Il Quaternario
Italian Journal of Quaternary Sciences
***16**(1), 2003, 91-108*

A REVIEW OF TEPHROSTRATIGRAPHY IN CENTRAL AND SOUTHERN ITALY DURING THE LAST 65 KA

Roberto Sulpizio[1,2], Giovanni Zanchetta[2], Martine Paterne[3] & Giuseppe Siani[4]
[1] Dipartimento Geomineralogico, via Orabona 4, 70125, Bari, Italy
[2] Dipartimento di Scienze della Terra, via S. Maria 53, 56126, Pisa, Italy
[3] Lab. des Sciences du Climat et de l'Environm., CNRS-CEA, 91198 Gif sur Yvette, France
[4] FRE 2566 Orsayterre Université Paris XI 91405 Orsay cedex

ABSTRACT
This work presents an attempt at correlating tephra layers through different proxies in central and southern Italy over the last 65 ka. On the basis of the recent refinement of stratigraphy of some Italian volcanoes (mainly Somma-Vesuvius and Phlegrean Fields) and new lacustrine and marine cores (from Lago Grande di Monticchio and south Adriatic sea) 35 dated tephra layers among terrestrial, lacustrine and marine settings are correlated. These correlations supply a detailed and comprehensive chronostratigraphic scheme previously not available. In particular, 9 tephra layers were related to the Somma-Vesuvius, 16 to the Phlegrean Fields, 3 to Ischia, and 1 to Procida, Etna, Lipari, Salina, Pantelleria and Palinuro seamount explosive activity. One tephra layer has an uncertain source between Ischia Island and Phlegrean Fields. Finally, dispersal maps of selected tephra layers are shown.

RIASSUNTO
Questo lavoro presenta un tentativo di correlazione di livelli di tephra di età minore di 65 ka rinvenuti in depositi marini e lacustri con i corrispondenti livelli piroclastici prossimali. L'area interessata dall'indagine comprende carote marine dai mari Tirreno, Adriatico, Ionio e dal Bacino di Bannock, mentre i dati dei tephra lacustri provengono da carote ottenute nei laghi di Monticchio, Vico, Mezzano, Nemi, Valle di Castiglione e da depositi di versante della conca del Fucino. Una carota proviene inoltre dalla laguna di Mljet in Croazia. Le correlazioni di dettaglio dei tephra marini e lacustri con i depositi prossimali sono state possibili grazie al recente raffinamento dei dati riguardanti la cronostratigrafia di alcuni vulcani italiani (in particolare Somma-Vesuvio e Campi Flegrei) e ai dati provenienti da nuove carote perforate nel mare Adriatico e nel Lago Grande di Monticchio. Dei 35 livelli di tephra correlati 9 appartengono ad eruzioni del Somma-Vesuvio, 16 ai Campi Flegrei, 3 ad Ischia e 1 a Procida, Etna, Lipari, Salina, Pantelleria e Palinuro seamount rispettivamente. Un solo livello di tephra risulta difficilmente discriminabile tra una origine flegrea o ischitana. Infine le mappe di dispersione di alcuni di questi livelli di tephra sono state tracciate sulla base dei dati prossimali e delle carote marine e lacustri distali.

Keywords: Tephra layers, marine, lacustrine, proximal deposits, italian volcanoes, central Mediterranean sea.

Parole chiave: Livelli di Tephra, Tephra marini, Tephra lacustri, vulcani italiani, Mediterraneo centrale.

INTRODUCTION

Over the last 50 years, tephra layers have been extensively investigated, since their widespread presence in marine and lacustrine sediments are an invaluable tool used to support geochronological and climatological studies (Kennett, 1982; Mangerud *et al*., 1984; Bard *et al*., 1994; Paterne *et al*., 1990; Siani *et al*., 2001; Ton-That *et al*., 2001, among many others). Indeed, tephrochronological studies provide precise chronostratigraphic constraints for proxy records and their correlation. Moreover, they improve our knowledge of both the areas affected by pyroclastic deposition and the mass of erupted magmas in the past (Sparks & Huang, 1980). These data are of primary importance in volcanic hazard mitigation, as they are hardly obtained only from terrestrial data. This is especially true for the distal products of ancient eruptions.

In the Mediterranean Sea, a lot of research has dealt with the study of marine cores from Tyrrhenian, Adriatic, Aegean or Levantine Seas. One of the earliest drilling expeditions in the area was carried out in 1947-48 (Norin, 1958), but the first comprehensive study of tephra layers is that of Keller *et al*. (1978). Further on, a refinement of the data was provided by Paterne *et al.* (1986; 1988), McCoy & Cornell (1990), Fontugne *et al.* (1989), Vezzoli (1991), Calanchi *et al*. (1994), Siani *et al*. (2003) for the Tyrrhenian, Adriatic and South Ionian (Bannock Basin) seas. In particular, Paterne et al. (1986; 1988) and Paterne & Guichard (1993) provided a detailed chronological and geochemical record of tephra layers over the last 80,000 years.

On the other hand tephra layers in lacustrine settings were investigated in detail in recent years, mostly inside the EU funded projects PALICLAS and EUROMAARS (i.e. Narcisi, 1996; Calanchi *et al*., 1996a;

Calanchi *et al.*, 1996b; Watts *et al.*, 1996; Narcisi, 1999a; Ramrath *et al.*, 1999). Several sedimentary successions of some lakes from central and southern Italy were drilled and investigated by interdisciplinary research. In particular, seven lakes (Fig. 1) have been considered in this work (Lakes of Mezzano, Vico, Albano, Nemi, Valle di Castiglione, Monticchio and Fucino basin), owing to the presence in their sediments of tephra layers of interest in the investigated time span (<65 ka).

This large set of data on marine and lacustrine tephra can be profitably matched with the new stratigraphic, geochemical and chronological data obtained in recent years for some important Quaternary volcanoes of southern Italy, such as Somma-Vesuvius (Andronico *et al.*, 1995; 1996; Cioni *et al.*, 2003a), Phlegrean Fields (Orsi *et al.*, 1996a; Di Vito *et al.*, 1999; Pappalardo *et al.*, 1999; Sulpizio *et al.*, 2003), Mt Etna (Coltelli *et al.*, 2000).

This paper deals with a review of tephrochronologic correlations among terrestrial (intended as deposits recognised on land, mostly in proximal sites), lacustrine and marine proxies of central-southern Italy, with the aim of proposing a comprehensive chronostratigraphic scheme of the tephra succession and dispersion for the last 65 ka. In particular, thephrochronologic correlations are better detailed for the last 18 ka, owing to the availability of a major amount of data on both marine-lacustrine and terrestrial environments (Andronico *et al.*, 1995; Narcisi, 1996; Di Vito *et al.*, 1999; Siani *et al.*, 2001; Wulf *et al.*, 2001; Siani *et al.*, 2003). However, the correlation in 18-65 ka time span are mainly based on the work of Sulpizio *et al.* (2003), which correlate several poorly-known terrestrial deposits to marine tephra of Adriatic and Tyrrhenian seas.

THE TERRESTRIAL RECORD

In the investigated time span (<65 ka) the explosive activity of the Italian volcanoes was mainly concentrated in the Neapolitan area (Rosi & Sbrana, 1987; Santacroce, 1987; Poli *et al.*, 1987; Vezzoli, 1988; Andronico *et al.*, 1995; Orsi *et al.*, 1996a; Di Vito *et al.*, 1999; Sulpizio *et al.*, 2003), while few large explosive eruptions occurred at Mount Etna (Kieffer, 1979; Coltelli *et al.*, 2000) and Eolian Islands (Keller, 1980; Pichler, 1980; Frazzetta *et al.*, 1983; Crisci *et al.*, 1991; Calanchi *et al.*, 1993; De Astis *et al.*, 1997; Gioncada *et al.*, 2003). During this time span, the Roman Province, Mount Vulture and Roccamonfina volcanoes were not active, while Pantelleria was characterised by a very weak activity out the Green Tuff eruption (45 ka; Gillot, 1984; Civetta *et al.*, 1984; Mahood & Hildreth, 1986; Orsi *et al.*, 1991).

The stratigraphic record of Neapolitan volcanoes has been improved in recent years, especially for the Late Pleistocene-Holocene. In particular, detailed sets of both stratigraphic, chronologic and geochemical data are available for Somma-Vesuvius (Santacroce, 1987; Andronico *et al.*, 1995; Cioni *et al.*, 2003a) and Phlegrean Fields (Rosi & Sbrana, 1987; Di Vito *et al.*, 1999; Orsi *et al.*, 1996a; Pappalardo *et al.*, 1999; Sulpizio *et al.*, 2003). Minor detail exists for the data from Ischia and Procida volcanoes (Vezzoli, 1988; Di Girolamo & Stanzione, 1973; Poli *et al.*, 1987; Crisci *et al.*, 1989; Orsi *et al.*, 1996b). All these data allow the reconstruction of a general chronostratigraphic scheme of the activity of these volcanoes (Fig. 2). In the same figure the major explosive eruptions of Eolian Islands, Palinuro seamount and Etna volcano are also reported (Crisci *et al.*, 1991; Calanchi *et al.*, 1993; De Astis *et al.*, 1997; Coltelli *et al.*, 2000). From this chronostratigraphic scheme, the explosive activity of Somma-Vesuvius and Phlegrean Fields emerges characterising the last 18 ka, whereas Phlegrean explosive activity dominates the 18-65 ka time span, with only few explosive events of Pantelleria, Ischia and Procida islands.

Figure 1 - Location map of the lacustrine and marine cores considered for this study. LMZ – Lago di Mezzano (Ramrath *et al.*, 1999; Narcisi, 1999b); VICO – Lago di Vico (Narcisi, 1999b); PALB1E – Lago di Albano, Lago di Nemi and Valle di Castiglione (Calanchi *et al.*, 1996a; Narcisi, 1999a); FUC – Conca del Fucino (slope deposits on the border of the basin; Narcisi, 1993); MON – Lago Grande di Monticchio (Narcisi *et al.*, 1996; Wulf , 2000; Wulf *et al.*, 2001); MLJ – Mljet Lagoon (Jahns & van den Bogaard, 1998); PAL948, PAL9466, CM9241, CM9242, RF9230 – Central Adriatic sea cores (Calanchi *et al.*, 1998); KET8216, KET8218, MD90-917 – South Adriatic sea cores (Paterne *et al.*, 1988; Fontugne *et al.*, 1989; Siani *et al.*, 2001; 2003); KET8003, 8004, 8011, 8019, 8022, ODP Leg 107 – Tyrrhenian sea cores (Paterne *et al.*, 1988; Kallel *et al.*, 1997; Calanchi *et al.*, 1994); V10-69, RC9-191 – Ionian sea cores (Keller *et al.*, 1978); BAN – Bannock basin cores (Vezzoli, 1991).

Tables 1 and 2 summarises the chronology and the main lithological and chemical characteristics of the proximal pyroclastic deposits used in this work for the correlation with marine and lacustrine tephra layers.

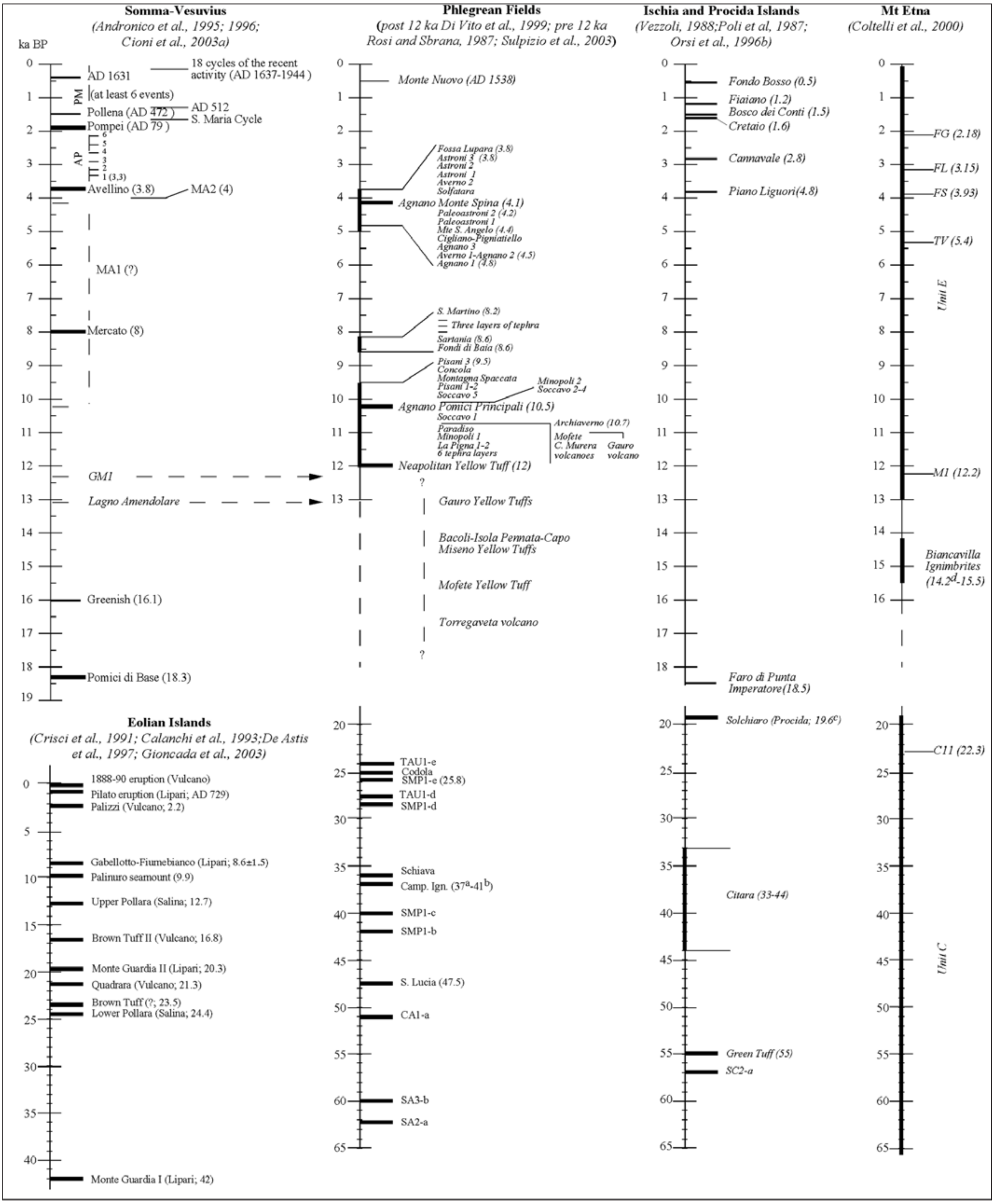


Figure 2 - Detailed chronostratigraphic scheme of Somma-Vesuvius and Phlegrean Fields volcanoes of the last 65 ka. In the Somma-Vesuvius chronostratigraphy are shown in Italic two eruptions attributed to Phlegrean Fields (Andronico, 1997; Zanchetta *et al.*, 2000). Schemes of the main explosive eruptions of Etna, Eolian Islands, Ischia and Procida Islands are also shown. The explosive eruption of Palinuro seamount is enclosed in the Eolian Islands chronostratigraphy. Note the change in scale for ages older than 19 ka and for Eolian Islands column. In brackets are shown the published ^{14}C or ^{39}Ar/^{40}Ar ages. [a] Deino *et al.* (1994); [b] Ton-That *et al.* (2001); [c] Pescatore and Rolandi (1981); [d] De Rita *et al.* (1991).

THE LACUSTRINE RECORD

In recent years seven lakes in central and southern Italy (Lakes Mezzano, Vico, Albano, Nemi, Valle di Castiglione, Fucino and Monticchio; Fig. 1) were drilled, mainly with the aim of studying environmental and climatic conditions in central-southern Italy in the past. Tephra layers recognised in these lacustrine environments have been investigated in detail by Calanchi *et al.* (1996a, b), Ramrath *et al.* (1999), Narcisi (1996; 1999a, b), Wulf (2000) and Wulf *et al.* (2001). The Lago Grande di Monticchio (Mt Vulture; Fig. 1) shows the most abundant and representative record of tephra layers, due to its location downwind of the Neapolitan volcanoes (Fig. 1). Narcisi (1996) provided the correlation of 13 tephra layers from the Lago Grande di Monticchio succession to the activity of Neapolitan volcanoes, while Wulf (2000) and Wulf *et al.* (2001) reported the same layers and several others not recognised by Narcisi (1996; Fig. 3). Indeed, Wulf *et al.* (2001) reported the occurrence of many tephra layers of unknown origin, but, unfortunately, they did not provided chemical analyses, thus preventing their correlations to terrestrial or marine correspondents. For this reason only the well-known and widespread tephra layers Y3 and Y1, together with the trachytic tephra of Agnano M. Spina, the latitic tephra of Solchiaro and the leucititic-tephrite-phonolite tephra of Pollena (AD 472) have been added to the Lago Grande di Monticchio succession reported by Narcisi (1996). The tephra layers recognised in the Lago Grande di Monticchio cores pertain to the major explosive eruptions of Somma-Vesuvius and Phlegrean Fields, which occurred in the last 18 ka, whereas the origin of tephra layers in the 18-65 ka time span is less clear, even if the predominance of Phlegrean Fields and Ischia Island sources can be inferred by geochemical data (Narcisi, 1996; Sulpizio *et al.*, 2003; Fig. 3).

Figure 3 shows some differences in respect to the previous correlations of tephra layers from Lago Grande di Monticchio made by Narcisi (1996). In particular, layer L3, previously attributed to the interplinian activity between Avellino and AD 79 eruptions of Somma-Vesuvius (Narcisi, 1996), has been correlated to the Avellino eruption of Somma-Vesuvius. This different correlation has been suggested by EDS chemical analyses (especially by the high content of Al_2O_3; Cioni *et al.*, 2000) and dispersal of fall deposits of APs and Avellino

Table 1 - Chronology and main lithological characteristics of the proximal terrestrial deposits of the last 18.3 ka correlated to the marine and lacustrine tephra layers. [a]- ^{14}C age from Andronico *et al.* (1995); [b]- ^{14}C age from Siani *et al.* (2001; 2003); [c]- ^{14}C age from Di Vito *et al.* (1999); [d]- ^{14}C age from Calanchi *et al.* (1993). [e]-Lacustrine layer from Wulf *et al.* (2001), marine layer from Fontugne *et al.* (1989); [f]-Keller *et al.* (1978); [g]-Narcisi *et al.* (1996), attribution to Avellino eruption: this work; [h]-Siani *et al.* (2003); [i]-Calanchi *et al.* (1998); [l]-Paterne *et al.* (1988), Paterne & Guichard (1993), Paterne (1985).Characteristics of proximal deposits and lithology of juvenile fragments of Pollena, Pompeii, Avellino, Mercato, Greenish, Pomici di Base from Santacroce (1987); AP1-2 from Andronico & Cioni (2002); Astroni, Agnano P.P. and Neapolitan Yellow Tuff from Rosi & Sbrana (1987); Agnano M. Spina from de Vita *et al.* (1999); Gabellotto-Fiumebianco from Crisci et al. (1991); GM1 from Zanchetta et al. (2000); Upper Pollara from Calanchi et al. (1993); Lagno Amendolare from Andronico (1997); Biancavilla Ignimbrite from De Rita *et al.* (1991).

Eruption	Age	Characteristics of proximal deposits	Lithology of juvenile fragments	Inferred source	Tephra layer
Pollena	AD 472	Pyroclastic fall deposit comprises a thin basal layer of greenish-grey pumice followed by several layers of dark grey scoria. Accidental lithics are mainly carbonate and lava fragments. Pyroclastic flows abundant in proximal areas.	Greenish-grey pumice: highly vesicular, porphyritic (lc+pyr+san). Tephri-phonolitic chemical composition. Dark grey scoria: highly to incipiently vesicular, porphyritic (lc+pyr+san). Leucititic-tephrite-phonolite chemical composition.	Somma-Vesuvius	Pollena[e]
Pompeii	AD 79	Pyroclastic fall deposit comprises a basal layer of white-pinkish pumice followed by an upper layer of grey pumice. Accidental lithics are mainly carbonate and lava fragments. Pyroclastic flows abundant in proximal areas.	White-pinkish pumice: highly vesicular, moderately porphyritic (san). Phonolitic chemical composition. Grey pumice: highly to moderately vesicular, moderately porphyritic (san+pyr). Tephri-phonolitic chemical composition.	Somma-Vesuvius	Z1[f]
AP1-2	3,220±65[a]	Pyroclastic fall deposits comprise a thin basal layer of white pumice followed by an alternation of grey scoria and ash beds. Pyroclastic flow deposits are very scarce.	White pumice: highly vesicular, almost aphiric. Phonolitic chemical composition. Grey scoria: highly to moderately vesicular, moderately porphyritic (san+pyr).	Somma-Vesuvius	L1-2[g]
Avellino	3,760±70[a]	Pyroclastic fall deposit comprises a basal layer of white pumice followed by an upper layer of grey pumice. Accidental lithics are mainly carbonate and lava fragments with subordinate syenites, cumulates and skarns. Pyroclastic flows abundant in proximal areas.	White pumice: highly vesicular, porphyritic (san). Phonolitic chemical composition. Grey pumice: highly to moderately vesicular, porphyritic (san+pyr). Tephri-phonolitic chemical composition.	Somma-Vesuvius	L3[g]

Segue Table 1

Eruption	Age	Characteristics of proximal deposits	Lithology of juvenile fragments	Inferred source	Tephra layer
Astroni 3	3,820±50[b]	Massive deposit formed by light grey pumice. Sparse accidental lithics, mainly lava fragments. Pyroclastic flows abundant in proximal areas.	Highly vesicular, porphyritic (san+plag+pyr+bt), light grey in colour. Trachytic to alkali-trachytic in composition.	Phlegrean Fields	140-17[h]
Agnano M. Spina	4,130±50[c]	Pyroclastic fall deposit comprises several poorly sorted pumice layers separated by thin, fine ash beds. Accidental lithics are hydrotermally altered lava fragments. Pyroclastic flows abundant in proximal areas.	Highly vesicular, porphyritic (san+plag+pyr+bt+lc). Pumice fragments show a yellowish patina. Inner colour: grey; outer colour: yellowish-brown. Trachytic to alkali-trachytic chemical composition.	Phlegrean Fields	AMS[i]
Gabellotto-Fiumebianco	7,770±35[b]	Several pumice and ash layers interbedded by massive and cross-stratified ashes	Highly vesicular, almost aphiric. Colour: white. Rhyolitic chemical composition	Lipari (Eolian) Islands)	E1[l]
Mercato	8,010±35[a]	Pyroclastic fall deposit comprises three main layers of white brown pumice separated by thin, pinkish-brown ash beds. Accidental lithics are mainly lava fragments and subordinate carbonates. Pyroclastic flows abundant in proximal areas.	Highly vesicular , almost aphyric. Colour: white. Phonolitic chemical composition.	Somma-Vesuvius	V-1[l]
Palinuro Seamount	9,990±90[b]	Co-ignimbrite deposits of brown, fine ash. Accidental lithics are absent.	Variably vesicular glass shards of trachytic composition	Palinuro Seamount	275-17 [h]
Agnano P. P.	10,480±90[b]	Pyroclastic fall deposit comprises three main layers of light brown pumice separated by thin, fine ash beds. Accidental lithics are lava fragments. Pyroclastic flows abundant in proximal areas.	Highly vesicular , porphyritic (san+plag+pyr+bt). Pumice fragments show a pinkish-brown patina. Inner colour: grey; outer colour: pinkish-brown. Trachytic chemical composition.	Phlegrean Fields	C1[l]
Neapolitan Yellow Tuff	12,100±170[b]	Several pumice and ash layers interbedded by massive and cross-stratified ashes	Juvenile fragments are highly vesicular, light grey in colour, almost aphiric (san+pl+pyr+bt) and alkali-trachytic to latitic in composition.	Phlegrean Fields	C2s.l. [l] /395-17[h]
GM1	12,600±110[b]	Pyroclastic fall deposit comprises an alternation of three layers of vesicular ash and light coloured pumice. A thick co-ignimbrite ash layer forms the upper part of the deposits.	Highly vesicular, aphiric, light grey in colour. Trachytic chemical composition.	Phlegrean Fields	405-17 [h]
Upper Pollara	12,750±140[d]	Alternation of pyroclastic fall and flow deposits that comprise white pumice.	Highly vesicular, porphyritic (bt+pyr+hbl+ol+pl), white in colour. Dacitic chemical composition.	Salina (Eolian Islands)	E2[l]
Lagno Amendolare	13,070±90[b]	Pyroclastic fall deposit comprises a basal layer of white pumice followed by fine brown ashes. Upper layer comprises mixed white and black pumice. Sparse accidental lithics, mainly lava fragments.	Highly vesicular, aphiric. Colour light to dark grey. Both types are trachytic in composition.	Phlegrean Fields	435-17[h]
Biancavilla Ignimbrite	14,230±85[b]	At least four ignimbritic flow units of ash and juvenile scoriae.	Highly to moderately vesicular. Colour varies from light to dark grey. Benmoreitic composition.	Mount Etna	Y1 [f]/Et1[l]
Greenish Pumice	16,070±170[b]	Pyroclastic fall deposit comprises an alternation of fine to coarse lapilli and ash layers. Different types of juvenile clasts mixed in the same layer. Accidental lithics are lava and carbonate fragments. Few pyroclastic flow deposits in proximal areas.	Highly to moderately vesicular, almost aphiric (san+pyr). Colour from light grey to dark green and brown. Trachytic composition.	Somma-Vesuvius	L8 [g]/530-17[h]
Pomici di Base	18,300±180[a]	Pyroclastic fall deposit comprises a white pumice basal layer followed by a black scoriae upper layer. Accidental lithics are lava and carbonate fragments. Some pyroclastic flow deposits in proximal areas.	White pumice: highly vesicular, almost aphiric (san+pyr), trachytic composition. Black scoriae: moderately vesicular, aphiric, latitic composition.	Somma-Vesuvius	595-17[h]

eruptions (Andronico & Cioni, 2002; Cioni *et al*., 2000). The correlation of layer L10 to the Sarno eruption was questioned by Sulpizio *et al.* (2003), on the basis of the attribution of the Sarno deposits to the distal products of the Pomici di Base eruption (Bertagnini *et al*., 1998; Andronico *et al*., 1995; 1996). Indeed, the layer L10 can be correlated to the TAU1-e eruption , very similar in lithology (light and dark coloured juvenile fragments; Table 2), chemical composition (trachytes-latites; Table 3) and age (about 24 ka) to the previously attributed Sarno eruption. Furthermore, the Codola eruption, previously reported as a Plinian eruption of Somma-Vesuvius (Santacroce, 1987), has been recently attributed to the activity of Phlegrean Fields, on the basis of lithology and dispersal of fall deposits (Andronico *et al*., 1995; 1996; Sulpizio *et al*., 2003). The recognition of tephra layers in cores from the other lakes is more sporadic and limited to the Somma-Vesuvius eruption of Avellino (Lago di Nemi and Lago di Albano), Biancavilla Ignimbrite (Lago di Albano, Lago di Mezzano and in the slope deposits on the flanks of the Fucino basin) and Neapolitan Yellow Tuff (Valle di Castiglione; Fig. 3).

THE MARINE RECORD

Siani (1999) and Siani *et al*. (2001; 2003) provided a detailed study and correlation of 11 tephra layers of the last 18 ka from a core located in the Adriatic Sea (MD90-917; Fig. 1). Three of these tephra layers belong to the eruptions of Agnano M. Spina (tephra AMS/PF), Agnano Pomici Principali (tephra C1) and Biancavilla Ignimbrite (tephra Et1/Y1) previously recognised in marine cores (Keller *et al*., 1978; Paterne *et al*., 1988; Vezzoli, 1991; Calanchi *et al*., 1998). A fourth tephra of rhyolitic composition (tephra E1) has been correlated to the Gabellotto-Fiumebianco eruption of Lipari (Eolian Islands) on the basis of chemistry and chronology. The other seven tephra layers have been for the first time correlated to terrestrial proximal deposits, on the basis of their chemistry, lithology and chronology (Table 1). Two of them (tephra 595-17 and 530-17) have been related to the Pomici di Base (Santacroce, 1987; Bertagnini *et al*., 1998) and Greenish (Santacroce, 1987; Cioni *et al*., 2003b) eruptions of Somma-Vesuvius respectively, whereas the tephra layer 275-17 has been related to the activity of Palinuro Seamount (Fig. 4 and Table 1). The other four tephra layers have been related to the Phlegrean Fields activity. In particular the tephra layer 140-17 has been correlated to the Astroni eruption, while tephra layers 395-17, 405-17, 435-17 clustered in a stratigraphic position very close to the previously recognised C2 tephra (Paterne *et al*., 1988; Calanchi *et al*., 1998), related to the Neapolitan Yellow tuff eruption (Paterne *et al*., 1988). Indeed, the accurate sampling of the core (every 3 cm; Siani, 1999; Siani *et al*., 2003) allowed to recognise three dif-

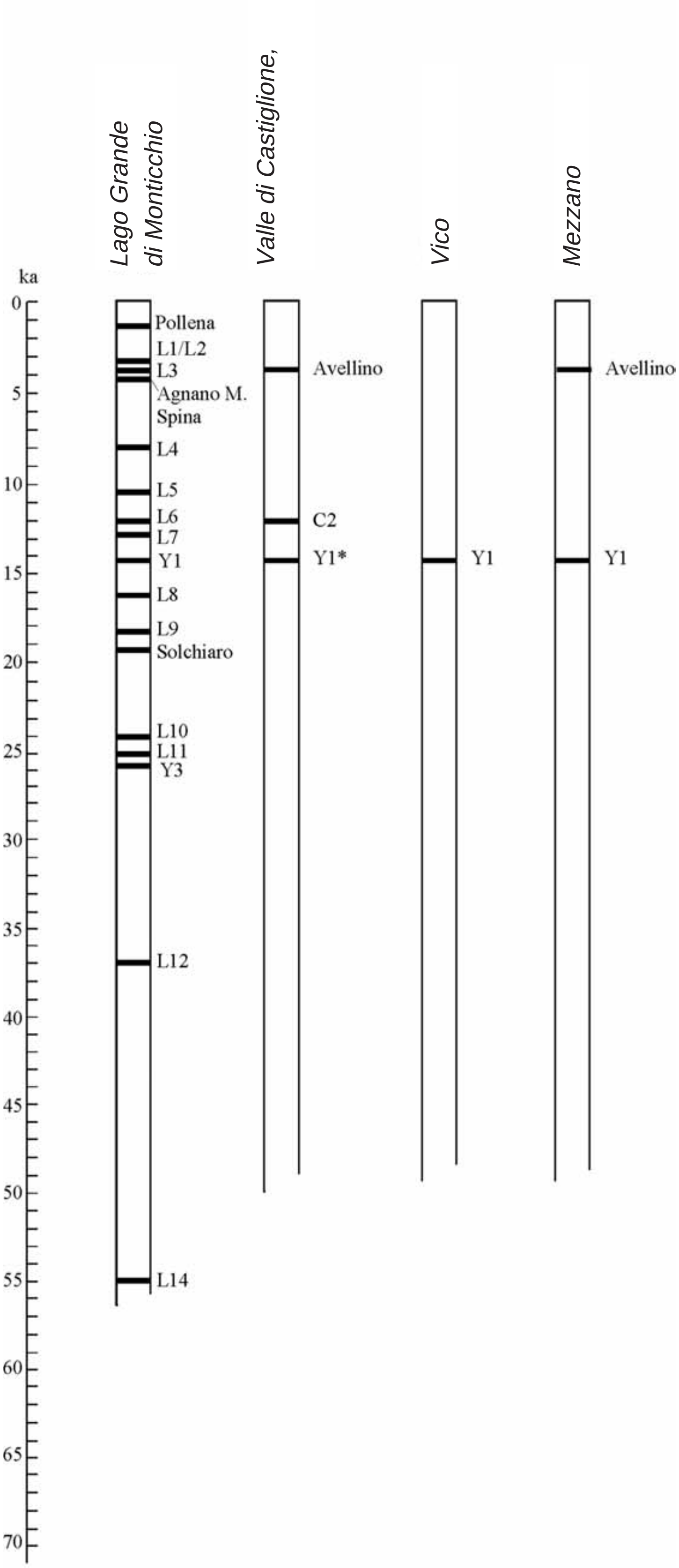


Figure 3 - Schematic correlation among tephra layers recognised in the lacustrine cores considered in this study. See Fig. 1 for locations. * Recognised in the detrital deposits on the flanks of Fucino basin (Narcisi, 1993).

Table 2 - Chronology and main lithological characteristics of the proximal terrestrial deposits of the 18.3-65ka time span correlated to the marine and lacustrine tephra layers. [m]- ^{14}C age from Paterne *et al.* (1988); [n]- ^{14}C age from Sulpizio *et al.* (2003); [o] ^{14}C and ^{39}Ar/^{40}Ar ages from Deino *et al.* (1994) and Ton-That *et al.* (2001); In Italic are shown the ages calculated by interpolation of ^{14}C data in marine cores (Paterne *et al.* 1988; Paterne & Guichard, 1993). [f]-Keller *et al.* (1978); [g]-Narcisi *et al.* (1996); [h]-Siani *et al.* (2003); [l]-Paterne *et al.* (1988), Paterne & Guichard (1993), Paterne (1985); [p]-Calanchi *et al.* (1994). Characteristics of proximal deposits and lithology of juvenile fragments of TAU1-d, e, SMP1-a, c, d, e, CA1-a, SC2-a, SA3-a, SA2-a, Codola and S. Lucia from Sulpizio *et al.* (2003); Solchiaro/Taurano from Di Girolamo & Stanzione (1973) and Zanchetta *et al.* (2000); Schiava Pumice from Zanchetta *et al.* (2000); Campanian Ignimbrite from Rosi & Sbrana (1987); Green Tuff of Pantelleria from Mahood & Hildreth (1986); Green Tuff of Ischia from Vezzoli (1988).

Eruption	Age (ka)	Characteristics of proximal deposits	Lithology of juvenile fragments	Inferred source	Tephra layer
Solchiaro /Taurano	19.62±0.27[m]	Massive layer formed by well sorted, black, scoriaceous, coarse lapilli. Sparse accidental lithics, mainly lava fragments.	Poorly vesicular , sub-aphiric (amph+pyr+san). Inner colour: N3-Dark grey; outer colour: N5-Medium grey. Latitic chemical composition.	Procida Island	C4[l]
TAU1-e	*24*	Basal layer formed by light coloured pumice followed by an upper layer of black scoriae. Accidental lithics are scarce and mainly are lava fragments.	Light coloured pumice: moderately vesicular, almost aphiric (amph+pyr). Colour N5, medium grey. Trachytic chemical composition. Black scoriae: moderately vesicular, almost aphiric (amph+pyr). Colour N3, dark grey. Latitic chemical composition.	Phlegrean Fields	L10[g] C6[l]
Codola	25.1±0.4[m]	Double alternation of fine grained, vesicular ash and light to dark grey pumice lapilli layers. Fine grained pumice lapilli scatterly occur inside the ash layers. Accidental lithics are dark coloured lava fragments.	Highly to medium vesicular, aphiric, pumice and scoria. Presence of banded pumice fragments. Color:5Y 8/1- Yellowish grey; N4-Medium dark grey. Trachytic chemical composition.	Phlegrean Fields	L11[g] C8[l]
SMP1-e	25.82±0.27[n]	Massive ash with sparse, light grey pumice lapilli. Absence of coarse accidental lithic fragments.	Highly vesicular, aphiric, pumice. Color:5Y 8/1-Yellowish grey. Trachytic chemical composition.	Phlegrean Fields	Y3[f]
TAU1-d	*27.8*	Massive pyroclastic fall deposit of light brown pumice lapilli. Sparse accidental lithics mainly are lava fragments.	Highly vesicular, aphiric pumice. Inner colour: 5Y 8/1-Yellowish grey; outer colour: 10YR 8/2-Very pale orange. Trachytic chemical composition	Phlegrean Fields	332-04[l]
SMP1-d	*28.5*	Massive pyroclastic fall deposit of brown, scoriaceous, coarse lapilli with good sorting. Sparse accidental lithics, mainly are lava fragments.	Highly vesicular, porphyritic (pyr+bt+san) scoria. Presence of cumulate xenoliths. Inner colour: 5Y 6/1-Light olive grey; outer colour: 10YR 6/2-Pale yellowish brown. Latitic chemical composition	Phlegrean Fields	360-18[l]
Schiava Pumice	**36**	Alternation of 5 fine grained, light brown, vesicular ash and 4 well sorted, light grey pumice lapilli layers. Accidental lithic are scarce and are lava fragments.	Highly microvesicular, sub-aphiric (bt+san), pumice. Colour: N8-Very light grey. Trachytic chemical composition	Ischia Island	C-9[l]
Campanian Ignimbrite	37-41[o]	Basal pyroclastic fall layer followed by impressive pyroclastic flow deposits which form the ignimbrite s.s. Large variability of juvenile fragments, which comprise light coloured pumice and dark, porphyritic scoriae. Accidental lithics are mainly lava fragments	Pumice fragments are highly vesicular, moderately porphyritic (san+bt). Colour: from pinkish-brown to light grey. Trachytic chemical composition	Phlegrean Fields	C13a[l]
SMP1-c	*~40*	Basal massive layer of pumice lapilli that graded into an alternation of ash and lapilli. Accidental lithics are scarce and are lava fragments	Highly vesicular, sub-aphiric (san+bt+pyr), pumice. Tubular vesicles. Colour: 5Y 6/4-Dusty yellow. Trachytic chemical composition	Phlegrean Fields	C13b[l]
SMP1-a	**42**	Massive, well to moderately sorted layer of greyish pumice lapilli. Accidental lithics are scarce and are lava fragments.	Highly vesicular, sub-aphiric (san+bt+pyr), pumice. Tubular vesicles. Colour: 5Y 6/1-Light olive grey. Trachytic chemical composition	Ischia Island/ Phlegrean Fields	C14[l]
Green Tuff	45	flow deposits, sometimes welded in proximal areas.	Alternation of pyroclastic fall and -	Pantelleria	Y6[f]
Santa Lucia	47.5±2.6[n]	Alternation of brown fine grained ash and light grey pumice lapilli layers. Fine grained pumice lapilli scatterly occur inside the ash layers. Accidental lithics are dark coloured lava fragments.	Highly vesicular, sub-aphiric (san+bt), pumice. Tubular vesicles. Inner colour: 5Y 6/1-Light olive grey; outer colour; 10YR 6/2-Pale yellowish brown. Trachytic chemical composition.	Phlegrean Fields	C15[l]

Segue Table 2

Eruption	Age (ka)	Characteristics of proximal deposits	Lithology of juvenile fragments	Inferred source	Tephra layer
CA1-a	*51*	Massive, well to moderately sorted layer of greyish brown coarse pumice lapilli. Accidental lithics are scarce and are lava fragments.	Highly vesicular, sub-aphiric (san+bt+pyr), coarse pumice lapilli. Tubular vesicles. Inner colour: 5Y 6/1-Light olive grey; outer colour: 10YR 6/2-Pale yellowish brown. Trachytic chemical composition	Phlegrean Fields	C16[l]
Green Tuff	55	Mainly pyroclastic flow deposits, sometimes welded in proximal areas, rich in accidental lithics and blocks of poorly vesicular juvenile fragments.	From highly to incipiently vesicular, porphyritic (san+pl+pyr). Colour from whitish to yellowish. Trachytic chemical composition.	Ischia Island	L14[g]
SC2-a	57	Alternation of grey, fine grained pumice lapilli and brown coarse ash layers. Accidental lithics are scarce and are lava fragments.	Fine grained, highly vesicular, sub-aphiric (bt), pumice lapilli. Elongated shape. Tubular vesicles. Colour: 5GY 6/1-Greenish grey. Trachytic chemical composition.	Ischia Island	C(i)6[l]
SA3-a	*60.3*	Basal layer formed by brown, fine ash followed by a well-sorted, massive, yellowish brown pumice lapilli layer. Accidental lithics are scarce and are lava fragments.	Highly vesicular, sub-aphiric (bt), pumice lapilli. Colour 5Y 6/4-Dusty yellow. Trachytic chemical composition.	Phlegrean Fields	C18[l]/Y7[f]/ T003[p]
SA2-a	*62.3*	Basal, dark coloured pumice lapilli layer overlaid by black, vesicular, fine ash with sparse fine pumice lapilli. Accidental lithics are reddish lava fragments.	Highly vesicular, sub-aphiric (bt+px+san), pumice. Inner colour: 5Y 4/1-Olive grey; outer colour: 10YR 6/2-Pale yellowish brown. Trachytic chemical composition.	Somma-Vesuvius	666-04[l]

ferent peaks of homogeneous glass shards in the 12-13 ka time span, correlable to the proximal pyroclastic deposits of Lagno Amendolare (tephra 435-17), GM1 (tephra 405-17) and Neapolitan Yellow Tuff (tephra 395-17; Table 1). The record of tephra layers younger than 18 ka is completed by the recognition of E2, V1, Avellino and Z-1, respectively related to Pollara eruption from Salina Island (Eolian Archipelago; Paterne *et al.*, 1988), Mercato, Avellino and AD 79 eruptions from Somma-Vesuvius (Keller *et al.*, 1978; Paterne *et al.*, 1988; Fontugne *et al.*, 1989). Anyway, the correlations regarding two of these tephra layers need some further comments. Tephra layer Z-1 has been related to the AD 79 eruption from Somma-Vesuvius, even if Keller *et al.* (1978) reported a possible correlation with the Avellino eruption from Somma-Vesuvius (3.8 ka; Cioni *et al.*, 1995; 2000). Anyway, mineralogical characteristics of tephra layer Z-1 (presence of melanite and leucite; Keller *et al.*, 1978) rules out the possible correlation with Avellino deposits, characterised by the presence of scapolite and nepheline (Cioni *et al.*, 2000). Up to now the tephra layers RF93-30 (530), recognised in the Adriatic sea (Calanchi *et al.*, 1998), has not been correlated to a precise Somma-Vesuvius explosive event due to its chemical similarity to both AD 79 and Avellino products (Calanchi et al., 1998). Indeed, both EDS chemical analyses of proximal deposits (Cioni *et al.*, 2000), age of RF93-30 (530) tephra layer (>3660±100 yr BP; Calanchi *et al.*, 1998) and diversity in dispersal of fall deposits (NE for Avellino, SE for AD 79 deposits; Cioni *et al.*, 2000; Sigurdsson *et al.*, 1985) support the correlation of RF93-30 (530) tephra layer to the Avellino eruption.

The correlation of many of the tephra layers older than 18 ka with terrestrial deposits still remains difficult, with the only exceptions of the Solchiaro eruption from Procida island (tephra layer C4; Paterne *et al.*, 1988; Paterne & Guichard,1993), Campanian Ignimbrite eruption from Phlegrean Fields (tephra layer Y5/C13; Keller *et al.*, 1978; Paterne *et al.*, 1988; Ton-That *et al.*, 2001) and Green Tuff from Pantelleria (tephra layer Y6; Keller *et al.*, 1978). Several authors (Keller *et al.*, 1978; Paterne *et al.*,1988; Paterne & Guichard,1993; Calanchi *et al.*, 1994; 1998) correlated numerous tephra layers of age between 18 and 65 ka from Tyrrhenian and Adriatic sea cores (Fig. 4) to different sources such as Etna, Eolian Islands and Ischia volcanoes, usually grouping together Phlegrean Fields and Somma-Vesuvius due to the chemical homogeneity of their products. However, the contribution of Somma-Vesuvius to the tephra record in the 18-65 ka is negligible, as testified by the lack of pyroclastic deposits of comparable age in the terrestrial record (Fig. 2). On the basis of lithology, chemistry and chronology (Tables 2 and 3), Sulpizio *et al.* (2003) correlated fourteen tephra layers of age between 18 and 65 ka to terrestrial pyroclastic deposits from Phlegrean Fields, Ischia, and dubitatively Somma-Vesuvius (Fig. 5). These correlations allow to unravel some important points about the existence of many primary vs secondary tephra layers in this time span (questioned by McCoy & Cornell, 1990 and Narcisi & Vezzoli, 1999) and the attribution of the tephra layers to precise volcanic sources, in many cases different to the previously hypotised (Keller *et al.*, 1978; Paterne *et al.*; 1988; Paterne & Guichard, 1993; Calanchi *et al.*, 1994). In particular, tephra layers C6 and C8 (Paterne, 1985; Paterne *et al.*, 1988) have been correlated to the pyro-

Table 3 - Chemical analyses of the proximal pyroclastic deposits older than 18.3 ka of the Campanian area and the correlated tephra layers. EDS analyses for all lacustrine and marine tephra layers. [a]-XRF chemical analyses. n=number of analysed samples.

3a)

Eruption	**TAU1-e**		**L10b**	*st. dev.*	**L10a**	*st. dev.*	**C6**	**Codola**	*st. dev.*		**L11**	*st. dev.*	**C8**	**SMP1-e**	**Y3**	**TAU-d**[a]	**332-04**	**SMP1-d**		*st.dev.*	**360-18**
	white[a]	black[a]						L. grey[a]	*(n=2)*	D. grey[a]								**XRF**	**EDS**	*(n=20)*	
SiO_2	63.3	61.78	64.23	*1.23*	63.87	*0,05*	63.58	58.75	*0.04*	60.73	60.01	*0,05*	60.4	62.02	62.26	63.81	63.48	56.45	59.78	*0.73*	60.27
TiO_2	0.56	0.6	0.39	*0.12*	0.41	*0.11*	0.32	0.64	*0.01*	0.57	0.55	*0.28*	0.23	0.35	0.43	0.49	0.31	0.74	0.18	*0.11*	0.53
Al_2O_3	18.02	19.13	18.36	*0.26*	18.24	*0.23*	19.4	18.36	*0.02*	18.11	20.56	*1.31*	20.02	18.66	18.4	18.07	19.31	15.41	18.1	*0.36*	19.09
Fe_2O_3	3.21	3.62	3.26	*0.36*	3.21	*0.24*	2.66	4.85	*0.44*	4.21	2.79	*1.26*	2.69	3.2	3.59	3.06	2.94	6.05	4.26	*0.3*	4.15
MnO	0.15	0.16	0.16	*0.12*	0.1	*0.1*	-	0.14	*0.01*	0.13	0.09	*0.07*	-	0.15	0.11	0.13	-	0.12	0.06	*0.08*	-
MgO	0.7	0.65	0.38	*0.18*	0.5	*0.22*	0.345	1.12	*0.33*	0.86	0.47	*0.43*	0.04	0.7	0.93	0.58	0.38	4.83	1.2	*0.19*	0.16
CaO	2.29	2.4	2.13	*0.2*	2.02	*0.19*	2.245	4.8	*0.38*	3.93	4.73	*0.92*	3.15	2.4	2.69	1.83	2.31	7.88	3.8	*0.42*	3.64
Na_2O	4.38	4.05	2.14	*0.29*	2.39	*0.41*	3.38	3.55	*0.66*	3.78	2.92	*0.52*	4.38	4.2	4.13	3.96	3.12	2.46	4.31	*0.19*	3.6
K_2O	7.34	7.53	8.63	*0.63*	8.95	*0.45*	8.07	7.7	*1.86*	7.56	7.58	*1.36*	9.05	8.2	7.47	7.98	8.12	5.74	8.29	*0.27*	8.52
P_2O_5	0.06	0.07	0.35	*0.23*	0.28	*0.15*	-	0.13	*0.03*	0.11	0.26	*0.17*	-	0.11	-	0.07	-	0.33	-	-	-
L.O.I.	4.79	4.52	3.67	*2.65*	6.99	*1.55*	-	3.58	*0.06*	2.74	4.62	*1.94*	-	2.8	4.54	4.21	-	1.99	-	-	-
Nb	67	74	-	-	-	-	-	53	*9*	54	-	-	-		-	68	-	28	-	-	-
Zr	458	504	-	-	-	-	-	309	*30*	315	-	-	-		-	542	-	235	-	-	-
Y	38	43	-	-	-	-	-	31	*4*	30	-	-	-		-	41	-	26	-	-	-
Sr	861	916	-	-	-	-	-	1125	*95*	1037	-	-	-		-	344	-	555	-	-	-
Rb	234	242	-	-	-	-	-	284	*16*	283	-	-	-		-	277	-	217	-	-	-
Ce	270	284	-	-	-	-	-	133	*12*	142	-	-	-		-	229	-	96	-	-	-
Ba	1036	1091	-	-	-	-	-	1817	*400*	1506	-	-	-		-	274	-	1063	-	-	-
La	152	147	-	-	-	-	-	73	*6*	74	-	-	-		-	131	-	48	-	-	-
Ni	3	4	-	-	-	-	-	6	*1*	6	-	-	-		-	3	-	73	-	-	-
Cr	3	4	-	-	-	-	-	10	*2*	7	-	-	-		-	5	-	202	-	-	-
V	61	66	-	-	-	-	-	91	*17*	78	-	-	-		-	56	-	153	-	-	-
Co	4	5	-	-	-	-	-	9	*1*	6	-	-	-		-	5	-	21	-	-	-
Total	100.01	99.99	100.03	-	99.97	-	99.99	100.01	-	99.99	99.96	-	99.96	99.99	100	99.98	99.97	100.01	100	-	99.96
Total Alkali	11.72	11.58	10.77	-	11.34	-	11.45	11.25	-	11.34	10.5	-	13.43	12.4	11.6	11.94	11.24	8.2	12.6	-	12.12
K_2O/Na_2O	1.68	1.86	4.03	-	3.74	-	2.39	2.26	-	2	2.6	-	2.07	1.95	1.81	2.02	2.6	2.33	1.92	-	2.37

Segue Table 3

3b)

Eruption	**Schiava**[a]	*st. dev.*	**C9**	**SMP1-c**[a]	**C13b**	**SMP1-a**[a]	**C14**	**S. Lucia**[a]	*st. dev.*	**C15**	**CA1-a**[a]	*st. dev.*	**C16**	*st. dev.*	**SC2-a**[a]	*st. dev.*	**C(i)6**	*st.dev.*	**SA3-A**[a]	**C18**	**SA2-a**[a]	*st.dev.*	**666-04**
		(n=3)							*(n=8)*			*(n=4)*				*(n=2)*		*(n=2)*				*(n=2)*	
SiO_2	67.71	*0.41*	66.16	60.71	60.98	62.24	63.14	59.74	*0.35*	61.35	61.09	*1.14*	61.63	0.93	63.46	*0.36*	64.37	*1.08*	62.3	61.36	59.24	*0.47*	60.8
TiO2	0.21	*0.01*	0.24	0.48	0.34	0.47	0.28	0.51	*0.03*	0.29	0.46	*0.05*	0.31	0.09	0.53	*0*	0.13	*0.13*	0.45	0.31	0.66	*0*	0.36
Al_2O_3	16.42	*0.34*	17.82	18.54	19.34	19.21	19.2	18.62	*0.69*	19.13	18.07	*0.08*	19.09	0.22	17.78	*0.23*	18.55	*0.07*	18.32	18.96	17.64	*0.1*	19.64
Fe_2O_3	2.27	*0.04*	1.98	3.72	3.25	3.84	2.58	5.03	*0.25*	3.06	4.45	*0.59*	2.97	0.47	3.86	*0.04*	2.39	*0.22*	3.57	3.17	5.64	*0.26*	3.09
MnO	0.14	*0*	-	0.15	-	0.24	-	0.15	*0.01*	-	0.14	*0*	-	-	0.32	*0.01*	-	-	0.18	-	0.14	*0*	-
MgO	0.41	*0.01*	0.04	0.58	0.55	0.56	0.13	1.24	*0.14*	0.13	1.09	*0.18*	0.14	0.07	0.51	*0.04*	0.01	*0.02*	0.63	0.32	2	*0.42*	0.09
CaO	2.29	*0.07*	2.26	3.47	2.52	1.9	1.54	3.40	*0.19*	1.95	3.07	*0.39*	1.84	0.29	1.62	*0.04*	1.56	*0.16*	2.15	2.78	4.79	*0.16*	2.59
Na_2O	3.79	*0.06*	3.6	3.55	3.4	4.92	5.76	3.26	*0.34*	6.52	3.37	*0.04*	6.27	0.49	5.59	*0.06*	4.99	*0.99*	3.99	3.4	3.31	*0.5*	4.93
K_2O	6.73	*0.11*	7.85	8.73	9.6	6.55	7.34	7.88	*0.34*	7.53	8.12	*0.21*	7.72	0.54	6.32	*0.1*	7.98	*0.42*	8.34	9.68	6.36	*0.41*	8.47
P_2O_5	0.03	*0*	-	0.06	-	0.07	-	0.17	*0.02*	-	0.15	*0.04*	-	-	0.04	*0*	-	-	0.06	-	0.23	*0.03*	-
L.O.I.	3.8	*0.08*	-	3.54	-	5.39	-	3.98	*0.61*	-	4.05	*0.54*	-	-	4.56	*0.11*	-	-	3.92	-	3.04	*0.21*	-
Nb	48	*3*	-	60	-	114	-	47	*4*	-	48	*2*	-	-	157	*2*	-	-	64	-	45	*7*	-
Zr	393	*10*	-	385	-	701	-	325	*16*	-	335	*13*	-	-	1026	*8*	-	-	404	-	332	*50*	-
Y	27	*2*	-	35	-	60	-	30	*3*	-	32	*1*	-	-	99	*1*	-	-	41	-	36	*3*	-
Sr	189	*7*	-	736	-	56	-	736	*50*	-	730	*33*	-	-	35	*13*	-	-	396	-	826	*29*	-
Rb	383	*8*	-	317	-	352	-	261	*19*	-	259	*13*	-	-	427	*4*	-	-	276	-	208	*11*	-
Ce	147	*5*	-	158	-	240	-	154	*12*	-	153	*3*	-	-	468	*11*	-	-	210	-	165	*24*	-
Ba	92	*3*	-	768	-	18	-	1203	*168*	-	1073	*72*	-	-	34	*10*	-	-	149	-	1158	*141*	-
La	90	*2*	-	91	-	131	-	85	*8*	-	86	*4*	-	-	252	*3*	-	-	114	-	87	*20*	-
Ni	4	*2*	-	4	-	4	-	6	*3*	-	5	*2*	-	-	4	*1*	-	-	3	-	10	*5*	-
Cr	4	*1*	-	4	-	2	-	9	*4*	-	7	*3*	-	-	3	*2*	-	-	2	-	27	*27*	-
V	17	*1*	-	58	-	17	-	84	*8*	-	68	*14*	-	-	15	*1*	-	-	34	-	106	*1*	-
Co	3	*1*	-	5	-	5	-	10	*1*	-	8	*2*	-	-	5	*1*	-	-	5	-	13	*1*	-
Total	100	-	99.95	99.99	99.98	100	99.97	100	-	99.96	100	-	99.97	-	100.01	-	99.98	-	99.99	99.98	100	-	99.97
Total Alkali	10.53	*0.14*	11.45	12.28	13	11.47	13.1	11.13	*0.64*	14.05	11.49	*0.22*	13.99	-	11.91	*0.16*	12.97	-	12.33	13.08	9.67	*0.08*	13.4
K_2O/Na_2O	1.78	*0.03*	2.18	2.46	2.82	1.33	1.27	2.43	*0.18*	1.15	2.41	*0.06*	1.23	-	1.13	*0*	1.6	-	2.09	2.85	1.95	*0.42*	1.72

clastic fall deposits of TAU1-e and Codola (Table 2) respectively, while the widely dispersed Y3 tephra layer (Keller *et al.*, 1978) has been correlated to the co-ignimbrite deposit SMP1-e, dated at 25.82±0.27 ka (Tables 2 and 3). The attribution of tephra layer C8 to Codola eruption needs some comments. This tephra layer was recognised in cores KET 8004, 8011 and 8218 from Tyrrhenian and Adriatic seas, and dated at 26.7±0.8 ka (Paterne, 1985). Anyway, in more recent papers (Paterne *et al.*, 1988; Paterne & Guichard, 1993) C8

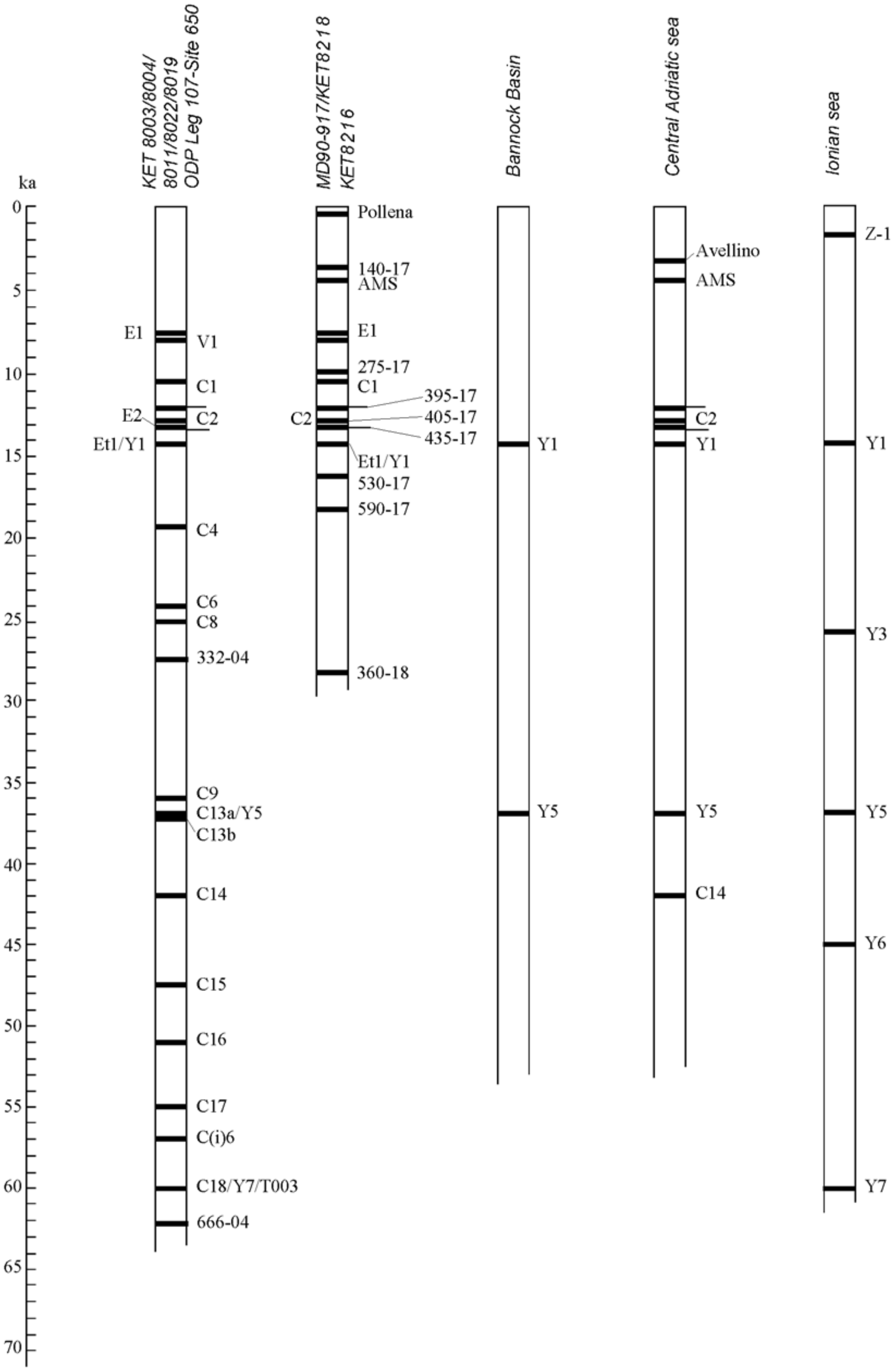


Figure 4 - Schematic correlation among tephra layers recognised in the marine cores considered in this study. See Figure 1 for locations.

tephra layer is not reported, due to the misleading attribution of tephra layer C10 to the Campanian Ignimbrite eruption made by Paterne et al. (1988) and the following "forced" adjustment of the stratigraphy of core KET 8004 on the basis of a C10 age of 33.5 ka (Paterne *et al.*, 1988). Indeed, new ^{14}C and ^{39}Ar/^{40}Ar data aged the terrestrial Campanian Ignimbrite deposits to about 37-39 ka (Deino *et al.*, 1994; De Vivo *et al.*, 2001), in agreement with the new correlation of these deposits to tephra layer C13 (dated at about 41 ka; Ton-That *et al.*, 2001). On the basis of these evidences the original stratigraphy of core KET 8004 reported by Paterne (1985) and age of tephra layer C8 of 26.7±0.8 ka have been considered correct and adopted for the correlation with proximal deposits. Similar problems affect also the tephra layers 332-04 and 360-18, which have been correlated to the TAU1-d and SMP1-d pyroclastic fall deposits. These two tephra layers were dated at about 33.5-33.7 ka (Paterne *et al.*, 1988), but these ages must not be considered correct, being influenced by the double error introduced by the correlation of layer C10 to the Campanian Ignimbrite deposits and to the age of 33.5 ka attributed to its proximal terrestrial deposits (Paterne *et al.*, 1988). On the basis of these considerations the original ages of 27.8 and 28.5 ka for tephra layers 332-04 and 360-18 (Paterne, 1985) have been adopted.

Moreover, an accurate inspection of chemical and stratigraphic data of C13 tephra layer shows the coexistence of at least two different tephra with similar chemical composition (peralkalic trachyte and trachyte; Paterne, 1985; Paterne *et al.*, 1988), here labelled C13a and C13b (Tables 2 and 3). Indeed, only the C13a tephra layer belong to the Campanian Ignimbrite deposits, while the C13b tephra layer has been correlated to

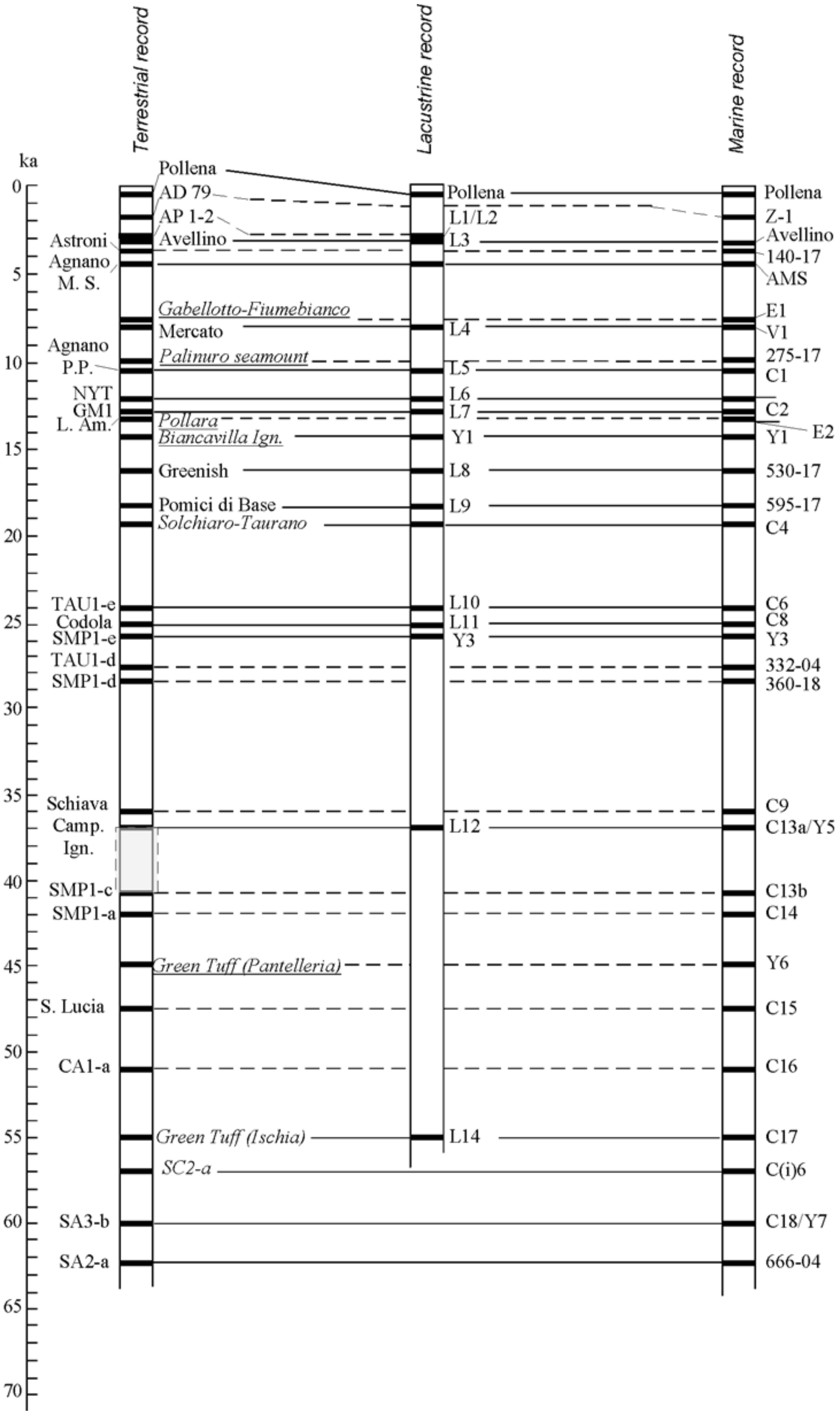


Figure 5 - Schematic correlation among terrestrial deposits and tephra layers recognised in lacustrine and marine cores. Dashed lines indicate the lack of tephra layer in lacustrine or marine cores. On the left of the terrestrial record column are shown the deposits from Phlegrean Fields activity, whereas on the right are shown the deposits of Somma-Vesuvius (Plain text), Ischia-Procida (Italic text) and Etna-Eolian Islands-Palinuro seamount-Pantelleria (underlined Italic text). The grey dashed box indicates the uncertainties in the age of Campanian Ignimbrite deposits.

the SMP1-c pyroclastic fall deposit, emplaced very close to the Campanian Ignimbrite eruption (Sulpizio *et al.*, 2003). The recognition of SMP1-c deposits can also help in the unravelling the discussion about the single or multiple occurrence of Campanian Ignimbrite(s) (Paterne *et al.*, 1988; Scandone *et al.*, 1991; Narcisi & Vezzoli, 1999). As shown for the C2 tephra layer (Siani *et al.*, 2003), this is probably due to the clustering of different large explosive eruptions of similar chemical composition occurred in a relatively short time span, which frequently results in a thick, single, marine tephra layer.

The correlation of tephra layer C9 (dated at 36 ka; Paterne & Guichard, 1993) to the Schiava eruption is supported by the most evolved chemical composition in the whole set of data shown by both deposits (Table 3), while tephra layer C14 has been correlated to the SMP1-a pyroclastic fall deposit (Tables 2 and 3).

The C15-C18 tephra layers were grouped in the Green Tuff Series by Paterne *et al.* (1988), and attributed to the activity of the Ischia Island. Indeed, only the tephra layer C17 can be correlated to the Green Tuff eruption of Ischia, while the other tephra layer have been correlated to terrestrial proximal deposits on the basis of chronology, lithology and chemical composition (Tables 2 and 3). Among them the only tephra layer correlable to Ischia activity is the C(i)6, dated at 57 ka (Paterne *et al.*, 1988), which correspond to the SC2-a pyroclastic fall deposit (Tables 2 and 3). The other tephra layers of the Green Tuff Series have been correlated to the explosive activity of Phlegrean Fields (Table 2; Sulpizio *et al.*, 2003). In particular, C15 tephra layer has been correlated to the large explosive eruption of S. Lucia, dated at 47.5±2.6 ka (Sulpizio *et al.*, 2003; Table 2), while C16 tephra layer has a terrestrial counterpart in the CA1-a pyroclastic fall deposit (Tables 2 and 3). Tephra layer C18 appear very widespread in the central Mediterranean cores, and correspond to the tephra layer 003 from ODP Leg 107-Site 650 (Calanchi *et al.*, 1994), and to the tephra layer Y7 (Keller *et al.*, 1978). It has an interpolated age of 60.3 ka (Paterne *et al.*, 1988; Paterne & Guichard, 1993) and corresponds to the terrestrial proximal deposit SA3-b (Tables 2 and 3). Finally, the oldest tephra layer correlated to a terrestrial counterpart is 666-04, dated at 62.3 ka by Paterne et al. (1988), which corresponds to SA2 pyroclastic fall deposit (Tables 2 and 3).

CORRELATIONS AMONG DIFFERENT PROXIES

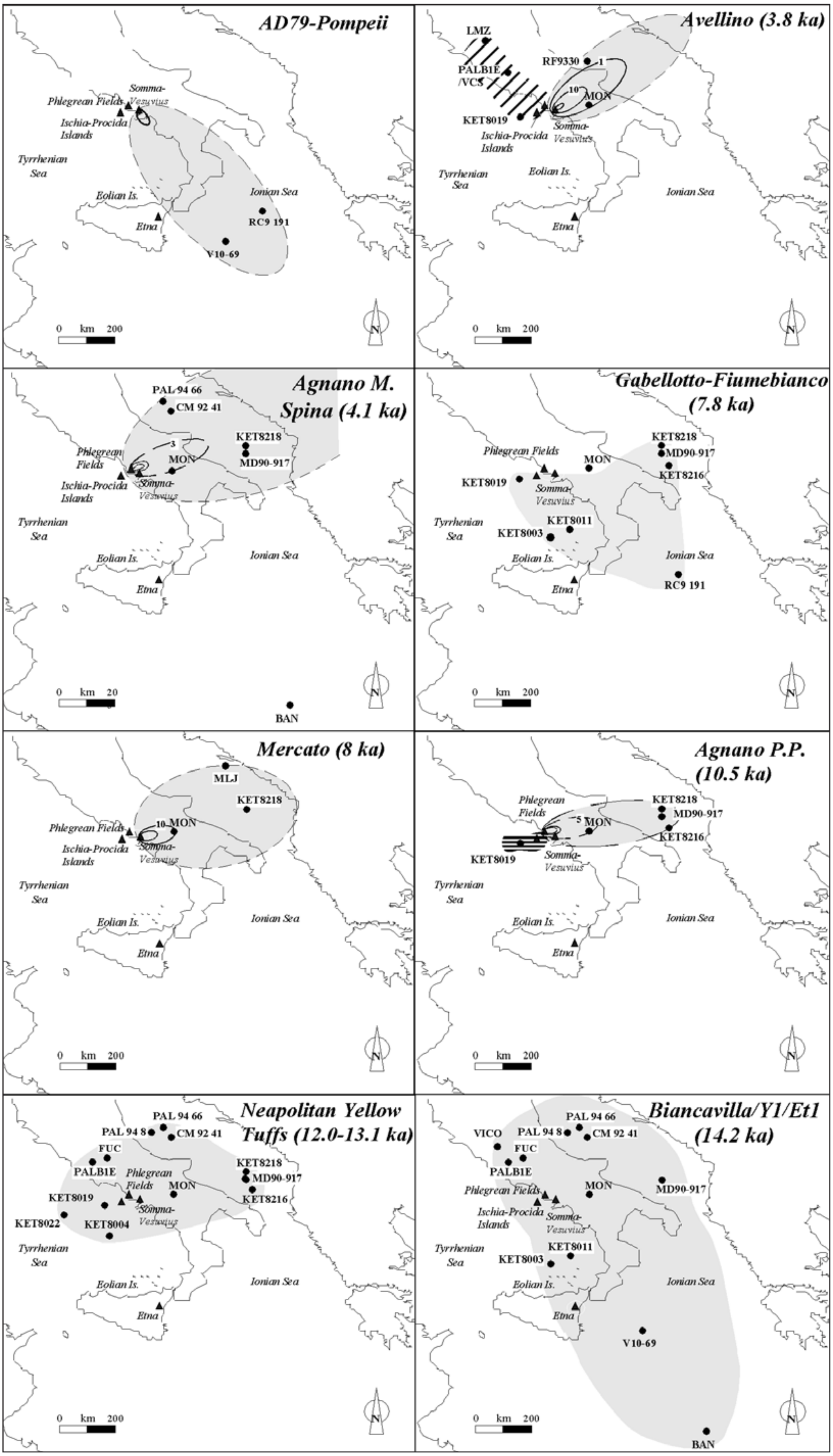
Figure 5 shows a schematic correlation among terrestrial, lacustrine and marine proxies. It represents an up-to-date, detailed chronostratigraphic scheme of the last 65 ka, useful for the correlation of different archives in the Mediterranean region. Seventeen tephra layers were correlated in the last 20 ka among the three proxies, while two tephra layers (AP1-2) were correlated between proximal terrestrial and lacustrine proxies. Most of them are concentrated in the <4.5 ka and in the 10.5-20 ka time spans, with the occurrence of only two tephra layers (Mercato and E1 tephra layers) in the 4.5-10.5 ka (Fig. 5). Other sixteen tephra layers were correlated in the 20-63 ka time span among terrestrial, marine and lacustrine proxies. A cluster of five tephra layers occurs between 24-27 ka, whereas ten tephra layers, almost regularly spaced, characterise the >35 ka time span (Fig. 5). Moreover, sources from Neapolitan volcanoes dominated throughout the whole succession, with the occurrence of only two Eolian (E1/Gabellotto-Fiumebianco and E2/Pollara; Paterne *et al.*, 1988; Calanchi *et al.*, 1993; Siani *et al.*, 2001; 2003) and Etnean (Y1/Et1/Biancavilla Ign.; Keller *et al.*, 1978; Paterne *et al.*, 1988) tephra.

On the basis of the proposed correlations the dispersal areas of several of these tephra layers can be traced (Figs. 6 and 7). These areas, even broadly defined and strongly dependent on the recognition of tephra in the marine and lacustrine cores, are generally in agreement with the main direction of dispersal of fall deposits of several well-known eruptions from Somma-Vesuvius and Phlegrean Fields, such as AD 79, Avellino, Agnano M. Spina, Mercato, Agnano P.P., Greenish, Pomici di Base, TAU1-e and S. Lucia (Figs. 6 and 7). In some cases, the dispersal areas indicate in Figures 6 and 7 comprise sites (i.e. cores) where the tephra layer has not been recognised. Several causes can account for this lack of recognition, such as settling of the marine tephra as multiparticle aggregates (Carey, 1997), erosion due to bottom currents or coring process. On the other hand, pyroclastic fall deposits are frequently dispersed along a defined dispersal axis and the isopach maps enclose ellipse-shaped areas, even if changes in dispersal axis is possible in very distal areas (Cas and Wright, 1987). In this way, in Figures 6 and 7 we traced the indicative dispersal areas on the basis of proximal isopachs, irrespective of the presence or not of the tephra layer in all the cores enclosed. Instead, broader and irregular dispersions characterise the tephra layers correlated to single (i.e. Campanian Ignimbrite) or clusters (Biancavilla, NYT) ignimbrite-forming eruptions (Fig. 6 and 7), due to the different eruptive dynamic and dispersal of volcanic clouds not linked to large convective columns (Cas and Wright, 1987).

CONCLUDING REMARKS

The proposed correlations highlights only part of the tephra layer record reported for the central Mediterranean region (i.e. Keller *et al.*, 1978; Paterne *et al.*, 1988; Vezzoli, 1991; Narcisi, 1996; Calanchi *et al.*, 1998; Wulf *et al.*, 2001), but more work is necessary to reach a comprehensive correlation among terrestrial, lacustrine and marine records. The correlations proposed in this work, although being as comprehensive as possible, intend to be preliminary. Indeed, it is only of transitory usefulness, because the knowledge of past activity for some Italian volcanoes is in tumultuous growth and in the near future new data will be available. In particular, the knowledge of stratigraphy and chronology of tephra layers older than 18 ka of central-southern Italy need to be supported by extensive studies on terrestrial records near volcanic centres. Specific studies should be addressed in this direction and it should be a specific task since active volcanoes are often studied only in respect to recent activity for the obvious purpose of hazard assessment.

6)


AD79-Pompeii
Somma-Vesuvius
Phlegrean Fields
Ischia-Procida Islands
Tyrrhenian Sea
Eolian Is.
Ionian Sea
Etna
RC9 191
V10-69
0 km 200
N
Avellino (3.8 ka)
LMZ
RF9330
PALB1E /VC5
10
1
MON
KET8019
Ischia-Procida Islands
Somma-Vesuvius
Tyrrhenian Sea
Eolian Is.
Ionian Sea
Etna
0 km 200
N
Agnano M. Spina (4.1 ka)
PAL 94 66
CM 92 41
KET8218
MD90-917
3
MON
Phlegrean Fields
Ischia-Procida Islands
Somma-Vesuvius
Tyrrhenian Sea
Eolian Is.
Ionian Sea
Etna
0 km 20
N
BAN
Gabellotto-Fiumebianco (7.8 ka)
KET8218
MD90-917
KET8216
Phlegrean Fields
MON
KET8019
Somma-Vesuvius
KET8011
KET8003
Tyrrhenian Sea
Eolian Is.
Ionian Sea
Etna
RC9 191
0 km 200
N
Mercato (8 ka)
MLJ
KET8218
Phlegrean Fields
10
MON
Ischia-Procida Islands
Somma-Vesuvius
Tyrrhenian Sea
Eolian Is.
Ionian Sea
Etna
0 km 200
N
Agnano P.P. (10.5 ka)
KET8218
MD90-917
Phlegrean Fields
5
MON
KET8216
KET8019
Somma-Vesuvius
Tyrrhenian Sea
Eolian Is.
Ionian Sea
Etna
0 km 200
N
Neapolitan Yellow Tuffs (12.0-13.1 ka)
PAL 94 66
PAL 94 8
CM 92 41
FUC
PALB1E
Phlegrean Fields
MON
KET8218
MD90-917
KET8216
KET8019
KET8022
KET8004
Somma-Vesuvius
Tyrrhenian Sea
Eolian Is.
Ionian Sea
Etna
0 km 200
N
Biancavilla/Y1/Et1 (14.2 ka)
PAL 94 66
VICO
PAL 94 8
CM 92 41
FUC
PALB1E
Phlegrean Fields
MON
MD90-917
Ischia-Procida Islands
Somma-Vesuvius
KET8011
KET8003
Tyrrhenian Sea
Eolian Is.
Ionian Sea
Etna
V10-69
0 km 200
N
BAN

7)

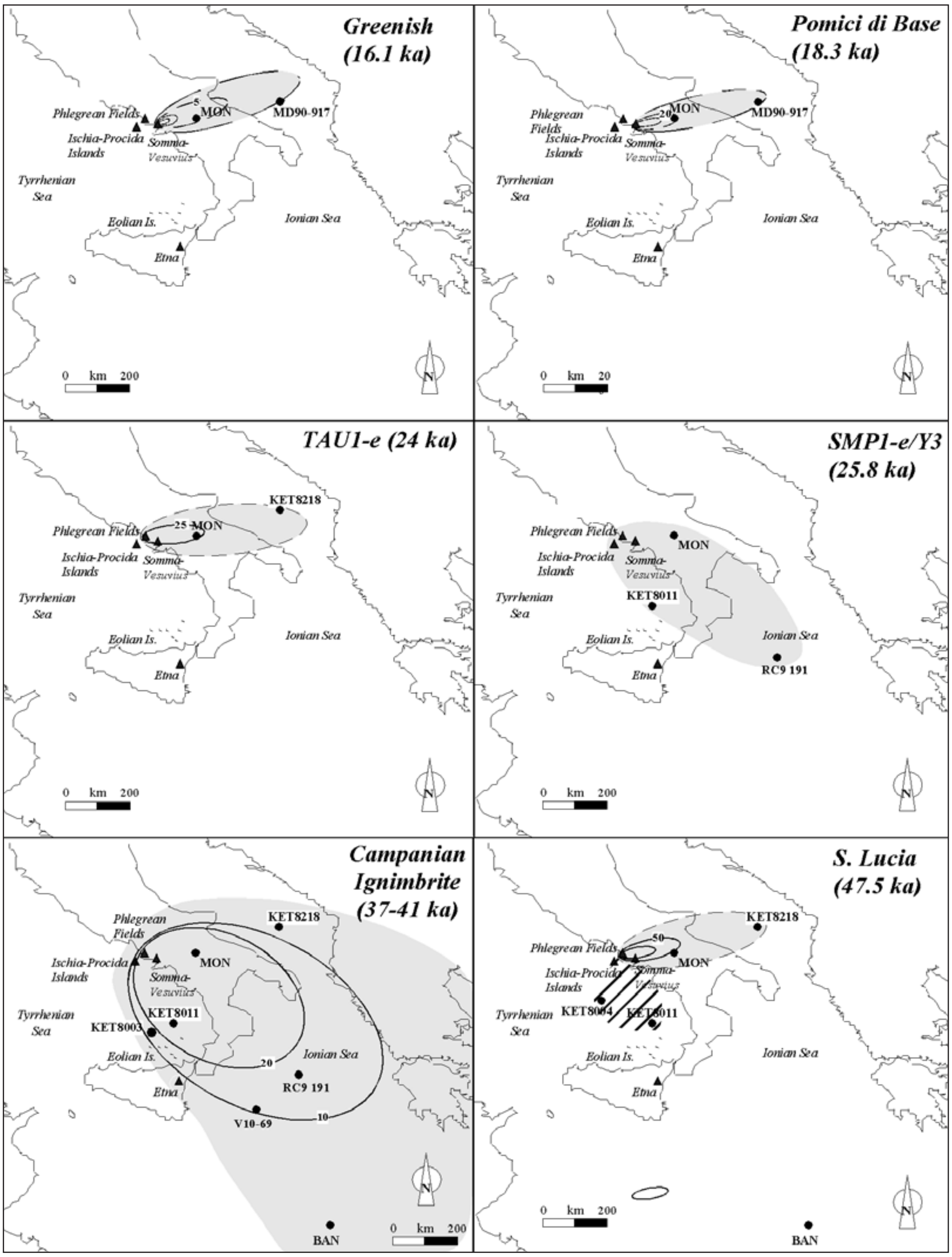


Figure 6 and 7 - Maps showing selected dispersal areas inferred from the recognition of tephra layers in lacustrine and marine cores. For deposits from sustained columns (fall deposits) the dispersal area has been traced using an ellipse with the same eccentricity of the proximal isopachs and delimited with a dashed line. The dashed areas in the Avellino, Agnano P.P. and S. Lucia maps indicate secondary lobes of dispersion of tephra. For co-ignimbrite deposit (Neapolitan yellow Tuffs, Biancavilla Ignimbrites and Campanian Ignimbrite) and for the Gabellotto-Fiumebianco eruption the shaded area indicates the present day limit of recognition of the respective tephra layers. Proximal isopach maps from: AD 79-Sigurdsson *et al.* (1985); Avellino-Cioni *et al.* (2000); Agnano M. Spina-de Vita et al. (1999); Mercato-Santacroce (1987); Agnano P.P.-Rosi & Sbrana (1987); Greenish-Cioni *et al.* (2003b); Pomici di Base-Bertagnini *et al.* (1998); TAU1-e-Sulpizio *et al.* (2003); Campanian Ignimbrite-Cornell *et al.* (1983); S. Lucia-Sulpizio *et al.* (2003).

REFERENCES

Andronico D. (1997) - *La stratigrafia dei prodotti dell'eruzione di Lagno Amendolare, Campi Flegrei, Napoli*. Atti Soc. Toscana Sci. Nat. Pisa Mem., serie A, **104**, 165-178.

Andronico D. & Cioni R. (2002) - *Contrasting styles of Mt. Vesuvius activity in the period between Avellino and Pompeii plinian eruptions, and some implications for assessments of future hazard*s. Bull. Volcanol., **64**, 372-391.

Andronico D., Calderoni G., Cioni R., Sbrana A., Sulpizio R. & Santacroce R. (1995) - *Geological map of Somma - Vesuvius volcano*. Per. Mineral., **64**, 77-78.

Andronico D., Cioni R., Marianelli P., Santacroce R., Sbrana A. & Sulpizio R. (1996) - *Introduction to Somma-Vesuvius*. In Santacroce R., Rosi M., Sbrana A., Cioni R. & Civetta L. (Eds): Vesuvius Decade Volcano Workshop Handbook, September 17-22, p. 1-13, Naples.

Bard E., Arnold M., Mangerud J., Paterne M., Labeyrie L., Duprat J., Mélières M., Sonstegaard E. & Duplessy J.C. (1994) - *The North Atlantic atmosphere-sea surface ^{14}C gradient during the Younger Dryas climatic event*. Earth. Planet. Sci. Letts. **126**, 275-287.

Bertagnini A., Landi P., Rosi M. & Vigliargio A. (1998) - *The Pomici di Base plinian eruption of Somma-Vesuvius*. J. Volcanol. Geotherm. Res. **83**, 219-239.

Calanchi N., De Rosa R., Mazzuoli R., Rossi P. & Santacroce R. (1993) - *Silicic magma entering a basaltic magma chamber: eruptive dynamics and magma mixing-an example from Salina (Aeolian islands, southern Tyrrhenian sea)*. Bull. Volcanol. **55**, 504-522.

Calanchi N., Gasparotto G. & Romagnoli C. (1994) - *Glass chemistry in volcaniclastic sediments of ODP Leg 107, Site 650, sedimentary sequence: provenance and chronological implications*. J. Volcanol. Geotherm. Res. **60**, 59-85.

Calanchi N., Dinelli E., Lucchini F. & Mordenti A. (1996a) - *Chemostratigraphy of the Late Quaternary sediments from Lake Albano and Central Adriatic Sea cores (PALICLAS project)*. Mem. Ist. Ital. Idrobiol. **55**, 247-263.

Calanchi N., Dinelli E., Gasparotto G. & Lucchini F. (1996b) - *Etnean tephra layer in Albano Lake and adriatic Sea cores: new findings of Y-1 layer in the Central Mediterranean area*. Acta Vulcanologica. **8**, 7-13.

Calanchi N., Cattaneo A., Dinelli E., Gasparotto G. & Lucchini F. (1998) - *Tephra layers in Late Quaternary sediments of the central Adriatic Sea*. Mar. Geol. **149**, 191-209.

Carey S. (1997) - *Influence of convective sedimentation on the formation of widespread tephra fall layers in the deep sea*. Geology. **9**, 839-842.

Cas R. & Wright J.W. (1987) - *Volcanic successions: modern and ancient*. Allen and Unwin, London, 528 pp.

Cioni R., Morandi D., Sbrana A. & Sulpizio R. (1995) - *L'eruzione delle pomici di Avellino: aspetti stratigrafici e vulcanologici*. In Albore Livadie C. (Ed): L'eruzione vesuviana delle "Pomici di Avellino" e la facies di Palma Campania (Bronzo antico). Territorio Storico e Ambiente 2. Centro Universitario Europeo per i Beni Culturali, Ravello, 61-82. Edipuglia, Bari.

Cioni R., Levi S. & Sulpizio R. (2000) - *Apulian bronze age pottery as a long distance indicator of the Avellino Pumice eruption (Vesuvius, Italy)*. In McGuire W.G., Griffiths D. & Stewart I (Eds): The Archaeology of the Geological Catastrophes. Geol. Soc. Special publications , 171, 159-177,

Cioni R, Longo A, Macedonio G, Santacroce R, Sbrana A., Sulpizio R. & Andronico D. (2003a) - *Assessing pyroclastic fall hazard through field data and numerical simulations: the example from Vesuvius.* J. Geophys. Res. **108**, doi:10.1029/2001 JB000642.

Cioni R., Sulpizio R. & Garruccio N. (2003b) - *Variability of eruption dynamic during a subplinian event: the Greenish Pumice of Somma-Vesuvius (Italy)*. J. Volcanol. Geotherm. Res. 124, 89-114.

Civetta L., Cornette Y., Crisci G., Gillot P.Y., Orsi G. & Requiejo C.S. (1984) - *Geology, geochronology and chemical evolution of the island of Pantelleria*. Geol. Mag. **121**, 541-668

Coltelli M., Del Carlo P. & Vezzoli L. (2000) - *Stratigraphic constraints for explosive activity in the past 100 ka at Etna volcano, Italy*. Int. J. Earth Sciences. **89**, 665-677.

Cornell W., Carey S. & Sigurdsson H. (1983) - *Computer simulation of transport and deposition of the Campanian Y-5 ash*. J. Volcanol. Geotherm. Res. **17**, 89-109.

Crisci G.M., De Francesco A.M., Mazzuoli R., Poli G. & Stanzione D. (1989) - *Geochemistry of recent volcanics of Ischia Island, Italy: evidences of crystallization and magma mixing*. Chem. Geol. **78**, 15-33.

Crisci G.M., De Rosa R., Esperanca S., Mazzuoli R. & Sonnino M. (1991) - *Temporal evolution of a three component system: the Island of Lipari (Aeolian Arc, southern Italy)*. Bull. Volcanol. **53**, 207-221.

De Astis G., La Volpe L., Peccerillo A. & Civetta L. (1997) - *Volcanological and petrological evolution of Vulcano island (Aeolian Arc, southern Tyrrhenian Sea)*. J. Geophys. Res. B4, **102**, 8021-8050.

De Rita D., Frazzetta G. & Romano R. (1991) - *The Biancavilla-Montalto ignimbrite (Etna, Sicily)*. Bull. Volcanol. **53**, 121-131.

De Vivo B., Rolandi G., Gans A., Calvert A., Bohrson W.A., Spera F.J. & Belkin H.E. (2001) - *New constraints on the pyroclastic eruptive history of the Campanian volcanic plain (Italy)*. Mineralogy and Petrology. **73**, 47-65.

Deino A.L., Courtis G.H., Southon J., Terrasi F., Campajola L. & Orsi G. (1994) - *^{14}C and ^{39}Ar/^{40}Ar dating of the Campanian Ignimbrite, Phlegrean fields, Italy*. Icog., Berkeley, CA, p. 77 (abstract).

de Vita S., Orsi G., Civetta L., Carandente A., D'Antonio M., Deino A., di Cesare T., Di Vito M.A., Fisher R.V., Isaia R., Marotta E., Necco A., Ort M., Pappalardo L., Piochi L. & Southon J. (1999) - *The Agnano-Monte Spina eruption (4100 years BP) in the restless Campi Flegrei (Italy)*. In Orsi G., Civetta L. & Valentine G.A. (Eds): Volcanism in the

Campi Flegrei. J. Volcanol. Geotherm Res. 91, p. 269-301.

Di Girolamo P. & Stanzione D. (1973) - *Lineamenti geologici e petrologici dell'isola di Procida*. Rendic. Soc. It. Min. Petr, 81-125.

Di Vito M.A., Isaia R., Orsi G., Southon J., de Vita S., D'Antonio M., Pappalardo L. & Piochi M. (1999) - *Volcanism and deformation since 12,000 years at the Campi Flegrei caldera (Italy)*. J. Volcanol. Geotherm. Res. **91**: 221-246.

Fontugne M., Paterne M., Calvert S.E., Murat A., Guichard F. & Arnold M. (1989) - *Adriatic deep water formation during the Holocene: implication for the reoxygenation of the deep Eastern Mediterranean sea*. Paleoceanography. **4**, 199-206

Frazzetta G., La Volpe L. & Sheridan M. (1983) - *Evolution of the Fossa cone*, Vulcano. J. Volcanol. Geotherm. Res. **17**: 329-360

Gillot P.Y. (1984) - *Datations par la methode du potassium-argon des roches volcaniques récentes (Pleistocene et Holocene). Contribution à l'étude chronostratigraphique et magmatique des provinces volcaniques de Campanie, des îles Eoliennes, de Pantelleria (Italie du Sud) et de la Reunion (Océan Indien)*. Thèse Dr Sc Paris Sud: 249 pp

Gioncada A., Mazzuoli R., Bisson M. & Pareschi M.T. (2003) - *Petrology of volcanic products younger than 42 ka on the Lipari-Vulcano complex (Aeolian Islands, Italy): an example of volcanism controlled by tectonics*. J. Volcanol. Geotherm. Res. **122**, 191-220.

Kallel N., Paterne M., Labeyrie L., Duplessy J.C. & Arnold M. (1997) - *Temperature and salinity records of the Tyrrhenian Sea during the last 18,000 years*. Palaeogeogr. Palaeoloclimatol. Palaeoecol. **84**, 191-215.

Keller J., Ryan W.B.F., Ninkovich D. & Altherr R. (1978) - *Explosive volcanic activity in the Mediterranean over the past 200,000 yr as recorded in deep-sea sediments*. Geol. Soc. Am. Bull. **89**, 591-604

Keller J. (1980) - *The island of Salina*. Rend. Soc. Ital. Mineral. Petrol. **36**, 489-524

Kennet J. (1982) - *Marine tephrochronology*. In: Emiliani E. (Ed): The Sea. Wiley and Sons, 1373-1436

Kieffer G. (1979) - *L'activité de l'Etna pendant les dernières 20 000 ans*. C. R. Acad. Sci. Paris. **280D**, 1023-1026

Jahns S. & van den Boogard C. (1998) - *New palynological and tephrostratigraphical investigations of two salt lagoons on the island of Mljet, south Dalmatia*, Croatia. Veget. Hist. Archaeobot. **7**, 219-234.

Mahood G.A., & Hildreth W. (1986) - *Geology of the peralkaline volcano at Pantelleria, strait of Sicily*. Bull. Volcanol. **48**, 143-172.

Mangerud J., Lie S.E., Furnes H., Kristiansen I.L. & Lomo A. (1984) - *A Younger Dryas ash bed in western Norway and its possible correlations with tephra in cores from the Norwegian Sea and the North Atlantic*. Quat. Res. **21**, 85-104.

McCoy F. & Cornell W. (1990) - *Volcaniclastic sediments in the Tyrrhenian basin*. In: Kastens K.A., Mascle J. et al. (Eds): Proc. ODP. Sci. Results, 107, 291-305. College Station, TX Ocean drilling Program.

Narcisi B. (1993) - *Segnalazione di un livello piroclastico di provenienza etnea nell'area del Fucino (Italia Centrale)*. Il Quaternario. **6**, 87-92.

Narcisi B. (1996) - *Tephrochronology of a Late Quaternary lacustrine record from the Monticchio maar (Vulture volcano, Southern Italy)*. Quat. Sci. Rev. **15**, 155-165

Narcisi B. (1999a) - *Neapolitan Yellow Tuff tephra in the lacustrine sediments of the Valle di Castiglione crater (Alban Hills)*. Acta Vulcanologica. **11**, 265-269.

Narcisi B. (1999b) - *Nuovi ritrovamenti del tephra tardiglaciale etneo in Italia Centrale*. Il Quaternario. **12**, 69-78.

Narcisi B. & Vezzoli L. (1999) - *Quaternary stratigraphy of distal tephra layers in the Mediterranean-An overview*. Global Planet. Change. **21**, 31-50.

Norin E. (1958) - *The sediments of the Tyrrhenian Sea.* Swedish Deep-Sea Exped. Repts., 1947-1948. **8**, 4-136.

Orsi G., Ruvo L. & Scarpati C. (1991) - *The recent explosive volcanism at Pantelleria*. Geol. Rundschau. **80**, 187-200.

Orsi G., de Vita S. & Di Vito M. (1996a) - *The restless, resurgent Campi Flegrei nested caldera (Italy): constraints on its evolution and configuration*. J. Volcanol. Geotherm. Res. **74**, 179-214.

Orsi G., Piochi M., Campajola L., D'Onofrio A., Gialanella L. & Terrasi F. (1996b) - *^{14}C geochronological constraints for the volcanic history of the island of Ischia (Italy) over the last 5000 years*. J. Volcanol. Geotherm. Res. **71**, 249-257.

Pappalardo L., Civetta L., D'Antonio M., Deino A., Di Vito M., Orsi G., Caradente A., de Vita S., Isaia R. & Piochi M. (1999) - *Chemical and Sr-isotopical evolution of the Phlegrean magmatic system before the Campanian Ignimbrite and the Neapolitan Yellow Tuff eruptions*. J. Volcanol. Geotherm. Res. **91**, 179-214.

Paterne M. (1985) - *Reconstruction de l'activitè explosive des volcans de l'Italie du Sud par tèphrochronologie marine*. Thèse Dr. Sciences Paris Sud, 144 pp.

Paterne M., Guichard F., Labeyrie J., Gillot P.Y. & Duplessy J.C. (1986) - *Tyrrhenian Sea tephrachronology of the oxygen isotope record for the past 60 000 years*. Mar. Geol. **72**: 259-285.

Paterne M., Guichard F. & Labeyrie J. (1988) - *Explosive Activity of the South Italian volcanoes during the past 80 000 years as determined by marine tephrochronology*. J. Volcanol. Geotherm. Res. **34**, 153-172.

Paterne M., Labeyrie J., Guichard F., Mazaud A. & Maitre F. (1990) - *Fluctuation of the Campanian explosive activity (South Italy) during the past 190,000 years, as determined by marine tephrochronology*. Earth Planet. Sci. Letts. **98**, 166-174

Paterne M. & Guichard F. (1993) - *Triggering of volcanic pulses in the Campania area, south Italy, by periodic deep magma influx*. J. Geophys. Res. **98**, 1861-1873.

Pescatore T., Rolandi G. (1981) - *Osservazioni preliminari sulla stratigrafia dei depositi vulcanoclastici nel settore SW dei Campi Flegrei*. Boll. Soc. Geol. It. **100**, 233-254.

Pichler H. (1980) - *The Island of Lipari*. Rend. Soc. Ital. Mineral. Petrol. **36**, 415-440.

Poli S., Chiesa S., Gillot P.Y. & Guichard F. (1987) - *Chemistry versus time in the volcanic complex of Ischia (Gulf of Naples, Italy): Evidence of successive magmatic cycles*. Contrib. Mineral. Petrol. **95**, 322-335.

Ramrath A., Zolitschka B., Wulf S. & Negendank J.F.W. (1999) - *Late Pleistocene climatic variations as recorded in two Italian maar lakes (Lago di Mezzano, Lago Grande di Monticchio)*. Quat. Sc. Rev. **18**, 977-992.

Rosi M. & Sbrana A., Eds. (1987) - *Phlegraean Fields*. CNR Quad. Ric. Sci. **114 (8)**, 175

Santacroce R., Ed. (1987) - *Somma-Vesuvius*. CNR Quad. Ric. Sci. **114(9)** 230.

Scandone R., Bellucci F., Lirer L. & Rolandi G. (1991) - *The structure of the campanian Plain and the activity of the Neapolitan volcanoes (Italy)*. J. Volcanol. Geotherm. Res. **48**, 1-31.

Siani G. (1999) - *Estimation de l'âge ^{14}C du réservoir des eaux de surface de la Méditerranée pendant les derniers 18 000 ans. Relations avec la circulation océanique*. Thèse, Université de Paris-Sud Orsay. 171.

Siani G., Paterne M., Michel E., Sulpizio R., Sbrana A., Arnold M. & Haddad G. (2001) - *Sea-Surface radiocarbon reservoir age changes since the last glacial maximum*. Science. **294**, 1917-1920.

Siani G., Sulpizio R., Paterne M. & Sbrana A. (2003) - *Detailed tephrochronology for the last 18,000 years in the south adriatic deep-sea sediments: correlations with terrestrial deposits*. Quat. Sc. Rev. Submitted.

Sigurdsson H., Carey S., Cornell W. & Pescatore T. (1985) - *The eruption of Vesuvius in A.D. 79*. National Geographic Research. **1** (3), 332-387.

Sparks R.J.S. & Huang T.C. (1980) - *The volcanological significance of deep-sea ash layers associated with ignimbrites*. Geol. Magaz. **117**, 425-436.

Sulpizio R., Zanchetta G. & Di Vito M.A. (2003) - *The Late Pleistocene pyroclastic deposits of the southern Campanian Plain: insights on their sources and relationships with tephrostratigraphy*. Int. Journ. Earth Sc. Submitted

Ton-That T., Singer B. & Paterne M. (2001) - *^{40}Ar/^{39}Ar dating of latest Pleistocene (41 ka) marine tephra in the Mediterranean Sea: implications for global climate records*. Earth Planet. Sci. Letts. **184**, 645-658.

Vezzoli L. (1988) - *Island of Ischia*. CNR Quad. Ric. Sci. **114(10)**, 230.

Vezzoli L. (1991) -*Tephra layers in Bannock Basin (Eastern Mediterranean)*. Mar. Geol. **100**, 21-34.

Watts W.A., Allen. J. R.M. & Huntley B. (1996) - *Vegetation history and climate of the Lastglacial period at Laghi di Monticchio, southern Italy*. Quat. Sc. Rev. **15**, 133-153.

Wulf S. (2000) - *Das tephrochronologische referenzprofil des Lago Grande di Monticchio*. PhD thesis. Universitat Potsdam. In German.

Wulf S., Brauer A., Frank U., Mingram J. & Negendank J.F.W. (2001) - *Detailed stratigraphy of the italian explosive volcanism in sediments of Lago grande di Monticchio.* Cities on Volcanoes 2, Auckland, New Zealand, February 22-26th, 2001. Poster with abstract.

Zanchetta G., Di Vito M., Fallick A.E. & Sulpizio R. (2000) - *Stable isotopes of pedogenic carbonate from Somma-Vesuvius area, southern Italy, over the last 18 ka: palaeoclimatic implications*. J. Quat. Sc. **15**, 813-824.

Ms. ricevuto il 20 novembre 2002
Testo definitivo ricevuto il 3 giugno 2003

Ms. received: November 20, 2002
Final text received: June 3, 2003