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Formal subdivision of the Quaternary System/Period: Past, present, and future



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ABSTRACT

The Quaternary System/Period represents the past 2.58 million years and is officially subdivided into the Pleistocene and Holocene series/epochs, with the base of the Holocene assigned an age of 11,700 calendar years before AD 2000. The two lowest stages of the Pleistocene, the Gelasian (base 2.58 Ma) and the Calabrian (base 1.80 Ma), have been ratified and these effectively constitute the Lower Pleistocene Subseries. All other official subdivisions are pending. For the Middle Pleistocene Subseries, three candidate global boundary stratotype sections and points (GSSPs) are under consideration: the Valle di Manche in Calabria and Montalbano Jonico in Basilicata, both in southern Italy, and the Chiba section in Japan. The Matuyama–Brunhes Chron boundary (~773 ka) serves as the principal guide for the base of the Middle Pleistocene. The base of the Upper Pleistocene Subseries is generally agreed to coincide approximately with that of the last interglacial (Marine Isotope Substage 5e ~130 ka): the Fronte section near Taranto in southern Italy represents a possible candidate GSSP, but an Antarctic ice core might also serve this purpose. A tripartite subdivision of the Holocene, with subseries/stage boundaries at 8200 and 4200 years B.P., is also under consideration. Additional fine-scale formal subdivision of the Quaternary is being explored, with the Last Glacial Maximum serving as a test case. The “Anthropocene” is both an informal and undefined interval of time that includes the present day. Its duration, formal/informal status, rank, and method of definition are all under debate, with one suggestion that it be defined as a formal unit beginning with the world’s first nuclear bomb explosion, on July 16th 1945. Suggested and proposed GSSPs are compared and critiqued. The history leading to ratification of the Quaternary Period in 2009 is examined drawing upon published and unpublished material.

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1. Introduction

The Quaternary System/Period represents the past 2.58 Ma and is officially subdivided into the Pleistocene and Holocene series/epochs. The Quaternary System/Period, Pleistocene Series/Epoch, and Gelasian Stage/Age are all defined by a single global boundary stratotype section and point (GSSP) at Monte San Nicola in Sicily (Gibbard and Head, 2010; Gibbard et al., 2010; Fig. 1). The Pleistocene is traditionally subdivided into Lower/Early, Middle, and Upper/Late Pleistocene subseries/subepochs, and although these subdivisions are not yet officially recognised, the Calabrian Stage has been defined by the Vrica GSSP in Calabria, southern Italy, effectively completing the definition of the Lower Pleistocene (Cita

et al., 2012). The Holocene is defined by a GSSP in the Greenland NGRIP2 ice core (Walker et al., 2009). No other GSSPs have yet been designated for the Quaternary. The current official time scale for the Quaternary, as sanctioned by the International Union of Geological Sciences (IUGS), including both ratified and suggested and proposed GSSPs, is shown in Fig. 2.

We draw a distinction between the terms “formal” and “official” with respect to chronostratigraphic units. Here, “formal” refers to a unit whose boundaries are widely understood and accepted, whereas “official” refers to a unit whose lower boundary is defined by a GSSP proposed by the International Commission on Stratigraphy (ICS) and ratified by the Executive Committee (EC) of the IUGS. In this sense the Lower, Middle and Upper Pleistocene subseries are formal but not official units; the Holocene Series is both.

All major boundaries of the Quaternary System should be defined by GSSP. For those that await definition, recommendations pass up through a “chain of command”. The initiative begins with

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Fig. 1. Southern and central Italy showing the location of ratified GSSPs and proposed or suggested GSSPs, as well as other sites discussed in the text. Monte San Nicola = GSSP for Gelasian Stage, Pleistocene Series, Quaternary System. Vrica = GSSP for Calabrian Stage. Montalbano Jonico and Valle di Manche = proposed GSSP for Middle Pleistocene Subseries. Fronte section = suggested GSSP for Upper Pleistocene Subseries.

| CENOZOIC | QUATERNARY | HOLOCENE | | STAGE AGE |
|----------|------------|--------------|-----------|---|
| | | SERIES EPOCH | SUBSERIES | |
| | | PLEISTOCENE | | STAGE AGE |
| 'Upper' | 'Middle' | | | |
| 'Lower' | | | | |
| | | | | ◀ July 16, 1945 (Anthropocene as an epoch defined by GSSA) |
| | | | | ◀ 4200 cal. years B.P. (Mawmluh Cave, NE India speleothem) |
| | | | | ◀ 8200 cal. years B.P. (Greenland NorthGRIP1 ice core) |
| | | | | ◀ 11,700 cal. years b2k (Greenland NorthGRIP2 ice core) |
| | | | | ◀ ca. 130 ka (beginning of Last Interglacial; base of Tarentian?) |
| | | | | ◀ ca. 770–773 ka (Chiba, Montalbano Jonico, Valle di Manche) |
| | | | | ◀ 1.80 Ma (Vrica, Calabria, Italy) |
| | | | | ◀ 2.58 Ma (Monte San Nicola, Sicily, Italy) |

Fig. 2. The current official time scale for the Quaternary, as sanctioned by the International Union of Geological Sciences (IUGS), including both ratified and suggested/proposed GSSPs. No subseries for the Pleistocene or Holocene have yet been ratified.

the Subcommittee on Quaternary Stratigraphy (SQS), one of currently 16 constituent subcommittees of the ICS. The SQS establishes an international boundary working group (officially a “task group”), led by a convener, and tasked with proposing a GSSP. This objective itself is preceded by a decision by the working group to select the primary guide for the boundary. The primary guide might be a paleomagnetic boundary, geochemical excursion, paleontological event, or some other marker that can be recognized widely, and its selection will determine the appropriateness of a candidate GSSP. This is why such a decision is taken first (the principle of “correlation precedes definition”; Cowie, 1986; Cowie et al., 1986; Remane et al., 1996). The boundary must satisfy several criteria. As a first priority, it must facilitate global correlation. It should also broadly reflect the narrative of Earth history by

separating one chapter from another, while respecting historical usage as far as is reasonable. Once the primary guide has been decided, the best stratotype is sought. In reality, multiple criteria are used to recognize a boundary, and a candidate GSSP ideally will display these in a well exposed, expanded, and accessible section. The full range of ideal criteria is listed in Table 1. A decision on whether to recommend a particular candidate GSSP is made first by the relevant boundary working group, next the SQS, and subsequently the full voting membership of the ICS, this being the ICS executive and the chairs of the constituent subcommittees. A 60% supermajority is needed for a GSSP proposal to proceed to the next level, and at any level the proposal can be returned for clarification, revision, or rejection. Once approved by ICS, a proposal is forwarded to the executive committee of the IUGS for ratification,

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