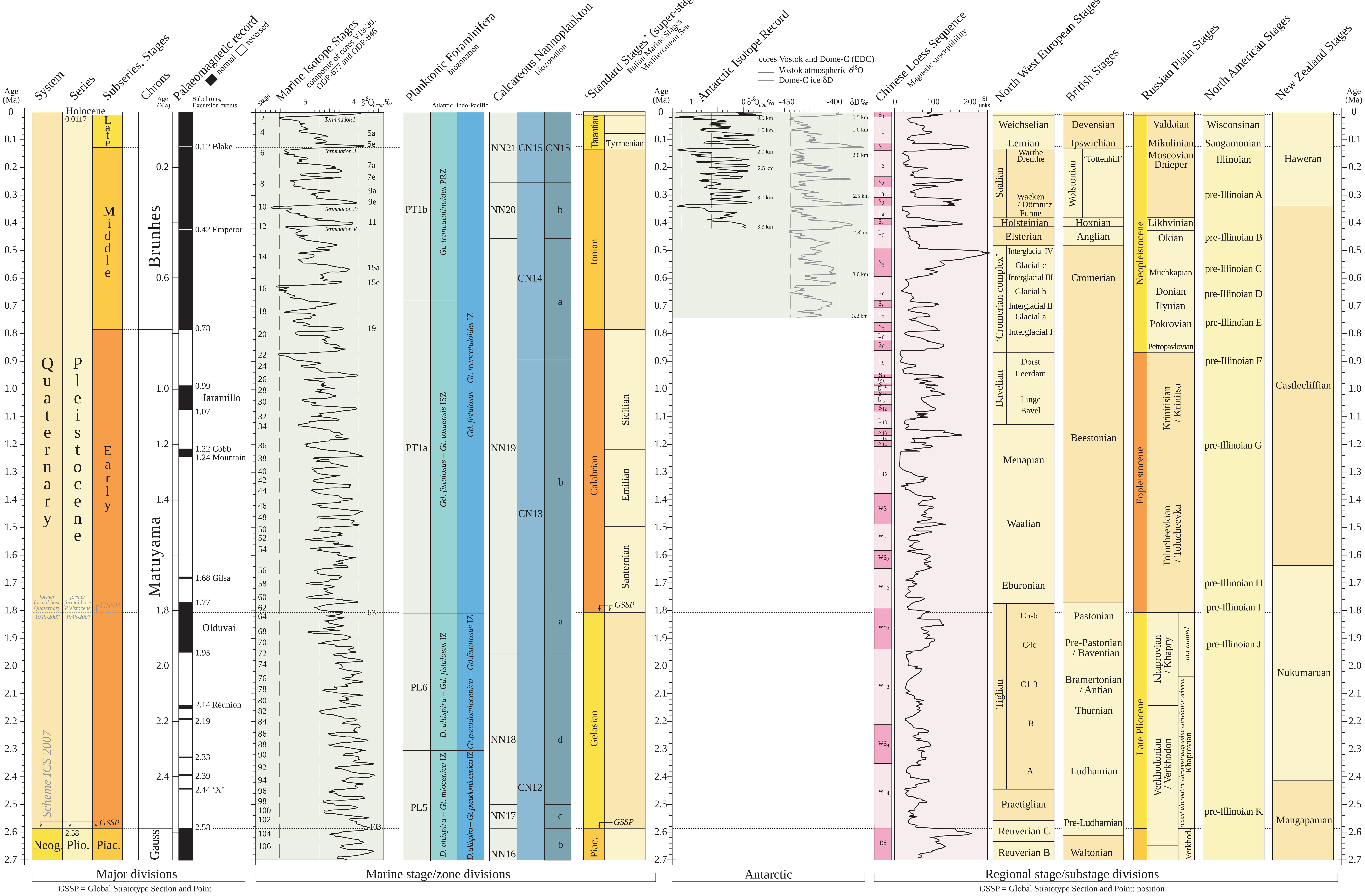
Global chronostratigraphical correlation table for the last 2.7 million years

v. 2007b



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This table provides a correlation of chronostratigraphical subdivisions of late Cenozoic geological time, spanning the last 2.7 million years. The formal division of the Quaternary is the responsibility of the International Commission on Stratigraphy's (ICS) Subcommission on Quaternary Stratigraphy (SQS), in partnership with the International Union for Quaternary Research's (INQUA) Commission on Stratigraphy and Chronology (SACCOM).

System, Series, Subseries

The timescale is based on the internationally-recognised formal time subdivisions: the Phanerozoic Eon; the Cenozoic Era; the Quaternary System or Period; the Pleistocene and Holocene Series, and finally the Early/Lower, Middle, Late/Upper Pleistocene Subseries. At present the subseries (Subepoch) divisions of the Pleistocene are not formalised. Series, and thereby systems, are formally-defined based on Global Stratotype Section and Points (GSSP) of which two have been ratified for the last 2.7 million years. The base of the Quaternary/Pleistocene is defined at 2.58 million years from a GSSP at Monte San Nicola in southern Italy. The chart extends to 2.7 million years, to include the very end of the preceding Piacenzian Stage of the Pliocene Series.

Base of the Quaternary and Pleistocene

Since 1948 there has been a consensus that the boundary should be placed at the first evidence of climatic cooling of ice-age magnitude. This was the original basis for placing the boundary in marine sediments in Calabria, in Italy (Aguirre & Pasini, 1985). It is now known that a major cooling occurred earlier, at *c*.2.55 million years, and even earlier cooling events are known from the Pliocene. Many consider that the basal Quaternary / Pleistocene boundary should logically be removed to this position (Gibbard *et al.* 2005, Bowen & Gibbard, 2007), effectively corresponding to the Gauss / Matuyama magnetic Chron boundary (e.g. Partridge, 1997; Suc *et al*., 1997). Until ratification by the IUGS in 2007/8, this was the base of the Pliocene Gelasian Stage (Rio *et al*., 1998), which was already a ratified GSSP (Aguirre & Pasini, 1985).

At the time of publication, there is a growing controversy about the status of the term Tertiary. Like Quaternary, it is generally regarded as a full System/Period but discussions are in progress on whether to adopt the Neogene and Paleogene as full systems/periods, or as subsystems (subperiods) of the Tertiary.

GSSPs

Formal GSSPs for the Pleistocene subseries will be proposed in the near future. The INQUA Commission on Stratigraphy/ICS Working Group on Major Subdivision of the Pleistocene agreed to place the Early/Lower - Middle boundary at the Brunhes / Matuyama magnetic reversal Chron boundary (Richmond, 1996); a stratotype locality has yet to be identified. Following recent re-evaluation, the Middle – Late/Upper boundary is placed, following historical precedent in NW Europe, at the Saalian-Eemian Stage boundary. The former is positioned at the basal-boundary stratotype of the Eemian in the Amsterdam-Terminal borehole, the Netherlands (Gibbard, 2003).

The Holocene is generally regarded as having begun 10,000 radiocarbon years, or 11.65k calibrated (i.e. calendar) years, before present (i.e. before 1950 AD, 'BP') or 11.7k annual laminations b2k (before 2000 AD). This boundary will be defined as a Global Standard Stratigraphic Age (GSSA). A stratotype is likely to be defined in an ice core of the Greenland Ice-Core Project (N-GRIP core, at 1492.45m depth; Rasmussen *et al.* 2005) or the Greenland Ice-Sheet Project (GISP2 core). Or alternatively it may be defined in an annually-laminated lake sequence in western Germany (Litt *et al*., 2001).

'Standard stages' (super-stages) global division

The desire to divide Quaternary/Pleistocene time into 'standard stages', that is units of approximately the same duration as those in the pre-Quaternary Tertiary time, has been advocated from time to time. The only sequence that has been divided in this way is the shallow marine sequences in the Mediterranean region, especially in southern Italy. For various reasons the scheme was considered unsatisfactory for use beyond this region, correlation being based principally on faunal and protist biostratigraphy. Renewed investigation in recent years has led to the proposal of units based on multidisciplinary investigation. The Italian shallow marine stages are derived from Van Couvering (1997) modified by Cita et al. (2006). In view of their duration, covering several climate cycles and periods for which regional stage units of markedly shorter duration have been defined, these 'standard stages' are considered as 'super-stages' in this chart.

Marine stage / zone divisions

Isotope studies from the bottom sediments of the world's oceans have indicated that as many as 52 cold and interspersed warm climate periods, often referred to as glacials and interglacials, occurred during the last 2.6 million years. In contrast to the deep sea, continental evidence is so incomplete and regionally variable that terrestrial glacial-interglacial stratigraphies must refer to the ocean record for a global chronological foundation.

Here the deep-sea based, climatically-defined chronostratigraphy is taken from oxygen isotope data collected and processed by S.J. Crowhurst (Delphi Project; 2002). It is plotted against the magnetostratigraphic time scale prepared and modified from Funnell (1996). The curve plots depict $\delta^{18}O$ (the ratio of ^{18}O *versus* ^{16}O) in the tests of fossil benthonic (ocean-floor dwelling) foraminifera. Shifts in this ratio are a measure of global ice-volume, which is dependant on global temperature and which determines global sea-level. Planktonic foraminifera and calcareous nannoplankton provide an alternative biostratigraphical means of subdivision of marine sediments. The micropalaeontological zonation is taken from Berggren *et al*. (1995).

Antarctic ice-core records

Two plots of isotope measurements from Antarctic ice-cores are shown. The first is the 420 kyr-long plot from the Vostok core and shows atmospheric $\delta^{18}O$ (Petit *et al*. 1999), determined from gas bubbles in the ice. This atmospheric $\delta^{18}O$ is inversely related to $\delta^{18}O$ measurements from seawater and therefore is a measure of ice-volume. It can also be used to separate ice volume and deepwater temperature effects in benthic foraminiferal $\delta^{18}O$ measurements. The deuterium measurements (δD) for the last 740 kyr are from the 3.2 km deep EDC core in Dome C (EPICA community members, 2004). They come from samples of the ice itself and give a direct indication of Antarctic surface palaeotemperature.

Regional stage/substage divisions

The continuous sequences provide the comparison for a selection of continental and shallow marine stage-sequences from around the world reconstructed from discontinuous sediment successions. Solid horizontal lines on the plots indicate observed boundaries, where no lines separate stages, additional events may potentially be recognised in the future.

The plot from the Chinese loess deposits shows the sequence of palaeosols (indicated by S and WS) and alternating loess units (L and WL) from Luochuan (An Zhisheng *et al*., 1990). It is accompanied by a continuous plot of magnetic susceptibility from the same sequence.

The NW European stages are taken from Zagwijn (1992) and De Jong (1988). The British stages are taken from Mitchell *et al*. (1973); Gibbard *et al*. (1991) and Bowen (1999). The Russian Plain stages are from the Stratigraphy of the USSR: Quaternary System (1982, 1984), Krasnenkov Iossifova & Semenov (1997), Shik, Borisov & Zarrina (2002), Iossifova *et al.* (2002, modified 2004) and Tesakov (unpublished). In addition, the Russian Pleistocene is also frequently divided into the Eopleistocene, equivalent to the Early Pleistocene Subseries, and the Neopleistocene, equivalent to the Middle and Late Pleistocene Subseries. The North American stages are taken from Richmond (unpublished). The New Zealand stages are from Pillans (1991) and Beu (2004).

Anthropocene

A recent proposal has been made to establish a new series status division following the Holocene, to be termed the Anthropocene. The term is being increasingly employed to identify the current interval of anthropogenic global environmental change, and may be adopted on stratigraphical grounds. It might be adopted at formal Series/Epoch level, for the time since the start of the Industrial Revolution when changes sufficient to leave a global stratigraphic signature distinct from that of the Holocene or of previous Pleistocene interglacial phases, occurred. A boundary definition may be made either using a Global Stratigraphic Section and Point ('golden spike') localities, and or by adopting a numerical date (GSSA). Formal adoption of this term depends on its utility, particularly to Earth Scientists working on late Holocene successions (Zalasiewicz *et al.* 2008). Because of its' short time duration, it has not been included in the chart.

References

Full bibliographic references are found on the web site: http://www.quaternary.stratigraphy.org.uk/

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