

## **DISCUSSION**

### **WHAT, IF ANYTHING, IS QUATERNARY?**

John A. Van Couvering<sup>1</sup>, Marie-Pierre Aubry<sup>2</sup>, William A. Berggren<sup>3</sup>, Brian McGowran<sup>4</sup>, Frits Hilgen<sup>5</sup>, Lucas Lourens<sup>6</sup>, and Felix M. Gradstein<sup>7</sup>

<sup>1</sup> The Micropaleontology Project, 256 Fifth Avenue, New York, NY 10001, USA- [vanc@micropress.org](mailto:vanc@micropress.org)

<sup>2</sup> Earth and Planetary Sciences, Rutgers University, Piscataway, NJ 08854-8066, USA – [aubry@rci.rutgers.edu](mailto:aubry@rci.rutgers.edu)

<sup>3</sup> Woods Hole Oceanographic Institution, Woods Hole, MA 02543, USA – [wberggren@whoi.edu](mailto:wberggren@whoi.edu)

<sup>4</sup> Earth and Environmental Sciences, University of Adelaide, SA 5005, Australia - [brian.mcgowran@adelaide.edu.au](mailto:brian.mcgowran@adelaide.edu.au)

<sup>5</sup> Department of Earth Sciences, Utrecht University, Utrecht, Netherlands - [fhilgen@geo.uu.nl](mailto:fhilgen@geo.uu.nl)

<sup>6</sup> Department of Earth Sciences, Utrecht University, Utrecht, Netherlands - [llourens@geo.uu.nl](mailto:llourens@geo.uu.nl)

<sup>7</sup> University of Oslo, POB 1172 Blindern, N-0318 Oslo, Norway - [felix.gradstein@nhm.uio.no](mailto:felix.gradstein@nhm.uio.no)

---

*The incorporation of Quaternary as a new Period/System, as voted by the ICS in May 2009, is a paradigm shift in the geological time scale. Until now the progressive, irreversible change of the earth's biota has been the single governing principle in organizing the global stratigraphic record according to age. The Quaternary, on the other hand, is explicitly defined according to paleoclimatological criteria, and the ICS vote holds that the concept of "first glacial episode in the Northern Hemisphere" supersedes the biochronological identity of the Neogene Period/System, the later part of which occupies the same interval. Furthermore, the primacy granted to this datum requires a 44% expansion of the Pleistocene Epoch/Series in order to bring it into conformity with the Quaternary concept, without regard for Lyell's original "conchological" meaning. These actions demonstrate that accommodating a time scale unit defined by non-paleontological criteria, with the goal of recognizing a special aspect of geological history, legitimizes ad hoc time scale boundaries without an inherent age and lacking a uniform philosophy. The increased potential for conflict between disciplines intent on recognition of their special interests in the time scale must also be considered.*

---

In May 2009, the International Commission on Stratigraphy (ICS) completed a vote on contending proposals from two ICS subcommissions concerning the status of Neogene and Quaternary. On the one side was a proposal advanced by the Subcommittee on Quaternary Stratigraphy (SQS) to formally adopt a Quaternary Period (and its equivalent System), where none had been before. The SQS was responding to the omission of Quaternary in the most recently revised ICS time scale (Gradstein, Ogg and Smith, 2004; Lourens, 2004.). The editors and authors of this work had taken the not unreasonable view (see Berggren, 1986; Hilgen, et al., 2008) that Quaternary was no more valid as a unit in the modern time scale unit than any of the other three unratified stages of lithification (Primary, Secondary and Tertiary) by which Arduino (1760) and other natural philosophers had initially arranged the earth's strata. To rectify this and give the Quaternary a formal reality in the time scale, the SQS proposed to create space for a Quaternary Period equivalent to Pleistocene and Holocene, with its base in a proper GSSP that could be explicitly associated with the beginning of continental glaciation in the Northern Hemisphere, as the modern defining concept of Quaternary (Gibbard, et al., 2005; Head, Gibbard and Salvador, 2008a).

The somewhat arbitrary concept of "first glaciation" (see Fig. 1) has most recently been agreed by the leaders of the Quaternary community to be represented in a cold-climate peak at approx. 2.6 Ma (cf. Head, et al., 2008a and references therein). By placing the base of the Quaternary at this level, the SQS proposed not only to overlap the upper Neogene System in its original sense but even in the abbreviated usage popularized by some later workers (Hilgen, et al., 2008; see Fig. 1). The SQS proposal also required a 44% enlargement of the Pleistocene Series/Epoch, moving its base to the 2.59-Ma GSSP of the Gelasian Stage at San Nicola (Head, et al., 2008a), in order to agree with the *a priori* definition of the Quaternary, and thereby superseding Lyell's characterization in terms of North Sea and Italian fossil marine faunas that

was recognized in the 1.81-Ma GSSP of the Calabrian Stage at Vrica (Aguirre and Pasini, 1985; Van Couvering, 1997).

The Subcommittee on Neogene Stratigraphy (SNS), on its side, offered an alternative proposal to accommodate a 2.6-Ma Quaternary without such disruption, by giving it status as a Neogene sub-unit composed of late Pliocene, Pleistocene and Holocene (cf. Lourens 2008; McGowran, et al., in review). During the protracted discussions that followed, other alternatives were also floated. One was the earlier suggestion by Aubry, et al. (2005) to place Quaternary and a resuscitated Tertiary in the status of Cenozoic sub-eras, and another (from the current ICS chairman) was to maintain a semblance of status quo by defining the Quaternary Period/System, if there was to be one, in the Vrica GSSP. It was also proposed to simply do away with Paleogene and Neogene altogether and install Tertiary and Quaternary in their place (Head, et al., 2008b). The ICS vote, however, was restricted to the two original proposals.

The comments made by the subcommittee chairs (ICS internal report, in litt.) make clear that the outcome of the vote was never in doubt, and in fact the 2.6-Ma Quaternary Period was included in a time scale published “to best reflect the needs of the GSA members” even before the vote was cast (Walker and Geissman, 2009). There are, however, major consequences that follow from this vote that were not brought into the discussion, and that should have been considered before the SQS proposal was even put on the table.

Both the SQS and SNS began with the assumption that Quaternary would become a formal unit in the time scale. Both proposals (as well as the unofficial alternatives) involved unconventional manipulations of hierarchical logic, and none of them were rationally compelling. Thus, the debate preceding the vote was reduced to a wrangle over which distorted arrangement was preferable as a way to seat the Quaternary in the standard time scale. What was overlooked in this debate was the question as to whether the Quaternary should be seated at all. Neither side recognized that the SQS proposal was based on assumptions about the definition of geological

time scale units that fundamentally conflict with the principles that have governed its organization up to the present day.

To be clear, there is no end-Cenozoic period, sub-period or sub-era -- Quaternary or otherwise -- in the time scale, because there is no change in the fossil record during the final 2.6, or even the final 20 million years of geological history that rises to the level of a period-boundary event (Aubry, et al. 2009). The fact that all major boundaries in the Phanerozoic time scale are characterized by paleobiotic changes is apparently so taken for granted that few bother to consider whether an important principle is involved. We all know that the full appreciation of geological time arose from the systematic observations of marine fossil sequences, but it is not so well recognized that no other features of the strata could have served this purpose. It is also taken for granted that boundaries continue to be characterized and positioned according to fossils (almost universally marine invertebrates) as chronostratigraphy has replaced the old biostratigraphic system (Aubry et al., 2009). Again, few appreciate that this is no more an accident than it was at the beginning, nor is it a relic of the past imposed, *faute de mieux*, by intellectual inertia. In fact, reliance on the fossil record is a fundamental property of the time scale, and to characterize it as a power grab by the marine community (Walsh, 2008) wilfully ignores reality. The linear progress of organic evolution means that biochronology is one of only two ordinal systems that spans geological time (Berggren and Van Couvering, 1978), the other being radioactive decay. It is the accessibility and complex meaning of the fossil record that makes paleontology preferable to radiometric analysis in organizing geologic history. Once biotic change becomes the medium of measurement, then logic dictates that the measured units be exclusively framed in these terms to avoid miscommunication and conflict.

Stanley (2009) has emphasized that the most recent faunal change in the geologic record that reaches the level of a period boundary is the emergence of the modern biota during the Oligocene-Miocene transition some 23 m.y ago. More than 150 years before, in the earliest days

of biochronology, this same transition was recognized by Hörnes (1853) when he distinguished Neogene time. By contrast, the time ascribed to Quaternary includes no significant biotic event (the modern catastrophe aside). True, the appearance of genus *Homo* at c. 2.4 Ma is widely cited as a significant paleontological distinction of Quaternary time, but at the biotic rather than emotional level this event is almost invisible, and for the next 2.2 m.y. its impact is limited to that of dispersed hunter-gatherers in the Old World tropics whose remains are some of the rarest fossils known (Aubry, et al., 2009). Indeed, the only notable biotic changes during this time, whether on land or sea, are shifts in the geographic ranges of the Neogene fauna in response to oscillations in climate, without any sharp or significant wave of worldwide extinction and origination (Stanley, 2009). Thus, without a convincing paleontological anchor, the time assigned to the Quaternary concept has varied from 0.4 to 2.6 Ma (Fig. 1), depending on which of the cold-climate cycles of the late Cenozoic has been esteemed as the true beginning of the Ice Ages.

The officers of SQS, setting aside any such considerations, have asserted that “the [period] status and rank of the Quaternary are not in debate” (M. J. Head, et al., communication to ICS chair S. C. Finney, Feb. 2009), citing past custom; preliminary approval by officers of IUGS; and the intention to use the San Nicolà GSSP to legitimize its chronostratigraphic identity. As conclusive justification, however, the writers (*ibid.*, point 5) stressed that “Users of the geological time scale must be considered, and the Quaternary community numbers 50,000 worldwide with INQUA serving as its voice. INQUA, which has equal status with the IUGS under the International Council of Science (ICSU), unanimously endorses the SQS proposal.” Here the assumption underlying the SQS proposal is most clearly expressed -- that the word "Period" may be freely appropriated and applied to any recognizable segment of time, for expedient reasons. Characterized as a “holistic” approach in the SQS memo (*ibid.*), this means that any event

in geological history can be the criterion for a time scale boundary, if it has sufficient support. To use an exaggerated simile, this could be likened to including police sirens in symphony orchestras, because many law enforcement officers attend concerts.

Seen in this light, the Quaternary subcommission's proposal would mean a profound change in the organizing principles of the standard time scale. We can imagine that with the door open to all, vulcanologists would feel entitled to their own Deccan Period and tectonicists could revise the mid-Phanerozoic as the Pangeatic. If this seems absurd, consider how easily the associated paleomagnetic reversals, isotopic peaks and/or orbital signals could shift from being carefully separated correlation tools to being defining criteria in GSSPs. Perhaps more to the point, we note the longstanding pressure from anthropologists (who in fact outnumber Quaternary geologists) to recognize an Anthropogene Period. Environmentalists, too, are suggesting that the time since the invention of the steam engine should be recognized as the Anthropocene (Crutzen and Stoermer, 2000). In this "holistic" scenario, decisions as to the nature and boundaries of units in the standard time scale would move entirely, and not just partially as now, into the realm of politics, where various disciplines would back their favorite time units.

In sum, as things now stand with paleoclimatic criteria irrelevant to the definition of chronostratigraphic boundaries, a Quaternary Period/System cannot be identified in Late Neogene paleofaunas. This, and much else, will change if the international authority, by ratifying the ICS vote, decides in favor of abandoning the fossil record as the uniform guiding standard for the geological time scale.

## REFERENCES

- Aguirre, E. and Pasini, G., 1985. The Pliocene-Pleistocene boundary. *Episodes*, vol. 8, pp. 116-120.
- Arduino, G., 1760. Sopra varie sue Osservazioni fatte in diverse parti del Territorio di Vicenza, ed altrove, appartenenti alla Teoria Terrestre, ed alla Mineralogia. [Letter to Prof. Antonio Vallisnieri, dated 30<sup>th</sup> March 1759]. *Nuova Raccolta do Opuscoli\* Scientifici e Filologici del Padre Abate Angiola Calagierà*, vol. 6, pp. 142-143.
- Aubry, M.-P., Berggren, W. A., Van Couvering, J. A., McGowran, B., Pillans, B. and Hilgen, F., 2005. Quaternary: status, rank, definition, survival. *Episodes*, vol. 28, pp. 118-120.
- Aubry, M.-P., Berggren, W. A., Van Couvering, J. A., McGowran, B., Hilgen, F., Steininger, F. and Lourens, L., 2009. Neogene and Quaternary: chronostratigraphic compromise or non-overlapping magsteria? *Stratigraphy*, vol. 6, pp. 1-16.
- Berggren, W. A., 1998, The Cenozoic Era: Lyellian (chrono)stratigraphy and nomenclatural reform at the millenium, *In* Blundell, D. J. and Scott, A. G., eds., *Lyell: The past is the key to the present*, pp. 111-132. London: The Geological Society. Special Publication 143.
- Berggren, W. A. and Van Couvering, J. A., 1978. Biochronology, *in* Cohee, G. V., Glaessner, M. F. and Hedberg, H. D., eds., *Contributions to the Geologic Time Scale*, pp. 39-55. Tulsa: American Association of Petroleum Geologists. Studies in Geology, no. 6.
- Crutzen, P. J. and Stoermer, E. F, 2000. The 'Anthropocene'. *IGBP Newsletters*, vol. 41, p. 12
- Gibbard, P. L., Smith, A. G., Zalasiewicz, J. A., Barry, T. L., Cantrill, D., Coe, A. L., Cope, J. C. W., Gale, A. S., Gregory, J., Powell, J. H., Rawson, P. F., Stone, P. and Waters, C. N., 2005. What status for the Quaternary? *Boreas*, vol. 34, pp. 1-6.
- Gradstein, F. M., Ogg, J. G., and Smith, A. G., eds., 2004. *A Geologic Time Scale 2004*. Cambridge: Cambridge University Press, 589 pp

Head, M. J., Gibbard, P. L., and Salvador, A., 2008a The Quaternary: its character and definition.

*Episodes*, vol. 131, no. 2, pp.234–238.

\_\_\_\_\_, 2008b. The Tertiary: a proposal for its formal definition. *Episodes*, vol. 31, pt. 3, pp. 248–250.

Hilgen, F. J., Aubry, M-P., Berggren, W. A., Van Couvering, J. A., McGowran, B. and

Steininger, F., 2008. The case for the original Neogene. *Newsletters on Stratigraphy*, vol. 43, no. 1, pp. 23-32.

Hörnes, G., 1853. Mitteilung an Prof. Bronn gerichtet: Wien, 3. Okt., 1853. *Neues Jahrbuch der*

*Mineralogie, Geologie und Geognosie der Petrefaktenkunde*, vol. 1853, pp. 806-810.

Lourens, L. J., 2008. On the Neogene-Quaternary debate. *Episodes*, vol. 31, pp.239-242.

Lourens, L. J., Hilgen, F., Shackleton, N.J., Laskar, J. and Wilson, D., 2004. The Neogene

Period. In Gradstein, F. M., Ogg, J. G. and Smith, A. G., eds., 2004. *A Geologic Time Scale 2004*, pp. 409-440. Cambridge: Cambridge University Press.

McGowran, B., Berggren, W. A., Hilgen, F., Steininger, F., Aubry, M.-P., Van Couvering, J. A.

and Lourens, L. Neogene and Quaternary coexisting in the geological time scale. the inclusive compromise. *Earth Science Reviews*, in review.

Stanley, S. M., 2009. *Earth system history, 3rd edition*. New York: W. H. Freeman, 551 pp.

Van Couvering, J. A., 1997. Preface: The new Pleistocene, in Van Couvering, J. A., ed., *The*

*Pleistocene boundary and the beginning of the Quaternary*, pp. xi-xvii. Cambridge: Cambridge University Press.

Walker, J. D. and Geissman, W., 2009. 2009 GSA Geologic Time Scale. *GSA Today*, vol. 19, no.

4, pp. 60-61.

Walsh, S. L., 2008, The Neogene: origin, adoption, evolution, and controversy. *Earth Science*

*Reviews*, vol. 89, pp. 42-72.



CAPTION, FIG. 1

-----

\*Figure 1. Variation in the Quaternary concept over the past 150 years (Hilgen et al., 2008, fig. 2). Modern calibrations of the stage and epoch boundaries are used for simplicity, and time scales that do not have Quaternary as a period/system are not shown. (*Dil*, diluvial; *Tyr*, Tyrhenian; *Sic*, Sicilian; *Cal*, Calabrian; *Gel*, Gelasian; *Ast*, Astian; *Pia*, Piacenzian; *Zan*, Zanclean).

-----