

**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 facies

**Example 1:** Onshore to offshore facies distribution based on sedimentary rocks

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

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

#### D. Radioactivity and Absolute Ages

- What types of rocks (etc.) are used for absolute age-dating and why?
- Who discovered radioactivity in rocks?
- Remember the definition of a radioactive isotope...
- 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. Radiometric Dating (hot rocks...)

- 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  
Magnetostatigraphy

#### 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



Era	System	Series	Epoch	Stage	Age Ma	GSSP	
Cenozoic	Tertiary*	Quaternary*	Anthropocene*		1800 AD		
			Holocene		0.0118		
			Pleistocene	Upper		0.126	
		Middle			0.781		
		Pliocene	Lower		1.806		
			Gelasian		2.588		
		Neogene	Oligocene	Piacenzian		3.600	
				Zanclean		5.332	
			Miocene	Messinian		7.246	
				Tortonian		11.608	
	Serravalian				13.82		
	Langhian				15.97		
	Eocene		Burdigalian		20.43		
			Aquitanian		23.03		
	Paleogene		Eocene	Chattian		28.4 ± 0.1	
				Rupelian		33.9 ± 0.1	
	Paleocene	Eocene	Priabonian		37.2 ± 0.1		
			Bartonian		40.4 ± 0.2		
	Cretaceous	Upper	Lutetian		48.6 ± 0.2		
			Ypresian		55.8 ± 0.2		
Cretaceous	Middle	Thanetian		58.7 ± 0.2			
		Selandian		61.7 ± 0.2			
Cretaceous	Lower	Danian		65.5 ± 0.3			
		Maastrichtian		70.6 ± 0.6			
Cretaceous	Upper	Campanian		83.5 ± 0.7			
		Santonian		85.8 ± 0.7			
Cretaceous	Middle	Coniacian		89.3 ± 1.0			
		Turonian		93.5 ± 0.8			
Cretaceous	Lower	Cenomanian		99.6 ± 0.9			
		Albian		112.0 ± 1.0			
Cretaceous	Lower	Aptian		125.0 ± 1.0			
		Barremian		130.0 ± 1.5			
Cretaceous	Lower	Hauterivian		138.4 ± 2.0			
		Valanginian		140.2 ± 3.0			
Cretaceous	Lower	Berriasian		145.5 ± 4.0			

Era	System	Series	Epoch	Stage	Age Ma	GSSP
Mesozoic	Triassic	Upper	Induan		249.7 ± 0.7	
			Olenekian		245.0 ± 1.5	
			Anisian		237.0 ± 2.0	
		Middle	Ladinian		228.0 ± 2.0	
			Carnian		216.5 ± 2.0	
			Norian		203.6 ± 1.5	
		Lower	Rhaetian		199.6 ± 0.6	
			Hettangian		196.5 ± 1.0	
			Sinemurian		189.6 ± 1.5	
			Plensbachian		183.0 ± 1.5	
	Jurassic	Upper	Toarcian		175.6 ± 2.0	
			Aalenian		171.6 ± 3.0	
			Bajocian		167.7 ± 3.5	
		Middle	Bathonian		164.7 ± 4.0	
			Callovian		161.2 ± 4.0	
		Lower	Oxfordian		155.7 ± 4.0	
			Kimmeridgian		150.8 ± 4.0	
			Tithonian		145.5 ± 4.0	
			Changhsingian		251.0 ± 0.4	
			Wuchiapingian		253.8 ± 0.7	
Permian	Capitanian		260.4 ± 0.7			
	Wordian		265.8 ± 0.7			
Permian	Lower	Roadian		268.0 ± 0.7		
		Kungurian		270.6 ± 0.7		
Permian	Upper	Artinskian		275.6 ± 0.7		
		Sakmarian		284.4 ± 0.7		
Permian	Middle	Asselian		294.6 ± 0.8		
		Gzhelian		299.0 ± 0.8		
Carboniferous	Upper	Kasimovian		303.9 ± 0.9		
		Moscovian		306.5 ± 1.0		
Carboniferous	Lower	Bashkirian		311.7 ± 1.1		
		Serpukhovian		318.1 ± 1.3		
Carboniferous	Lower	Viséan		326.4 ± 1.6		
		Tournaisian		345.3 ± 2.1		
Carboniferous	Lower	Mississippian		359.2 ± 2.5		
		Stensånian		359.2 ± 2.5		

Era	System	Series	Epoch	Stage	Age Ma	GSSP
Paleozoic	Ordovician	Upper	Hirnantian		443.7 ± 1.5	
			Katian		445.6 ± 1.5	
			Sandbian		455.8 ± 1.6	
		Middle	Dartmouthian		460.9 ± 1.6	
			Dapingian		468.1 ± 1.6	
			Floian		471.8 ± 1.6	
		Lower	Tremadocian		478.6 ± 1.7	
			Stage 10		488.3 ± 1.7	
			Stage 9		~492.0*	
			Palbian		~496.0*	
	Cambrian	Upper	Stage 7		501.0 ± 2.0	
			Stage 5		~503.0*	
	Cambrian	Middle	Stage 4		~506.5*	
			Stage 3		~510.0*	
	Cambrian	Lower	Stage 2		~517.0*	
			Fortunian		~521.0*	
	Cambrian	Lower	Terreneuvian		~534.6*	
			Stage 1		542.0 ± 1.0	

Era	System	Epoch	Stage	Age Ma	GSSP	
Proterozoic	Archean	Eoarchean	Stage 1		~3600	
			Stage 2		3200	
			Stage 3		2800	
			Stage 4		2500	
			Stage 5		2300	
	Proterozoic	Paleo-proterozoic	Siderian		2050	
			Rhyacian		1800	
			Orosirian		1600	
			Statherian		1400	
			Calymnian		1200	
Proterozoic	Meso-proterozoic	Stenian		1000		
		Tonian		850		
		Cryogenian		~630		
		Ediacaran		542		
		Neoproterozoic				

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](http://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 the 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](http://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.

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

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\* 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).