Pliocene Standard Chronostratigraphy: A Proposal

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In the last twenty years paramount improvements have been made in dating and correlating the global marine and continental Pliocene stratigraphic record by integrating biomagnetostratigraphy and astrocyclostratigraphy (see Berggren et al., this volume). By contrast, the standard Chronostratigraphy of the Pliocene is in a flux state. Specifically, the lower boundary, the standard stages and the subdivision of the Pliocene have not been rigidly and unequivocally defined. Various specialists have established their own subdivision (twofolded *versus* threefolded) and/or "biostratigraphic definitions" of chronostratigraphic boundaries, which in most instances have quite different chronologic meanings. As a result chronostratigraphy is often a source of confusion and misunderstandings rather than the common language which should facilitate long-distance correlations and communication among Earth scientists.

In order to overcome this state of affairs and in the firm belief of the usefulness of an internationally agreed upon standard Chronostratigraphic Scale, we have recently reviewed the state of the Pliocene stratigraphy and we have made an organic proposal for its chronostratigraphic subdivision (Rio et al., 1991; Cita et al., in press; Rio et al., in press). Specifically, we have proposed that the Miocene/Pliocene boundary be defined in the Mediterranean stratigraphic record in correspondence with the restoration of normal oceanographic conditions after the termination of the Messinian salinity crisis, and that the Pliocene/Pleistocene boundary be retained in the Vrica section. In addition, we have proposed that the most convenient subdivision of the Pliocene is into three stages (Zanclean, Piacenzian and Gelasian) with the Global Stratotype and Point Sections (GSSP) of each stage defined in the lithostratigraphic record of Southern Sicily. Our proposal is summarized in Figure 1 and briefly commented below for a discussion within the Neogene community, before submitting it formally to the International Commission of Stratigraphy for approval.

Why a threefolded subdivision?

The chronostratigraphic subdivision of the Pliocene has varied over the years. However, a general twofold subdivision into a lower Pliocene Zanclean stage and an upper Pliocene Piacenzian stage appears to be the most widely accepted practice today (e. g. Berggren et al., 1985). This practice results in placing in the same chronostratigraphic unit (the Piacenzian) sediments predating and following the onset of Northern Hemisphere glaciation around the Gauss-Matuyama boundary, one of the most important event in the Cenozoic evolution of the global climatic system, easily recognizable in the continental and marine stratigraphic records. Actually, a chronostratigraphic boundary in correspondance with this event is used regionally in many parts of the world and the distinction of a preglacial and glacial Pliocene is widespred. The top of the stratotype section of the Piacenzian itself is below a climatic deterioration which can be correlated with the onset of the Northern Hemisphere glaciation (Rio et al., 1991 and in press). The rationale in preferring a threefolded subdivision of the Pliocene is simply the convenience and the utility of distinguishing in the Standard Chronostratigraphic Scale an interval of geologic time which is easily recognized and correlated on global scale, thus improving chronostratigraphic resolution.

Gelasian and Astian

Rio et al. (in press) have proposed the Gelasian stage as the third uppermost Pliocene subdivision of the Pliocene. The stage name is derived from the greek name of the town of Gela, in southern Sicily, nearby which the GSSP has been proposed. In the past the term Astian has been used for indicating the third uppermost stage of the Pliocene. However, the use of the Astian has been abandoned because its type, located in Piemonte region, is represented by shallow water sandy sediments, difficult to frame in time, and certainly older than the Gelasian as defined by Rio et al.(in press).

Philosophy in proposing GSSPs.

Our most important guidelines in proposing GSSPs (or reiterating proposals made by others) for the bases of the Zanclean, the Piacenzian and the Gelasian have been the worldwide correlatability and the maximum of stability in the stratigraphic nomenclature. The global correlatability of the proposed chronostratigraphic units (discussed in Cita et al., in press, and in Rio et al., in press), is assured by biostratigraphy, magnetostratigraphy, climatostratigraphy and cyclostratigraphy. The proposed boundaries most probably can be recognized with good approximations in both marine and continental records. However, as well important is the fact that the proposed subdivision does not violate the position in time of the historical stratotypes and does not demand a major upset of the existing geological literature. The need of stability has been the rationale in maintaning the historical definition of the Miocene-Pliocene boundary at the restoration of open marine condition in the Mediterranean after the termination of the Messinian salinity crisis and of the definition of the Pliocene-Pleistocene boundary in Vrica section. In this context, we strongly oppose to the proposal of Benson et al. (1990) of shifting the definition of the Miocene-Pliocene boundary at the Chron 3A-Gilbert boundary because it will lead to placing most of the Mediterranean upper Messinian evaporites in the Pliocene thus upsetting a well consolidated literature more than a century old. For similar reasons we strongly oppose to the mounting proposal by continental stratigraphers of shifting the base of the Pleistocene to the Gauss-Matuyama boundary (at the base of the Gelasian). Gelasian sediments in Castell'Arquato area are the type of the Pliocene as introduced by Lyell and the practice of recognizing the Pliocene-Pleistocene boundary close to the top of the Olduvai subchron as implied by its definition in Vrica section (Aguirre and Pasini, 1985) has proved well practicable and widely accepted (see for example DSDP and ODP Reports and Scientific Results). We do not see any advantage for stratigraphy to "adjust" continuously chronostratigraphic boundaries on the base of new findings.

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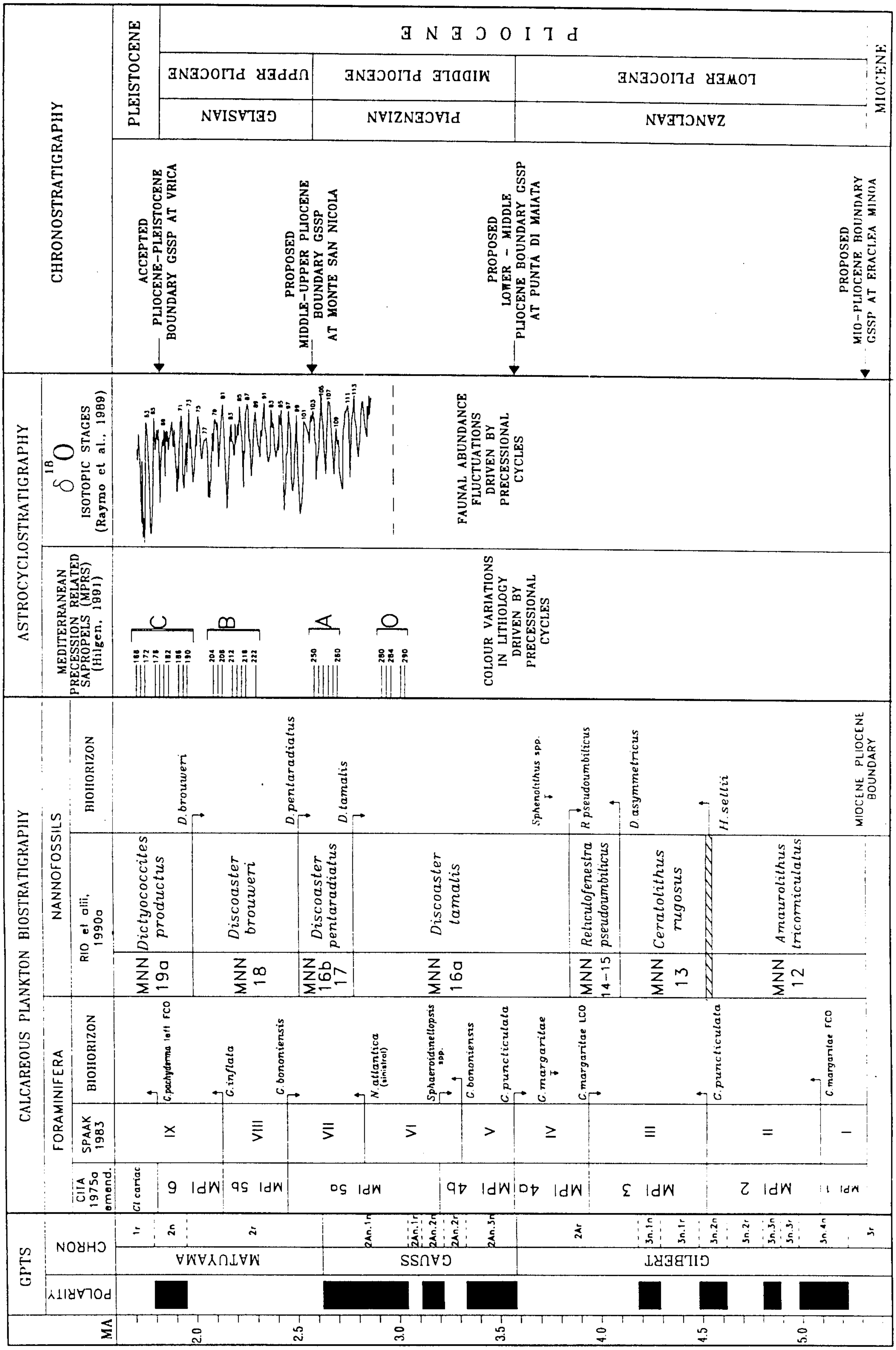
FIGURE 1 CAPTION

Mediterranean Pliocene time framework and the proposed Chronostratigraphy of the Pliocene Series. The chronology of the Geomagnetic Reversal Time Scale is after Hilgen (1991).


CHRONOSTRATIGRAPHY
PLEISTOCENE
PLIOCENE
MIOCENE
UPPER PLIOCENE
MIDDLE PLIOCENE
LOWER PLIOCENE
GELASIAN
PIACENZIAN
ZANCLEAN
ACCEPTED PLIOCENE-PLEISTOCENE BOUNDARY GSSP AT VRICA
PROPOSED MIDDLE-UPPER PLIOCENE BOUNDARY GSSP AT MONTE SAN NICOLA
PROPOSED LOWER - MIDDLE PLIOCENE BOUNDARY GSSP AT PUNTA DI MAIATA
PROPOSED MIO-PLIOCENE BOUNDARY GSSP AT ERACLEA MINOA
ASTROCYCLOSTRATIGRAPHY
$\delta^{18}O$ ISOTOPIC STAGES (Raymo et al., 1989)
FAUNAL ABUNDANCE FLUCTUATIONS DRIVEN BY PRECESSIONAL CYCLES
MEDITERRANEAN PRECESSION RELATED SAPROPELS (MPRS) (Hilgen, 1991)
COLOUR VARIATIONS IN LITHOLOGY DRIVEN BY PRECESSIONAL CYCLES
C
B
A
0
CALCAREOUS PLANKTON BIOSTRATIGRAPHY
NANNOFOSSILS
RIO et alii, 1990a
BIOHORIZON
D. brouweri
D. pentaradiatus
D. tamalis
Sphenolithus spp.
R. pseudoumbilicus
D. asymmetricus
H. sellii
MIOCENE PLIOCENE BOUNDARY
MNN 19a Dictyococcites productus
MNN 18 Discoaster brouweri
MNN 16b 17 Discoaster pentaradiatus
MNN 16a Discoaster tamalis
MNN 14-15 Reticulofenestra pseudoumbilicus
MNN 13 Ceratolithus rugosus
MNN 12 Amaurolithus tricorniculatus
FORAMINIFERA
SPAAK 1983
BIOHORIZON
C. pachyderma left FCO
G. inflata
G. bononiensis
N. atlantica (sinistral)
Sphaeroidinellopsis spp.
G. bononiensis
G. puncticulata
G. margaritae
G. margaritae LCO
G. puncticulata
G. margaritae FCO
IX
VIII
VII
VI
V
IV
III
II
I
CITA 1975a emend.
Gl. cariac.
MPl 6
MPl 5b
MPl 5a
MPl 4b
MPl 4a
MPl 3
MPl 2
MPl 1
GPTS
CHRON
POLARITY
MATUYAMA
GAUSS
GILBERT
1r
2n
2r
2An.1n
2An.1r
2An.2n
2An.2r
2An.3n
2Ar
3n.1n
3n.1r
3n.2n
3n.2r
3n.3n
3n.3r
3n.4n
3r
MA
2.0
2.5
3.0
3.5
4.0
4.5
5.0