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NEW CONSTRAINTS ON THE OCCURRENCE OF Y-3 UPPER PLEISTOCENE TEPHRA MARKER LAYER IN THE TYRRHENIAN SEA

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ABSTRACT: Munno R. & Petrosino P., *New constraints on the occurrence of Y-3 Upper Pleistocene tephra layer in the Tyrrhenian Sea*. (IT ISSN 0394 – 3356, 2004).
A widespread tephra layer, other than the well known Y-5, has been identified in the Upper Pleistocene marine succession in the Tyrrhenian Sea. Two investigated gravity cores showed, in fact, the presence of two companion pyroclastic tephra layers, separated by a varying thickness of pelagic sediments. The pyroclastic layers are mainly made up of pumice fragments and glass shards together with few K-feldspars and clino-pyroxene crystals. Both layers are alcali-trachytic in composition, even though a sharp difference emerges in the K/Na ratio that characterizes the two glasses. 14C dating of foraminiferous shells embedded in the clay layers directly underlying the most recent tephra gave an age of about 26 ka. An accurate review of literature regarding tephrostratigraphy in the Mediterranean area made it possible to correlate the older one to the Y-5 marker layer, joined to the Campanian Ignimbrite eruption, a paroxystic event in the Campi Flegrei area. The younger layer has been correlated with the Y-3 marker layer and probably represents another huge pyroclastic flow event from the Campanian area, whose products have not yet been distinguished in the field from those of typical Campanian Ignimbrite. This work clearly identifies the layer Y-3, firstly recorded by Keller et al. (1978), as the result of a specific volcanic event different from the Campanian Ignimbrite (marker layer Y-5), defines its mineralogical and chemical composition together with its relative age offering an useful support for paleoclimatic and paleoenvinromental reconstruction of the sedimentation in the Tyrrhenian area.

RIASSUNTO: Munno R. & Petrosino P., Caratterizzazione di Y-3, un tefra per il Pleistocene superiore nel Mar Tirreno. *(IT ISSN 0394 – 3356, 2004).*
Nella successione marina del Pleistocene Superiore, nel basso Tirreno, è stato identificato e caratterizzato un livello di tefra diverso dall'Y-5, che è il livello marker in genere associato con la grossa eruzione dell' Ignimbrite Campana. Molti gravity cores analizzati hanno infatti mostrato la presenza di una doppietta di livelli piroclastici, separati da uno spessore variabile di sedimenti pelagici. I livelli di tefra sono entrambi costituiti da frammenti di pomici e shard vetrose con una minima percentuale di cristalli di k-feldspato e clinopirosseno. Entrambi i livelli mostrano un chimismo alcalitrachitico, ma sono caratterizzati da una netta differenza nel rapporto K/Na. Datazioni 14C ottenute su gusci di foraminiferi prelevati all'interno dell'argilla alla base del tefra più recente hanno fornito un'età di circa 26 ka. Una revisione accurata della letteratura riguardante la tefrostratigrafia nell'area mediterranea ha permesso di correlare il più antico con il marker Y-5, che rimanda all'eruzione dell'Ignimbrite Campana, un evento parossistico proveniente dall'area flegrea. Il livello più recente è stato correlato con il marker Y-3 e, probabilmente, rappresenta un altro evento di rilievo dell'area campana, i cui prodotti, sul campo, non sono stati ancora distinti da quelli dell'Ignimbrite Campana. Il lavoro identifica in maniera definitiva il livello Y-3, individuato per la prima volta da Keller et al. (1978), come il risultato di un evento specifico diverso dall'Ignimbrite Campana (marker layer Y-5), ne definisce la composizione mineralogica e chimica, l'età relativa e, mappandone la distribuzione, offre un utile supporto per la ricostruzione paleoclimatica e paleoambientale della sedimentazione nell'area mediterranea.

Keywords: gravity core, tephra layer, tephrocronology, Campanian Ignimbrite

Parole chiave: carote, livello di tefra, tefrocronologia, Ignimbrite Campana

1. Introduction

During the last 40000 years several violent volcanic eruptions took place in the Campanian volcanic province, southern Italy. In particular, the main volcanic sources in the area for that time-span are Campi Flegrei and Somma-Vesuvio. Although a good knowledge of their activity is now available, and the products are quite well mapped in areas proximal to the sources, some difficulty however persists in the identification of the origin of tephra layers when they are found interbedded to sedimentary sequences in areas many kilometres far from the volcanoes. This is the particular field of interest of tephrostratigraphy and tephrochronology that, together with a detailed biostratigraphy, make it possible to identify marker horizons useful for geological and geomorphological reconstructions.

Starting from about 40 ka B.P. the best represented Campanian tephra layer in the Central Mediterranean is Y-5, so labelled according to the nomenclature of tephra layers in the Eastern Mediterranean of Keller et al. (1978). Although a great deal of testified occurrences of this pyroclastic layer are available, no clear attribution to a source has been made until recent. Firstly, Keller *et al*. (1978), in fact, attributed it to the Ischia Citara-Serrara Fontana Formation, even if this formation, which is the product of several small-volume eruptions, is not widely dispersed in the field (Vezzoli, 1988). Shortly following this attribution, Thunnel *et al*. (1979) definitely correlated the Y-5 tephra layer with the Campanian Ignimbrite, recorded in the field as a widespread pyroclastic flow deposit (Barberi *et al*., 1978; Fisher *et al*., 1993; Rosi *et al*., 1996) joined to a thick pyroclastic fall layer emplaced

towards the East from the Campi Flegrei source area (Rosi *et al*., 1999). Most of the recent tephrostratigraphic studies agree with a Campanian Ignimbrite origin for the Y-5 layer; only Paterne *et al.* (1986, 1988), in fact, still ascribe the tephra to the Citara-Serrara Fontana Formation of the Ischia Island.

Actually, the attribution of Y-5 to the Campanian Ignimbrite rises also some chronological problems. The deposit has been dated by single crystal high precision $^{40}Ar/^{39}Ar$ method to 37.1±0.4 ka B.P. (Deino *et al*., 1992,1994), but new $^{40}Ar/^{39}Ar$ geochronology defines the age of the Campanian Ignimbrite at 39.28±0.11 ka, about 2000 years older than the previous estimate (De Vivo *et al*., 2002). A great deal of ^{14}C dates on paleosols and charbonized wood, available in literature (Alessio *et al*., 1971; 1973; 1974), however, gave an age scattering between 25 and 40 ka B.P. Two K/Ar dates (Curtiss, 1966; Cassignol and Gillot, 1982) gave an age of 30 and 34.5 B.P. ka, respectively. According to this data some authors believe that the Campanian Ignimbrite must not be considered as a single eruptive episode, entailing the emplacement of a single pyroclastic flow deposit, but as the result of a series of eruptive episodes, separated by significant temporal hiatuses (Scandone *et al*., 1991; Calderoni *et al*., 1993), that brought to the emplacement of the ignimbrite deposit observed in Campania. More recently, De Vivo *et al*., 2002, identify on the Campanian Plain volcanic events other than the Campanian Ignimbrite, displaying similar field features. The hypothesis of the existence of more than a single volcanic event representing the Campanian Ignimbrite l.s. is supported by the occurrence, in the tephrostratigraphical record of the Central Mediterranean area, of more than one ash layer in the 25-40 ka time-span, attributed by Paterne *et al*. (1988) to a "Campanian Ignimbrite Series".

A second Campanian Tephra layer has never been recorded along the Tyrrhenian coast, but only detected in some deep sea cores in the Ionian Sea. The layer, named Y-3, displays an extrapolated age of about 25 ka B.P. (Narcisi & Vezzoli, 1999), is trachytic in composition and has generically been attributed by Keller *et al*. (1978) to the Campanian Province. Paterne et al. (1988), on the contrary, ascribed it to the "Campanian Ignimbrite Series".

A late glacial Campanian marker tephra layer, labelled C-2 in Paterne *et al*., 1988, has been recorded in the Central Mediterranean and correlated with the 12 ka B.P. Campi Flegrei eruption of Neapolitan Yellow Tuff.

The main Holocene Campanian tephra layers are linked to the Somma-Vesuvio activity. The most diffused marker layers are Z-1, correlated to the Somma-Vesuvio Avellino eruption (ca 3800 B.P., Rolandi *et al*., 1998) and the tephra related to the A.D. 79 plinian eruption. They both feel the effect of the different direction of emplacement of fall products, so Z-1 is mainly recorded in the East Mediterranean, whereas A.D. 79 tephra is better represented in the Central Mediterranean.

The present paper investigates in detail the tephra interbedded to the sedimentary records in two gravity cores of the southern Tyrrhenian Sea. The aims of the research are:

- to definitely identify the presence of a single or of more than one tephra layer of Campanian origin in the age range 40-25 ka B.P., that encompasses all the ^{14}C dating obtained on paleosols underlaying Campanian Ignimbrite deposits,
- to point out the distribution of the tephra layers and, eventually, to hypothesize a source for the pyroclastic products.

In this regard, the work investigates gravity cores located near the Campanian Tyrrhenian coastal area, since the emplacement of Campi Flegrei and Vesuvio products is more probable in this area, and uses sedimentological and biostratigraphic data as a support to chronologically locate the identified tephra layers. The present work is part of a multidisciplinary research that involved, through the last five years, geologists, sedimentologists, palinologists, palaeontologists and volcanologists, aiming to investigate environmental and climatic evolution of the southern Tyrrhenian Sea through high resolution records. The results of these researches are here reported only when useful to argue tephrostratigraphical conclusions. More detailed information about strictly sedimentological and palaeontological aspects can be found in Buccheri *et al*. 2002a,b. Few chemical data on glass shards and preliminary tephrostratigraphical considerations have been reported by one of the authors (R.M.) in Buccheri *et al.* 2002a. The present paper represents a step forward, using new tephra and mineral characterization on the two cores and on-land comparison samples, and revising the Upper Pleistocene tephrostratigraphical record in the whole Tyrrhenian area.

2. EXPERIMENTAL

2.1 Tephra layers in the cores

Two gravity cores located offshore the Campanian Tyrrhenian border have been investigated to reconstruct the tephrostratigraphical record of the area.

The first core, named C106 (φ = 40°29'32'', λ = 14°42'32'', depht = 292 m) is located in the Salerno Gulf, directly offshore the Sele River mouth, and is 6,40 m long.

The second core, named C45 (φ = 39°45'10'', λ = 15°20'20'', depht = 1053 m) is located in the Policastro Gulf, in a valley-type depression of the sea floor, about 63 nautical miles SW of Sapri town, and is 4.70 m long. Figure 1 shows the location of investigated cores together with main deep sea morphological contours.

Both the cores consist of an alternance of clay, silt, silt-sandy and rare sandy layers, in which the coarse fraction is made up of organic (planktonic and bentonic Foraminifers, Pteropods) and inorganic material (pumice fragments, quartz and mica crystals). Along the cored successions some coarse grained layers, mainly made up of sharp edged pumice fragments and crystals, displaying features of a primary volcanic deposition, have been fully investigated to reconstruct the complete tephrostratigraphical record (Fig.2).

Along the core C106 the first tephra layer has been identified at 55.5 cm from the top and its lower limit is 110.5 cm. The whole thickness is 55 cm. The layer shows a sharp basal contact with the underlying clay layer. The basal part of the pyroclastic layer (110.5-88.5 cm) consists of whitish pumice fragments (sample A1(a)), overlain by a 10cm thick layer consisting of gray

pumice and rare lava lithic fragments (sample A1(b)). Both the samples display maximum clasts grain-size greater than 2mm and contain pumice fragments, a minor fraction of lava lithic fragments and rare limestone fragments.

The second tephra layer of C106 has been identified at 565 cm from the top of the core and its lower limit is 579 cm. The whole thickness is 14 cm. The layer does not show a sharp basal contact with the underlying clay layer. The layer consists of some sublayers containing white and gray pumice fragments (sample A2), and passes towards the top to a dark clay level. All samples display maximum clasts grain-size greater than 2mm and contain pumice fragments and rare lava lithic fragments.

Juvenile fraction in both samples was represented by elongated pumice clasts, with very well developed elongated vesicles.

Along the C45 core three main tephra layers have been recognized. The first one has been identified at 25 cm from the top of the core and its thickness is about 7 cm. The layer is mainly made up of grey pumice fragments - sample B1(b), maximum grain size 1 mm and rare lava and limestone lithic fragments, but in the basal part whitish pumice fragments are abundant - sample B1(a).

The second tephra layer of C45 core is located at 380 cm from the top and is 3 cm thick. It is made up of pumice fragments and glass shards, maximum grain size of clasts is 2 mm; no lithic fraction has been detected (sample B2).

The third tephra layer is 460 cm deep and 3.5 cm thick. Juvenile fraction is represented by glass shards and pumice fragments whose maximum grain-size is 1 mm; very rare lava lithic fragments have also been found (sample B3).

Mineralogical component percentage evaluation has been performed by counting at least 100 crystals for each level; the results of the analysis are shown in Table 1. K-feldspar, biotite and clinopyroxene are almo-

Table 1 - Mineralogical component percentage evaluation for all investigated tephra layers.

Valutazione semiquantitativa delle fasi minerali presenti all'interno dei livelli di tefra.

core	sample	feldspar	leucite	biotite	cpx	garnet	Fe-Ti oxides
C106	A1 (a)	••	••		•		
	A1 (b)	••	•		•	•	
	A2	•••		•	•		
C45	B1 (a)	••	••		•		
	B1 (b)	••	•		•	•	
	B2	••		•	•		•
	B3	••		•	•		•

• l represents about 20%

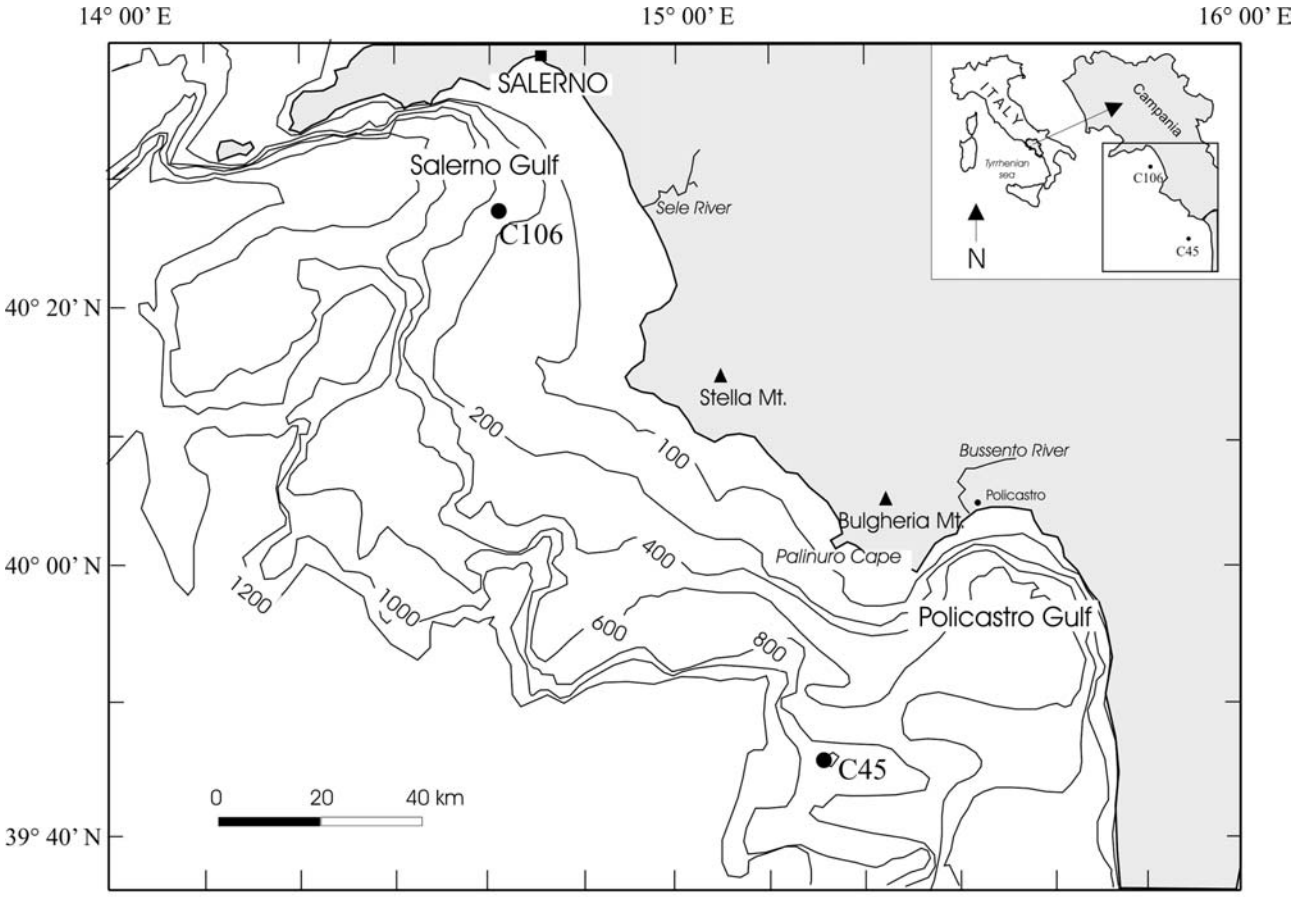

Fig.1 - Map of the Salerno and Policastro Gulfs with main submarine morphological contours and location of investigated cores.

Carta batimetrica dei Golfi di Salerno e Policastro con l'ubicazione dei gravity cores studiati.

st ubiquitous phases. Only the topmost layer of both cores shows leucite and garnet among the mineral phases.

Chemical composition of glass fragments and crystal grains was determined by microprobe analysis using E.D.S. system on loose fragments of 0.5 mm grain-size, at CISAG (Centro Interdipartimentale di Servizio per Analisi Geomineralogiche) at University of Naples Federico II. With regards to the chemical composition of glasses, the reported one represents a mean composition, obtained from at least ten punctual analyses on different glass shards. Chemical composition of all the samples is reported in Table 2.

As a reference for correlations with the products of volcanic eruptions recorded in the field, Table 3 reports the representative analyses of mineral grains for C45 core, chosen because it contains all the recognized tephra layers. The whole set of analytical data on minerals, both for tephra layers in the cores and for comparison samples, are at disposal upon request to the authors.

2.2 Comparison analyses

In order to better clarify the possible correlations, chemical analyses other than on the C106 and C45 pyroclastic layers have been performed. The comparison samples have been selected among the most widespread Campi Flegrei and Somma Vesuvio eruptions products ranging in age between about 40 and the present. The age range has been chosen taking into account the ^{14}C AMS dating that provided the chronostratigraphic framework for both cores, as reported in Buccheri et al. (2002a,b) and in Figure 2.

The first comparison sample is represented by pumice fragments extracted from the pyroclastic fall layer directly underlaying the Ignimbrite Campana grey tuff at Cologna, NE of Salerno.

The other comparison samples are represented by the Somma-Vesuvio Codola and Pomici di Base eruptions products (Rolandi, 1997), samples courtesy of prof. Giuseppe Rolandi.

Apart from this, to better define the characteristics of Y-3, prof. Keller has been asked a little sample of the

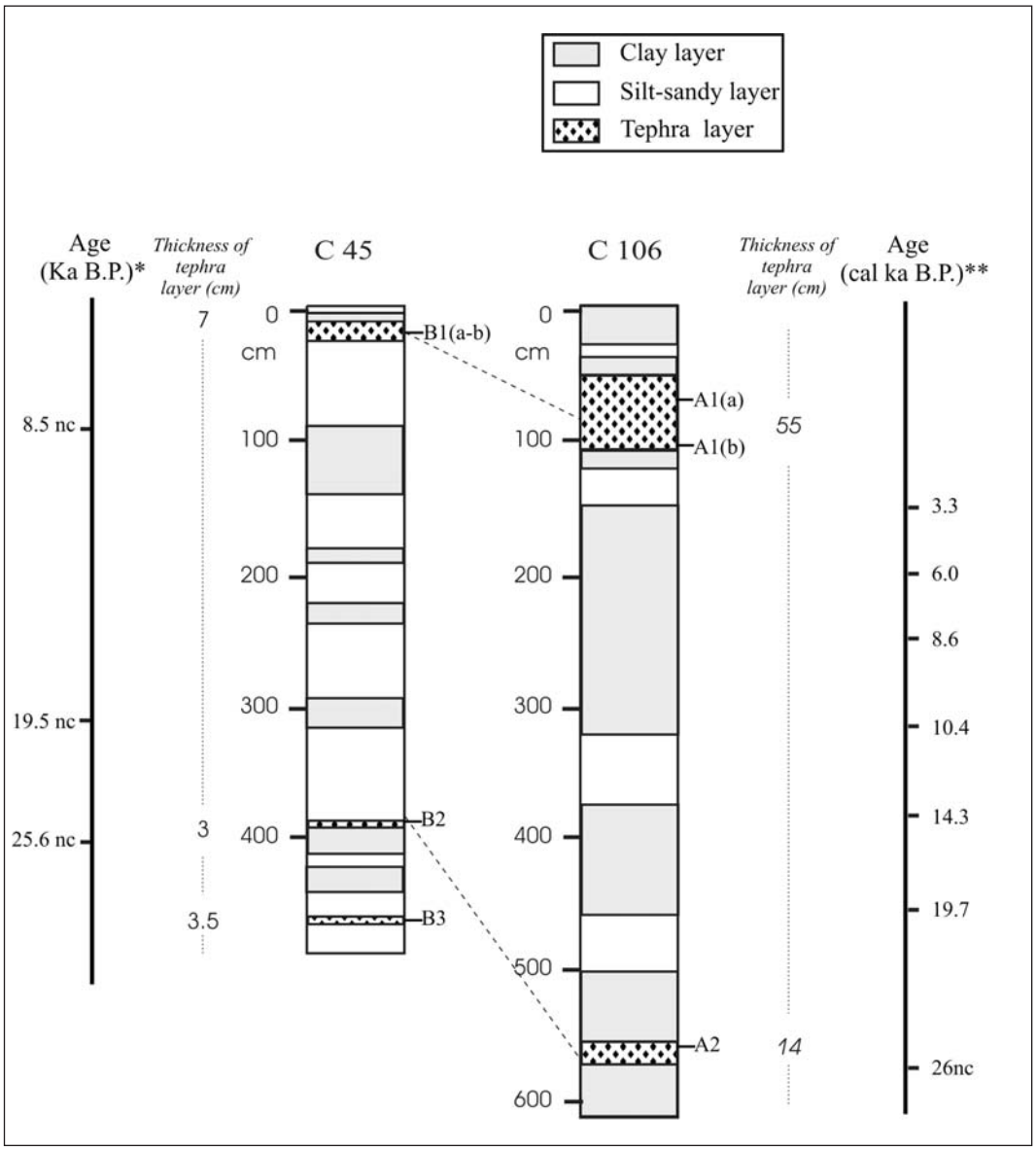

Fig. 2 - Stratigraphic succession of C45 and C106 core with interbedded tephra layers and thickness of tephra layers. *data from Buccheri et al., 2002a;**data from Buccheri *et al.*, 2002b; nc = not calibrated.

*Successione stratigrafica delle carote C45 and C106 con indicazione dei livelli di tefra intercalati e dei relativi spessori. *dati da Buccheri et al., 2002a;**dati da Buccheri et al., 2002b; nc = età non calibrata.*

Table 2 - SEM-EDS glass composition recalculated to 100 water free of all the investigated tephra samples. n= number of analyses; standard deviation in parentheses.

Composizione SEM-EDS del vetro ricalcolata a 100 per i livelli di tefra esaminati. n= numero di analisi; deviazione standard in parentesi.

sample	C106 A1(a)	C106 A1(b)	C106 A2	C45 B1(a)	C45 B1(b)	C45 B2	C45 B3
n	11	10	21	10	12	11	11
SiO_2	55.36 *(0.27)*	56.54 *(0.19)*	62.63 *(0.20)*	54.86 *(0.24)*	56.04 *(0.32)*	62.41 *(0.32)*	61.53 *(0.48)*
TiO_2	0.48 *(0.05)*	0.24 *(0.03)*	0.34 *(0.06)*	0.45 *(0.08)*	0.55 *(0.07)*	0.33 *(0.10)*	0.39 *(0.06)*
Al_2O_3	21.01 *(0.17)*	22.72 *(0.28)*	18.24 *(0.12)*	20.74 *(0.20)*	21.36 *(0.14)*	18.30 *(0.29)*	18.73 *(0.17)*
FeO*	4.07 *(0.16)*	2.36 *(0.21)*	3.15 *(0.12)*	3.93 *(0.11)*	3.39 *(0.12)*	3.17 *(0.10)*	3.16 *(0.19)*
MnO	0.17 *(0.08)*	0.13 *(0.11)*	0.15 *(0.08)*	0.13 *(0.04)*	0.09 *(0.03)*	0.15 *(0.08)*	0.23 *(0.07)*
MgO	0.59 *(0.06)*	0.11 *(0.06)*	0.47 *(0.08)*	1.38 *(0.09)*	0.48 *(0.08)*	0.50 *(0.09)*	0.50 *(0.10)*
CaO	4.23 *(0.29)*	2.98 *(0.15)*	2.12 *(0.10)*	4.47 *(0.24)*	4.06 *(0.31)*	2.13 *(0.10)*	1.74 *(0.06)*
Na_2O	5.83 *(0.21)*	7.39 *(0.64)*	4.15 *(0.19)*	5.37 *(0.17)*	7.13 *(0.21)*	4.30 *(0.15)*	6.05 *(0.33)*
K_2O	8.28 *(0.44)*	7.54 *(0.76)*	8.75 *(0.14)*	8.67 *(0.29)*	6.90 *(0.30)*	8.71 *(0.08)*	7.67 *(0.21)*
D.I.	79.56	86.03	86.82	77.40	81.75	86.95	89.53
Ne	22.10	24.89	0.00	22.78	22.88	1.07	8.24

FeO* = total Fe as FeO

Table 3 - Representative microprobe analyses of mineral phases extracted from C45 core tephra layers.

Analisi in microsonda dei minerali rappresentativi estratti dai livelli di tefra della carota C45.

B1 (a-b)

	leucite	k-feldspar	cpx	cpx	biotite	amphibole
SiO_2	54.50	63.48	51.18	43.96	36.00	33.68
TiO_2	0.11	0.10	0.43	1.55	3.53	1.89
Al_2O_3	22.76	18.81	2.36	8.30	15.50	15.21
FeO*	0.37	0.09	4.65	11.05	11.65	24.84
MnO	0.02	0.05	0.12	0.12	0.08	1.02
MgO	0.08	0.18	16.22	10.26	18.03	4.30
CaO	0.12	0.33	23.85	23.58	0.00	11.55
Na_2O	0.83	1.23	0.44	0.46	0.49	1.47
K_2O	20.51	15.03	0.00	0.00	10.33	3.37
Total	99.30	99.30	99.25	99.28	95.61	97.33

B2

	k-feldspar	cpx	biotite	magnetite
SiO_2	63.60	49.31	35.81	0.29
TiO_2	0.13	0.57	4.56	6.23
Al_2O_3	18.88	3.77	14.50	2.56
FeO*	0.23	8.31	14.49	80.91
MnO	0.03	0.36	0.23	0.87
MgO	0.13	13.53	15.41	1.58
CaO	0.55	23.00	0.00	0.06
Na_2O	1.84	0.53	0.56	0.10
K_2O	13.95	0.00	9.84	0.04
Total	99.34	99.38	95.40	92.64

B3

	k-feldspar	cpx	biotite	amphibole	magnetite
SiO_2	63.58	49.01	35.40	38.15	0.36
TiO_2	0.24	0.49	4.79	1.94	5.22
Al_2O_3	18.87	2.97	15.06	12.20	4.11
FeO*	0.27	11.28	13.89	19.54	79.73
MnO	0.02	0.71	0.17	0.48	0.57
MgO	0.07	11.31	15.70	8.83	2.58
CaO	0.48	22.83	0.00	11.84	0.00
Na_2O	1.82	0.79	0.53	1.57	0.40
K_2O	14.12	0.03	10.02	2.77	0.00
Total	99.48	99.42	95.56	97.32	92.97

FeO* = total Fe as FeO

layer firstly ascribed to Y-3, from the core RC9-191 of the Ionian Sea. The sample has been analysed using the same methods as the unknown layers object of the paper. The analysis of Keller *et al*. (1978) had, in fact, been performed by X-ray fluorescence on a glass enriched sample and, at present, it is well known (Rinaldi, 1979; Narcisi & Vezzoli, 1999) that punctual analytical methods (EDS, WDS, etc) best suit tephrostratigraphycal problems.

The last comparison sample is split into two subsamples respectively of white and grey pumice fragments from the A.D. 79 eruption, extracted from the Poggiomarino and Zabatta outcrops. It has been analysed since its south-west trending diffusion makes its presence expected in the Salerno Gulf recent sedimentary record.

Table 4 reports SEM-EDS glass compositions for

Table 4 - SEM-EDS glass compositions recalculated to 100 water free for the comparative samples. n= number of analyses; standard deviation in parentheses.

Composizione SEM-EDS del vetro ricalcolata a 100 per i campioni di riferimento. n= numero di analisi; deviazione standard in parentesi.

	1	2	3	4	5	6	7	8
n	*10*	XRF	*10*	*10*	*8*	*11*	*9*	*15*
SiO_2	61.52 *(0.20)*	61.78	62.76 *(0.36)*	57.87 *(0.30)*	62.45 *(0.08)*	56.46 *(0.25)*	54.88 *(0.21)*	61.01
TiO_2	0.37 *(0.06)*	0.44	0.36 *(0.03)*	0.58 *(0.08)*	0.35 *(0.03)*	0.42 *(0.05)*	0.44 *(0.03)*	0.40
Al_2O_3	18.88 *(0.15)*	18.96	18.21 *(0.16)*	19.16 *(0.20)*	18.34 *(0.08)*	21.35 *(0.18)*	20.67 *(0.11)*	18.63
FeO*	3.06 *(0.12)*	3.23	2.98 *(0.21)*	3.90 *(0.16)*	2.74 *(0.14)*	3.34 *(0.17)*	4.09 *(0.16)*	3.55
MnO	0.23 *(0.05)*	0.17	0.17 *(0.12)*	0.16 *(0.06)*	0.13 *(0.09)*	0.21 *(0.10)*	0.23 *(0.04)*	0.05
MgO	0.47 *(0.05)*	0.59	0.25 *(0.12)*	0.63 *(0.11)*	0.35 *(0.04)*	0.56 *(0.09)*	0.67 *(0.08)*	0.77
CaO	1.75 *(0.08)*	1.98	2.07 *(0.15)*	4.43 *(0.46)*	2.75 *(0.09)*	4.05 *(0.28)*	5.03 *(0.17)*	2.47
Na_2O	6.01 *(0.24)*	5.57	4.44 *(0.19)*	3.30 *(0.27)*	4.24 *(0.08)*	7.17 *(0.23)*	5.55 *(0.15)*	2.65
K_2O	7.71 *(0.20)*	7.28	8.75 *(0.26)*	9.96 *(0.54)*	8.66 *(0.06)*	6.45 *(0.21)*	8.45 *(0.28)*	9.93
D.I.	89.48	86.86	88.18	78.47	85.98	80.81	77.67	80.77
Ne	8.20	3.89	1.28	9.82	1.26	21.24	22.73	0.00

FeO* = total Fe as FeO

1 - Pumice fragment from Campanian Ignimbrite pyroclastic fall deposit at Cologna (Salerno).
2 - Y-5 tephra from core RC9-191, in Keller et al. (1978), recalculated water free.
3 - Y-3 tephra from core RC9-191, sample courtesy of prof. J. Keller.
4 - Pumice fragment from Somma Vesuvio Codola eruption pyroclastic fall products, sample courtesy of prof. G. Rolandi.
5 - Pumice fragment from Somma Vesuvio Pomici di Base eruption pyroclastic fall products, sample courtesy of prof. G. Rolandi.
6 - White pumice fragment from Somma Vesuvio AD 79 eruption pyroclastic fall deposit from the Poggiomarino outcrop.
7 - Grey pumice fragment from Somma Vesuvio AD 79 eruption pyroclastic fall deposit from the Zabatta (San Giuseppe Vesuviano) outcrop.
8 - Unit C Ignimbrite matrix glass from Scarafea (Signorelli *et al*., 1999).

the comparative samples.

Figure 3 reports the TAS classificative plot (Le Maitre, 1989) for the investigated tephra layers and the comparison samples, and Figure 4a reports the DI-Ne plot of Armienti et al. (1983), more apt to the slighty saturated and alkali-rich rocks of Campanian area.

3. RESULTS AND DISCUSSION

The modal and chemical compositions of pyroclastic layers, identified in the two gravity cores, show two compositional fields, phonolitic s.l. and alkali-trachytic.

The presence of a phonolitic layer

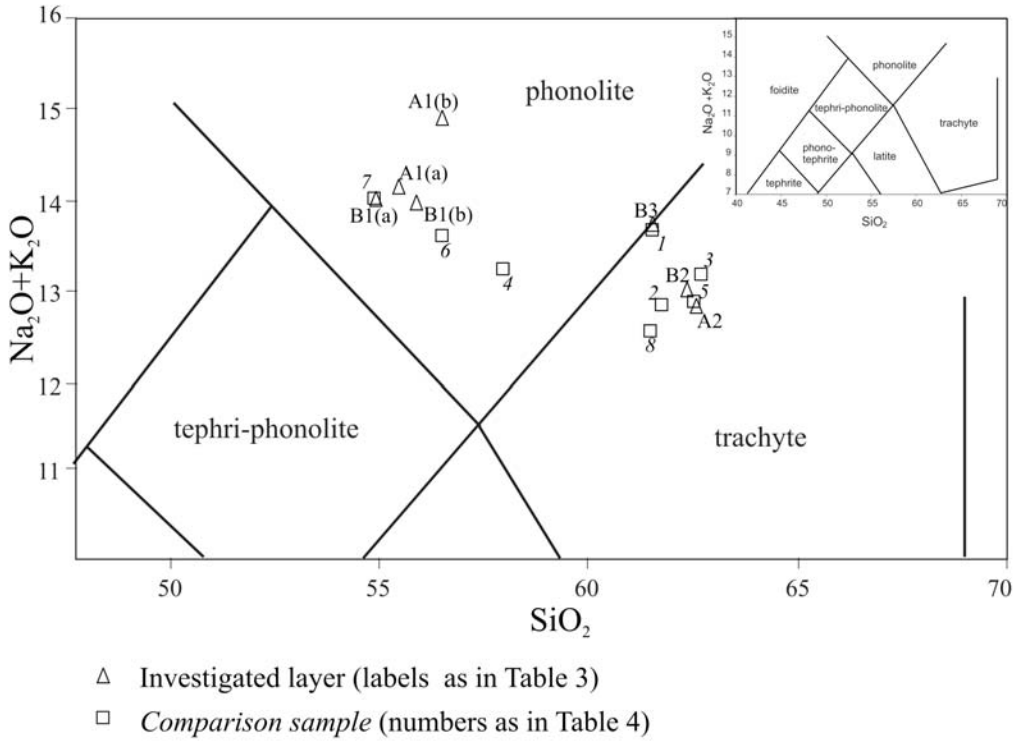

Fig. 3 - TAS classificative plot for investigated tephra layers and for comparison samples. For comparison samples symbols legend see Table 4.

Diagramma classificativo TAS per i livelli di tefra e per i campioni di riferimento. Per la legenda dei simboli dei campioni di riferimento vedi Tabella 4.

in the higher part of the C106 (samples A1(a) and A1(b), Tab.2) and C45 (samples B1(a) and B1(b), Tab.2) core makes it possible to hypothesize the relationship with the Somma-Vesuvio A.D. 79 eruption (samples 6 and 7, Tab.4). The fall phase of this eruption, in fact, was dispersed towards the Salerno Gulf. Besides this, the change in colour (from white to gray) and in composition (from phonolitic to tephry-phonolitic) of pumice fragments is a diagnostic feature for A.D. 79 eruption products. Moreover, garnet is a typical mineralogical phase for white pumice fragments as leucite is for gray.

The tephra layers alkali-trachytic in composition, found both in C106 and C45, represented by samples A2 and B2 (Tab.2), respectively, could be related to Somma-Vesuvio first activity, namely to Codola (25.1±0.4 ka B.P. - Alessio et al., 1974 – sample 4, Tab.4) and Pomici di Base (18.3±0.18 ka B.P. - Andronico *et al*., 1995– sample 5, Tab.4) eruptions, but also repeat the general chemical features of Campi Flegrei products. The dispersal of Somma-Vesuvio Codola eruption fall products is, at present, not well known, but the comparison of Si/Ca ratio in Codola and in sample A2 and B2 juvenile fraction makes it possible to exclude the correlation (Fig.3, 4). As regards the Pomici di Base eruption products, even if the chemical composition is quite comparable, reconstructed fall products distribution is towards the NE from Vesuvio and not in good agreement with the presence of the layer in the Salerno Gulf. Besides this, the age of Pomici di Base eruption does not fit the ^{14}C age of 26030±150 y B.P (Buccheri *et al*., 2002a) and of 25570±110 y B.P. (Buccheri *et al.*, 2002b) obtained on the microfossils in the clay layer directly underlying the tephra, respectively in the C106 and in the C45 core. This is very reliable since: - in C45 core a ^{14}C AMS age of 19490±110 y B.P. has been recorded in the clay 70 cm above the pyroclastic layer, - in C106 core a calibrated ^{14}C AMS age of about 19.7 ka B.P. has been recorded in the clay 100 cm above the pyroclastic layer (see Fig.2) - no evidence of hiatuses in sedimentation is present along these clay layers.

A2 and B2 tephra, however, find a very good correspondence in mineralogical content and chemical composition (Tab.4) of Y-3 tephra found in the Ionian Sea. Besides this, in core RC9-191, investigated by Keller *et al*. (1978), the dating of sapropels gave an age of about 26.000, well fitting the paleontological age obtained for the same layer in the two cores investigated here.

As to the third pyroclastic layer in the C45 core, represented by sample B3, it repeats the composition of the fall products of the Campanian Ignimbrite eruption sampled at Cologna. Apart from this, it well resembles the composition of Y-5 marker layer as reported in Keller *et al*. (1978), definitely correlated to the Campanian Ignimbrite in Narcisi and Vezzoli (1999), and that of the comparison sample. The attribution of lowermost layer to Y-5 is consistent with the presence of 25 cm thickness of pelagic sediments between the layer and the clay level dated at about 26 ka B.P. in C45 core, taking into account a sedimentation rate of about 1,7 cm/ka, as deduced by Buccheri *et al.* (2002a).

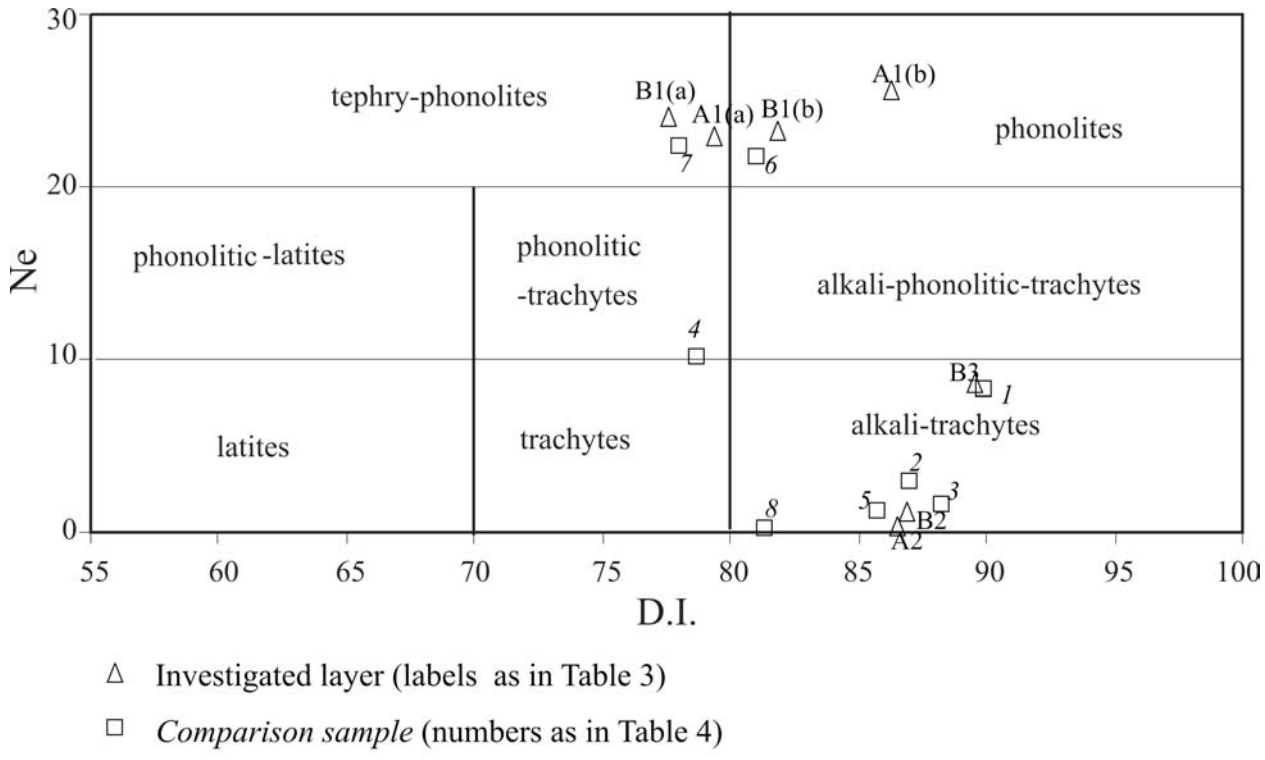

Fig. 4 D.I. - Ne plot for investigated tephra layers and for comparison samples. For comparison samples symbols legend see Table 4.

Diagramma D.I. - Ne per i livelli di tefra e per i campioni di riferimento. Per la legenda dei simboli dei campioni di riferimento vedi Tabella 4.

4. CONCLUSIVE REMARKS

The results of the tephrostratigraphical investigation of C45 and C106 tephra layers are so summarized:

- layer B3 of C45, the oldest tephra layer identified, is correlable to the Y-5 marker layer and to the Campanian Ignimbrite basal pumice fall.
- Layer B2 of C45 and layer A2 of C106 represent the product of the same volcanic event and have been correlated to the Y-3 marker layer.
- Layer B1(a,b) of C45 and layer A1 (a,b) of C106 represent the pumice fall products of the A.D. 79 Somma-Vesuvio eruption.

In order to confirm the presence of two different tephra layers in the 40-25 ka time-span, the tephrostratigraphical literature reporting data for primary tephra layers in the Tyrrhenian Sea has been revised (Paterne 1985; Paterne et al., 1986; Paterne et al., 1988; McCoy and Cornell, 1990; Calanchi et al., 1994). The revision of data entailed the recovering of all stratigraphical relations, modal compositions and chemical analyses of juvenile fraction and, where available, of mineral phases of tephra layers identified in many cores and new correlations have been made in the light of the obtained results. Tab. 5 reports these new correlations that confirm the presence of Y-3 tephra layer in southern Tyrrhenian Sea and along the Campanian coast, whereas Y-5 results more widely dispersed (Fig. 5).

Table 5 - SEM-EDS glass composition of Y-3 and Y-5 tephra layers occurring in the Tyrrhenian sea.

Composizione SEM-EDS dei vetri dei livelli di tefra Y-3 and Y-5 reperiti in alcune carote del Mar Tirreno.

	Y-5	Y-5	Y-5	Y-5	Y-3	Y-3	Y-3
core	KET 8003	KET 8004	KET 8011	KET 8022	KET 8003	KET 8004	KET 8011
	°	°	°°	°	°	°	°°
SiO_2	62.29	62.46	61.90	63.19	60.42	60.59	59.90
TiO_2	0.36	0.36	0.34	0.00	0.40	0.23	0.36
Al_2O_3	19.54	19.59	19.63	19.45	20.18	20.08	20.19
FeO*	2.75	2.49	2.58	2.66	2.34	2.43	2.46
MnO	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
MgO	0.11	0.11	0.12	0.00	0.08	0.04	0.07
CaO	1.63	1.63	1.88	1.73	3.38	3.16	3.56
Na_2O	5.99	6.01	5.86	5.69	3.92	4.39	4.59
K_2O	7.33	7.35	7.69	7.27	9.28	9.08	8.87

° in Paterne et al., 1986 °° in Paterne, 1985 FeO* = total Fe as FeO

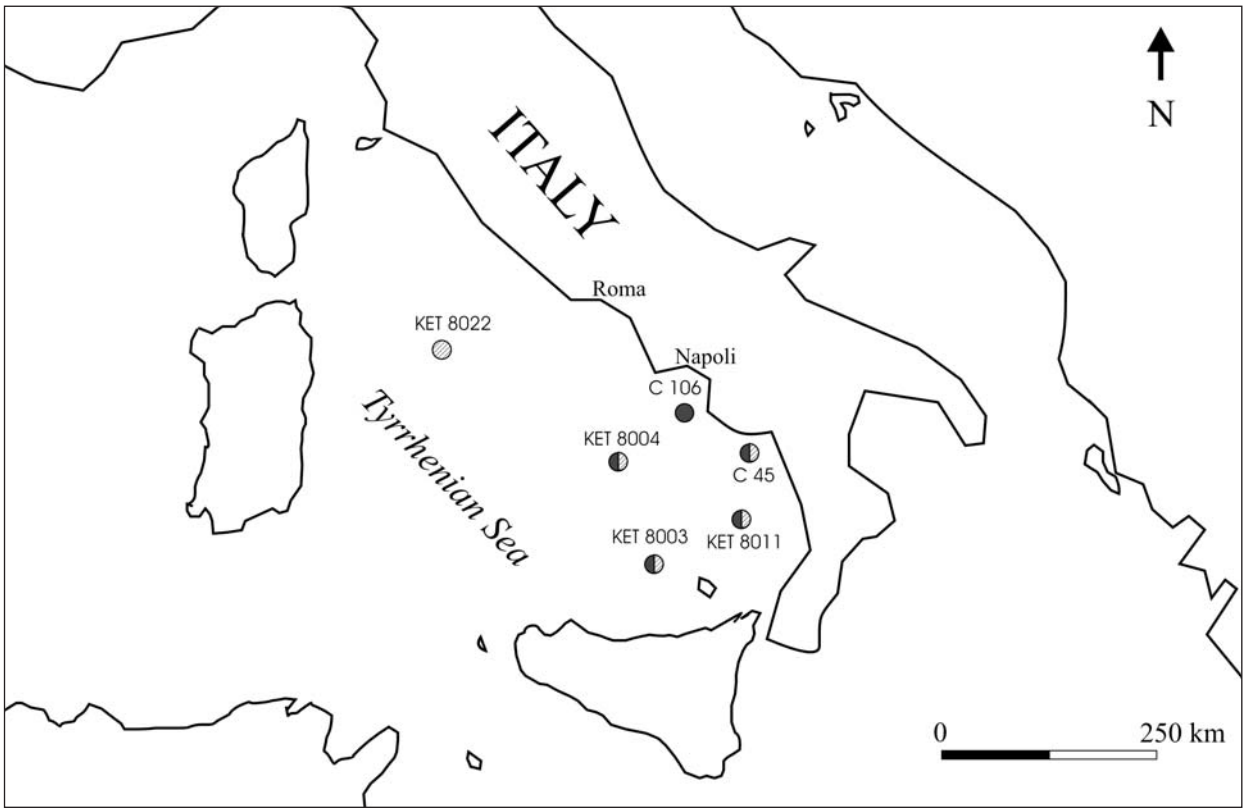

Fig. 5 - Sketch map of Tyrrhenian Sea reporting the occurrence of Y-3 and Y-5 primary tephra layers, as deduced from the revision of tephrostratigraphic literature regarding the Tyrrhenian Sea and from present paper data. Circles indicate coring sites; black area in the circle indicates the occurrence of Y-3 tephra, dashed area in the circle indicates the occurrence of Y-5 tephra. For core references see Table 5.

Schema del Mar Tirreno che riporta la presenza dei livelli marker Y-3 and Y-5, dedotta dalla revisione della letteratura riguardante la tefrostratigrafia del Tirreno e da dati del presente lavoro. I cerchi indicano l'ubicazione delle carote; l'area nera nel cerchio indica la presenza all'interno della carota del marker Y-3, l'area tratteggiata nel cerchio indica la presenza all'interno della carota del marker Y-5. Per il riferimento alla carota vedi Tabella 5.

The presence of two alcali-trachytic tephra layers offshore the Tyrrhenian coast, namely B2 and B3 in C45, separated by the deposition of pelagic sediments, makes it possible to hypotesize, in the 40-25 ka B.P. time span, the occurrence of two distinct intense volcanic events with a widely dispersed associated fall phase. The different age, together with the slightly different chemical composition, suggests that no link exists between them, apart from the source.

The lower layer (B3 in C45) is well linkable to the Campanian Ignimbrite eruption, that we can now term First Campanian Ignimbrite, and its presence in the Policastro Gulf core well agrees with the distribution hypothesized for the associated fall phase by Rosi et al. (1999). The sequence cored in C106, offshore the Sele river mouth, where no record of Y-5 has been found, probably stops before encountering this tephra layer.

The topmost alkali-trachytic layer (A2 in C106 and B2 in C45) tesifies to the presence of the Y-3 marker layer in the Tyrrhenian area, and no clear attribution to a recognized volcanic event is at present possible. However, it can be interpreted as the record of an eruptive event from the Campanian area. The absence of a Somma-Vesuvio eruption as the origin of the layer, restricts the field of possible sources to Campi Flegrei. Chemical features of Y-3 are quite peculiar, and distinguish it from Y-5, here definitely linked to Campanian Ignimbrite. It can be concluded that the presence of this layer accounts for the hypothesis that what is found in the field and ascribed to the Campanian Ignimbrite eruption may be the result of at least two distinct eruptive episodes, each with an associated fall phase. Y-3 can be considered the record of another eruptive event, that we term Second Campanian Ignimbrite eruption. The occurrence in volcanological literature of ^{14}C dating ranging between 40 and 25 ka can so be read as the result of the sampling of different paleosoil, underlying somewhere the older, elsewhere the younger pyroclastic deposit.

As to the chemical composition, a slight chemical difference in the composition of Campanian Ignimbrite units has been detected by Signorelli *et al*. (1999). According to these authors, the last unit of C.I. (sampled in the northern area of Naples, Giugliano municipality, in a quarry at the Scarafea locality) is much richer in K than the first one and seems well to resemble the composition of Y-3. We hypothesize that this unit can be the pyroclastic flow associated to the fall phase emplacing Y-3. This hypothesis can be supported by the recorded presence of a paleosol between the Campanian Ignimbrite Tuff and the topmost pyroclastic flow deposit at Giugliano and by the $^{40}Ar/^{39}Ar$ dating of the same deposit, that results much younger than Campanian Ignimbrite (Rolandi et al., 2003). At present more field studies are necessary, aimed at mapping the two different ignimbrite deposits linked to Y-5 and Y-3 tephra marker layers.

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