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Quaternary: "Quo Vadis"?

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The Quaternary, like the long-abandoned terms Primary, Secondary and Tertiary, is a very ambiguous word, whose chronological meaning is not very well defined. Its usage spread very quickly, perhaps due to its more-or-less close relationship with the human history and with the latest glaciations. However, the oldest of human fossil record, according to recent discoveries in Africa (Djourab Desert in Tchad), is about 7 million years old, rather than 2 million years as suggested by fossils at Olduvai. Moreover, for some time now, it has been known that the first Quaternary-type glaciations occurred in several regions of the Earth between 2.5 and 3 million years ago, that is prior to the Pliocene-Pleistocene limit at 1.81 million years ago, as determined by the GSSP. These facts have led some researchers, mostly from the International Union of Geological Sciences (IUGS), and from the International Association for Quaternary Research (INQUA), to suggest changes in the subdivision of the Neocenozoic. Certainly, discussions on this subject will be raised at many scientific meetings in the near future until almost unanimous agreement can be attained. Some additional suggestions are presented here, as a contribution to resolution of these nomenclatorial issues.

Introduction

According to Phillips (1840), the present *Cenozoic Era* was subdivided in schemes still subjected to much discussion, until at least the middle of the 19th century, based on field relationships and/or on biological evolution. In 1760 Arduino, professor of the Padova University (Italy), used the word *Primary* for the oldest rocks followed by rocks of *Secondary*, during lithostratigraphical classification surveys of northern Italy mountainous region. The lower hills composed of gravelly, sandy and clayey sediments were attributed to the *Tertiary*. On the other hand, the term *Quaternary*, Desnoyers (1829) was proposed for alluvial and marine sediments containing the remains of associations of extant animals and plants, and overlying *Tertiary* deposits of the Paris Basin.

The use of the word *Quaternary*, even without more precise chronological definition, spread very rapidly particularly in the mapping of less consolidated superficial deposits. Ages attributed to *Quaternary* units on older geologic maps are very uncertain.

Based on relative similarity of fossil assemblages with the modern fauna, Lyell (1833) subdivided the *Tertiary* Period into the *Eocene, Miocene* and *Pliocene Epochs*. Apparently ignoring the previous proposal from Desnoyers (1829), Lyell named the post-Tertiary time as *Recent* (Fairbridge, 1968). The *Recent* Epoch was later renamed *Holocene Epoch* by Gervais (1867). Lyell never used the word *Quaternary*, but assumed that Desnoyer's concept was approximately equivalent to the time interval from the *Tertiary Period Newer Pliocene* through the *Recent*.

The *Neogene* and *Paleogene* Stages were introduced by Hörnes (1853) to subdivide Cenozoic deposits and were adopted by the International Commission on Stratigraphy (ICS). The *Paleogene* of Hörnes included the *Paleocene, Eocene* and *Oligocene Epochs* and the *Neogene*, the *Miocene, Pliocene*, and *Pleistocene Epochs*.

When the International Commission on Stratigraphy (ICS) and the International Association for Quaternary Studies (INQUA) decided to standardize the *Pliocene-Pleistocene* limit during the 1950s, there were three proposals for formal definition:

a) Lyell's (1833) *Newer Pliocene* at approximately 1 My;

b) Top of Olduvai palaeomagnetic subzone at about 2 My, and

c) Near the Gauss-Matuyama palaeomagnetic polarity reversal at about 2.5 My.

Option (b) was chosen during the INQUA International Congress in 1982 (Moscow) by the INQUA Commission on Stratigraphy, acting as a subcommission of the International Commission on Stratigraphy (ICS); it was formally approved by this commission in 1983. According to this decision, the base of the Pleistocene (boundary stratotype), composed of deepwater marine deposits, would be located in Vrica, Sicily (Italy), near the top of Olduvai normal polarity palaeomagnetic subzone at about 1.8 My. It characterizes the time of greatest spreading of the mollusk *Arctica islandica* which was, in general, thought to be restricted to boreal waters of the interglacial stage. According to Aguirre & Pasini (1985), this boundary stratotype does not take into account the situation of the *Quaternary* in the chronostratigraphic scale. The stratotype was presented by Pasini & Colalongo (1997) and, moreover, was characterized in detail by stratigraphers from many countries from sedimentological, palaeoecological, biostratigraphical, biochronological and magnetostratigraphical viewpoints.

The word *Quaternary*, even without a formal definition, became very entrenched and amongst other peculiarities, traditionally has been correlated with glacial episodes of the Northern Hemisphere (Figure 1).

However, chronological evidence, based on marine isotopic records and on ice-drifted sediments of the Northern Atlantic Ocean, indicates that the most important increase in the volume of continental glaciers must have begun about 2.6 Ma. Because of this, this subject was reevaluated in 1998 by the Neogene Stratigraphy Commission of ICS and by the Quaternary Stratigraphic Commission of ICS-INQUA, which again resulted in the formal rejection of placement of the Pliocene-Pleistocene limit at the base of the Gelasian Stage. Its boundary-stratotype was maintained at base *Pleistocene* in Vrica, Sicily (Italy), dated at 1.806 Ma. Thus, if the *Quaternary* is defined on the basis of the most important oscillations in Northern Hemi-

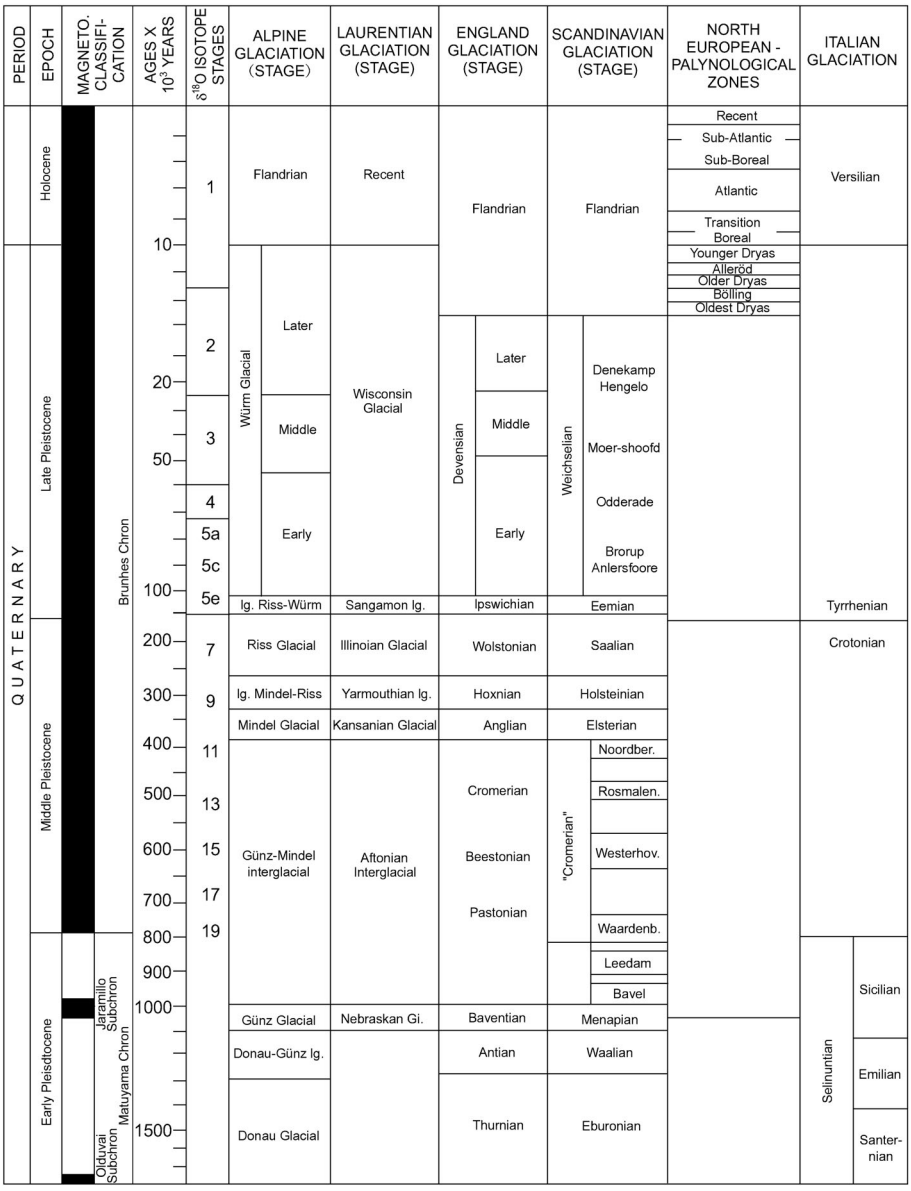

Figure 1 Tentative correlation between the Quaternary Period and Northern Hemisphere glacial and interglacial (Ig) episodes (Geosciences Research Group of Japan, 1996).

sphere glacier volume, it began 800 thousand years before the *Pleistocene Epoch* base (Figure 2).

Some proposals for formalizing the Quaternary

Subdivision proposed by the International Commission on Stratigraphy (ICS)

The Cenozoic Era, with a total duration of about 65 My, would be subdivided into *Paleogene* (42 My) and *Neogene* (23 My) *Periods*, consisting of comparable time intervals (Figure 3). The *Tertiary* (about 63 My or more than 95% of the Cenozoic) and the *Quaternary* (about 2 My or less than 5% of the Cenozoic) Periods would be formally abandoned, but maintained informally, like the equally important unit term Precambrian.

The decision to abandon the word *Tertiary* follows in the same tradition that led to the suppression of *Primary* and *Secondary*: they are very ambiguous words. In the subdivision presented by Gradstein et al. (2004), *Quaternary* was also omitted, but *Pleistocene* and *Holocene* were maintained with the *Pliocene-Pleistocene* boundary being set at 1.8 My and the *Pleistocene-Holocene* limit at 0.0115 My.

Subdivision of the International Association for Quaternary Research (INQUA)

Recently, Pillans (2004) emphasized the need for maintaining the *Quaternary,* as an international subdivision of the *Neogene Period* (Figure 4). According to this author, the *Quaternary* represents a word too important to be simply omitted from the Geologic Time Scale, as happened with the *Primary, Secondary* and, more recently, *Tertiary*. As one his justifications, the author states that the *Quaternary* represents a link between humankind and geology. Moreover, it would provide the needed umbrella-type protection for other disciplines correlatable with geosciences, as for example, archaeology, palaeopedology, palaeoclimatology, etc. Pillans proposed redefinition of the *Quaternary* as a Subperiod (or Subsystem) of the Neogene Period (or System), beginning at about 2.6 My and including at its base the Gelasian stage (Rio et al., 1998). The most important arguments in favor of this proposal are:

a) There is very strong support by INQUA members, who answered positively to the proposal for maintenance of the *Quaternary* as a formal stratigraphic unit.

b) Precedence already exists for introducing the Subperiod (or Subsystem) in the Geologic Time Scale as, for example, the Mississippian and Pennsylvanian Subperiods (or Subsystems) of the Carboniferous Period.

c) Disassociation of the base of the *Quaternary* from the Pliocene-Pleistocene boundary (1.8 My) would finish discussions about the position of this limit.

d) The majority of INQUA members seems to be favorable to the "longer" Quaternary (2.6 My), instead of the "shorter" Quaternary (1.8 My). This choice reflects the

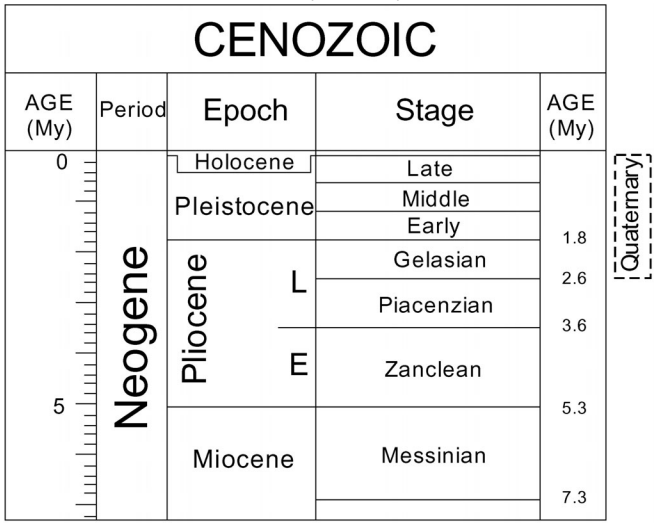

Figure 2 Current span of the Quaternary without formal definition based on the most important oscillations in Northern Hemisphere glacier volumes (Ogg, 2004).

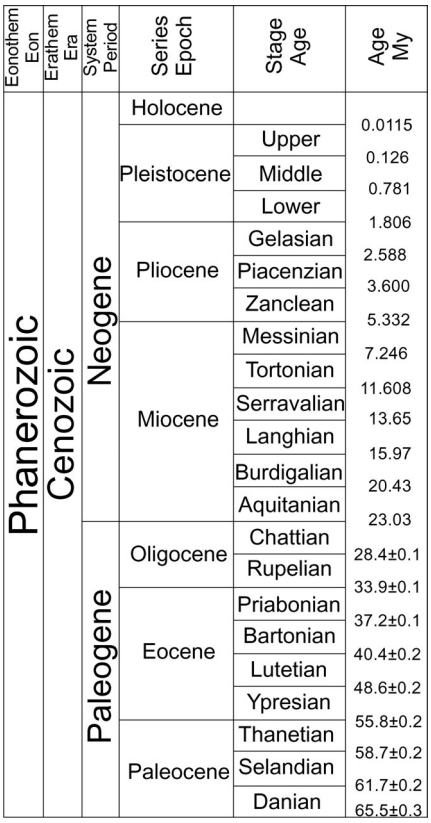

Figure 3 Proposal of the International Commission on Stratigraphy (ICS) of the International Union of Geological Sciences (IUGS) published by Gradstein et al. (2004) and Lourens et al. (2004).

understanding of significance of continuity of the properties through time. For example, loess deposition in China became more intense and more extensive about 2.6 My ago, with quite different properties from the underlying "red clays" (Ding et al. 1997).

e) At about 2.6 My, deep sea oxygen isotope records show a series of cycles of growing glacial intensities, which are also associated with first record of more abundant North Atlantic Ocean glacial detrital sediments. For many researchers this would represent the advent of Quaternary glacial ages. This boundary corresponds to the transition from equinox precession to ecliptical obliquity as the dominant process in climatic forcings (Milankovitch, 1920).

According to the INQUA Stratigraphy and Chronology Commission, consultations about this subject must continue, during the International Union of Geological Sciences (IUGS) congresses, like that recently finished in Florence (Italy), as well as during the next INQUA International Congress in Cairns (Australia), to be held in 2007.

Present proposal

It is suggested here that, for the same reasons alleged for the abandonment of the terms Primary, Secondary and Tertiary, the word Quaternary could be eliminated from the Geological Time Scale as well, because of its extreme ambiguity. The word Holocene, which is commonly considered as synonymous of Recent or Post-glacial, could be also omitted (Figure 5).

In support of our suggestion, the following questions could be raised:

a) Why Post-glacial, if until now there is no irrefutable evidence that Pleistocene glaciations have really finished?

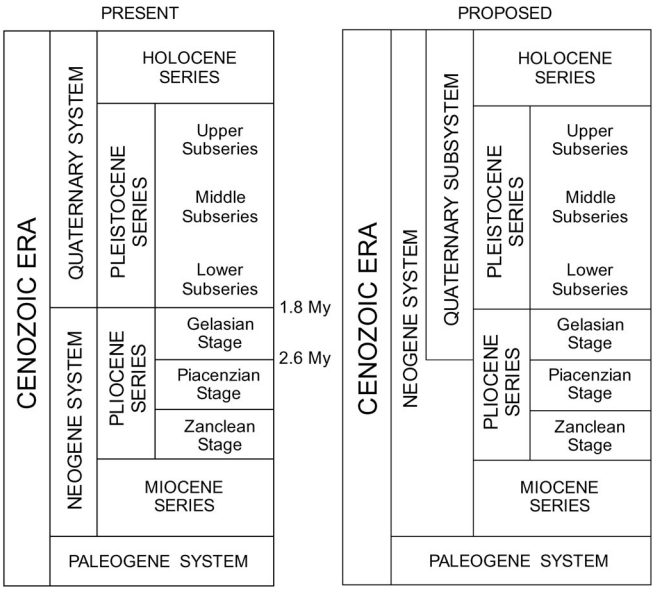

Figure 4 Present situation of the Quaternary and the proposal by Pillans (2004), changing Quaternary to Subperiod (or Subsystem) of the Neogene Period (or System).

b) Why couldn't the well-known mild climate of the Holocene (or Post-glacial) simply represent an interglacial stade, as many palaeoclimatologists think?

c) If the previous hypothesis is believable, isn't an imminent new glacial stade quite possible within the near future, in a few hundred or few thousand years?

In this case, the Pleistocene Epoch could be extended till the present. The Holocene, as a possible Pleistocene interglacial stade, does not deserve any formal title as an Epoch of Neogene Period (Suguio & Soares, 2004). On the other hand, the above mentioned uncertainties do not annul the possibility to consider the Quaternary as an informal chronostratigraphic unit, whose beginning could be located at the base of the Gelasian Stage, coincident with the commencement of the Pleistocene Epoch at about 2.6 My, thereby reducing the duration of Pliocene Epoch by 800 thousand years. This informal use of Quaternary would be somewhat analogous to that of Precambrian, at the other end of the time scale, maintained as such by the strength of tradition. However, we are aware that it remains to be seen if re-opening (for the third time in the last two decades) of

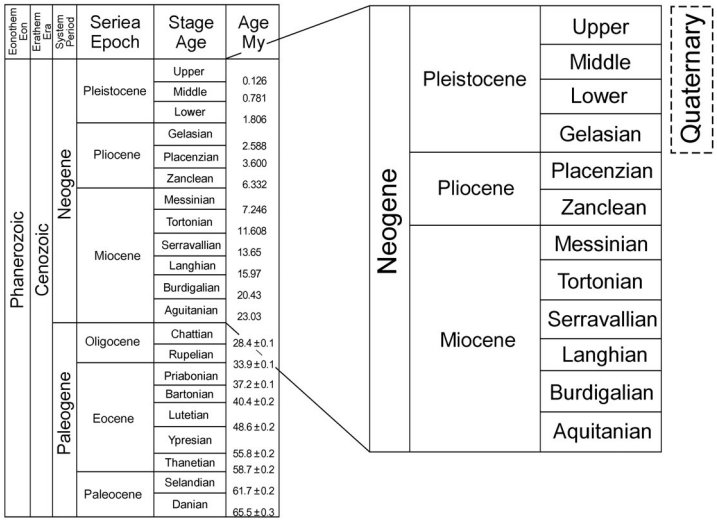

Figure 5 New proposal for the Neogene Period subdivision, composed by Miocene, Pliocene and Pleistocene, with omission of the Holocene Epoch.

the formal debate on re-positioning of the base Pleistocene would be fruitful.

Final considerations

The use of anthropological criteria in characterizing the last chapter (Pleistocene Epoch or "Quaternary") of historical geology makes the Geological Time Scale too anthropocentric, and apparently inconsistent, since mankind may well have appeared in the Miocene Epoch. On the other hand, humankind became conscious of its own existence only about 10 thousand years ago (at the beginning of the "Holocene"). At that time, mankind began to abandon instinctive wandering behaviour, like wild animals, and adopted more sedentary life. This change in lifestyle became possible with "domestication" of animals and plants for food.

The abandonment of Holocene and maintenance of "Quaternary", as an informal chronostratigraphic unit are proposed in this paper. The Quaternary would become synonymous with the Pleistocene Epoch, which began about 2.6 My. This proposal would safeguard the continuity of such important and traditional research organizations as INQUA and similar national associations, like the Brazilian Association of Quaternary Studies (ABEQUA), as well as of their on going multi and interdisciplinary studies. Finally, the authors believe that this proposal is the best one, because it is in perfect agreement with the Geological Timetable based on the Earth history and evolution.

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