isotope records of foraminifera and from major element compositions of glass-shards. Seventy-one eruptions were detected in the time interval 90,000–200,000 yrs during which the volcanoes of the Roman and Campanian regions and of the southern Italy were in activity. This is attested by the consistency of the geochemical compositions of both marine and terrestrial deposits. Most of the marine tephra consisted in trachytes and phonolites characterizing a Roman and Campanian origin. Several tephra were proposed as key-horizons for proximal and distal sediments. Among them, one tephra originating from Mount Etna (149,300 yrs) and five tephra from Pantelleria island (130,000 yrs, 163,600 yrs, 192,500 yrs, 197,400 yrs and 198,400 yrs) were northerly dispersed. Several other key horizons originated from the Campanian or Roman provinces were detected as far as 1000 km from the vents.

1. Introduction

Since their first systematic investigation in deep-sea sediments (Keller et al., 1978; McCoy, 1981; Paterne et al., 1986, 1988), tephra were extensively studied in the Mediterranean region either in lake deposits (Calanchi et al., 1996; Narcisi, 1996; Magri, 1999; Magri and Sadori, 1999; Ramrath et al., 1999; Munno et al., 2001; Wülf et al., 2004; Freda et al., 2006), or in deep-sea sediments (Thunell et al., 1979; Sparks and Huang, 1980; McCoy, 1981; Vinci, 1985; Vezzoli, 1991; Calanchi et al., 1994, 1996, 1998; Narcisi and Vezzoli, 1999; van der Bogaard et al., 1999; Siani et al., 2001, 2004), or in prehistoric human settlements (Paterne, 1992; Pyle et al., 2006; Anikovich et al., 2007). Detailed marine tephra studies, based on the conjugated analyses of both the timing and the geochemical evolution of the eruptions in a continuous sedimentary framework, provide a unique opportunity of understanding the long-term mechanisms and causes of triggering of eruptions (Kennett et al., 1977; Paterne et al., 1990; Paterne and Guichard, 1993). They may also help in evaluating volcanic hazard, as the timing and the frequency of critical eruptive events are precisely documented as well as their geographic dispersal, and consequently the amounts of ejected magma (Thunell et al., 1979; Sparks and Huang, 1980). Finally, tephra provide unique chrono-stratigraphic markers of either continental or marine archives due to the long-distance dispersal of volcanic particles over thousands of kilometers (Barberi et al., 1978; Guichard et al., 1993; Pyle et al., 2006).

In the central Mediterranean region, previous studies of distal tephra identified unprecedented occurrence of hundreds eruptions originating from the Italian volcanoes over the past ~90,000 yrs (Paterne et al., 1988; Wülf et al., 2004), and some tephra were tentatively correlated to individual eruption (Keller et al., 1978; Vinci, 1985; Paterne et al., 1986; Vezzoli, 1991; Calanchi et al., 1994, 1996, 1998; Narcisi and Vezzoli, 1999; van der Bogaard et al., 1999; Ton-That et al., 2001; Siani et al., 2001, 2004; Sulpizio et al., 2003; Wulf et al., 2004). In the same time, detailed chronological and geochemical studies of proximal volcanic deposits in the Campanian and Roman areas and in south Italy were performed (Delibrias et al., 1979; Gillot et al., 1982; Capaldi et al., 1985; Nappi et al., 1985; Laurenzi and Villa, 1987; Poli et al., 1987; Radicati di Brozolo et al., 1988; Civetta et al., 1998; Cole et al., 1992, 1993; Deino et al., 1992; De Vita et al., 1998; Karner and Renne, 1998; Karner and Marra, 1998; Coltelli et al., 2000; Karner et al., 2001; De Vivo et al., 2001; Brocchini et al., 2001; Marra et al., 2003; Sulpizio et al., 2003; Marra et al., 2004 and reference therein; Quidelleur et al., 2005; Freda et al., 2006).

Here, we present new data, which extend to the last ~200,000 yrs a previous marine tephra record of the Italian volcanic activity (Paterne et al., 1988). This study intends to identify potential tephra markers for distal volcanic deposits and for marine and terrestrial sediments, and to contribute to the knowledge of the old volcanic activity in Italy by precisely documenting the geochemical, mineralogical and chronological

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characteristics of marine tephra. These are described with respect to the marine oxygen isotope fluctuations, as stratigraphy of volcanic deposits may be referred to high-sea stands along the Italian coasts (Karner et Renne, 1998; De Astis et al., 2003; Lucchi et al., 2007) and to the organic-rich horizons, known as sapropels, as they are deposited over the whole Mediterranean Sea.

2. Materials and methods

The tephra were analyzed in three deep-sea cores collected on top of seamounts in the central Tyrrhenian Sea at the same location (KET 80-04; DED 87-08) during the Etna-80 cruise on the N/O Noroît and during the DEDALE-87 cruise on the N/O Marion Dufresnes, and in the Ionian Sea (KET 82-22) during the Etna-82 cruise on the N/O Sûroit (Fig. 1). Methods of marine tephrochronology were presented elsewhere (Paterne et al., 1986, 1988; Siani et al., 2004) and are briefly described below.

The age of the tephra layers is estimated from the orbital tuning of the oxygen isotope records of foraminifera (Martinson et al., 1987) and from that of sapropels (Lourens, 2004). The mean uncertainty on the ages is about ±5000 yrs (Martinson et al., 1987). The oxygen isotope records of cores KET 80-04 and DED 87-08 were presented previously (Paterne, 1985; Paterne et al., 1986, 1988; Kallel et al., 2000). In the last core, the oxygen isotope record was developed beyond ash-layer C-22, which is very widespread over the whole Tyrrhenian Sea (Paterne, 1985; Tric et al., 1992). Its stratigraphical position in core KET 80-22 indicates unambiguously that C-22 occurred close to and beyond the marine oxygen isotope sub-stage MIS5.2 (Paterne et al., 1986). In core KET 82-22, the oxygen isotope record extends from stage 1 up to the end of stage 7 (Fig. 2). While the last climatic cycle from stage 1 to stage 5 is likely uncompleted, the oxygen isotope sub-stages MIS6 and MIS7.2 are well-developed and comparable to the same isotopic events in cores KET 80-04 and DED 87-08 (Fig. 2). Thus we reconstructed the eruptive history of the Italian volcanoes from 90,000 yrs to isotopic sub-stage MIS7.2 dated at 205,000 yrs (Martinson et al., 1987).

The tephra layers were identified in the deep-sea sediments by a peak of abundance of glass-shards above the background, determined by the counting of glass-shards, crystals and lithics in the whole detritic material coarser than 40 µm. Major element analyses of 15 to 20 individual polished glass-shards were then measured on a JEOL/EDS instrument for core DED 87-08 and on a CAMEBAX/SEM equipment for the cores KET 80-04 (Paterne, 1985; Paterne et al., 1986; 1988; Fontugne et al., 1989) and KET 82-22. Four internal standards were measured prior any series of measurements to evaluate the precision and accuracy of the analyses. No systematic and significant offset was observed and the mean precision is about 2% for SiO_2, 5% for Al_2O_3 and K_2O and 10% for the other elements. The age of the ash-layers was calculated by linear interpolation between oxygen isotope events in each core (Table 1), and then the ages were averaged.

3. Results

The geochemical compositions of selected tephra are reported in Table 2A and B. Many ash-layers present heterogeneous chemical

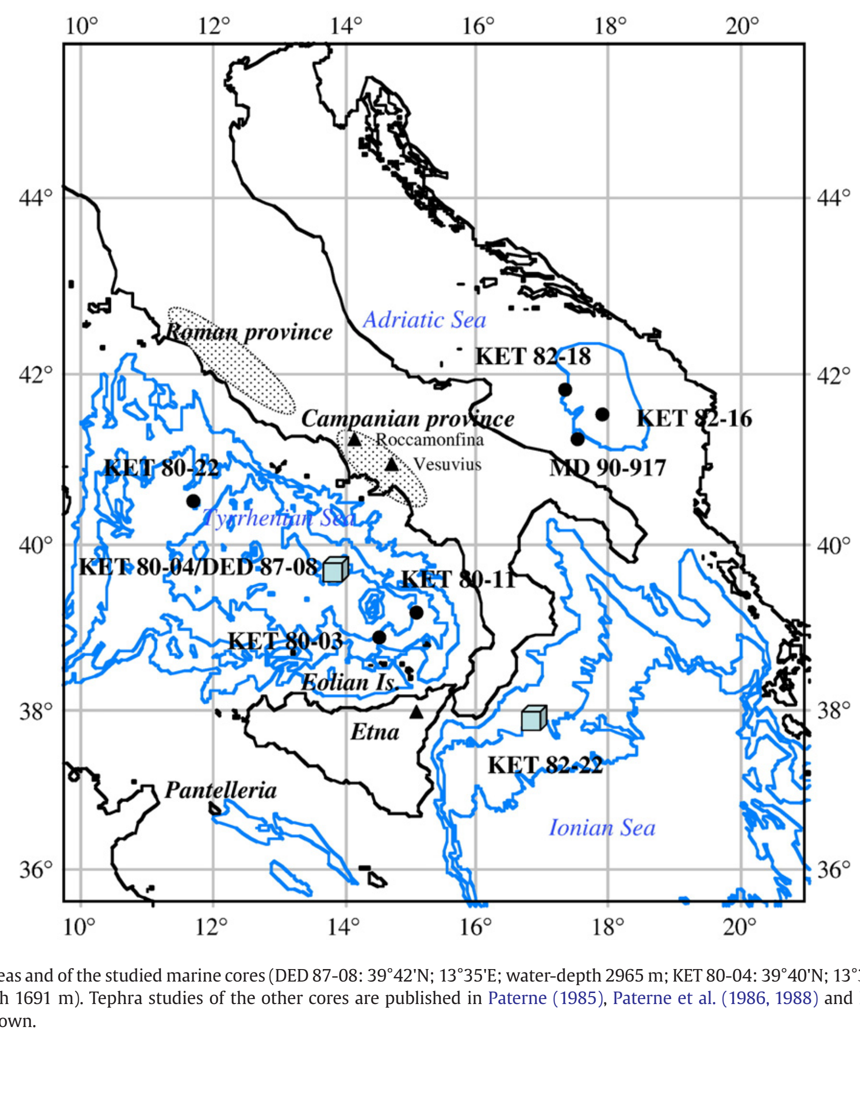

Fig. 1. Locations of the volcanic areas and of the studied marine cores (DED 87-08: 39°42′N; 13°35′E; water-depth 2965 m; KET 80-04: 39°40′N; 13°34′E; water-depth 2909 m; KET 82-22: 37°56′N; 16°53E; water-depth 1691 m). Tephra studies of the other cores are published in Paterne (1985), Paterne et al. (1986, 1988) and Fontugne et al., 1989. The 1000 m bathymetric contours are also shown.