The Global Standard Stratotype-section and Point (GSSP) of the Piacenzian Stage (Middle Pliocene)

The base of the Piacenzian Stage, representing the Lower Pliocene-Middle Pliocene boundary, has been recently defined and ratified by IUGS. The boundary-stratotype is located in the Punta Piccola section (Sicily, Italy).

Introduction

The aim of this report is to announce the ratification of the Global Standard Stratotype-section and Point of the Piacenzian Stage (Middle Pliocene). Together with the Gelasian (Upper Pliocene; reported on in this same issue) and the Zanclean (Lower Pliocene) Stages, the Piacenzian represents the threefold subdivision of the Pliocene Series in the Global Standard Chronostratigraphic Scale.

A brief description of the stratotype-section of the boundary itself ("golden spike") and of the different stratigraphic tools available for the worldwide correlation of the boundary will be provided. More information can be found in the proposal (Cita et al., 1996) voted by the Subcommission on Neogene Stratigraphy (SNS) and the International Commission on Stratigraphy (ICS) reported in Neogene Newsletter no 3 and in the literature referred to in this paper.

A postal ballot on the proposal by Cita et al. (1996) was forwarded to all voting members of the Subcommission on Neogene Stratigraphy (SNS) in 1996 and unanimously accepted. Following the results of the postal ballot, a formal recommendation of SNS was submitted to the Secretary General of the International Commission on Stratigraphy (ICS) in October 1996. Official acceptance by ICS and ratification by the Executive Committee of IUGS were obtained in January 1997.

Background and motivation

The erection of the Gelasian as third (and uppermost) Stage of the Pliocene Series (published in this issue), formally settled the controversies concerning the upward extension of the Piacenzian Stage. As a consequence, the Piacenzian now represents the (entire) Middle Pliocene because its top is automatically defined by the base of the overlying Gelasian Stage in the Monte San Nicola section (also in Sicily), a point in the rock with an approximate age of 2.588 Ma, close to the Gauss/Matuyama magnetic reversal.

Immediately after having reached an agreement on the Gelasian Stage, the Subcommission on Neogene Stratigraphy was faced with the problem of defining the base of the Piacenzian Stage. According to the guidelines for defining chronostratigraphic boundaries (see Remane et al., 1996 for detailed information), a unit stratotype, as the one defined by Barbieri (1967; see below) for the Piacenzian, is no longer appropriate for the definition of a Stage. The only (formally) acceptable way to define the Piacenzian Stage was to select and approve a boundary stratotype for its base.

Since in the type-area of the Piacenzian (near Castell'Arquato, Northern Apennines, Italy) a hiatus was proved to be present right at the base of this chronostratigraphic unit (see further on), the attention focused on Sicily, where a continuous succession of hemipelagic limestones and marls, or marls and sapropelic layers, is exposed along the southern coast.

At first sight, it seems arbitrary to have a Piacenzian Stage defined on Sicily (Piacenza is a town on the Emilian side of the Po river in Northern Italy); however, move outside the type-area for the selection of the most suitable section to define the base of a chronostratigraphic unit is common in modern stratigraphy. This allows for preserving name and approximate time-significance of widely used chronostratigraphic units and maintaining, as far as possible, the stability of stratigraphic nomenclature.

In the following paragraph, we will briefly introduce the historical Piacenzian Stage to document how the ratified GSSP is respective of its original definition.

The Piacenzian Stage

Since its introduction (Mayer-Eymar, 1858), the Piacenzian Stage has been quite popular in the geologic literature. It was soon adopted by Pareto (1865), who clearly indicated the fossiliferous sediments ("blue clays") outcropping between Castell'Arquato and Lugagnano (Northern Apennine) as typical of the unit. He ascribed the Piacenzian to the (upper) Tortonian which at that time was considered a Pliocene unit. Afterwards, the term Piacenzian has been widely used, although with rather different meanings. Reviewing the literature, one may gain the impression that the term was more often used as a lithostratigraphic than a chronostratigraphic term, indicating the "Argille azzurre" of the Italian Pliocene (see Gignoux, 1950).

The designation of a unit-stratotype in the Castell'Arquato section by Barbieri (1967) was an important step towards the clarification of the Piacenzian Stage. The base was defined at the lithofacies change from slope-basin to outer-shelf sediments coincident with the local disappearance of the planktonic foraminifer Globorotalia margaritae. The latter bioevent was subsequently used in most geologic time scales to mark the base of the Piacenzian (e.g., Cita, 1973; Berggren and Van Coupering, 1974; Berggren et al., 1985, 1995b; Haq and Van Eysinga, 1987; Haq et al., 1988; Harland et al., 1982, 1990).

As already mentioned, an integrated calcareous plankton bionstratigraphic study carried out by Rio et al. (1988) and Raffi et al. (1989) clearly demonstrated that a hiatus is present right at the base of the type-Piacenzian and that the local disappearance of G. mar-
garietiae does not correspond to its extinction datum. According to these Authors, the Piacenzian base lies at an undetermined point in between the last occurrence (LO) of *Reticulofenestra pseudoubabouticus* (dated at 3.89 Ma, according to the time scale of Lourens et al., 1996a) and the temporary disappearance in the Mediterranean of *Globorotalia puncticulata* (3.57 Ma). The outcome of this investigation was twofold. In the first place, the LO of *G. margaritae* could not be used to export the base of the Piacenzian away from the type-area; secondly, the type-area is not suitable to formally define the base of the Piacenzian Stage and a suitable continuous section had to be found elsewhere.

### The GSSP of the Piacenzian Stage

Having to move away from the Castell' Arquato section, our attention focused immediately on the Punta Piccola section for two obvious reasons. In the first place, the Italian stratigraphic record is considered as the type of the Pliocene Series and, secondly, the Rossello Composite Section (of which the Punta Piccola is the upper segment) has recently become a reference standard for Pliocene Time Scales (Langereis & Hilgen, 1991; Hilgen, 1991b; Berggren et al., 1995a; Lourens et al., 1996a). The superior quality of the selected section is discussed below.

#### The section

**Location**

The Punta Piccola section is located along the road from Porto Empedocle to Realmonite, 4 km to the east of Capo Rossello, and about 3 km to the W-NW of Porto Empedocle (Agrigento province, Sicily, Italy), at a latitude of 37°17'20" N and a longitude of 13°39'36" E of Greenwich (1°02'51" E of Monte Mario). The area is represented on the *Carta Topografica d'Italia* at 1:25,000 Foggia 271, IV NO (Porto Empedocle) (Figures 1 and 2).

**The stratigraphic succession**

The Punta Piccola section is situated in the Caltanissetta Basin: from a structural point of view, the section belongs to a major tectonic element known as Gela nappe or Gela thrust system (Ogniben, 1969; Butler et al., 1995). The Rossello Composite Section is made up by about 100 m of alternating limestones and marls of the Trubi Formation gradually passing upwards into the more marly Monte Narbone Formation, characterized by the cyclical occurrence of laminated (sapropelic) layers (Figures 2 and 3). The transition from the

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Figure 1 Location of the Punta Piccola section.

Figure 2 (a) Punta Piccola section, showing the topmost Trubi beds at the left and the overlying Monte Narbone marls and sapropels, strike and dip: 330° and 10° (photo courtesy after M.J. Brolsma, 1978), (b) Close-up of the Zanclean/Piacenzian boundary (solid line) interval of the Trubi marls at Punta Piccola, (c) Close-up of the Trubi-Monte Narbone boundary interval. Dark colored ferromanganese and organic enriched beds are indicated with A to L after Brolsma (1978).
Figure 3 Chronology of the Rossello composite section based on the correlation of small-scale carbonate cycle patterns to the La90(t) (Laskar, 1990; Laskar et al., 1993) precession and 65° N summer insolation curves (Hilgen, 1991b; Lourens et al., 1996a).
Trubi to the Monte Narbone formations actually occurs in the Punta Piccola segment of the Rossello Composite, at about 20 m from its base. The depositional environment is inferred to be an open marine slope-basin setting (Brolsma, 1978; Sprovieri & Barone, 1982). According to the abundance of planktonic foraminifers, the presence of rare psychrothermic ostracods and the composition of the benthic assemblage, the water depth is estimated to range from 800 to 1,000 m.

**Biomagnetostratigraphy, astrocyroclatigraphy, and isotope stratigraphy**

During the last decade, detailed field work carried out on rhythmically bedded sedimentary successions widely outcropping in Sicily and Calabria led to the reconstruction of an ideal stratigraphic composite section which ranges from the base of the Pliocene to the middle Pleistocene (e.g. Hilgen, 1987, 1990, 1991a, b; Langereis and Hilgen, 1991; Zijderveld et al., 1991; Lourens et al., 1996a, b; Lourens et al., 1997). The cyclic limestone-marl and marl-sapropel alternations in this succession were tightly linked to every single fluctuation of the Earth’s precessional parameter (in turn modulated by orbital eccentricity), resulting in a continuous astrochronology of the lithostratigraphic record (Hilgen, 1991a, b). Later on, the influence of obliquity was also recognized in the lithologic record and the astronomical calibration slightly adjusted and improved (Lourens et al., 1996a).

This astrochronologic stratigraphy, intimately linked to an integrated biostratigraphy (nannofossils and foraminifers) (among many others, Rio et al., 1990; Sprovieri, 1992, 1993) and magnetostratigraphy (e.g. Zachariasse et al., 1989, 1990; Zijderveld et al., 1991; Langereis & Hilgen, 1991), resulted in a stratigraphic framework for the Mediterranean Pliocene and Pleistocene with unprecedented accuracy and resolution. This framework allows for a bed-by-bed correlation of stratigraphic sections hundreds of kilometers apart, testing stratigraphic continuity of specific intervals.

In the Punta Piccola section calcareous nannofossils were studied by Rio et al. (1984) and Driever (1988). The section is referable to Zone MN16a to MNN16b/17 (in terms of the zonation by Rio et al., 1990), to Zone NN16 of Martini (1971) and to Subzones CN12a and CN12b of Okada & Bukry (1980).

Planktonic foraminifers have been studied by Brolsma (1978), Spak (1983), Rio et al. (1984), Zachariasse et al. (1989, 1990), Sprovieri (1992, 1993), and Lourens et al. (1996a). The section ranges from Zone MP14a to MP15a (according to the zonation by Cita, 1973, 1975b, emended by Sprovieri, 1992) and from Interval IV to VII of Spak (1983).

The Punta Piccola section provided an excellent magnetostratigraphy (Zachariasse et al., 1989, 1990) which was straightforwardly correlated to the upper part of the Gilbert (C2Ar of Canale & Kent, 1992, 1995), to the entire Gauss (with the Mammoth and Kaena Subchrons), and to the lowermost part of the Matuyama chron.

Sprovieri (1992) used the percentage of Globigerinoides ruber to reconstruct temporal variations in sea surface temperature (SST). In addition, high-resolution quantitative planktonic foraminiferal and stable isotope records have been established by Lourens et al. (1996a) for the entire Rossello Composite Section (Figure 4). These authors recognized the influence of both precession and obliquity in these records. Obliquity controlled variations could be correlated in detail to ODP Site 659 (eastern tropical Atlantic) and Site 846 (eastern equatorial Pacific).

All the analytical data reported above clearly indicate that the Punta Piccola section is basically continuous, possible hiatuses having a duration below the resolution provided by astroclatigraphy (few kyrs). The sedimentation rate ranges between 4.5 to 5.5 cm/kyr, increasing to 12 cm/kyr towards the top of the section.

In the upper part of the Punta Piccola section the base of the newly defined Gelasian Stage (see this issue) can be easily recog-

**Figure 4** Stable isotope stratigraphy of the Punta Piccola section (Lourens et al., 1996a), ODP Site 659 (Tiedemann et al., 1994), and ODP Site 846 (Shackleton et al., 1995b).
The definition of the base of the Zanclean Stage (Lower Pliocene) is not yet achieved. SNS plans to work hard in that direction in the next few months.

References


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Episodes, Vol. 21, no. 2