A1 Macrostratigraphy Lab

<u>Note to Search Committee:</u> I developed this laboratory exercise during the Fall of 2010 while participating in the Instructional Materials Development course as part of the DELTA Program at the University of Wisconsin-Madison. At the end of the semester I implemented this lab exercise in the Sedimentology and Stratigraphy course (GEOSCI 430). From talking with the GEOSCI 430 students and Graduate Teaching Assistant, I found that the lab was well received, both for the novelty of the exercise and the use of quantitative methods in an otherwise qualitative course.

Laboratory Exercise: The macrostratigraphy of North America

Introduction

In the 1970s and 1980s the Geological Survey of Canada and the American Association of Petroleum Geologists produced a series of stratigraphic correlation charts that show the geology of North America from the crystalline basement to the surface at over 800 locations. These charts were indented to standardize the stratigraphic nomenclature of geologic units and allow geologists to easily determine which units are roughly equivalent. However, these charts also contain a wealth of information on the geology of North America, including lithology, thickness paleoenvironments and economic minerals. Although the effort that went into producing these charts they have gone largely unnoticed by geologists. In this laboratory exercise you will use these charts to explore the spatial and temporal dynamics of North American geology; will quantify where and when rocks are preserved. This basic quantification will then form the basis of an interpretation of Earth History.

The group will work on Parts I-III as a group. The lab group will turn in one report for these parts. Part IV will be done individually. Although you are encouraged to discuss possibilities for the prospectus with your lab-mates, it is unacceptable for two individuals to turn in a prospectus on the same idea.

Part I: Digitizing the correlation charts

You will work in groups of 3 or 4. Each group will be given a correlation chart, a geologic time scale and an Excel spreadsheet. The correlation charts are divided into stratigraphic columns that each represent the geology of a different area. The rocks in each column are then divided into a vertical series of temporally continuous "packages" of rock separated by unconformities (white space). Your group must identify and first appearance datum (FAD) and last appearance datum (LAD) of every package on your chart (Figure 1). As you identify the FAD and LAD of each package enter the numeric age for each into your Excel spread sheet. To obtain the numeric age, find the geologic stage that the datum of interest resided in from the time scale on the chart. Then look up the numeric age on the time scale provided at the end of this lab packet or on the Excel spread sheet (these two are the same). **<u>Do not</u>** use the numeric ages on the charts! After you have identified the FAD and LAD of a package, fill in the number 1 in each cell in which the package spans (Figure 2; you can type in a 1 for the LAD then drag the cell down to the FAD). As you fill in your chart, the duration of each package, the mean duration of all packages and the number of packages present in each time interval will be filled in automatically. Only enter packages whose LAD is in the

Phanerozoic; exclude packages that are entirely Precambrian. **NOTE: *You should rotate chart-reading and data entry tasks after every two columns are completed. It's important that everyone in the group is equally involved in all aspects of the data collection process.***

When your group is done compiling the package data from your chart, save it and give a copy to the lab instructor. Once all the spreadsheets have been completed, the lab instructor will provide a summary containing all the data collected by each group (this may be a short time after the lab period is over, depending on how quickly groups finish). While you are waiting for the total summary begin answering the questions below. Figure 3 shows the approximate locations of all the North American Correlation charts.

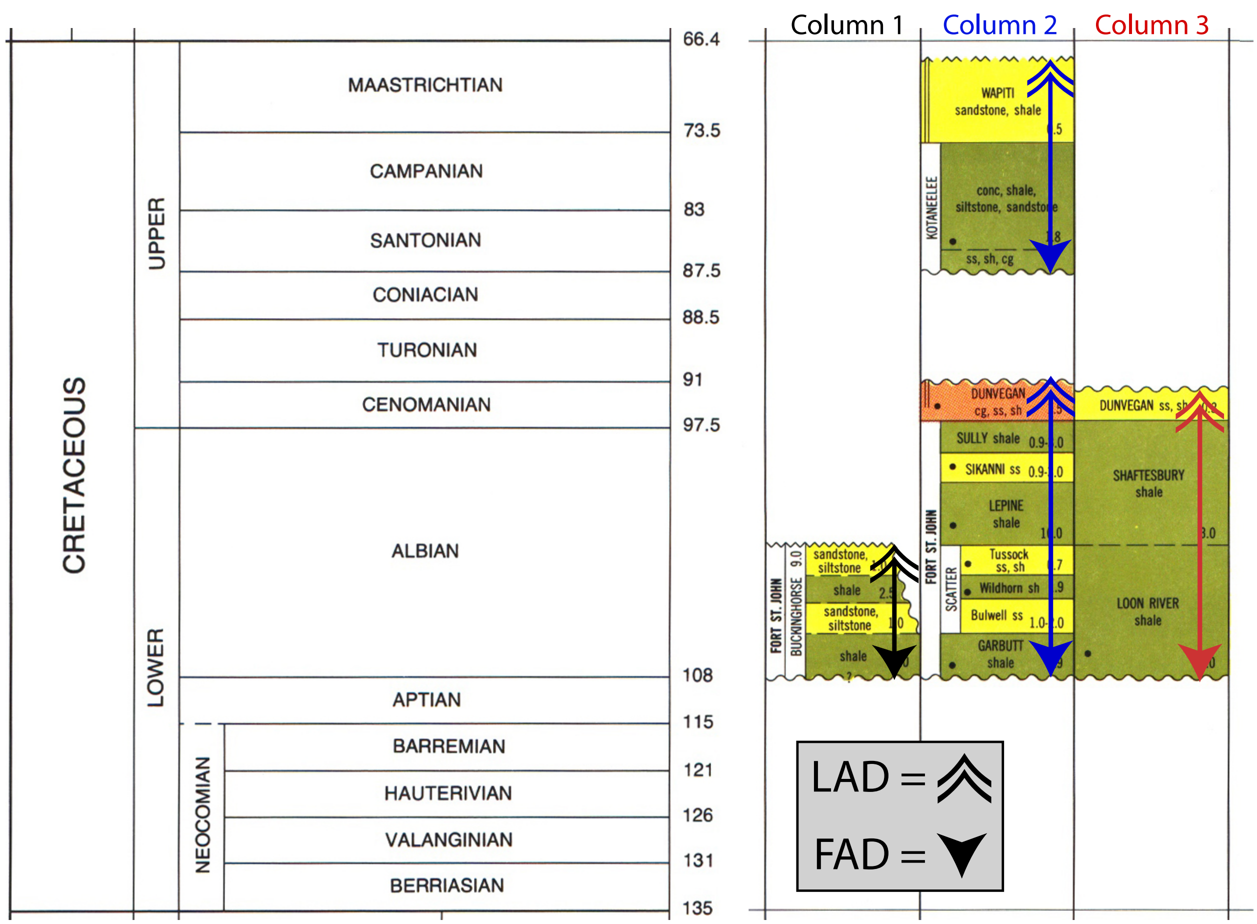

Figure 1. Three partial columns from a correlation chart showing FAD and LAD of four packages.

		package 1	package 2	package 3	package 4	# Packages	mean duration
	column	1	1	2	2		
	LAD	0.0117	99.6	65.6	2.588		
	FAD	65.5	251	199.6	23.03		
	Duration	65.4883	151.4	134	20.442		92.832575
Age (Ma)							
0.0117	Holocene					0	
2.588	Pleistocene	1				1	
5.332	Pliocene	1			1	2	
23.03	Miocene	1			1	2	
33.9	Oligocene	1				1	
55.8	Eocene	1				1	
65.5	Paleoence					0	
199.6	Late K			1		1	
145.5	Early K		1	1		2	
161.2	Late J		1	1		2	
175.6	Middle J		1	1		2	
199.6	Early J		1	1		2	
245.0	Late Tr		1			1	
228.0	Middle Tr		1			1	
251.0	Early Tr		1			1	

Figure 2. A partial spread sheet illustrating how it should be filled out.

Figure 3. Locations of all 25 stratigraphic correlation charts for North America.

What is the name of the sheet from which you collected data?

What geographic area does your sheet represent?

Part II: Data Analysis

Using the graphing functionality of Excel to plot a time series of the number of packages in each time interval (see Figure 4 for an example of a time series plot with time in the correct stratigraphic order).

Using the graphing functionality of Excel to plot a time series of the total number of packages in North America using the summary data.

What are the similarities and differences between the plot for your chart and the chart for the whole of North America?

Part III: Interpretation

Figure 5 may be useful in generating answers for answering the following questions.

What might account for the gaps between successive packages within any given column?

Assume that all the rocks you have plotted are sedimentary (this assumption is of course not true, but it's approximately correct [see Figure 4]). What does your plot tell you about the depositional history of your region of North America?

What might the similarities and differences between your chart and the whole of North America mean for your interpretation of the sedimentary history of North America and your chart region?

Part IV: Research prospectus

Please write a short research prospectus, ~1-2 pages, based on your experience with this lab exercise. Describe a geologic question you might like to answer with the type of data provided on these stratigraphic correlation charts or in conjunctions with other types of geologic data you can fit into this type of data structure. Keep in mind that the charts contain lots of information that was not used for this lab (e.g., variation within packages, thickness, lithology). Feel free to consider the integration of fossil, geochemical, sedimentological or other geologic data with the correlation charts.

The first part of your prospectus should clearly state a hypothesis, how it relates to the observations and analyses you made during this lab and explain why you feel it is interesting. The bulk of the prospectus should be an outline of the type of data you would need to test your hypothesis and the methods you would use to test the hypothesis. Finally, the prospectus should conclude with a discussion of what your research project will tell you about the geologic history of North America.

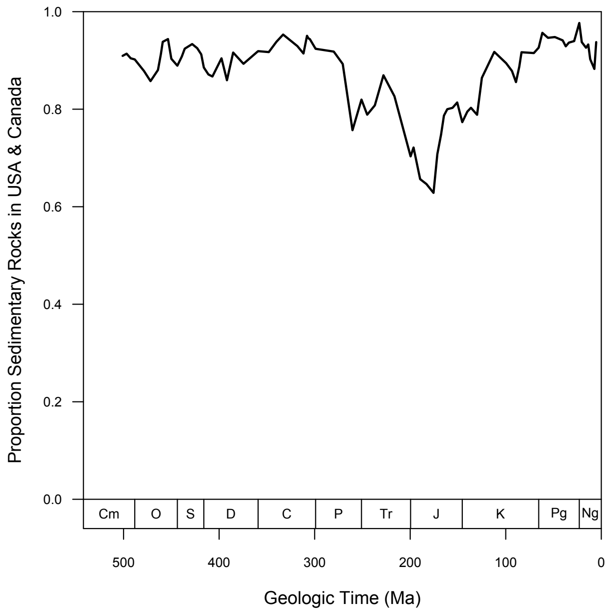

Figure 4. The proportion of sedimentary (i.e., not igneous or metamorophic) rock units (individual colored blocks on correlation charts) in North America through time.

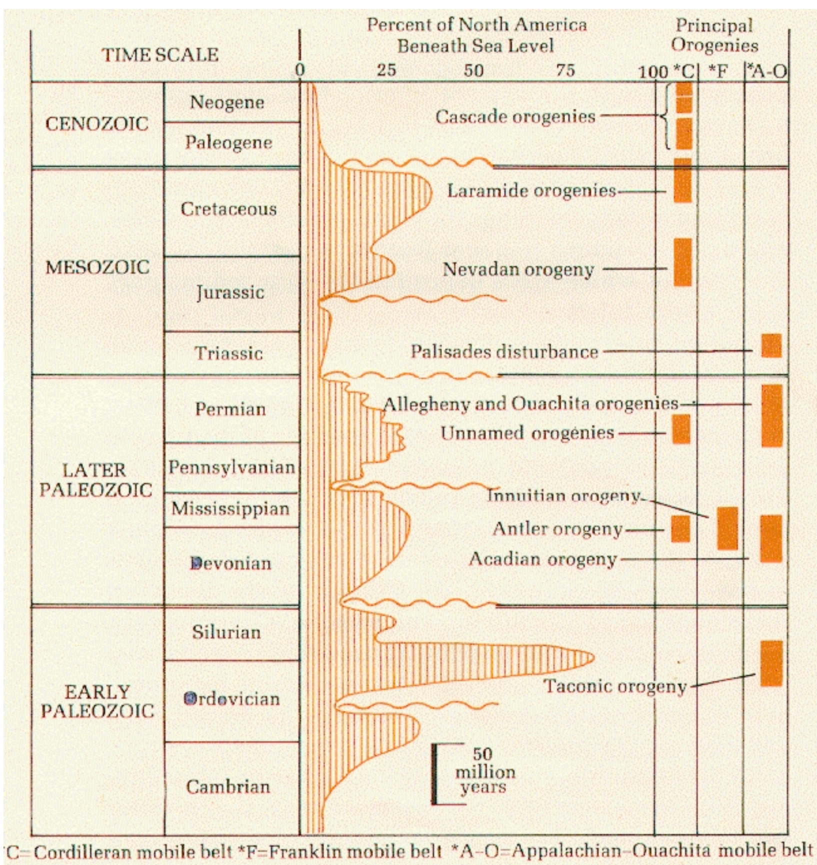

Figure 5. Continental flooding and timing of major North America orogenies. This figure was taken from Bates, Sweet, & Utgard. 1973. Geology - An Introduction (2nd ed.). D. C. Heath and Co.

ICS

INTERNATIONAL STRATIGRAPHIC CHART

International Commission on Stratigraphy

IUGS

Eonothem Eon	Erathem Era	System Period	Series Epoch	Stage Age	Age Ma
					0.0
Phanerozoic	Cenozoic	Quaternary	Holocene		0.0117
Phanerozoic	Cenozoic	Quaternary	Pleistocene	Upper	0.126
Phanerozoic	Cenozoic	Quaternary	Pleistocene	"Ionian"	0.781
Phanerozoic	Cenozoic	Quaternary	Pleistocene	Calabrian	1.806
Phanerozoic	Cenozoic	Quaternary	Pleistocene	Gelasian	2.588
Phanerozoic	Cenozoic	Neogene	Pliocene	Piacenzian	3.600
Phanerozoic	Cenozoic	Neogene	Pliocene	Zanclean	5.332
Phanerozoic	Cenozoic	Neogene	Miocene	Messinian	7.246
Phanerozoic	Cenozoic	Neogene	Miocene	Tortonian	11.608
Phanerozoic	Cenozoic	Neogene	Miocene	Serravallian	13.82
Phanerozoic	Cenozoic	Neogene	Miocene	Langhian	15.97
Phanerozoic	Cenozoic	Neogene	Miocene	Burdigalian	20.43
Phanerozoic	Cenozoic	Neogene	Miocene	Aquitanian	23.03
Phanerozoic	Cenozoic	Paleogene	Oligocene	Chattian	28.4 ±0.1
Phanerozoic	Cenozoic	Paleogene	Oligocene	Rupelian	33.9 ±0.1
Phanerozoic	Cenozoic	Paleogene	Eocene	Priabonian	37.2 ±0.1
Phanerozoic	Cenozoic	Paleogene	Eocene	Bartonian	40.4 ±0.2
Phanerozoic	Cenozoic	Paleogene	Eocene	Lutetian	48.6 ±0.2
Phanerozoic	Cenozoic	Paleogene	Eocene	Ypresian	55.8 ±0.2
Phanerozoic	Cenozoic	Paleogene	Paleocene	Thanetian	58.7 ±0.2
Phanerozoic	Cenozoic	Paleogene	Paleocene	Selandian	~ 61.1
Phanerozoic	Cenozoic	Paleogene	Paleocene	Danian	65.5 ±0.3
Phanerozoic	Mesozoic	Cretaceous	Upper	Maastrichtian	70.6 ±0.6
Phanerozoic	Mesozoic	Cretaceous	Upper	Campanian	83.5 ±0.7
Phanerozoic	Mesozoic	Cretaceous	Upper	Santonian	85.8 ±0.7
Phanerozoic	Mesozoic	Cretaceous	Upper	Coniacian	~ 88.6
Phanerozoic	Mesozoic	Cretaceous	Upper	Turonian	93.6 ±0.8
Phanerozoic	Mesozoic	Cretaceous	Upper	Cenomanian	99.6 ±0.9
Phanerozoic	Mesozoic	Cretaceous	Lower	Albian	112.0 ±1.0
Phanerozoic	Mesozoic	Cretaceous	Lower	Aptian	125.0 ±1.0
Phanerozoic	Mesozoic	Cretaceous	Lower	Barremian	130.0 ±1.5
Phanerozoic	Mesozoic	Cretaceous	Lower	Hauterivian	~ 133.9
Phanerozoic	Mesozoic	Cretaceous	Lower	Valanginian	140.2 ±3.0
Phanerozoic	Mesozoic	Cretaceous	Lower	Berriasian	145.5 ±4.0

Eonothem Eon	Erathem Era	System Period	Series Epoch	Stage Age	Age Ma
					145.5 ±4.0
Phanerozoic	Mesozoic	Jurassic	Upper	Tithonian	150.8 ±4.0
Phanerozoic	Mesozoic	Jurassic	Upper	Kimmeridgian	~ 155.6
Phanerozoic	Mesozoic	Jurassic	Upper	Oxfordian	161.2 ±4.0
Phanerozoic	Mesozoic	Jurassic	Middle	Callovian	164.7 ±4.0
Phanerozoic	Mesozoic	Jurassic	Middle	Bathonian	167.7 ±3.5
Phanerozoic	Mesozoic	Jurassic	Middle	Bajocian	171.6 ±3.0
Phanerozoic	Mesozoic	Jurassic	Middle	Aalenian	175.6 ±2.0
Phanerozoic	Mesozoic	Jurassic	Lower	Toarcian	183.0 ±1.5
Phanerozoic	Mesozoic	Jurassic	Lower	Pliensbachian	189.6 ±1.5
Phanerozoic	Mesozoic	Jurassic	Lower	Sinemurian	196.5 ±1.0
Phanerozoic	Mesozoic	Jurassic	Lower	Hettangian	199.6 ±0.6
Phanerozoic	Mesozoic	Triassic	Upper	Rhaetian	203.6 ±1.5
Phanerozoic	Mesozoic	Triassic	Upper	Norian	216.5 ±2.0
Phanerozoic	Mesozoic	Triassic	Upper	Carnian	~ 228.7
Phanerozoic	Mesozoic	Triassic	Middle	Ladinian	237.0 ±2.0
Phanerozoic	Mesozoic	Triassic	Middle	Anisian	~ 245.9
Phanerozoic	Mesozoic	Triassic	Lower	Olenekian	~ 249.5
Phanerozoic	Mesozoic	Triassic	Lower	Induan	251.0 ±0.4
Phanerozoic	Paleozoic	Permian	Lopingian	Changhsingian	253.8 ±0.7
Phanerozoic	Paleozoic	Permian	Lopingian	Wuchiapingian	260.4 ±0.7
Phanerozoic	Paleozoic	Permian	Guadalupian	Capitanian	265.8 ±0.7
Phanerozoic	Paleozoic	Permian	Guadalupian	Wordian	268.0 ±0.7
Phanerozoic	Paleozoic	Permian	Guadalupian	Roadian	270.6 ±0.7
Phanerozoic	Paleozoic	Permian	Cisuralian	Kungurian	275.6 ±0.7
Phanerozoic	Paleozoic	Permian	Cisuralian	Artinskian	284.4 ±0.7
Phanerozoic	Paleozoic	Permian	Cisuralian	Sakmarian	294.6 ±0.8
Phanerozoic	Paleozoic	Permian	Cisuralian	Asselian	299.0 ±0.8
Phanerozoic	Paleozoic	Carboniferous	Pennsylvanian – Upper	Gzhelian	303.4 ±0.9
Phanerozoic	Paleozoic	Carboniferous	Pennsylvanian – Upper	Kasimovian	307.2 ±1.0
Phanerozoic	Paleozoic	Carboniferous	Pennsylvanian – Middle	Moscovian	311.7 ±1.1
Phanerozoic	Paleozoic	Carboniferous	Pennsylvanian – Lower	Bashkirian	318.1 ±1.3
Phanerozoic	Paleozoic	Carboniferous	Mississippian – Upper	Serpukhovian	328.3 ±1.6
Phanerozoic	Paleozoic	Carboniferous	Mississippian – Middle	Visean	345.3 ±2.1
Phanerozoic	Paleozoic	Carboniferous	Mississippian – Lower	Tournaisian	359.2 ±2.5

Eonothem Eon	Erathem Era	System Period	Series Epoch	Stage Age	Age Ma
					359.2 ±2.5
Phanerozoic	Paleozoic	Devonian	Upper	Famennian	374.5 ±2.6
Phanerozoic	Paleozoic	Devonian	Upper	Frasnian	385.3 ±2.6
Phanerozoic	Paleozoic	Devonian	Middle	Givetian	391.8 ±2.7
Phanerozoic	Paleozoic	Devonian	Middle	Eifelian	397.5 ±2.7
Phanerozoic	Paleozoic	Devonian	Lower	Emsian	407.0 ±2.8
Phanerozoic	Paleozoic	Devonian	Lower	Pragian	411.2 ±2.8
Phanerozoic	Paleozoic	Devonian	Lower	Lochkovian	416.0 ±2.8
Phanerozoic	Paleozoic	Silurian	Pridoli		418.7 ±2.7
Phanerozoic	Paleozoic	Silurian	Ludlow	Ludfordian	421.3 ±2.6
Phanerozoic	Paleozoic	Silurian	Ludlow	Gorstian	422.9 ±2.5
Phanerozoic	Paleozoic	Silurian	Wenlock	Homerian	426.2 ±2.4
Phanerozoic	Paleozoic	Silurian	Wenlock	Sheinwoodian	428.2 ±2.3
Phanerozoic	Paleozoic	Silurian	Llandovery	Telychian	436.0 ±1.9
Phanerozoic	Paleozoic	Silurian	Llandovery	Aeronian	439.0 ±1.8
Phanerozoic	Paleozoic	Silurian	Llandovery	Rhuddanian	443.7 ±1.5
Phanerozoic	Paleozoic	Ordovician	Upper	Hirnantian	445.6 ±1.5
Phanerozoic	Paleozoic	Ordovician	Upper	Katian	455.8 ±1.6
Phanerozoic	Paleozoic	Ordovician	Upper	Sandbian	460.9 ±1.6
Phanerozoic	Paleozoic	Ordovician	Middle	Darriwilian	468.1 ±1.6
Phanerozoic	Paleozoic	Ordovician	Middle	Dapingian	471.8 ±1.6
Phanerozoic	Paleozoic	Ordovician	Lower	Floian	478.6 ±1.7
Phanerozoic	Paleozoic	Ordovician	Lower	Tremadocian	488.3 ±1.7
Phanerozoic	Paleozoic	Cambrian	Furongian	*Stage 10*	~ 492 *
Phanerozoic	Paleozoic	Cambrian	Furongian	*Stage 9*	~ 496 *
Phanerozoic	Paleozoic	Cambrian	Furongian	Paibian	~ 499
Phanerozoic	Paleozoic	Cambrian	Series 3	Guzhangian	~ 503
Phanerozoic	Paleozoic	Cambrian	Series 3	Drumian	~ 506.5
Phanerozoic	Paleozoic	Cambrian	Series 3	*Stage 5*	~ 510 *
Phanerozoic	Paleozoic	Cambrian	Series 2	*Stage 4*	~ 515 *
Phanerozoic	Paleozoic	Cambrian	Series 2	*Stage 3*	~ 521 *
Phanerozoic	Paleozoic	Cambrian	Terreneuvian	*Stage 2*	~ 528 *
Phanerozoic	Paleozoic	Cambrian	Terreneuvian	Fortunian	542.0 ±1.0

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

	Eonothem Eon	Erathem Era	System Period	Age Ma
				542
Precambrian	Proterozoic	Neoproterozoic	Ediacaran	~635
Precambrian	Proterozoic	Neoproterozoic	Cryogenian	850
Precambrian	Proterozoic	Neoproterozoic	Tonian	1000
Precambrian	Proterozoic	Mesoproterozoic	Stenian	1200
Precambrian	Proterozoic	Mesoproterozoic	Ectasian	1400
Precambrian	Proterozoic	Mesoproterozoic	Calymmian	1600
Precambrian	Proterozoic	Paleoproterozoic	Statherian	1800
Precambrian	Proterozoic	Paleoproterozoic	Orosirian	2050
Precambrian	Proterozoic	Paleoproterozoic	Rhyacian	2300
Precambrian	Proterozoic	Paleoproterozoic	Siderian	2500
Precambrian	Archean	Neoarchean		2800
Precambrian	Archean	Mesoarchean		3200
Precambrian	Archean	Paleoarchean		3600
Precambrian	Archean	Eoarchean		4000
Precambrian	*Hadean (informal)*			~4600

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 Boundary Stratotype 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*).

Numerical ages of the unit boundaries in the Phanerozoic are subject to revision. Some stages within the Cambrian will be formally named upon international agreement on their GSSP limits. Most sub-Series boundaries (e.g., Middle and Upper Aptian) are not formally defined.

Colors are according to the Commission for the Geological Map of the World (*www.cgmw.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) and "The Concise Geologic Time Scale" by J.G. Ogg, G. Ogg and F.M. Gradstein (2008).

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