Geology 1122: Earth's History of Global Change Dr. Walker Fall 2008

LECTURE 3: Telling Time in the Rock Record: Using rocks, fossils, principles of geology and radioactive isotopes to determine absolute and relative age of Earth's major events.

Note: This will be Wednesday and Friday's lecture (Sept. 3 and 5)

I. Interpreting Time and Events from the Rock Record

A. Differences between relative and absolute time

B. Geologic Principles for determining relative age of rock units

i. Nicholas Steno (mid-1600's) and his three principles (what are they used for?):

- Law of Original Horizontality
- Law of Lateral Continuity
- Law of Superposition

ii. James Hutton (1700's) and his four principles:

- Unconformities **in the rock record mean...**
- Principle of Cross-Cutting Relationships
- Law of Included Fragments
- Principle of Uniformitarianism ***(note, this principle is often attributed to Sir Charles Lyell, but Hutton was the first to discuss this principle and use it).***
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- **Sir Charles Lyell used Steno's, Hutton's, and W. "Strat" Smith's principles to put together the rudiments of the first Geologic Time Scale based on relative age dating. Codified in his book, *Principles of Geology* published in the mid-1800's.**

iii. William "Strata" Smith (early 1800's) and his one principle:

- Principle of Floral and Faunal Succession

Used in correlation of the rock and fossil record

The dat he used

(see Walther's Law below for one additional principle)

C. Development of Geologic Time Scale also includes:

i. Stratigraphic and Biostratigraphic Units

Index fossil (also known as *a Guide Fossil*); what are the important characteristics of guide fossils?

ii. *Correlation* is used to make geologic maps and stratigraphic columns for interpreting the sequence of environments through time.

iii. Environments of deposition where fossils are found are called <u>facies</u>

<u>Example 1</u>: Onshore to offshore facies distribution based on sedimentary rocks

Example 2: "Transgressions and Regressions" or On-Lap and Off-Lap of sea

- **<u>Principle of Geology:</u> <u>Walther's Law</u> that follows from these examples (Example 1 and 2, above).**

D. Radioactivity and Absolute Ages

i. What types of rocks (etc.) are used for absolute age-dating and why?
ii. Who discovered radioactivity in rocks?
iii. Remember the definition of a radioactive isotope...
iv. Let's look at Uranium, an element (aka: rock, mineral) named after the Planet Uranus. What is its importance? And, how does Uranium turn into lead?

v. <u>Radiometric Dating (hot rocks...)</u>

- **Types of decay, especially alpha- and beta decay**
- **Decay rates and half life**

Examples of radiometric dating and their utility in dating Earth's events (Uranium-238-Lead-206; Rubidium-87-Strontium-87; Potassium-40-Argon 40; C-14 dating)

E. Other ways to date Earth's events

Tree rings (example, Bristle Cone Pines from out West)
Sedimentary Lake Varves
Magnetostratigraphy

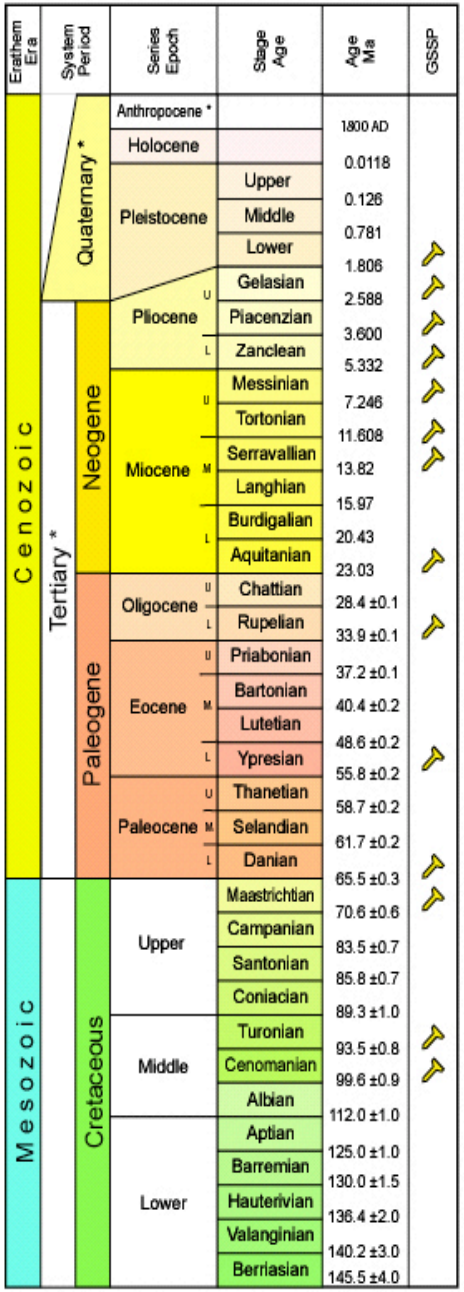
F. Accuracy of correlation: fossils versus radiometric dating
And, the Geologic Time Scale Completed!

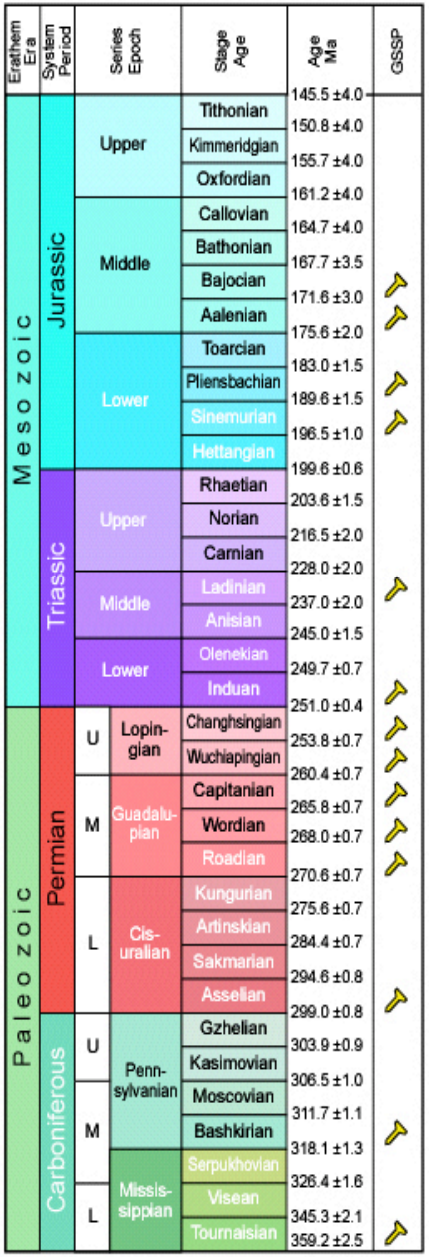
SEE LATEST GEOLOGIC TIME SCALE--That is currently being discussed to include the Quaternary--ON NEXT PAGE!

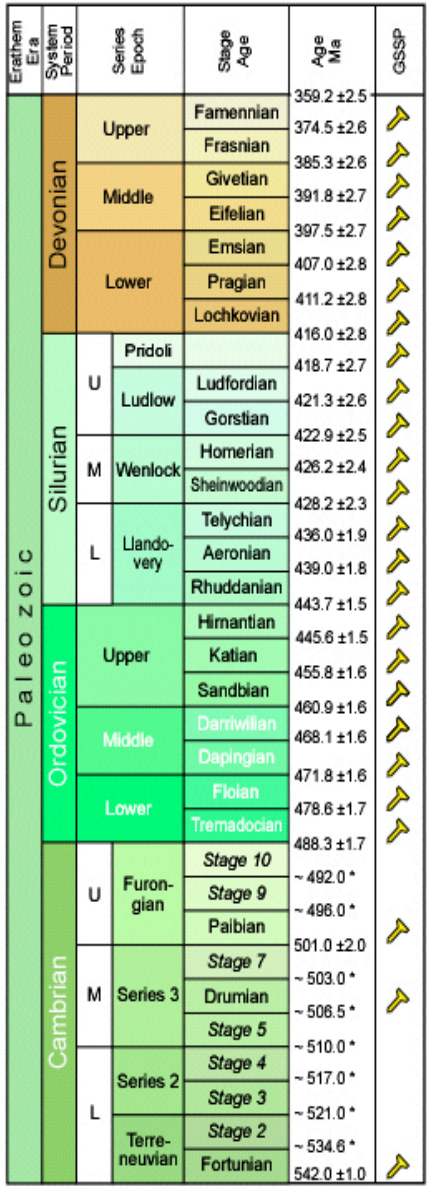
(FROM, J. G. OGG, 2007, International Commission on Stratigraphy after Gradstein et al., 2004, *A Geologic Times Scale, 2004*, Cambridge University Press.)
http://www.quaternary.stratigraphy.org.uk/images/GeolAug.jpg

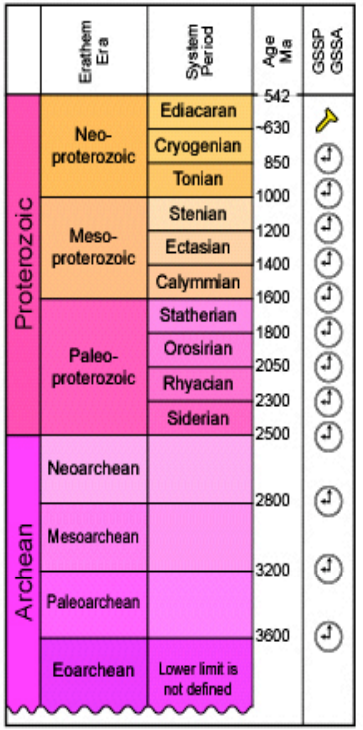
A Proposal for Simplifying the International Geological Time Scale Chart

ICS









This chart was drafted by Gabi Ogg. Intra Cambrian unit ages with * are informal, and awaiting ratified definitions.

This version of the International Stratigraphic Chart contains a simplification of the nomenclature for Paleozoic/Mesozoic series, in which a systematic Lower-Middle-Upper designation has been indicated. In addition, a "Tertiary" has been inserted into the Cenozoic that spans the ratified Neogene and Paleogene periods. This type of chart was requested by professional earth scientists and is under discussion in ICS.

Official international chronostratigraphic units, rank, names and formal status are approved by the International Commission on Stratigraphy (ICS) and ratified by the International Union of Geological Sciences (IUGS). These are displayed on the regular International Stratigraphic Chart, which is available at the ICS website (www.stratigraphy.org).

Subdivisions of the global geologic record are formally defined by their lower boundary. Each unit of the Phanerozoic (~542 Ma to Present) and the base of Ediacaran are defined by a basal Global Standard Section and Point (GSSP), whereas Precambrian units are formally subdivided by absolute age (Global Standard Stratigraphic Age, GSSA). Details of each GSSP are posted on the ICS website (*www.stratigraphy.org*).

The listed numerical ages are from 'A Geologic Time Scale 2004', by F.M. Gradstein, J.G. Ogg, A.G. Smith, et al. (2004; Cambridge University Press). Ages of the unit boundaries in the Precambrian and Phanerozoic are subject to revision.

* Anthropocene is a chronostratigraphic unit proposed in 2007 by the Stratigraphic Commission of the Geological Society, UK.
The status of the Quaternary is not yet decided. Its base may be assigned as the base of the Gelasian and extend the base of the Pleistocene to 2.6 Ma.
Tertiary is an informal chronostratigraphic unit, sensu Aubry et al. (2005, Episodes 28/2).