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The Quaternary System/Period: current status and future challenges

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Summary

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 officially defined and these effectively constitute the Lower Pleistocene Subseries/Subepoch. The Middle and Upper Pleistocene have yet to be formally defined, representing an important future challenge along with the subdivision of the Holocene, consideration of the Anthropocene, and fine-scale subdivision elsewhere within the Quaternary.

Keywords: Quaternary, Pleistocene, Holocene, Anthropocene, GSSP

In June, 2009, the Executive Committee of the International Union of Geological Sciences (IUGS EC) ratified a proposal submitted by the International Commission on Stratigraphy (ICS) to lower the bases of the Quaternary System and Pleistocene Series to that of the Gelasian Stage, and each is now defined at its base by the global boundary stratotype section and point (GSSP) at Monte San Nicola in Sicily (Gibbard & Head, 2010; Gibbard *et al.*, 2010). This GSSP has a currently assigned age of 2.58 Ma based on astronomically-calibrated sapropel stratigraphy and the duration of deposition of the Nicola bed (GIBBARD & HEAD, 2009). The Gelasian Stage had previously served as the highest stage of the Pliocene Series (RIO *et al.*, 1998). The GSSP is placed at the base of a marly layer immediately overlying a sapropel (the Nicola bed) assigned to Mediterranean Precession-Related Sapropel (MPRS) 250, and corresponds to Marine Isotope Stage (MIS) 103. It lies just 1 m above the Gauss–Matuyama palaeomagnetic reversal. Ratification brought closure to many years of vigorous debate within the geological community and with it a 10-year moratorium on further official discussions of the boundary. Figure 1 outlines the official and proposed subdivision of the Quaternary.

On December 5, 2011, the IUGS EC ratified the Calabrian Stage with a base defined by the GSSP at Vrica, Calabria, Italy, this GSSP having previously defined the base of the Pleistocene Series. The Calabrian thus

became the second stage of the Pleistocene Series, defining the top of the Gelasian Stage and effectively completing the Lower Pleistocene Subseries. The GSSP occurs at the base of the marine claystone conformably overlying sapropelic bed 'e' in the Vrica section, and has a presently assigned age of 1.80 Ma based on astronomically-tuned sapropel stratigraphy and consideration of the duration of sapropelic bed 'e'. It coincides with the transition from MIS 65 to 64, and the underlying sapropel bed 'e' is assigned to MPRS 176 (Cita *et al.*, 2012). The top of the Olduvai Subchron is identified about 8 m above the GSSP.

The Lower–Middle Pleistocene boundary has yet to be defined although the Brunhes–Matuyama boundary, dated at ca. 773 ka and coinciding with the middle of MIS 19, is widely agreed to be the best primary guide (Head *et al.*, 2008). The three contending global stratotype sections, Valle di Manche in Calabria, and Montalbano Jonico in Basilicata, both in southern Italy, and the Chiba section in Japan, are all well researched and all have strengths and weaknesses. Valle di Manche has magnetostratigraphy, Montalbano Jonico has a highly-resolved and well-integrated stratigraphy but no magnetostratigraphy, and Chiba has outstanding magnetostratigraphy but a literature mostly in Japanese. Establishing the Lower–Middle Pleistocene boundary is a high priority of the ICS Subcommission on Quaternary Stratigraphy (SQS).

The Middle–Upper Pleistocene boundary also has yet to be defined, although the beginning of the last interglacial, which approximates the MIS 6–5 transition at around 130 ka, is a widely accepted guide for the base of the Upper Pleistocene. In the Mediterranean it broadly coincides with the base of the Tarentian, a regional stage yet to be formally defined.

The Holocene Series/Epoch was ratified by the IUGS EC in May 2008, with a GSSP at 1492.45 m depth within the NorthGRIP ice core from Greenland. The GSSP corresponds to an abrupt shift in deuterium excess values that reflects the start of climatic warming following the Younger Dryas/Greenland Stadial 1 cold phase. An age of 11 700 calendar years before AD 2000 is estimated for the base of the Holocene, with a maximum counting error of 99 years (WALKER *et al.*, 2008).

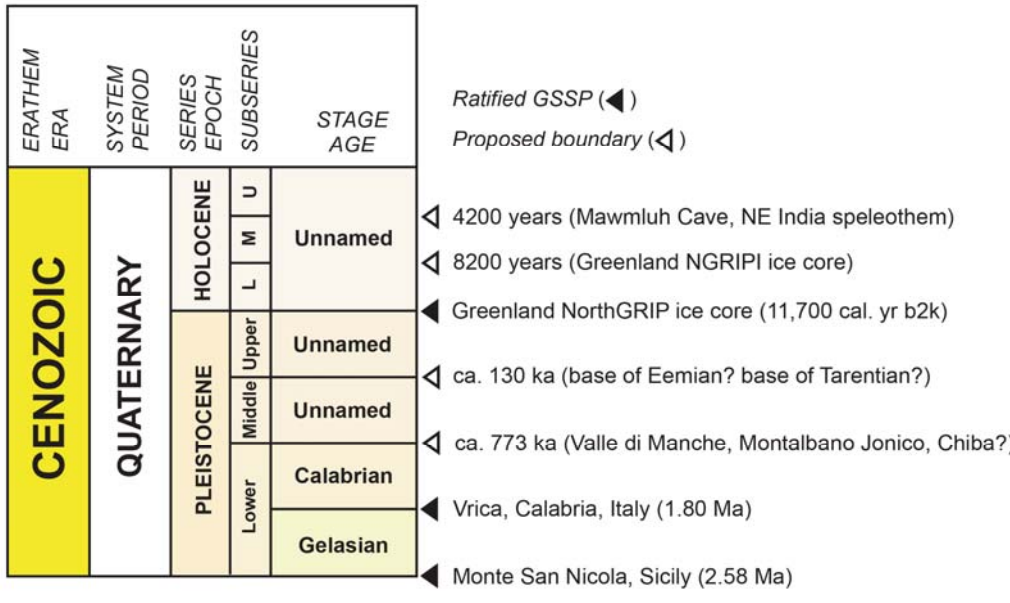

Fig. 1 – Subdivision of the Quaternary System/Period showing the positions of IUGS-ratified GSSPs and proposed boundaries as discussed in the text.

The Holocene has not yet been subdivided formally, but this is an important objective of the SQS. A discussion paper by Walker *et al*. (2012) proposed a Lower/Middle Holocene subseries boundary at 8200 years B.P. and a Middle/Upper Holocene subseries boundary at 4200 years B.P., with suggested GSSPs in the Greenland NGRIP1 ice core, and a speleothem record from Mawmluh Cave, northeast India, respectively.

The Anthropocene, first proposed by Crutzen & Stoermer (2000), is an attempt to recognize formally the substantial acceleration in human-induced changes to our planet during historical time and especially over the

past decades (WILLIAMS *et al.*, 2011). An Anthropocene Working Group has been established by SQS to explore whether the Anthropocene should be treated as a formal chronostratigraphic unit of designated rank and with a defined base, although it currently remains an informal term.

The SQS is also addressing the fine-scale subdivision of other parts of the Quaternary, an example of which is the Last Glacial Maximum, to improve understanding, communication, and stratigraphic correlation, as the demand for ever higher levels of resolution increases. The essential underlying need is to increase precision in communication by drawing distinctions between local and global stratigraphic schemes, and between events and chronostratigraphic units within the narrative of Earth history. SQS intends to take a lead in clarifying these terminological schemes in the future, as well as advocating the proper use of stratigraphical terminology within the Quaternary community.

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