Divisions of geologic time – Major chronostratigraphic and geochronologic units

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INTRODUCTION

Effective communication in the geosciences requires consistent uses of stratigraphic nomenclature, especially divisions of geologic time. A geologic time scale is composed of standard stratigraphic divisions based on rock sequences and calibrated in years (Harland et al. 1982). Over the years, the development of new dating methods and refinement of previous ones have stimulated revisions to geologic time scales.

Since the mid-1990s, geologists from the U.S. Geological Survey (USGS), State geological surveys, academia, and other organizations have sought a consistent time scale to be used in communicating ages of geologic units in the United States. Many international debates have occurred over names and boundaries of units, and various time scales have been used by the geoscience community.

NEW TIME SCALE

Since the publication by the USGS of the 7th edition of "Suggestions to Authors" (Hansen 1991), no other time scale has been officially endorsed by the USGS. For consistency purposes, the USGS Geologic Names Committee (GNC; see box for members) and the Association of American State Geologists (AASG) developed **Divisions of Geologic Time** (text-fig. 1). The **Divisions of Geologic Time** is based on the previous USGS-endorsed time scale (Hansen 1991, p. 59) and updates it with the unit names and boundary age estimates ratified by the International Commission on Stratigraphy (IC S). Scientists should note that other published time scales may be used, provided that these are specified and referenced (for example, Palmer 1983; Harland et al. 1990; Haq and Eysinga 1998; Gradstein et al. 2004). Advances in stratigraphy and geochronology require that any time scale be periodically updated. Therefore, the **Divisions of Geologic Time** is dynamic and will be modified as needed to include accepted changes of unit names and boundary age estimates.

The **Divisions of Geologic Time** shows the major chrono-stratigraphic (position) and geochronologic (time) units; that is, enonothem/eon to series/epoch divisions. Workers should refer to the ICS time scale (Ogg 2007) for stage/age terms. Most systems of the Paleozoic and Mesozoic are subdivided into series utilizing the terms "Lower," "Middle," and "Upper." The geochronologic counterpart terms for subdivisions of periods are "Early," "Middle," and "Late." The international geoscience community is applying names to these subdivisions based on stratigraphic sections at specific localities worldwide. All series/epochs of the Silurian and Permian have been named. Although the usage of these names is preferred, "lower/early," "middle," and "upper/late" are still acceptable as informal units (lowercase) for these two systems/periods. Also the Upper Cambrian has been named "Furongian" in the ICS time scale. However, the GNC will not recognize this name and include it in the **Divisions of Geologic Time** until all series/epochs of the Cambrian are named.

CENOZOIC

There has been much controversy related to subdivisions of the Cenozoic, particularly regarding retention or rank of the terms "Tertiary" and "Quaternary." Although some stratigraphers have suggested that these terms be abandoned, the issue remains unresolved. If the terms are retained, there will need to be agreement on the status of the Quaternary as a system/period or subsystem/subperiod. Another controversial issue is the position of the base of the Quaternary; is it at the base of the Pleistocene or within the late Pliocene? These positions have age estimates of 1.8 Ma and 2.6 Ma, respectively (see box for age terms). Until a decision is made on the subdivisions of the Cenozoic, the **Divisions of Geologic Time** will follow the general structure of the time scale published in Hansen (1991) in accepting the use of the terms "Tertiary" and "Quaternary" and the equivalence of the bases of the Quaternary and Pleistocene. The map symbols "T" (Tertiary) and "Q" (Quaternary) have been used on geologic maps for more than a century and are widely used today.

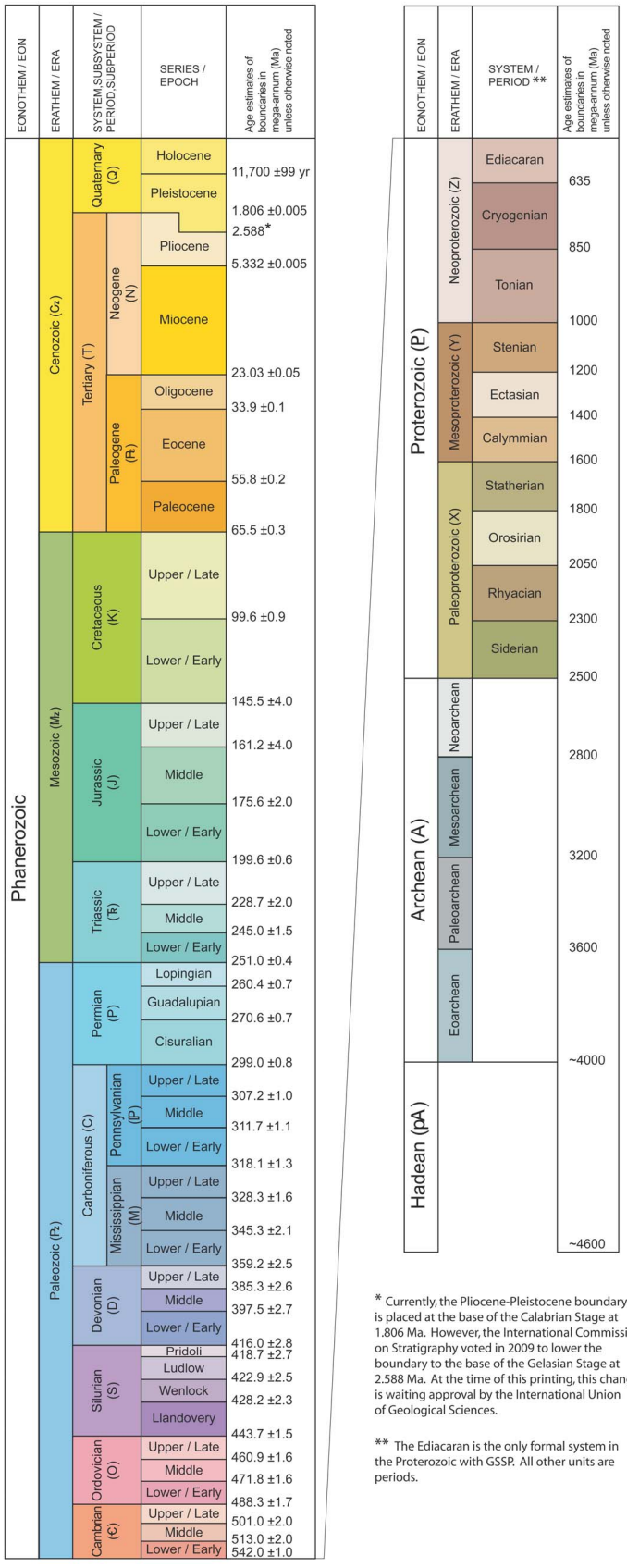
For many years, the term "Precambrian" was used for the division of time older than the Phanerozoic. For consistency with the time scale in Hansen (1991), the term "Precambrian" is considered to be informal and without specific stratigraphic rank (although it is capitalized). Also of note, the Ediacaran is the only formal system in the Proterozoic. All other units are periods until global boundary stratotype sections or points are defined.

AGE TERMS

The age of a stratigraphic unit or the time of a geologic event may be expressed in years before present (before A.D. 1950). The "North American Stratigraphic Code" (North American Commission on Stratigraphic Nomenclature 2005) recommends abbreviations for ages in standard prefixes coupled with "a" for annum (properly "annus"): ka for kilo-annum, 10^3 years before present; Ma for mega-annum, 10^6 years before present; and Ga for giga-annum, 10^9 years before present. Duration of time should be expressed in millions of years (Myr). For example, deposition began at 85 Ma and continued for 2Myr

GEOLOGIC MAP COLORS

Geologic maps utilize color schemes based on standards that are related to the time scale. Two different schemes are used, one by the Commission for the Geologic Map of the World (CGMW) and another by the USGS. Colors typically shown on USGS geologic maps have been used in a standard fashion since the late 1



* Currently, the Pliocene-Pleistocene boundary is placed at the base of the Calabrian Stage at 1.806 Ma. However, the International Commission on Stratigraphy voted in 2009 to lower the boundary to the base of the Gelasian Stage at 2.588 Ma. At the time of this printing, this change is waiting approval by the International Union of Geological Sciences.

** The Ediacaran is the only formal system in the Proterozoic with GSSP. All other units are periods.

TEXT-FIGURE 1
Divisions of geologic time approved by the U.S. Geological Survey Geologic Names Committee 2006. The chart shows major chronostratigraphic and geochronologic units. It reflects ratified unit names and boundary estimates from the International Commission on Stratigraphy (Ogg 2007). Map symbols are in paranetheses.

800s and recently have been published in the digital cartographic standard for geologic map symbolization (Federal Geographic Data Committee, Geologic Data Subcommittee 2006). The GNC decided in 2006 that the USGS colors should be used for large-scale and regional geologic maps of the United States. For international maps or small-scale maps (for instance, 1:5 million) of the United States or North America, the GNC recommends the use of the international colors. Specifications for the USGS colors are in Federal Geographic Data Committee, Geologic Data Subcommittee (2006), and those for the CGMW colors are in Gradstein et al. (2004).

APPENDIX 1

Members of the Geologic Names Committee

Randall C. Orndorff (chair), Nancy Stamm (recording secretary), Steven Craigg, Terry D'Erchia, Lucy Edwards, David Fullerton, Bonnie Murchey, Leslie Ruppert, David Soller (all of the USGS), and Berry (Nick) Tew, Jr. (State Geologist of Alabama).

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