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WORKSHOP ON MARINE SECTIONS FROM THE GULF OF TARANTO (SOUTHERN ITALY) USABLE AS POTENTIAL STRATOTYPES FOR THE GSSP OF THE LOWER, MIDDLE AND UPPER PLEISTOCENE

(Bari, Italy, Sept. 29 - Oct. 4, 1994)

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BACKGROUND

The Quaternary Working Group of the Italian Commission on Stratigraphy organized a first Workshop in November 1992 in Sicily and Calabria to investigate and discuss in the field several marine, fossiliferous, continuous, well exposed sections potentially usable as stratotypes for the Pliocene and lower Pleistocene.

At the conclusion of the Workshop, the possibility of introducing a new stage for the Upper Pliocene, to fill the gap existing in between the top of the Piacentian and the N/Q Boundary as defined by its GSSP at Vrica, was discussed and considered viable. The San Nicola Section (see Channell *et al.*, 1992) close to Gela (Sicily) visited during the Workshop, was considered to meet the international requirements.

On the contrary, other exposures visited during the November 1992 Workshop and previously proposed as stratotypes for the "Selinuntian" (lower Pleistocene) by Ruggieri & Sprovieri (1979) and for the "Crotonian" (middle Pleistocene) by Ruggieri et al. (1977) were judged, by the Working Group, unsuitable as a reference for a global standard because of their near-shore setting strongly affected by eustatic/tectonic disturbances, and consequent sedimentary gaps.

Highly interesting exposures of terrigenous to hemipelagic sediments deposited in the depocenter of the Apennine foredeep (NW of the Gulf of Taranto) were visited: there the marine sedimentation lasted longer than in other Sicilian and Calabrian peripheral basins, extending into the middle Pleistocene. Professor N. Ciaranfi from the University of Bari and his associates are actively working in the area, in order to provide the necessary stratigraphic multi-proxy data.

After the 1992 Workshop, **a**) Professor G.B. Vai, from the University of Bologna, concentrated on a critical re-visitation of all the marine Pleistocene stages previously defined in Italy, some of them largely used in the international literature, others more obscure or misused; **b**) the Gelasian stage was proposed (Rio *et al.*, 1994) with reference to the San Nicola Section mentioned above, and **c**) a GSSP was defined for the base of the Emilian stage in the Vrica Section, 75 m above the Pliocene/Pleistocene GSSP (Pasini & Colalongo, 1994).

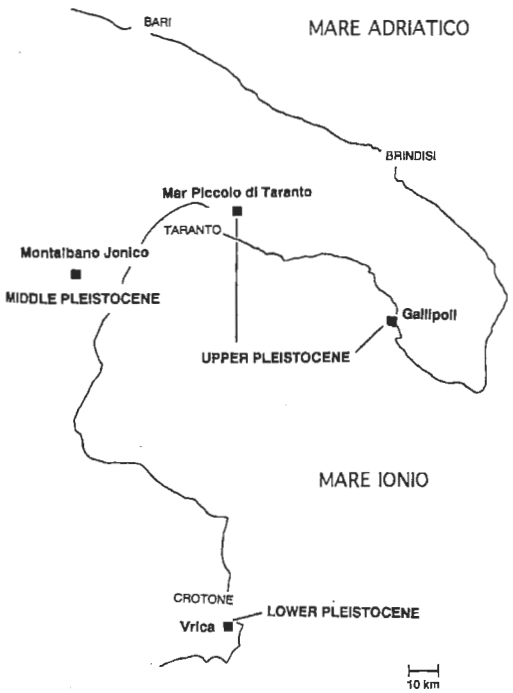

Fig. 1 - Location map.
Mappa delle località.

THE 1994 WORKSHOP

Purpose of the second Workshop was to extend the *in-situ* observations and discussions to the marine sections of the middle and upper Pleistocene, moving around the Gulf of Taranto (Fig. 1), where spectacular *Strombus*-bearing raised beaches occur.

The Workshop consisted of three parts:

1) Visit to the upper Pleistocene sections near Gallipoli and Taranto (Mare Piccolo), under the guidance of Drs. Dai Pra and Mazzanti (September 29-30);
2) Discussion of the basic philosophy and principles of stratigraphy as applied to the Quaternary marine sequences. Boundary stratotypes versus Stage stratotypes, with reference to the newly published International Stratigraphic Guide (Salvador A., Editor, 1994) (Bari, October 1);
3) Visit to the Vrica Section under the guidance of Dr. G. Pasini and to the middle Pleistocene sections of the Apennine foredeep (Fossa Bradanica) under the guidance of Prof. N. Ciaranfi.

The Workshop was long planned by the Quaternary Working Group of the Italian Commission on Stratigraphy, but the new developments of the Quaternary Subcommission of the International Commission on Stratigraphy (ICS) and the proximity of the INQUA Congress (Berlin, 1995) suggested to make it more open and international.

AIQUA, the Italian Association for the Study of the Quaternary, and the Subcommission on Neogene Stratigraphy of the ICS co-sponsored the Workshop.

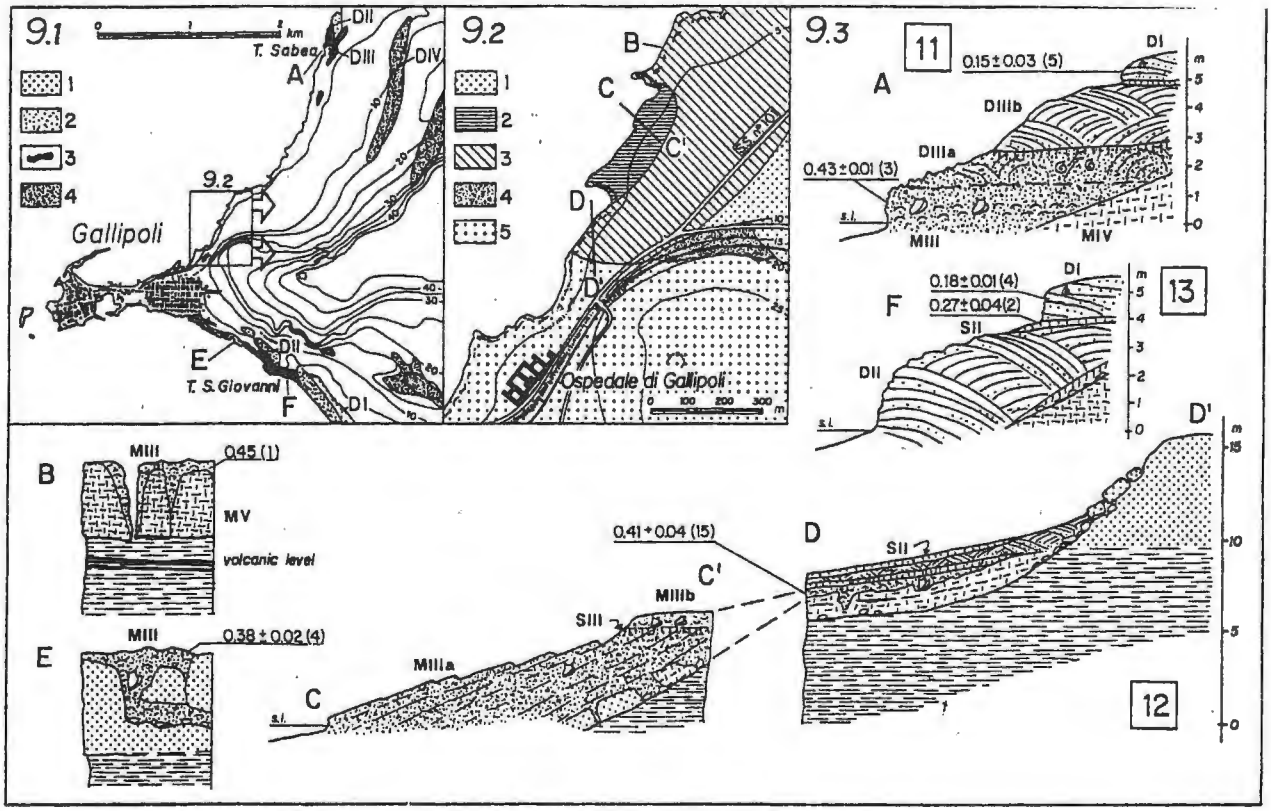

Fig. 2 - Quaternary stratigraphy of the area around Gallipoli (after Hearty & Dai Pra, 1992).

Stratigrafia del Quaternario dell'area circostante Gallipoli (da Hearty & Dai Pra, 1992).

EXCURSIONS

The first two days of the Workshop were dedicated to visit outcrops of Tyrrhenian sediments in stratigraphic contact with underlying and overlying strata near Gallipoli (Figs. 2 & 3) and in the area around the Mar Piccolo di Taranto (Figs. 4 & 5).The Tyrrhenian raised beaches are richly fossiliferous, and several radiometric age determinations based on aminoacids analyses and U/Th support their stratigraphic attribution (see Hearty and Dai Pra, 1992, and references therein).

The outcrops of the area around the Mare Piccolo appeared the most promising for the definition of a GSSP for the good conditions of the exposures (eventually subject to be further improved with artificial cuts) and the thickness of the deposits.

Fig. 3 - Workshop partecipants walk on the shore of Gallipoli towards a Tyrrhenian outcrop (29/9/1994).

Partecipanti del Workshop *sulla spiaggia di Gallipoli verso un affioramento del Tirreniano (29/9/1994).*

The Vrica section near Crotone, which extends from the upper Pliocene to the lower Pleistocene, and where the GSSP for the P/P boundary was formally defined (Bassett, 1985; Aguirre and Pasini, 1985), was subsequently visited. The same section has been recently used by Pasini and Colalongo (1994) to propose the GSSP of the Emilian substage (Santernian/Emilian boundary) at level p, some 75 m above the P/P GSSP. The main biostratigraphic criteria usable to recognize the base of the Emilian are the first occurrence of *Hyalinea balthica* and the first occurrence of large *Gephyrocapsa,* with an

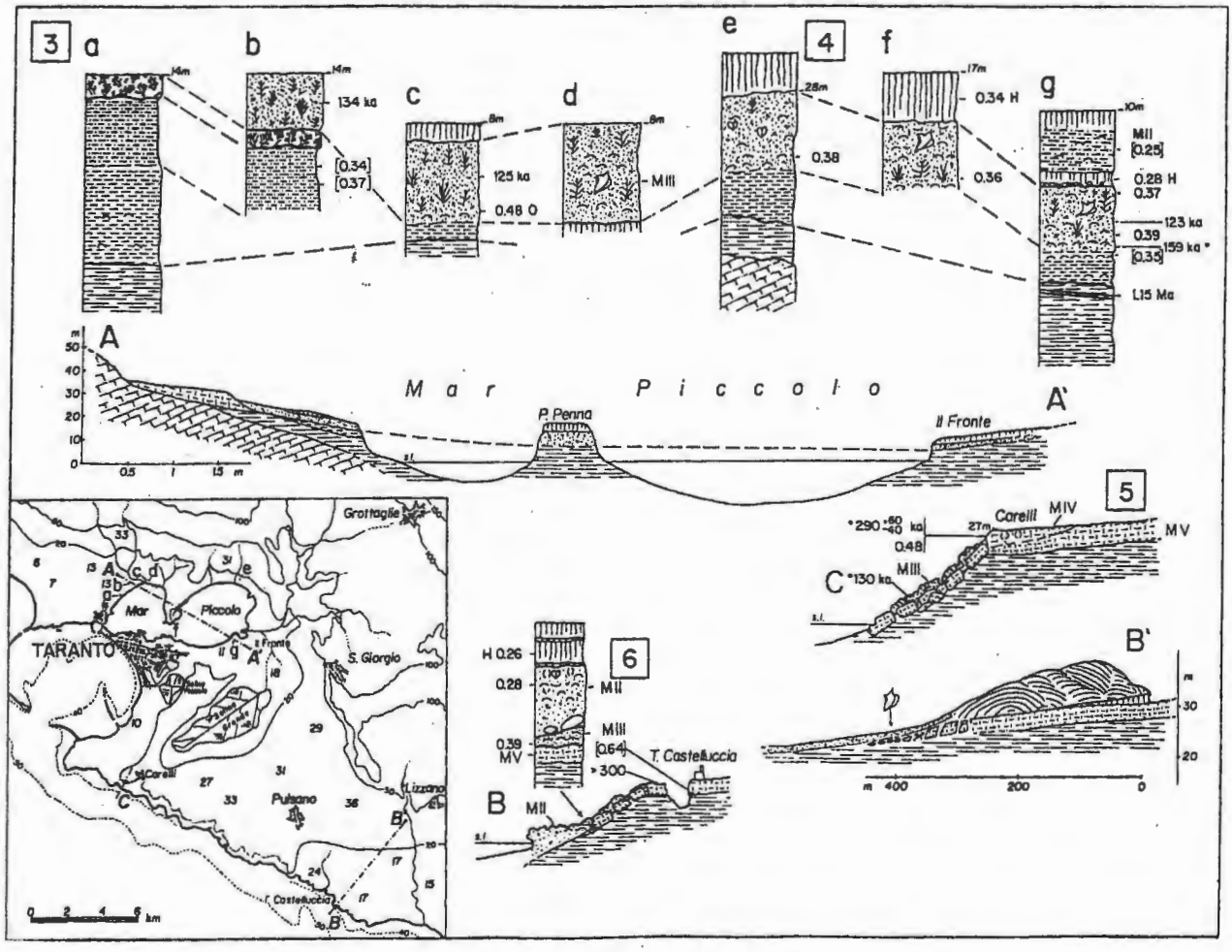

Fig. 4 - Quaternary stratigraphy of the area around the Mar Piccolo di Taranto (after Hearty & Dai Pra, 1992).

Stratigrafia dei depositi quaternari dell'area circostante il Mar Piccolo di Taranto (da Hearty & Dai Pra, 1992).

interpolated age of approximately 1.48 Ma. Figure 6 (after Pasini and Colalongo, 1994) shows the distribution of calcareous nannofossils in the Vrica section and the position of the Santernian in this section, whereas Fig. 7 shows the position of level e, which identified the P/P GSSP.

If the classic Vrica section was already familiar to several Workshop participants, the Montalbano Ionico section, here presented as potential reference for the middle Pleistocene, was only known to a limited number of scientists who had taken part to the 1992 Workshop. A terrific work has been accomplished in less than two years, and is concisely reported in the following pages (see also Figs. 8-11).

The Montalbano Jonico Section in the Bradanic Foredeep (southern Italy): a potential early-middle Pleistocene Boundary Stratotype

(contribution by: **N. Ciaranfi, A. D'Alessandro, M. Marino & L. Sabato** - Geology and Geophysics Dept., University of Bari)

In the south-western part of the Bradanic Foredeep, not far from the present-day Gulf of Taranto shoreline, along the Agri river, west of Montalbano Jonico, a new detailed geological mapping (Fig. 8) has shown some continuous stratigraphic successions, previously attributed to the early Pleistocene (Verhallen, 1991). The reconstructed section of Montalbano Jonico (Fig. 9) that forms a monocline gently dipping towards SE, has a thickness of about 350 m. It mainly consists of well stratified silty clays, intercalated

Fig. 5 - Workshop participants sample a Tyrrhenian/pre-Tyrrhenian section at Punta Penna, Mar Piccolo di Taranto (30/9/94)

Partecipanti del Workshop *mentre campionano una sezione del Tirreniano/pre-Tirreniano a Punta Penna, Mar Piccolo di Taranto (30/09/94).*

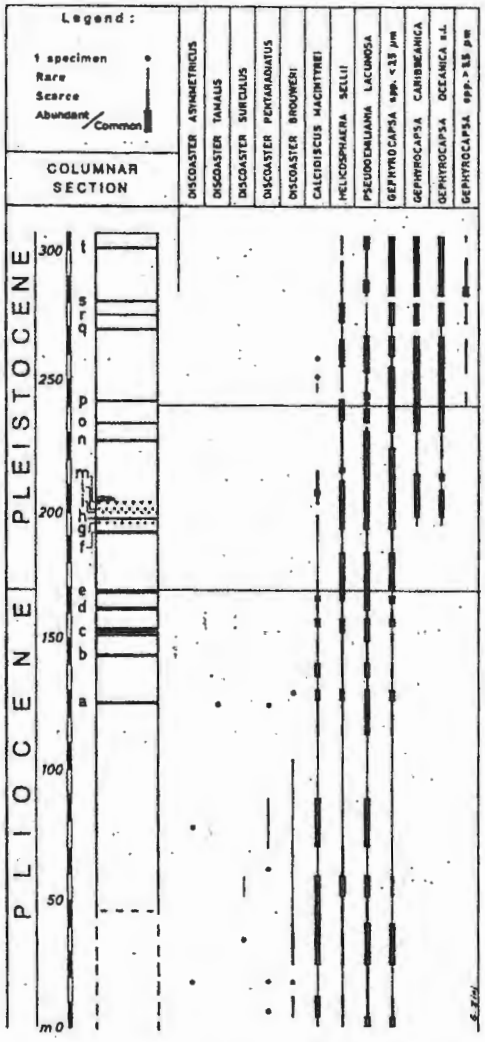

Fig. 6 - Distribution of calcareous nannofossils in the Vrica section and definition of Santernian/Emilian boundary (after Pasini & Colalongo, 1994).

Distribuzione dei nannofossili calcarei nella sezione di Vrica e definizione del limite Santeriano/Emiliano (da Pasini & Colalongo, 1994).

with several volcaniclastic layers (V1-V9) and marly-silty and/or sandy-silty bodies; these lithohorizons are useful to correlate successions of different localities. The nine volcaniclastic layers consist of pure ash, sand rich in volcanic minerals and pumice clasts. They belong, from a compositional and geochemical point of view, to two different series (De Rosa, pers. comm.): alkaline undersaturated volcanism (V1-V4) and calcoalkaline volcanism (V5-V9).

The upper part of the Montalbano section represents the local regressive emicycle of the foredeep, due to the presence of marine sands and conglomerates at the base, and of continental conglomerates at the top (Figs. 10-11). Biostratigraphic analyses of nannofloral assemblages based on several samples collected from the middle part of the section (about 250 m thick), allowed us to recognize three Pleistocene biozones according to the Rio *et al.* (1990) scheme (Fig. 9). The lower part of the sampled section has been referred to the large *Gephyrocapsa* Zone; the interval between the V1 layer and a stratigraphic level 5 m below the V2 layer has been referred to the small *Gephyrocapsa* Zone: both biozones indicate the younger part of the early Pleistocene. The upper part of the sampled section is referable to the *Pseudoemiliania lacunosa* Zone, on the basis of the occurrence of *Gephyrocapsa parallela* (*Gephyrocapsa* sp. 3, *sensu* Rio, 1982). The distribution of this species (first occurrence at 944 ka, last occurrence at 584 ka, Castradori, 1993) is discontinuous in the Mediterranean area with a "temporary disappearance" (recorded in the Montalbano section near the V3 layer) and a "reappearance" (in the Montalbano section 20 m above the V4 layer) (see Rio *et al.*, 1990; Castradori, 1993). The above mentioned results suggest the presence of the early-middle Pleistocene boundary in the Montalbano section. Researches are in progress, including: sedimentology, calcareous nannofossil biostratigraphy, planktonic and benthonic foraminiferal biostratigraphy, paleoecology of macrofossil communities, petrology of volcaniclastic layers, magnetostratigraphy, radiometric dating.

DISCUSSION

One full day (October 1, 1994) was dedicated to discuss the principles, the sections, the chronostratigraphic subdivisions to be proposed.

In order to prevent a disorganised discussion and to provide all the background information available, a tentative program was dressed (Table 1). All the planned presentations were given with minor changes in the schedule. Table 2 provides the list of Workshop participants, with their home institutions and qualifications.

The discussions were alive and sometimes heated, especially those concerning the lower and the upper Pleistocene. The points of discussion may be categorized as follows:

a) The **principles of stratigraphy**, as applied to the definition of boundary stratotypes, with reference to the new Guide (Salvador A., Editor, 1994), and the role that priority plays versus world-wide correlability. See also contribution by J. van Couvering in the following pages, a document distributed to all Workshop participants.

b) The **major boundaries**. On this point the consensus was full.

The lower Pleistocene has to start with the GSSP defined, and formally accepted, in the Vrica section (Bassett ,1985; Aguirre & Pasini, 1985). There is no reason whatsoever to change its position, which has a correlation potential much better known now than ten years ago.

The middle Pleistocene should start with a point close to the upper Jaramillo reversal, to isotopic stage 25 and to the small *Gephyrocapsa/Pseudoemilianla lacunosa* nannofossil zonal boundary. Such a point was considered to have a better correlation potential than a boundary coinciding with the Brunhes/Matuyama magnetic reversal. The proposed lower/middle Pleistocene boundary is easily recognizable in the land record on the basis of mammal faunas (see contribution by A. Azzaroli later on).

Fig. 7 - Workshop participants G.B. Vai and S.Iaccarino sit on the Pliocene/Pleistocene GSSP in the Vrica section (2/10/94).

I partecipanti del Workshop *G.B. Vai e S. Iaccarino sul GSSP Pliocene/Pleistocene nella sezione di Vrica (2/10/94).*

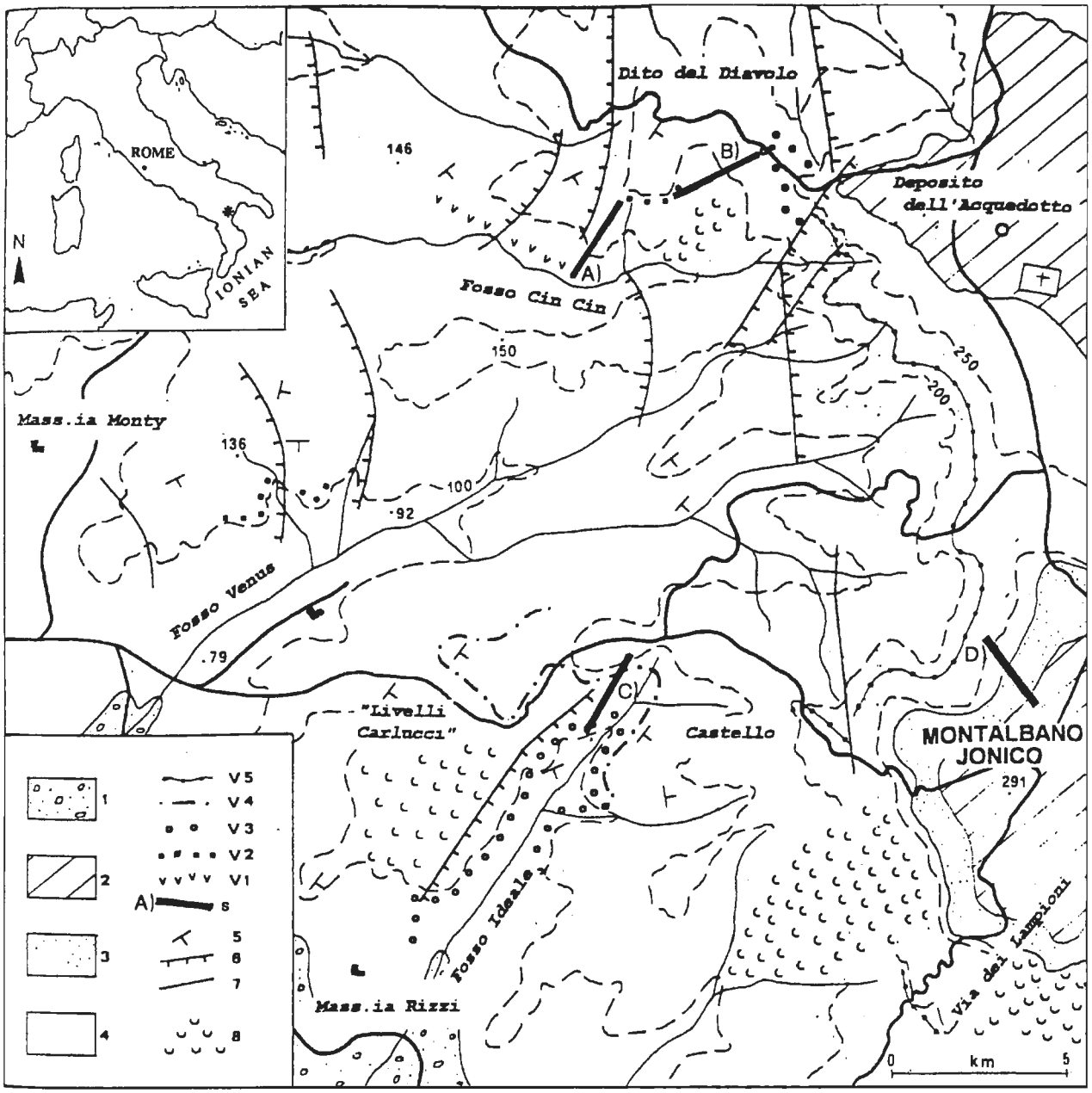

Fig. 8 - Sketch map of the area studied by Ciaranfi *et al.* (1994) near Montalbano Ionico; 1: alluvial deposits; 2: continental conglomerates; 3: marine sands and conglomerates; 4: silty clays and clayey silts; 8: landslides; s: measured sections.

Carta schematica dell'area studiata da Ciaranfi et al. *(1994) in vicinanza di Montalbano Ionico; 1: depositi alluvionali; 2: conglomerati continentali; 3: sabbie e conglomerati marini; 4: argille limose e limi argillosi; 8: frane; s: sezioni misurate.*

The upper Pleistocene also obtained a general consensus; it had to start with termination II, with the transition from isotopic stage 6 to stage 5 and with the base of the oldest *Strombus* raised beach.

c) The **names** to be used for the **stage** corresponding to the lower, middle and upper Pleistocene, as defined above.

The discussion of this item was really heated and difficult sometimes, maybe because some Workshop participants were personally involved as proponents of new stage names, or users of chronostratigraphic units not properly defined, or not largely used elsewhere or both. Points of discussion were the role of priority in the definition of a stage, the opportunity to emend deeply rooted terms, widely used in the international literature; the importance to have a good standard reference section with a clearly defined GSSP versus the interpretation given tens of years ago by various authors to some poorly known fossil localities, at times when several proxy data now used in the integrated stratigraphic approach were not available yet.

Further details on the discussion points are found in Cita and Castradori (in press, Bollettino Società Geologica Italiana) to which reference is made.

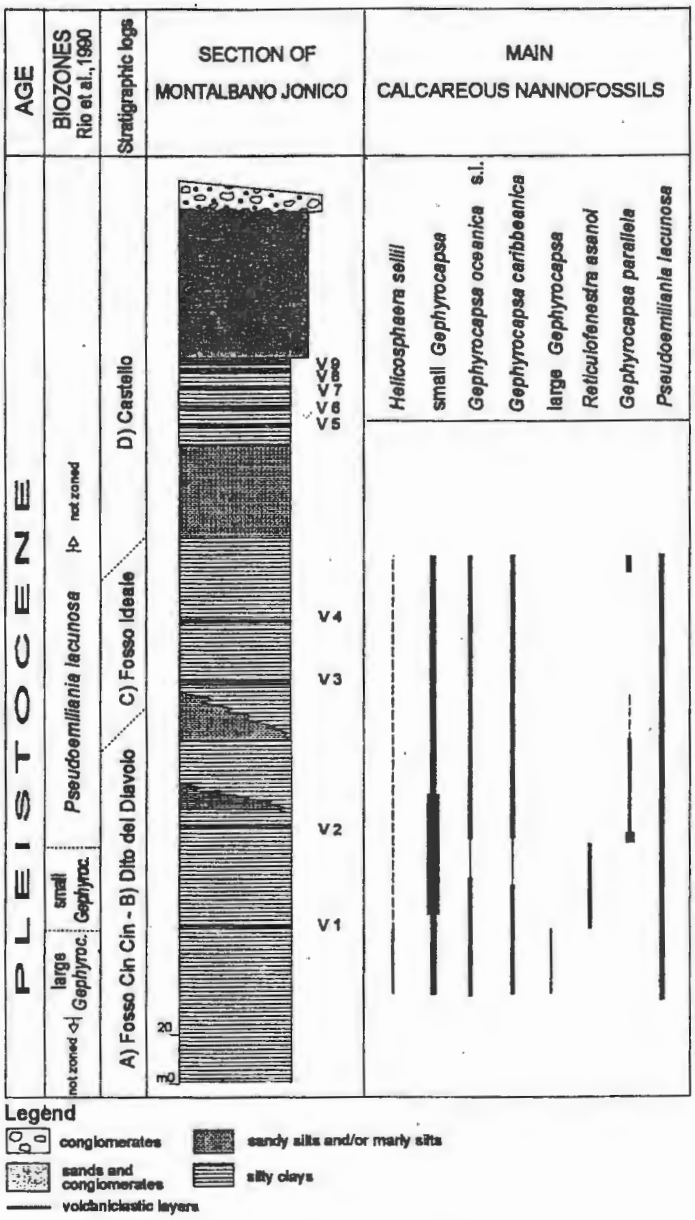

Fig. 10 - Workshop participants climb the beautifully exposed Fosso Ideale section (3/10/1994).

Partecipanti al Workshop si arrampicano sul bellissimo affioramento della sezione di Fosso Ideale (3/10/1994).

Fig. 9 - Composite section of Montalbano Ionico and distribution of calcareous nannofossils (after Ciaranfi *et al.*, 1994).

Sezione composita di Montalbano Ionico e distribuzione dei nannofossili calcarei (da Ciaranfi et al., *1994).*

Fig. 11 - Panoramic view of the badlands west of Montalbano Ionico; VS is a prominent volcaniclastic marker-bed.

Panorama delle argille a calanchi (badlands) *ad ovest di Montalbano Ionico; VS indica uno strato guida di materiale clastico di origine vulcanica.*

Table 1 - Program of the "Discussion day". - *Programma del* "Discussion day".

Società Geologica Italiana
Commissione Italiana di Stratigrafia
Gruppo di lavoro per il Quaternario
Presidente M.B. Cita
Segretario A. Bini

ASSOCIAZIONE ITALIANA PER LO STUDIO DEL QUATERNARIO

INTERNATIONAL UNION OF GEOLOGICAL SCIENCES
INTERNATIONAL COMMISSION ON STRATIGRAPHY

SUBCOMMISSION ON NEOGENE STRATIGRAPHY SNS

WORKSHOP ON MARINE SECTIONS FROM THE GULF OF TARANTO
(SOUTHERN ITALY) USABLE AS POTENTIAL STRATOTYPES FOR
THE GSSP OF LOWER, MIDDLE AND UPPER PLEISTOCENE

OCTOBER 1 - DISCUSSION DAY

TENTATIVE AGENDA

Morning Session 9.30 - 12.30

9.30 M.B. CITA - *The workshop: background and motivation*
9.50 D. RIO & R. SPROVIERI - *Early Pleistocene section and possible subdivision*
10.10 N. CIARANFI - *The evolution of chain-foredeep-foreland system in southern Italy: geodynamic explanation for the presence of continuous Quaternary sections and possible subdivision: present-day knowledge and related problems*
10.30 D. RIO - *Stratigraphic and biostratigraphic evidences for Middle Pleistocene*
10.50 R. MAZZANTI & G. DAI PRA - *Late Pleistocene (Tyrrhenian) sections*
11.30 J. VAN COUVERING - *What is the relationship between the base of Quaternary and the base of Pleistocene?*

General Discussion

Afternoon Session 14.30 - 18.30

14.30 G.C. PASINI & J. VAN COUVERING - *The GSSP of the Vrica section and its world-wide correlability*
15.00 A. AZZAROLI & P. AMBROSETTI - *The point of view of continental stratigraphers*
15.20 A. D'ALESSANDRO - *Ecostratigraphy and its application to the Montalbano sections*
15.40 N. CIARANFI - *Presentation of the excursion*

16.00 *Coffee Break*

16.20 - 17.20 *General Discussion possibly followed by a round table discussion*
Interventions by M. BASSETT, G.B. VAI, D. RIO, J. VAN COUVERING, I. RAFFI are foreseen

PROPOSALS

The proposed subdivision presented here (Fig. 12) is the main result of the Workshop(s). It has not been approved by consensus, but results from a) two polls among Workshop participants, the first questionnaire being distributed after the general discussion in Bari, the second one, with even more focussed questions, after another meeting held in Crotone on October 2, 1994 and b) a postal ballot among the members of the Quaternary Working Group of the Italian Commission on Stratigraphy (indicated as GLQ on Table 2). The rules of IUGS have been applied (60% QUORUM) to calculate the majority, which was large enough as to consider the proposed subdivision on firm grounds.

The following comments are aimed at clarifying the scheme, which extends into the Pliocene, starting from its lower, older parts.

The GELASIAN stage has been recently proposed (Rio *et al.*, 1994) for the stratigraphic interval above the Piacenzian and above the event at approximately 2.5 Ma (final event of the gradual initiation of glaciation in the northern hemisphere). This interval was not covered by a formal chronostratigraphic unit defined by a stratotype (Rio *et al.*, 1991; Cita *et al.*, in press). The GSSP at the base of the Gelasian has been proposed in the San Nicola section (Sicily) in a position slightly postdating the Gauss/Matuyama magnetic reversal (Rio *et al.*, 1994).

The Pliocene/Pleistocene boundary, located in the Vrica section at the base of the marls overlying sapropelic layer "e" (see Fig. 7) is the only one represented in Fig. 12 to have been formally accepted by ICS and ratified by IUGS (Bassett, 1985; Aguirre & Pasini, 1985). The Italian Working Group is strongly supportive of its validity and worldwide correlability.

It is pointed out that the scheme (Fig. 12) does not include a formal tripartition of the Pleistocene series in subseries (Lower,

Table 2 - Workshop participants, including affiliations and qualifications.
I partecipanti al Workshop, con indicazione della qualifica e dell'organizzazione di appartenenza.

Ambrosetti, P. *	Dip. Scienze Terra Univ. Perugia	Palæontology Professor Italian delegate at INQUA GLQ
Azzaroli, A.	Dip. Scienze Terra Univ. Firenze	Palæontology Professor Italian Delegate at INQUA GLQ
Bassett, M. G.	Dept. of Geology National Museum of Wales, Cardiff	Professor (Univ. of Wales, Cardiff) ICS Vice Chairman Chairman UK Commission on Stratigraphy
Carobene, L. *	Dip. Scienze Terra Univ. Genova	Geology Professor GLQ
Carrozzini, B.	Dip. Geomineralogico Univ. Bari	Post-doc
Castradori D. (Rapporteur)	AGIP S.p.A. Lab. Bolgiano	Stratigrapher at AGIP
Ciaranfi, N. * (Workshop organizer)	Dip. Geol. Geof. Univ. Bari	Geology Professor GLQ
Cita, M. B. * (Workshop convener)	Dip. Scienze Terra Univ. Milano	Geology Professor SNS Chairman CIS Chairman GLQ Chairman
Colalongo, M. L.	Dip. Scienze Geol. Univ. Bologna	Palæontology Professor GLQ
Dai Pra, G. *	ENEA-Amb/Saf/Ter Casaccia, Roma	ENEA Researcher GLQ
D'Alessandro, A. (Workshop organizer)	Dip. Geol. Geof. Univ. Bari	Palæoecology Professor
Di Stefano, E.	Dip. Geol. Geodesia Univ. Palermo	Researcher ODP
Iaccarino, S. *	Ist. Geologia Univ. Parma	Micropalæontology Professor SNS Voting Member, ODP
Maiorano, P.	Dip. Geol. Geof. Univ. Bari	Doctoral Student
Marino, M. (Workshop organizer)	Dip. Geol. Geof. Univ. Bari	Post-doc
Mazanti, R. *	CNR-Centro Geologia Dinamica e Strutturale dell'Appennino	CNR Researcher
Pasini, G.	CNR-Geol. Marina Bologna	CNR Researcher GLQ
Raffi, I. *	Facoltà di Scienze Univ. Chieti	Researcher; ODP SNS Working Group on Pliocene Time Scale
Rio, D.*	Dip. Geologia Univ. Padova	Micropalæontology professor CIS; GLQ SNS Voting Member; ODP
Sabato, L. (Workshop organizer)	Dip. Geol. Geof. Univ. Bari	Researcher (Sedimentologist)
Sprovieri, R.	Dip. Geol. Geodesia Univ. Palermo	Micropalæontology Professor CIS; GLQ SNS Corresponding Member; ODP
Vai, G. B. *	Dip. Scienze Geol. Univ. Bologna	Stratigraphy Professor CIS GLQ
Van Couvering, J.	Micropaleontology Press, New York, USA	Editor-in-chief (*"Micropaleontology"*) PhD Geol. Cambridge SNS Expert
Vernuccio, S.	Dip. Geol. Geodesia Univ. Palermo	Researcher

CS: International Commission on Stratigraphy
SNS: Subcommission on Neogene Stratigraphy of ICS
CIS: Commissione Italiana di Stratigrafia della Società Geologica Italiana
GLQ: Gruppo di Lavoro sul Quaternario della CIS
ODP: *Ocean Drilling Program*
CNR: Consiglio Nazionale delle Ricerche
*: AIQUA (Associazione Italiana per lo Studio del Quaternario) Member

Middle and Upper). This choice derives from the short time involved (less than two million years), also following the advice of M. Bassett. It also derives from the intent to induce scientists to the extensive and correct use of stage names.

The CALABRIAN stage covers the entire lower Pleistocene, and extends from the GSSP defined for the Pliocene/Pleistocene in the Vrica section to the GSSP to be defined in the Montalbano Ionico section, the best candidate available for the middle Pleistocene (see Excursion, and further on).

A redefinition of the stage, whose use is deeply rooted in the international literature but not consistent throughout, is required (see notes by J. van Couvering in the following pages; see also discussion in Cita & Castradori, in press, Boll. Soc. Geol. Ital.).

The possibility to further subdivide the lower Pleistocene or Calabrian in three chronostratigraphic formal units, namely SANTERNIAN, EMILIAN and SICILIAN, was unanimously accepted. Their rank is that of substages. A GSSP for the Emilian substage has been recently proposed by Pasini and Colalongo (1994), at sapropel layer "p" of the Vrica section (see Fig. 6).

The second stage of the Pleistocene, as here proposed, includes the sediments deposited in the time interval corresponding to the "glacial Pleistocene", predating the large Tyrrhenian deglaciation. The name for this stage (IONIAN, from the Ionian Sea) and the basic criterion for the choice of its GSSP were widely supported (practically by consensus) by the polls and by the postal ballott, with the lower boundary close to the last (youngest) warm episode (isotopic stage 25) predating the beginning of the "glacial" Pleistocene (isotopic stage 22). The latter alternative was considered, but discarded because a cold, regressive phase results inevitably in hiatuses on continental margins, and consequently is unfavourable for the base of a chronostratigraphic unit.

The Montalbano Ionico section has the potential to be a candidate section, as soon as properly documented, because of the continuous, undisturbed succession, rich fossil content, expanded sequence.

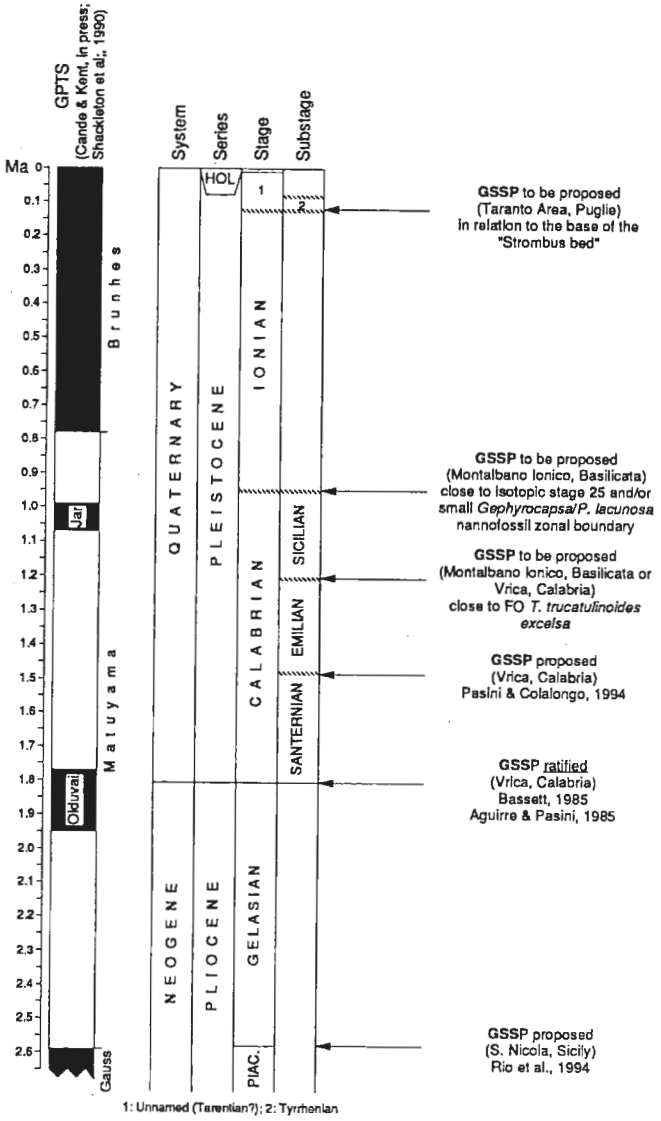

Fig. 12 - Chronostratigraphic scheme resulting from the Workshop.
Lo schema cronostratigrafico risultante dal Workshop.

The problem concerning the late Pleistocene is that the idea to extend the term TYRRHENIAN, deeply rooted in the international literature, up to the base of the Holocene, was clearly rejected by the postal ballott. The name TARENTIAN (after Tarentum, the Latin name of Taranto), proposed by some, was not discussed enough, and is not supported at present by adequate sections. The Tyrrhenian, limited to the "warm" isotopic stage 5, with an age range of approximately 130,000-80,000 y BP, should thereafter have the rank of substage.

Figura 13 schematically shows the extension of some classic Plio-Pleistocene sections from southern Italy and adjacent areas. The figure caption contains some fundamental references, from the rich literature published in the latest few years. The last section to the right refers to the longest piston core investigated so far from the eastern Mediterranean (Calabrian Ridge, Ionian Sea). This section (Castradori, 1993; Sanvoisin *et al.*, 1993) is particularly interesting because it extends back to approximately 1 Ma, contains three magnetic reversals, has isotopic stage 22 very well expressed (M. Paterne, pers. communication, Nov. 1994) and represents a perfect link with the upper part of the lower Pleistocene, the entire middle Pleistocene and the upper Pleistocene sections from the Gulf of Taranto.

Proposal for a Calabrian boundary stratotype

(a contribution by: **J. van Couvering**, Micropaleontology Press, AMNH, New York)

Introduction

The 1948 IGC Resolution, which has never been rescinded, states as follows: *"The Pliocene-Pleistocene boundary should be based on changes in marine faunas..."*, *"The lower Pleistocene should include as its basal member in the type area the Calabrian for-*

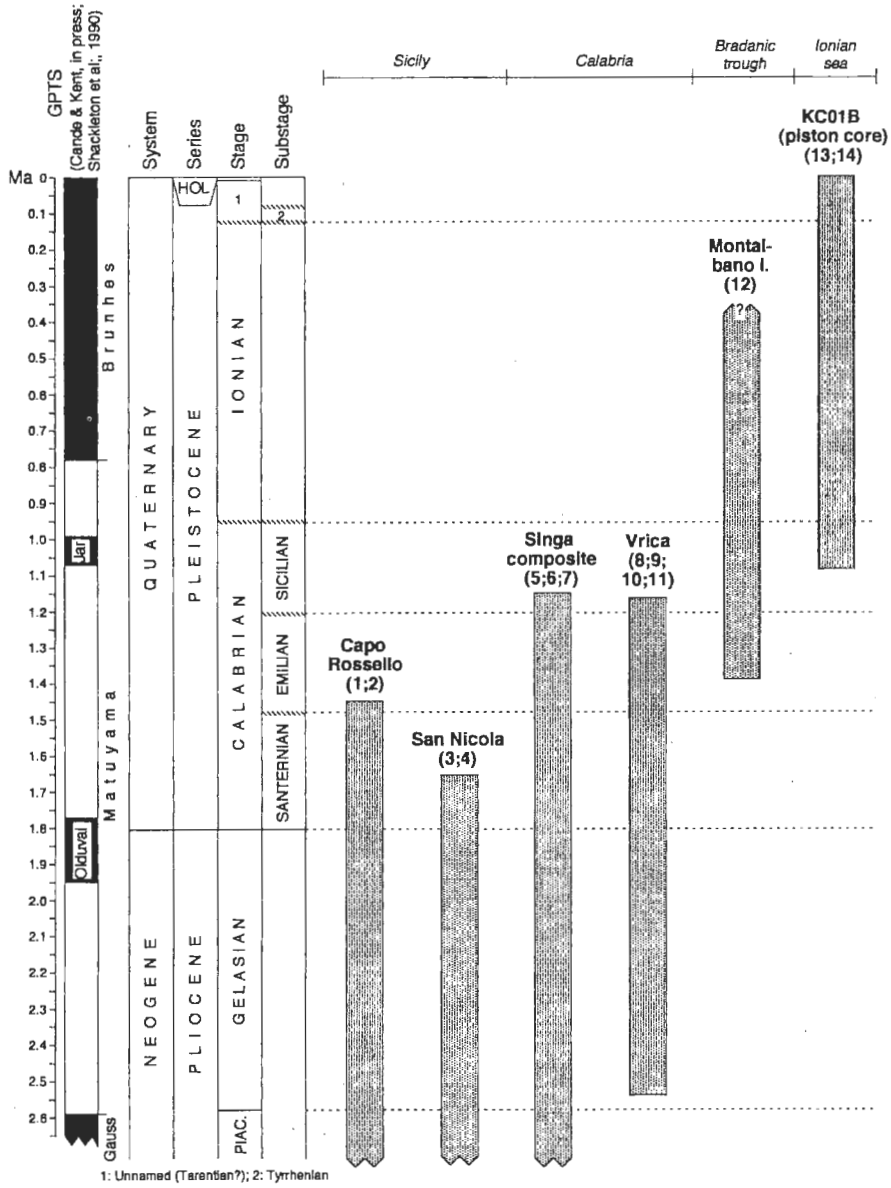

Fig. 13 - Schematic stratigraphic extension of some classic Plio-Pleistocene sections from southern Italy and adjacent seas. Basic references are as follows: 1) Cita & Gartner (1973); 2) Di Stefano *et al.* (1993); 3) Channell *et al.* (1992); 4) Rio *et al.* (1994); 5) Zijderweld *et al.* (1991); 6) Hilgen (1987); 7) Hilgen (1991); 8) Selli *et al.* (1977); 9) Aguirre & Pasini (1985); 10) Pasini & Colalongo (1994); 11) See text for additional references; 12) Ciaranfi *et al.* (1994); 13) Castradori (1993); 14) Sanvoisin *et al.* (1993).

Estensione stratigrafica schematica di alcune sezioni plio-pleistoceniche classiche dell'Italia meridionale e tratti di mare adiacenti. I principali riferimenti bibliografici sono: 1) Cita & Gartner (1973); 2) Di Stefano et al. *(1993); 3) Channell* et al. *(1992); 4) Rio* et al. *(1994); 5) Zijderweld* et al. *(1991); 6) Hilgen (1987); 7) Hilgen (1991); 8) Selli* et al. *(1977); 9) Aguirre & Pasini (1985); 10) Pasini & Colalongo (1994); 11) See text for additional references; 12) Ciaranfi* et al. *(1994); 13) Castradori (1993); 14) Sanvoisin* et al. *(1993).*

mation (marine).." and that *"according to evidence given this usage would place the boundary at the horizon of the first indication of climatic deterioration in the Italian Neogene succession".*

From the above, we see that the criteria in order of increasing specificity are:

i. Change to colder climate at the end of the Pliocene;

ii. Change in marine faunas indicating a change to colder climate;

iii. Physical base of the Calabrian Stage in its type area in Italy, selected because it contains evidence of the change to colder climate.

The Pleistocene is a chronostratigraphic unit, in the standard Global Chronostratigraphic Scale (9). It is therefore not a "climatostratigraphic" unit, or a biostratigraphic unit (8), or even a magnetostratigraphic unit (14). Chronostratigraphic units are defined in boundary-stratotypes, primarily the lower boundary (12), which in the case of the Global Chronostratigraphic Scale are denoted as GSSP (7). The GCS is hierarchal (9), so the Pleistocene series is defined by the base of its lowest constituent GCS stage (10).

POINT 1: The Calabrian is the lowest stage in the Pleistocene, per IGC 1948 subcommission recommendation (11).

POINT 2: The usage of the Calabrian as the lowest stage in the Pleistocene is universally well established in the Standard Global Chronostratigraphic Scale (3).

POINT 3: The base of the Calabrian, as presently defined at Santa Maria di Catanzaro, does not coincide with the base of the Pleistocene, as presently defined, and it does not adequately represent the Calabrian Stage as described by Gignoux (5) [1].

POINT 4: The section at Vrica has been thoroughly described, analyzed and documented in a large number of studies (5,13).

POINT 5: The ratified GSSP for the beginning of the Pleistocene at Vrica adequately represents the concept of lower Calabrian in the sense of Gignoux, as well as the customary and long standing practise in Italy and the meaning of the 1948 London IGC resolu-

[1] Gignoux considered that all of the sections which he described were part of a synthetic concept of the Calabrian Stage, and he refused on principle to designate a stratotype when requested by the IGC Subcommission (Vai, pers.comm.). To use this name for an equivalent chronostratigraphic unit requires that an appropriate stage stratotype is designated which exemplifies the fundamental characteristics (fauna, age, lithology) of Gignoux' synthesis, and that an appropriate boundary-stratotype is designated which exemplifies the oldest part of the synthesis. Neither of these considerations has been met adequately to this date.

tion, in regard to faunal and sedimentological evidence of a change to colder climate. It has been shown by IGCP 41, "N/Q Boundary", that this change is synchronous with evidence for the first typical Pleistocene glacial cycle regionally and worldwide as intended by the 1948 London IGC Subcommission in making its recommendation (10,13).

Conclusion

The base of marker bed "e" in component section B at Vrica should be recognized henceforth as the lower boundary-stratotype of the Calabrian Stage, according to the 1948 IGC resolution which designated Calabrian as the lowest stage of the Pleistocene (1,2,12). The strata above this level to the top of the Vrica Section as described in the referenced literature should be recognized henceforth as the boundary-stratotype section of the Calabrian Stage (13).

Quotations

(1). "There are stratigraphic situations where hard and fast rules cannot be applied and that common sense may indicate what will best promote clarity, understanding and progress." (p. 4)

(2). "The revision and redefinition of a previously proposed and named unit requires a statement of intent to revise the unit, the reasons for doing so, and a discussion of the history of the unit—author, original reference, previous treatment. If necessary, it should include a comprehensive description of the unit and designation of a new type section or type locality (or revision of the old one). The revision of a unit, to be valid, must be published in a recognized scientific medium." (p. 17)

(3). Re priority, in regard to new names (*e.g.* Santernian): (p. 23) "Priority in publication of a properly proposed, named and defined unit should be respected...the critical factors should be the usefulness of the unit, the adequacy of its description, freedom from ambiguity, and suitability for widespread publication." (p. 23)

(4). Re priority, in regard to earlier, obscure names: "Priority alone does not justify displacing a well-established name by one not well known or only occasionally used; nor should an inadequately established (earlier obscure name) be preserved merely for the sake of priority." (p. 23)

(5). "Revision or redefinition of previously established stratigraphic units. Revision or redefinition of an adequately established unit without changing its name requires as much justification and the same kind of information as for proposing a new unit. ... Redefinition may also become desirable because of....errors in an earlier work. ...Changes in major chronostratigraphic units of international scope should be made only after consultation with appropriate stratigraphic organizations." (p. 24)

(6). "b. Parastratotype. A supplementary stratotype used by the original author. c. Lectostratotype. A stratotype for a previously described stratigraphic unit selected later in the absence of an adequately described original stratotype." (p. 28)

Note (1). Gignoux did not designated a stratotype. Selli's was the first, thus the holostratotype, not the lectostratotype.

(7). "Global boundary stratotype section and point (GSSP) is the term proposed for these standard boundary-stratotypes of units of the Global Chronostratigraphic Scale (Cowie et al 1986)."(p. 29. See references 12,13)

(8). "Biostratigraphic units (biozones) are bodies of rock strata that are defined or characterized on the basis of their contained fossils." (p.53)

(9). "The named units composing each rank in this Standard Global Chronostratigraphic Scale encompass, as a whole, the entire stratigraphic sequence, without gaps and without overlaps." (p. 78)

(10). "The selection of the boundaries of the stages of the Standard Global Chronostratigraphic Scale deserves particular emphasis because such boundaries serve to define not only the stages but also chronostratigraphic units of higher rank such as series and systems of which stages are components." (p. 79)

(11). "Series are defined by boundary stratotypes. If a series has been completely divided into stages its boundaries should be the lower boundary of its oldest stage and the upper boundary of its youngest stage, or the lower boundary of the lowermost stage in the overlying series. If stage subdivisions are not available, the series may be defined independently by its own boundary-stratotypes." (p. 80)

(12). "The definition of chronostratigraphic units is best accomplished....by the selection of boundary-stratotypes of their lower boundaries. These boundary-stratotypes are specific and representative sequences of strata in specific geographic localities that contain unique and specific points that are the record of unique instants of geologic time." (p. 90)

(13). "The selection of the boundary-stratotypes of chronostratigraphic units of the Global Chronostratigraphic Scale, where possible, should take account of historical priority and usage and should approximate the traditional boundaries. To insure its acceptance and use over wide areas, preferably worlwide, a boundary-stratotype should be selected to contain as many specific good marker horizons or other features favourable for long-distance time correlation (chronocorrelation) as possible. Examples are significant biohorizons characterized by distinctive marine, cosmopolitan fossils; magnetic polarity reversals; and stratigraphic intervals favourable for accurate numerical dating." (p. 91)

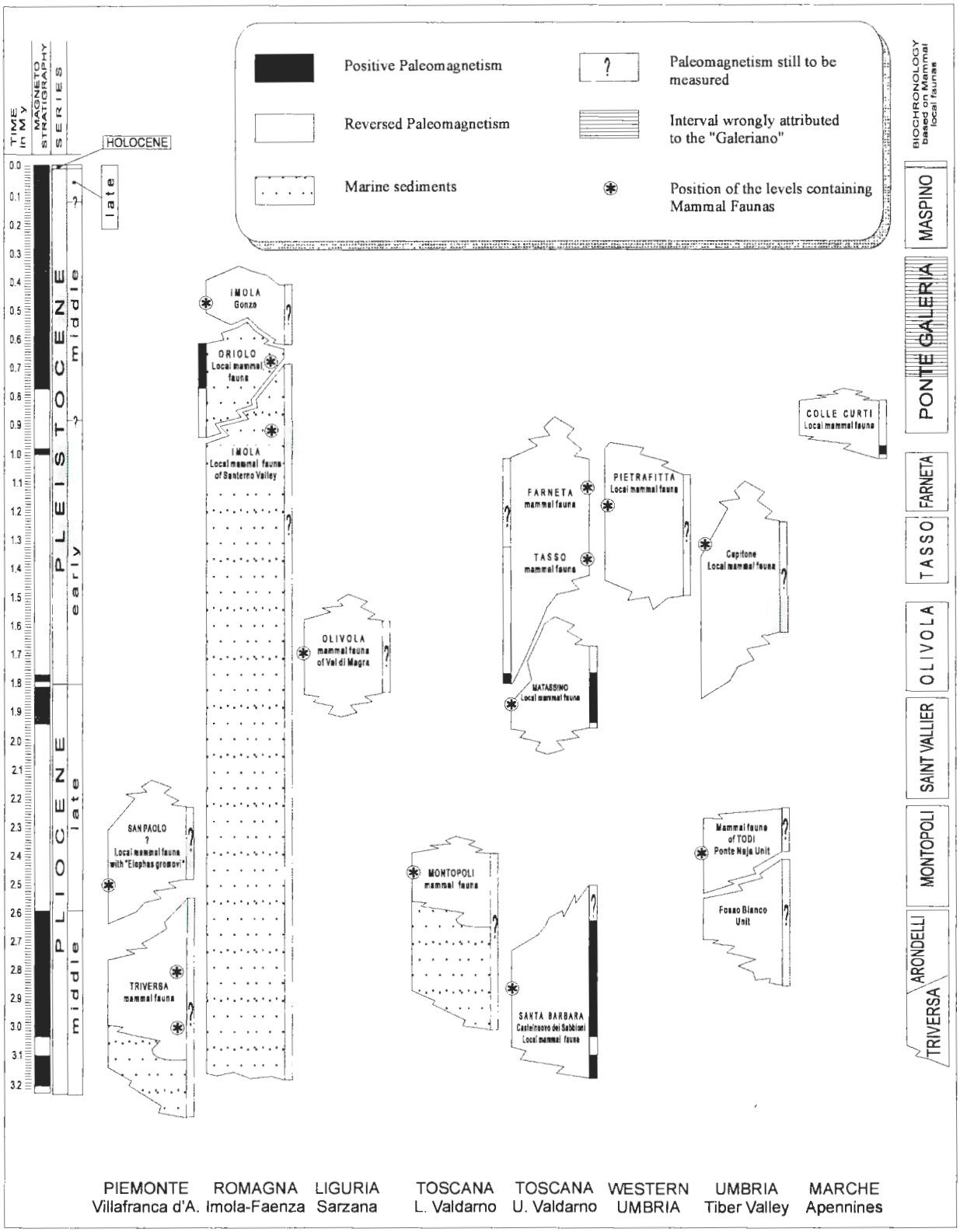

Fig. 14 - Correlation of continental fossiliferous successions from northern and central Italy and the paleomagnetic stratigraphy (P. Ambrosetti, unpublished, 1994). The columnar logs indicate the results of paleomagnetic investigations, when available. Question marks indicate questionable data.

Correlazione fra successioni continentali fossilifere dell'Italia settentrionale e centrale e la stratigrafia paleomagnetica (P. Ambrosetti, inedito, 1994). Le stratigrafie mostrano i risultati degli studi paleomagnetici; i "?" indicano che i dati possono non essere certi.

(14). "...the body of rock strata lying between magnetic-polarity-reversal horizons....constitutes a polarity unit containing everywhere strata representing essentially, but not exactly, the same time span. Such units may approximate chronostratigraphic units, but, strictly speaking, they are not chronostratigraphic units because they are defined primarily not by the record of time but by a specific physical property, a change of the polarity of remanent magnetization, which is not instantaneous." (p. 101).

Major breaks in continental faunal successions in Europe and the need of high resolution datings for the Pleistocene

(a contribution by **A. Azzaroli**, Earth Sciences Dept., University of Florence)

Analysis of faunal successions of the Plio-Pleistocene is linked with the problem of correlation with marine sequences and calibration with the geomagnetic scale. Only few sites have been reliably calibrated so far. The very rich fauna of the Maar of Senèze, French Central Massif, has been calibrated to the early Matuyama chron, in a reversed polarity interval between a short normal episode (Réunion) and the Olduvai event. The age of the Tegelen fauna of the Netherlands, less rich but of similar composition, is comprised between the Olduvai event and the underlying reversed polarity interval. Only one late Villafranchian (early Pleistocene) fauna has been calibrated with the geomagnetic scale: the Matassino local fauna in the Upper Valdarno lies about 5 m above the end of the Olduvai event (Torre *et al.*, 1993).

Faunal change at the Pliocene-Pleistocene transition was marked by extinctions and new appearances of species but was not sharp, and the early Pleistocene fauna still keeps close links with the faunas of the late Pliocene. Evidence presently available is not adequate to pinpoint the faunal change in the chronological scale, the more so as appearances of new elements in the faunas were not sudden, and some characteristic early Pleistocene species occur sporadically in late Pliocene levels: Sus strozzii, Leptobos etruscus.

A faunal revolution of much greater moment took place later, at the Villafranchian-Galerian transition. Many species became extinct and were replaced by new species, either immigrants or more derived descendants of late Villafranchian species.

The faunal assemblage changed its character: it lost its Pliocene affinities and assumed a modern aspect. The present faunal assemblage assumed its fundamental outlines at this time. New types of adaptation developed: the heavy bovids *Bison, Bos, Ovibos,* the recently extinct giant deer, *Megaloceros, Megaceroides, Cervalces latifrons.* This revolution was not sudden, and localities with mixed faunal assemblages, in which late Villafranchian holdovers are associated with modern elements, have been discovered at several sites and are under active study. Still, there are reasons to believe that the revolution was rapid; moreover, it appears that it was not contemporary over Eurasia. The revolution started in NE Siberia with the first lemmings and muskoxen, somewhere around 1.2 Ma and spread westwards. In Germany, the main fauna of Mosbach (Graues Mosbach), a typically Galerian assemblage, dates from the early Brunhes; an older level, with Villafranchian elements associated with Galerian immigrants (Graues Mosbach), dates from the Jaramillo episode.

Vertebrate paleontologists and students of continental stratigraphy feel the need of a high resolution chronology in order to analyze cause-to-effect relationships in faunal events and in changes in climate and vegetation.

The marine stratigraphic scale offers good prospects for a high resolution chronology. A boundary between early and middle Pleistocene defined in a marine sequence on the basis of biological and climatic events may become a useful term of reference for detailed datings of continental formations and fossils, provided its age is not too far removed from the dates of the major revolutions on the continents.

BIBLIOGRAFIA

Aguirre E. & Pasini G., 1985 - *The Pliocene-Pleistocene Boundary.* Episodes, **8**, 116-120.

Bassett M.G., 1985 - *Towards a "Common Language" in stratigraphy.* Episodes, **8**, 87-92.

Castradori D., 1993 - *Calcareous nannofossil biostratigraphy and biochronology in eastern Mediterranean deep-sea cores.* Riv. It. Paleont. Strat., **99**, 107-126.

Channell J., Di Stefano E. & Sprovieri R., 1992 - *Calcareous Plankton Biostratigraphy, Magnetostratigraphy and Paleoclimatic History of the Plio-Pleistocene Monte San Nicola Section (Southern Sicily).* Boll. Soc. Paleont. It., **31**, 351-382.

Ciaranfi N., D'Alessandro A., Marino M. & Sabato L., 1994 - *La successione argillosa infra e mediopleistocenica della parte sudoccidentale della Fossa Bradanica: la sezione di Montalbano Ionico in Basilicata.* In: *Guida alle escursioni*, Congresso Soc. Geol. It., Bari (1994), Quaderni Bibl. Prov. Matera, **15**, 117-156.

Cita M.B. & Gartner S., 1973 - *Studi sul Pliocene e gli strati di passaggio dal Miocene al Pliocene. IV. The stratotype Zanclean. Foraminiferal and nannofossil biostratigraphy.* Riv. It. Paleont. Strat., **79**, 503-558.

Cita M.B., Rio D. & Sprovieri R., in stampa - *The Pliocene Series: Chronology of the Type Mediterranean Record and Standard*

Chronostratigraphy. Wrenn *et al.* (Eds.), AASP Sp. Vol. (Baton Rouge).

Colalongo M.L., Pasini G. & Sartoni S., 1980 - *Neogene-Quaternario e definizione del relativo stratotipo nella sezione Vrica (Calabria).* Paleontol. Stratigr. ed Evoluz., Quad., **1**, 91-94.

Colalongo M.L., Pasini G. & Sartoni S., 1981 - *Remarks on the Neogene/Quaternary boundary and the Vrica Section (Calabria, Italy).* Boll. Soc. Paleont. It., **20**, 99-120.

Dai Pra G., 1982 - *The Late Pleistocene Marine deposits of Torre Castiglione (Southern Italy).* Geogr. Fis. Dinam. Quat., **5**, 115-119.

Dai Pra G. & Hearty P.J., 1988 - *I livelli marini pleistocenici del Golfo di Taranto. Sintesi geocronostratigrafica e tettonica.* Mem. Soc. Geol. It., **41**, 637-644.

Dai Pra G. & Hearty P.J., 1989 - *Variazioni del livello del mare sulla costa ionica salentina durante l'Olocene. Epimerizzazione dell'isoleucina in* Helix *sp.* Mem. Soc. Geol. It., **42**, 311-320.

Di Stefano E., Sprovieri R. & Caruso A., 1993 - *High resolution biochronology in the Monte Narbone formation of the Capo Rossello section and the Mediterranean first occurrence of* Globorotalia truncatulinoides. Riv. It. Paleont. Strat., **99**, 357-370.

Doderlein P., 1872 - *Note illustrative della carta geologica del Modenese e del Reggiano.* Memoria III, 74 pp.

Gignoux M., 1913 - *Les formations marines pliocènes et quaternaires de l'Italie du Sud et de la Sicile.* Ann. Univ. Lyon, N.S., 1, 24-693.

Hearty P.J. & Dai Pra G., 1992 - *The Age and Stratigraphy of Middle Pleistocene and Younger Deposits along the Gulf of Taranto (Southeast Italy).* J. Coastal Res., **8**, 882-905.

Pasini G. & Colalongo M.L., 1994 - *Proposal for the erection of the Santernian/Emilian boundary-stratotype (lower Pleistocene) and new data on the Pliocene/Pleistocene boundary-stratotype.* Boll. Soc. Paleont. It., **33**, 101-120.

Pelosio G., Raffi S. & Rio D., 1980 - *The Plio-Pleistocene Boundary Controversy. Status in 1979 at the light of International Stratigraphic Guide.* In: F. Petrucci & R. Cavazzini (eds.), Volume dedicato a Sergio Venzo, 131-140.

Raffi I. & Rio D., 1980 - *Nannoplancton calcareo del Pliocene superiore-Pleistocene inferiore della serie del fiume Santerno.* Paleontol. Stratigr. ed Evoluz., Quad., **1**, 187-195.

Rio D., 1982 - *The fossil distribution of Coccolithophore Genus Gephyrocapsa Kamptner and related Plio-Pleistocene chronostratigraphic problems.* Init. Rep. DSDP, **68**, 325-343.

Rio D., Raffi I. & Villa G., 1990 - *Pliocene-Pleistocene calcareous nannofossils distribution patterns in the Western Mediterranean.* Proc. ODP, Sci. Results, **107**, 513-533.

Rio D., Sprovieri R. & Thunell R., 1991 - *Pliocene - lower Pleistocene chronostratigraphy: A re-evaluation of Mediterranean type sections.* Geol. Soc. Am. Bull., **103**, 1049-1058.

Rio D., Sprovieri R. & Di Stefano E., 1994 - *The Gelasian Stage: a proposal of a new chronostratigraphic unit of the Pliocene Series.* Riv. It. Paleont. Strat., **100**, 103-124.

Ruddiman W.F., Raymo M.E., Martinson D.G., Clement B.M. & Backman J., 1989 - *Pleistocene evolution: northern hemisphere ice sheets and North Atlantic Ocean.* Paleoceanography, **4**, 353-412.

Ruggieri G. & Sprovieri R., 1976 - *Ricerche sul Siciliano di Palermo: le argille del fiume Oreto.* Boll. Soc. Geol. It., **94**, 1613-1622.

Ruggieri G., Unti A., Unti M. & Moroni M.A., 1977 - *La Calcarenite di Marsala (Pleistocene inferiore) e i terreni contermini.* Boll. Soc. Geol. It., **94**, 1623-1657.

Ruggieri G. & Sprovieri R., 1979 - *Selinuntiano, nuovo superpiano per il Pleistocene inferiore.* Boll. Soc. Geol. Ital., **96**, 797-802.

Ruggieri G. & Sprovieri R., 1983 - *Recenti progressi nella stratigrafia del Pleistocene inferiore.* Boll. Soc. Paleont. It., **22**, 315-321.

Ruggieri G., Buccheri G., Greco A. & Sprovieri R., 1976 - *Un affioramento di Siciliano nel quadro della revisione della stratigrafia del Pleistocene inferiore.* Boll. Soc. Geol. It., 94, 889-914.

Ruggieri G., Rio D. & Sprovieri R., 1984 - *Remarks on the chronostratigraphic classification of Lower Pleistocene.* Boll. Soc. Geol. It., **103**, 251-259.

Salvador A. (Ed.), 1994 - *International Stratigraphic Guide. A guide to stratigraphic classification, terminology, and procedure.* Second Edition, Boulder, CO, The Geol. Soc. of America.

Sanvoisin R., D'Onofrio S., Lucchi R., Violanti D. & Castradori D., 1993 - *1 Ma paleoclimatic record from the eastern Mediterranean. Marflux Project: first results of a micropaleontological and sedimentological investigation of a long piston core from the Calabrian ridge.* Il Quaternario, **6**, 169-188.

Selli R., 1971 - *Calabrian.* Giorn. Geologia, s.2, **37**, 55-64.

Selli R., Accorsi C.A., Bandini Mazzanti M., Bertolani Marchetti D., Bigazzi G., Bonadonna F.P., Borsetti A.M., Cati F., Colalongo M.L., D'Onofrio S., Landini W., Menesini E., Mezzetti R., Pasini G., Savelli C. & Tampieri R., 1977 - *The Vrica section (Calabria, Italy). A potential Neogene/Quaternary boundary stratotype.* Giorn. Geol. ser.2, **42**, 181-204.

Tauxe L., Opdyke N.D., Pasini G. & Elmi C., 1983 - *Age of the Plio-Pleistocene boundary in the Vrica section, southern Italy.* Nature, **304**, 125-129.

Torre D., Albianelli A., Azzaroli A., Ficcarelli G., Magi M. & Napoleone G., 1993 - *Paleomagnetic calibration of Late Villafranchian mammal faunas from the Upper Valdarno, Central Italy.* Mem. Soc. Geol. It., **49**, 335-344.

Vergnaud-Grazzini C., Capotondi L. & Lourens L., 1994 - *A refined Pliocene to early Pleistocene chronostratigraphic frame at ODP*

Hole 653A (West Mediterranean). Mar. Geol., **117**, 329-349.

Verhallen P.J.J.M., 1991 - *Late Pleistocene to Early Pleistocene Mediterranean mud-dwelling Foraminifera; infuence of a changing environment of community structure and evolution.* Utrecht Microplaeont. Bull., **40**, 1-219.

Zijderveld J.D.A., Hilgen F.J., Langereis C.G., Verhallen P.J.J.M. & Zachariasse W.J., 1991 - *Integrated magnetostratigraphy and biostratigraphy of the upper Pliocene-lower Pleistocene from the Monte Singa and Crotone areas in Calabria (Italy).* Earth and Planet. Science Letters, **107**, 697-714.