The Chronostratigraphic Nomenclatorial History of the Pennsylvanian:

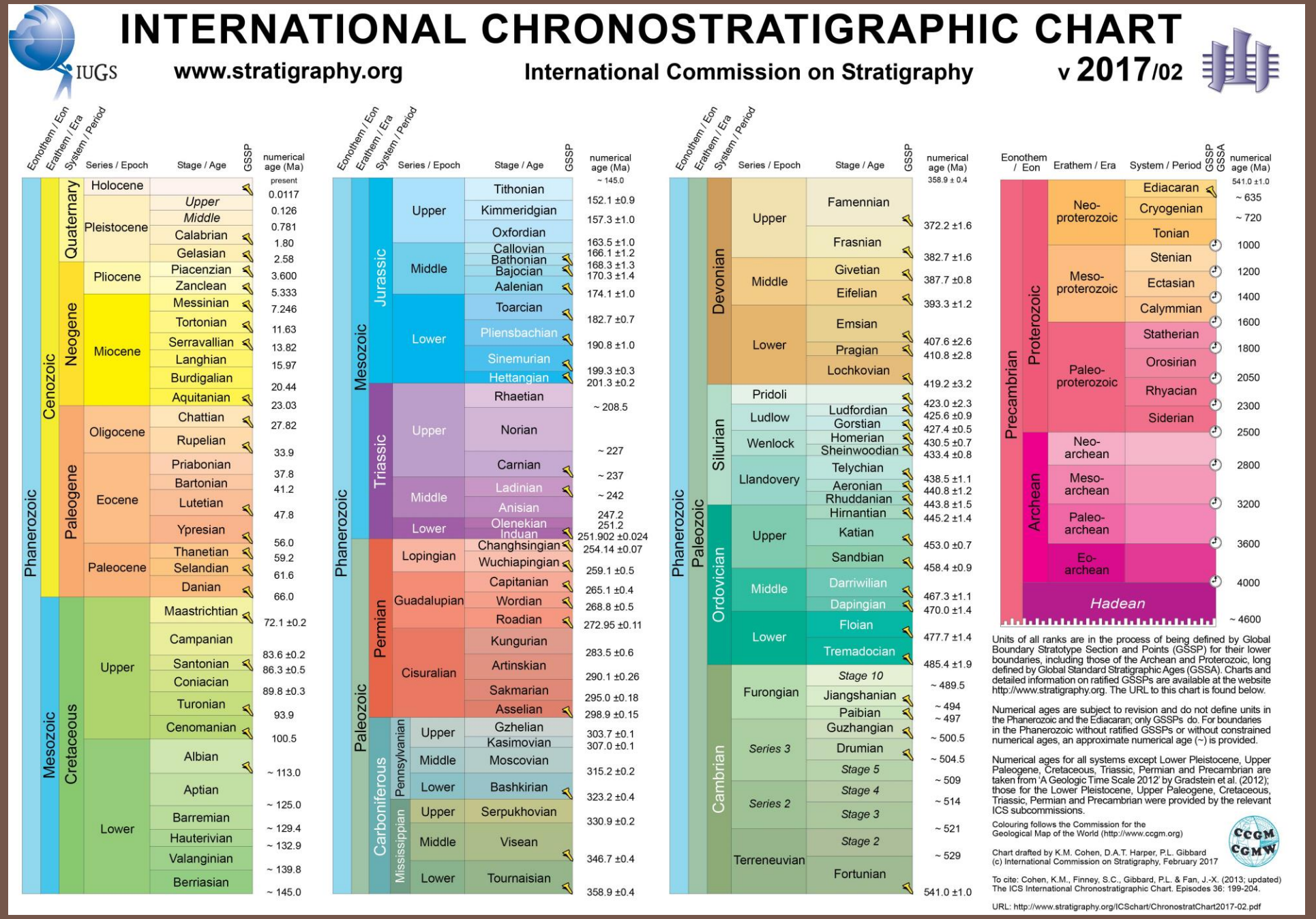
Series to System to Subsystem

Noah Morris

Dr. Walter L. Manger

South-Central GSA Meeting

March 12, 2018


INTERNATIONAL CHRONOSTRATIGRAPHIC CHART
IUGS
www.stratigraphy.org
International Commission on Stratigraphy
v 2017/02
Eonothem / Eon
Erathem / Era
System / Period
Series / Epoch
Stage / Age
GSSP
numerical age (Ma)
Phanerozoic
Cenozoic
Quaternary
Holocene
present
0.0117
Pleistocene
Upper
0.126
Middle
0.781
Calabrian
1.80
Gelasian
2.58
Neogene
Pliocene
Piacenzian
3.600
Zanclean
5.333
Miocene
Messinian
7.246
Tortonian
11.63
Serravallian
13.82
Langhian
15.97
Burdigalian
20.44
Aquitanian
23.03
Paleogene
Oligocene
Chattian
27.82
Rupelian
33.9
Eocene
Priabonian
37.8
Bartonian
41.2
Lutetian
47.8
Ypresian
56.0
Paleocene
Thanetian
59.2
Selandian
61.6
Danian
66.0
Mesozoic
Cretaceous
Upper
Maastrichtian
72.1 ±0.2
Campanian
83.6 ±0.2
Santonian
86.3 ±0.5
Coniacian
89.8 ±0.3
Turonian
93.9
Cenomanian
100.5
Lower
Albian
~ 113.0
Aptian
~ 125.0
Barremian
~ 129.4
Hauterivian
~ 132.9
Valanginian
~ 139.8
Berriasian
~ 145.0
Jurassic
Upper
Tithonian
152.1 ±0.9
Kimmeridgian
157.3 ±1.0
Oxfordian
163.5 ±1.0
Middle
Callovian
166.1 ±1.2
Bathonian
168.3 ±1.3
Bajocian
170.3 ±1.4
Aalenian
174.1 ±1.0
Lower
Toarcian
182.7 ±0.7
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190.8 ±1.0
Sinemurian
Hettangian
199.3 ±0.3
201.3 ±0.2
Triassic
Upper
Rhaetian
~ 208.5
Norian
~ 227
Carnian
~ 237
Middle
Ladinian
~ 242
Anisian
247.2
Lower
Olenekian
251.2
Induan
251.902 ±0.024
Permian
Lopingian
Changhsingian
254.14 ±0.07
Wuchiapingian
259.1 ±0.5
Guadalupian
Capitanian
265.1 ±0.4
Wordian
268.8 ±0.5
Roadian
272.95 ±0.11
Cisuralian
Kungurian
283.5 ±0.6
Artinskian
290.1 ±0.26
Sakmarian
295.0 ±0.18
Asselian
298.9 ±0.15
Carboniferous
Pennsylvanian
Upper
Gzhelian
303.7 ±0.1
Kasimovian
307.0 ±0.1
Middle
Moscovian
315.2 ±0.2
Lower
Bashkirian
323.2 ±0.4
Mississippian
Upper
Serpukhovian
330.9 ±0.2
Middle
Visean
346.7 ±0.4
Lower
Tournaisian
358.9 ±0.4
Devonian
Upper
Famennian
372.2 ±1.6
Frasnian
382.7 ±1.6
Middle
Givetian
387.7 ±0.8
Eifelian
393.3 ±1.2
Lower
Emsian
407.6 ±2.6
Pragian
410.8 ±2.8
Lochkovian
419.2 ±3.2
Silurian
Pridoli
423.0 ±2.3
Ludlow
Ludfordian
425.6 ±0.9
Gorstian
427.4 ±0.5
Wenlock
Homerian
430.5 ±0.7
Sheinwoodian
433.4 ±0.8
Llandovery
Telychian
438.5 ±1.1
Aeronian
440.8 ±1.2
Rhuddanian
443.8 ±1.5
Ordovician
Upper
Hirnantian
445.2 ±1.4
Katian
453.0 ±0.7
Sandbian
458.4 ±0.9
Middle
Darriwilian
467.3 ±1.1
Dapingian
470.0 ±1.4
Lower
Floian
477.7 ±1.4
Tremadocian
485.4 ±1.9
Cambrian
Furongian
Stage 10
~ 489.5
Jiangshanian
~ 494
Paibian
~ 497
Series 3
Guzhangian
~ 500.5
Drumian
~ 504.5
Stage 5
~ 509
Series 2
Stage 4
~ 514
Stage 3
~ 521
Terreneuvian
Stage 2
~ 529
Fortunian
541.0 ±1.0
Precambrian
Proterozoic
Neo-proterozoic
Ediacaran
541.0 ±1.0
Cryogenian
~ 635
Tonian
~ 720
Meso-proterozoic
Stenian
1000
Ectasian
1200
Calymmian
1400
Paleo-proterozoic
Statherian
1600
Orosirian
1800
Rhyacian
2050
Siderian
2300
Archean
Neo-archean
2500
Meso-archean
2800
Paleo-archean
3200
Eo-archean
3600
Hadean
4000
~ 4600
Units of all ranks are in the process of being defined by Global Boundary Stratotype Section and Points (GSSP) for their lower boundaries, including those of the Archean and Proterozoic, long defined by Global Standard Stratigraphic Ages (GSSA). Charts and detailed information on ratified GSSPs are available at the website http://www.stratigraphy.org. The URL to this chart is found below.
Numerical ages are subject to revision and do not define units in the Phanerozoic and the Ediacaran; only GSSPs do. For boundaries in the Phanerozoic without ratified GSSPs or without constrained numerical ages, an approximate numerical age (~) is provided.
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Colouring follows the Commission for the Geological Map of the World (http://www.ccgm.org)
CCGM CGMW
Chart drafted by K.M. Cohen, D.A.T. Harper, P.L. Gibbard
(c) International Commission on Stratigraphy, February 2017
To cite: Cohen, K.M., Finney, S.C., Gibbard, P.L. & Fan, J.-X. (2013; updated) The ICS International Chronostratigraphic Chart. Episodes 36: 199-204.
URL: http://www.stratigraphy.org/ICSchart/ChronostratChart2017-02.pdf

European Stratigraphy

Character	Proposed names	Wernerian names	Other writers
1. Formations (chiefly of *sand & clay*) *above the chalk.*	*Superior order.*	Newest flœtz class.	Tertiary class.
2. Comprising *a. Chalk.* *b.* sands & clays *beneath the chalk.* *c.* calcareous freestones (*oolites*), & argillaceous beds. *d. New red sandstone, conglomerate & magnesian limestone.*	*Supermedial order.*	Flœtz class.	Secondary class.
3. Carboniferous rocks, comprising *a. Coal-measures.* *b. Carboniferous limestone.* *c. Old red sandstone.*	*Medial order.*	Sometimes referred to the preceding sometimes to the succeeding class by writers of these schools; very often the coal-measures are referred to the former —the subjacent limestone and sandstone to the latter.	
4. *Roofing slate, &c. &c.*	*Submedial order.*	Transition class.	Intermediate class.
5. *Mica slate.* *Gneiss.* *Granite, &c.*	*Inferior order.*	Primitive class.	Primitive class.

[Page vii.]

Conybeare and Phillips, 1822, p. vii

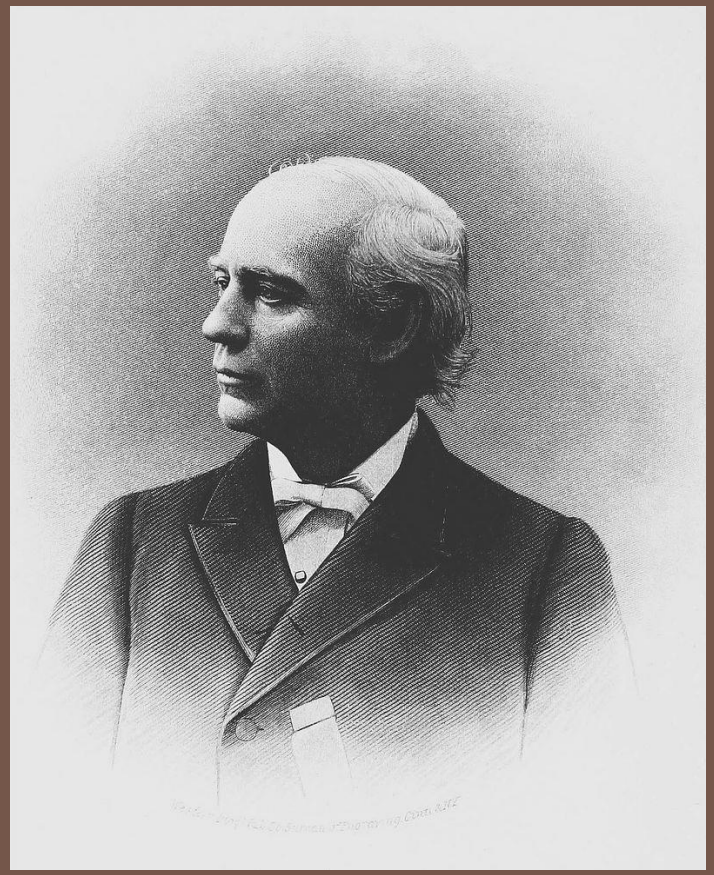
North American Stratigraphy

- Mid- to late-1800s:
  - Increase in coal production
  - Several geological surveys and university geologists study coal
  - Various stratigraphic nomenclatures in use for the “Coal Measures” of the Carboniferous

19th Century

- 1883: Edward Orton Sr., the State Geologist of Ohio, writes a paper titled "The Lower Coal Measures of Ohio," and notes nomenclature problems between state surveys

- Proposes using the "Pennsylvania System" for the Ohio stratigraphic units
  - i.e. the system of nomenclature used by the Pennsylvanian Geological Survey



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19th Century

- 1889: USGS holds a conference to resolve nomenclatorial problems and to begin preparation of *A Geologic Atlas of the United States*
  - Adopts the Carboniferous Period
  - Use “system” as a separate stratigraphic term

19th Century

- 1891: “Pennsylvanian series” as chronostratigraphic term
- Henry Shaler Williams writes in USGS Bulletin 80:
  - Table of Contents -

CHAPTER V. The Coal Measures or Pennsylvanian series: The development of its nomenclature and classification in the Appalachian Province (1836–1888).

  - Chapter 4 Title -

CHAPTER IV.

THE COAL MEASURES OR PENNSYLVANIA SERIES. THE DEVELOPMENT OF ITS NOMENCLATURE AND CLASSIFICATION IN THE APPALACHIAN PROVINCE.

19th Century

- 1891: J.C. Branner, State Geologist of Arkansas, publishes a stratigraphic chart citing Williams for both the Mississippian and Pennsylvanian Series name

THE FORMATIONS OF WASHINGTON COUNTY.

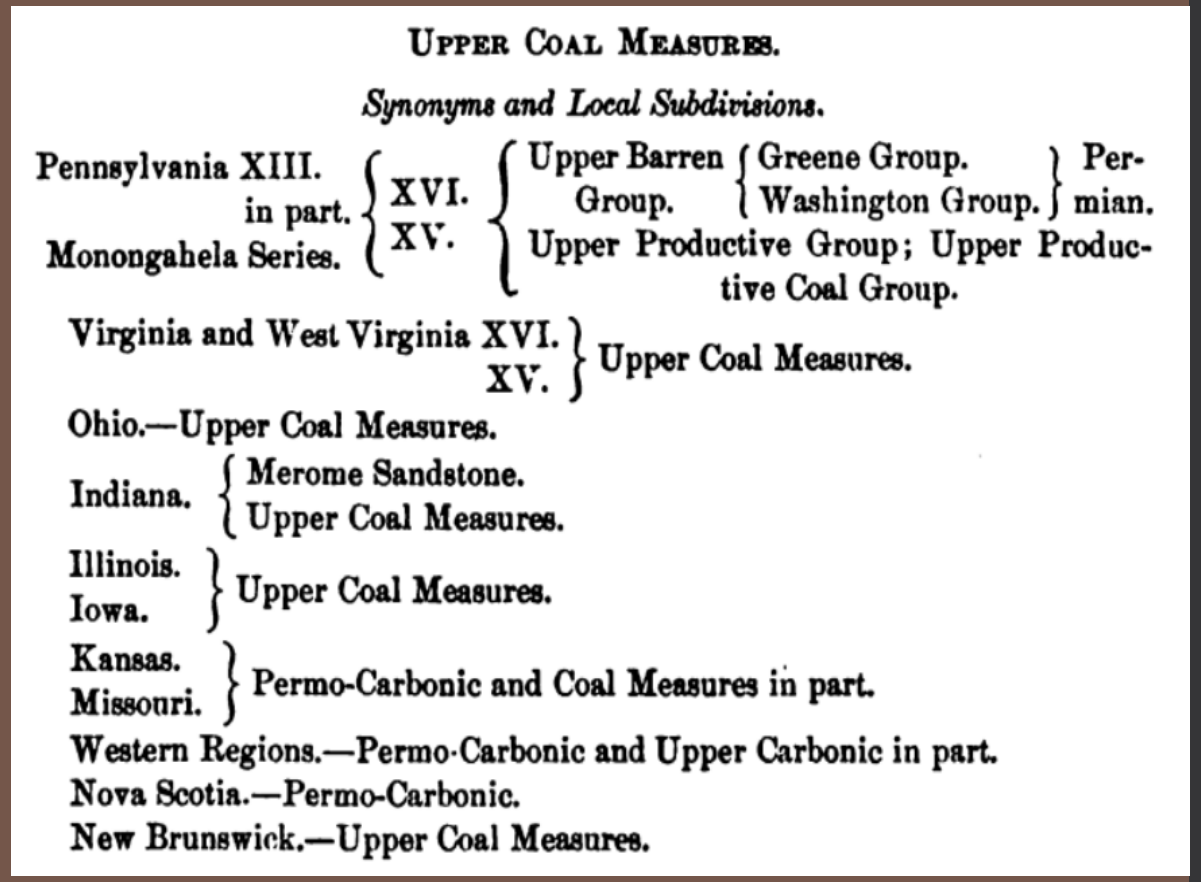
System.	Series.	Group.	Approximate Equivalence. (H. S. Williams)	Washington County.
Carboniferous or Pennine.	Coal Measures or Pennsylvanian (H. S. Williams)			Millstone grit.
		Boston (Branner). Genevieve (H. S. Wms).	"Chester." "St. Louis." "Warsaw."	Kessler limestone (Simonds.) Coal-bearing shale (Simonds.) Pentremital limestone (Simonds) Washington shale and sandstone (Simonds). Archimedes limestone (Simonds). Marshall shale (Branner).
	Lower Carboniferous or Mississippian (H. S. Wms.)	Osage (H. S. Wms).	"Keokuk." "Burlington."	Batesville sandstone (Branner). Fayetteville shale (Simonds). Wyman sandstone (Simonds). Boone chert and limestone (Branner).
Devonian?				Eureka shale (Branner).
Silurian.				(Sandstones).

Branner, 1891, p. xiii

Pennsylvanian Author

- Some credit John James Stevenson (1888) for proposing the Pennsylvanian System
  - Gradstein, et al., 2004
  - Gradstein, et al., 2012
  - Richards, 2012
  - Humbold University website, 2014

- Unclear as to why this is



UPPER COAL MEASURES.

Synonyms and Local Subdivisions.

Pennsylvania XIII. in part. Monongahela Series. { XVI. XV. } { Upper Barren Group. { Greene Group. Washington Group. } Permian. Upper Productive Group; Upper Productive Coal Group. }

Virginia and West Virginia XVI. XV. } Upper Coal Measures.

Ohio.—Upper Coal Measures.

Indiana. { Merome Sandstone. Upper Coal Measures.

Illinois. Iowa. } Upper Coal Measures.

Kansas. Missouri. } Permo-Carbonic and Coal Measures in part.

Western Regions.—Permo-Carbonic and Upper Carbonic in part.

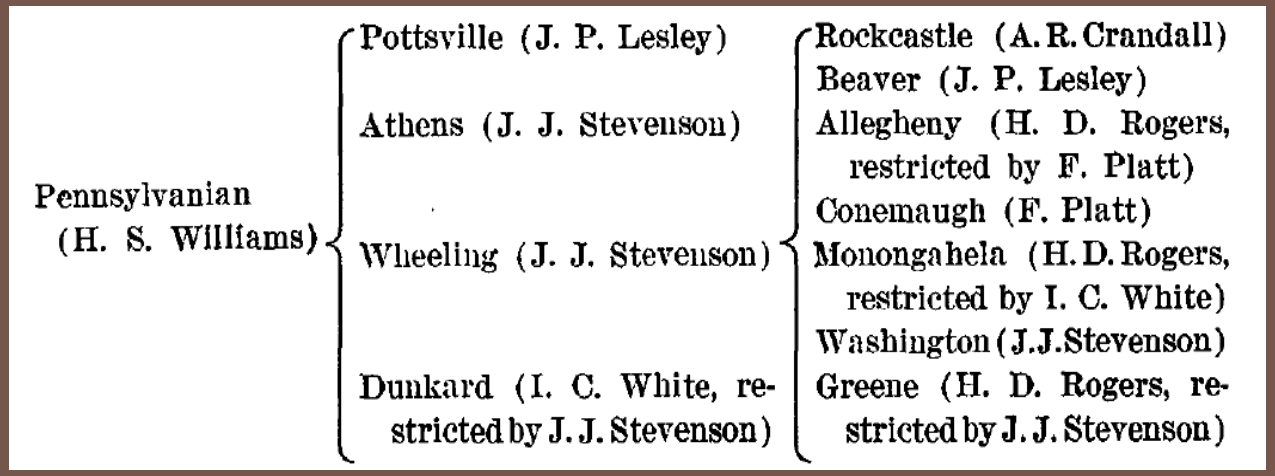
Nova Scotia.—Permo-Carbonic.

New Brunswick.—Upper Coal Measures.

Stevenson, 1888, p. D4

Pennsylvanian Author

- Stevenson (1907) cites Williams as author



Pennsylvanian (H. S. Williams)	Pottsville (J. P. Lesley)	Rockcastle (A. R. Crandall)
		Beaver (J. P. Lesley)
	Athens (J. J. Stevenson)	Allegheny (H. D. Rogers, restricted by F. Platt)
		Conemaugh (F. Platt)
	Wheeling (J. J. Stevenson)	Monongahela (H. D. Rogers, restricted by I. C. White)
		Washington (J. J. Stevenson)
	Dunkard (I. C. White, restricted by J. J. Stevenson)	Greene (H. D. Rogers, restricted by J. J. Stevenson)

Stevenson, 1907, p. 178

20th Century

- Increase in natural resource production in early 1900s
- Post-WWI years: National Academy of Sciences establishes subcommittees on the Mississippian and Pennsylvanian stratigraphy
- Post-WWII years: GSA and AAPG later begin own subcommittees

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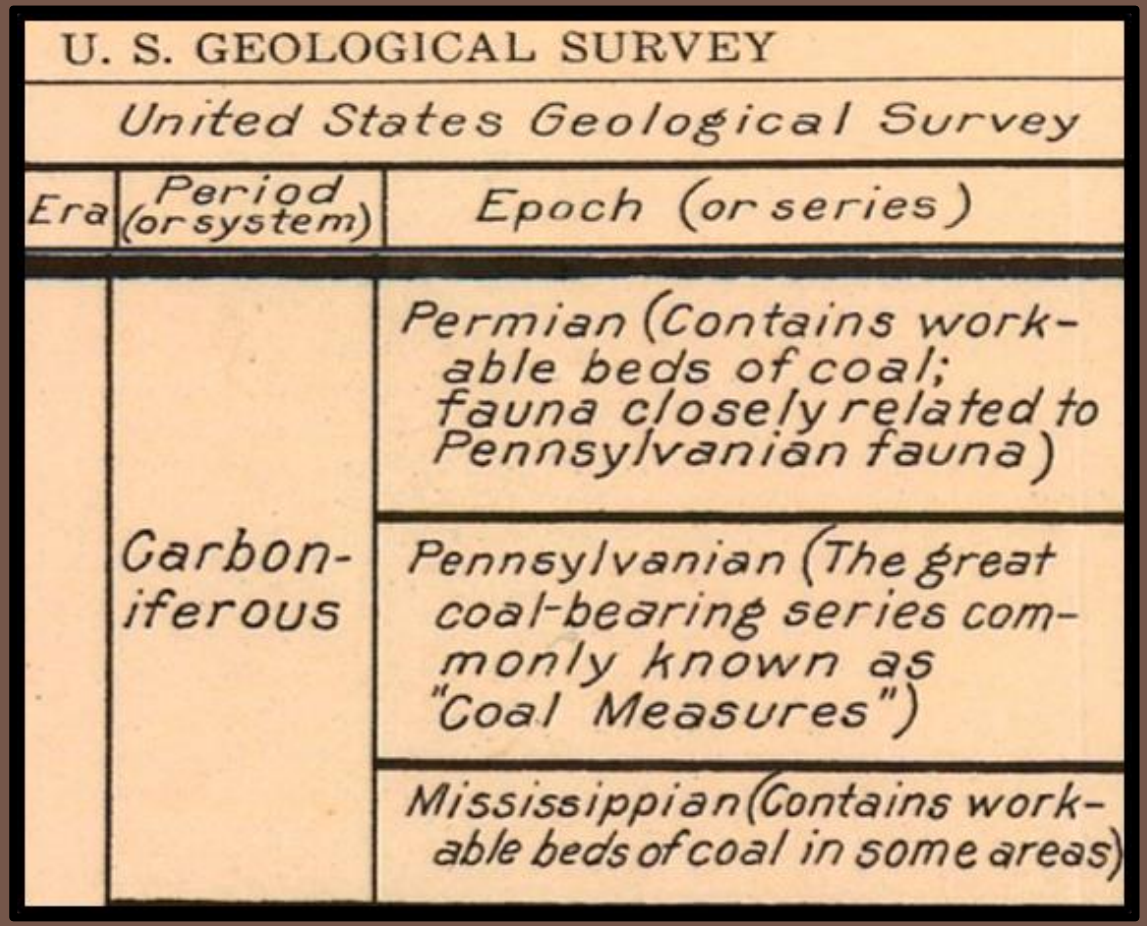
20th Century

- 1924: USGS adopts the Mississippian and Pennsylvanian as "**series**" within the Carboniferous Period



U. S. GEOLOGICAL SURVEY

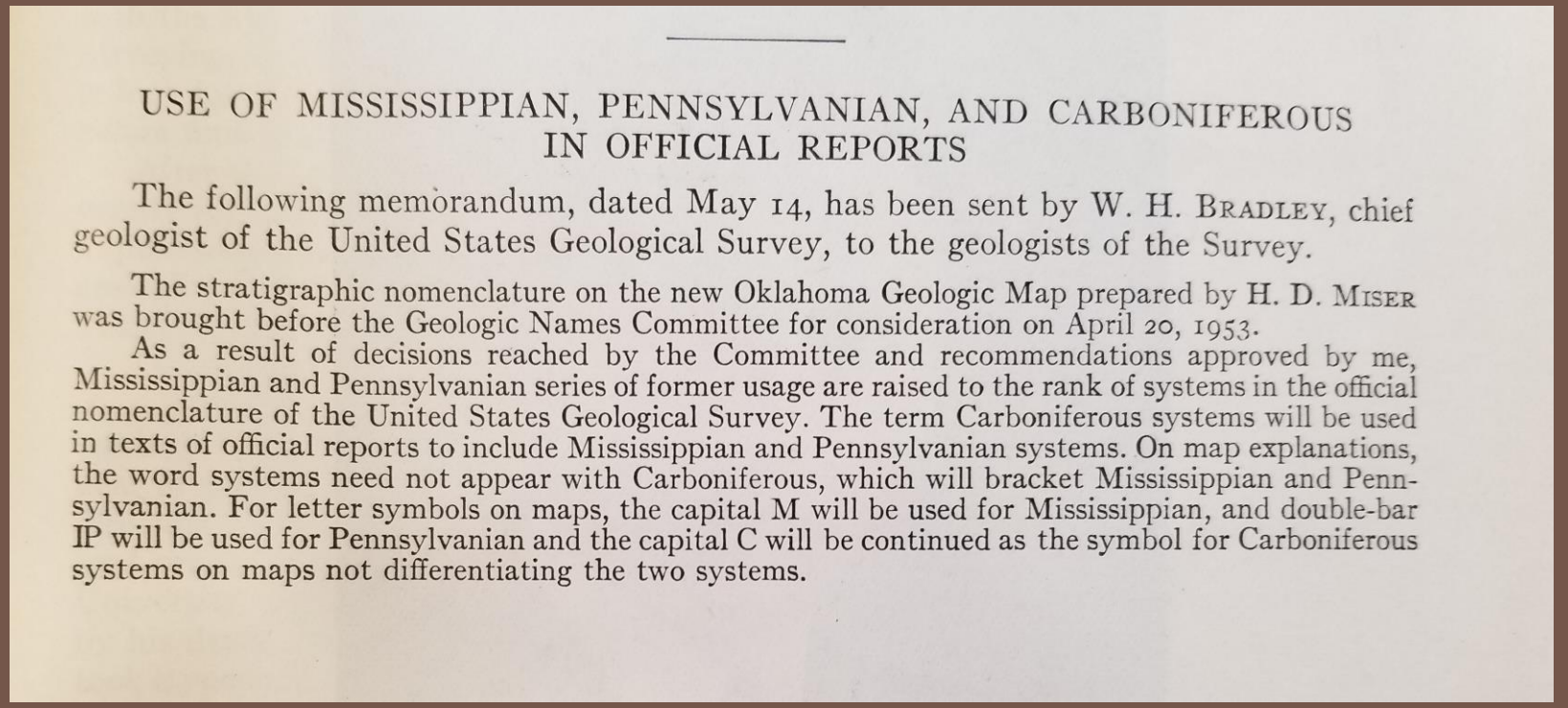
United States Geological Survey

Era	Period (or system)	Epoch (or series)
	Carboniferous	Permian (Contains workable beds of coal; fauna closely related to Pennsylvanian fauna)
		Pennsylvanian (The great coal-bearing series commonly known as "Coal Measures")
		Mississippian (Contains workable beds of coal in some areas)

Wilmarth, 1924, published 1925

20th Century

- 1953: USGS elevates the Mississippian and Pennsylvanian to "**systems**"



USE OF MISSISSIPPIAN, PENNSYLVANIAN, AND CARBONIFEROUS IN OFFICIAL REPORTS

The following memorandum, dated May 14, has been sent by W. H. BRADLEY, chief geologist of the United States Geological Survey, to the geologists of the Survey.

The stratigraphic nomenclature on the new Oklahoma Geologic Map prepared by H. D. MISER was brought before the Geologic Names Committee for consideration on April 20, 1953.

As a result of decisions reached by the Committee and recommendations approved by me, Mississippian and Pennsylvanian series of former usage are raised to the rank of systems in the official nomenclature of the United States Geological Survey. The term Carboniferous systems will be used in texts of official reports to include Mississippian and Pennsylvanian systems. On map explanations, the word systems need not appear with Carboniferous, which will bracket Mississippian and Pennsylvanian. For letter symbols on maps, the capital M will be used for Mississippian, and double-bar IP will be used for Pennsylvanian and the capital C will be continued as the symbol for Carboniferous systems on maps not differentiating the two systems.

Bradley, 1953

20th Century

- 1956: USGS memo reminding that the Mississippian and Pennsylvanian are "**systems**"

USE OF SERIES SUBDIVISIONS OF THE MISSISSIPPIAN AND PENNSYLVANIAN SYSTEMS IN REPORTS BY MEMBERS OF THE U. S. GEOLOGICAL SURVEY[1]

W. H. BRADLEY[2]
Washington, D. C.

Pennsylvanian system

1. In the Appalachian region, Lower, Middle, and Upper Pennsylvanian will be used. The division between Lower and Middle Pennsylvanian is at the top of the New River and equivalent rocks, and the division between Middle and Upper Pennsylvanian is at the approximate boundary between the Allegheny and the Conemaugh.
2. In the Mid-Continent region (including Arkansas, Iowa, Kansas, Missouri, Nebraska, and Oklahoma), Morrow, Atoka, Des Moines, Missouri, and Virgil series will be used.
3. In other areas, Lower, Middle, and Upper Pennsylvanian will be used. These series in marine sections are approximate equivalents of the corresponding series Lower, Middle, and Upper of the Appalachian region; and Lower is equivalent to the Morrow, Middle to the Atoka and Des Moines, and Upper to the Missouri and Virgil of the Mid-Continent region.

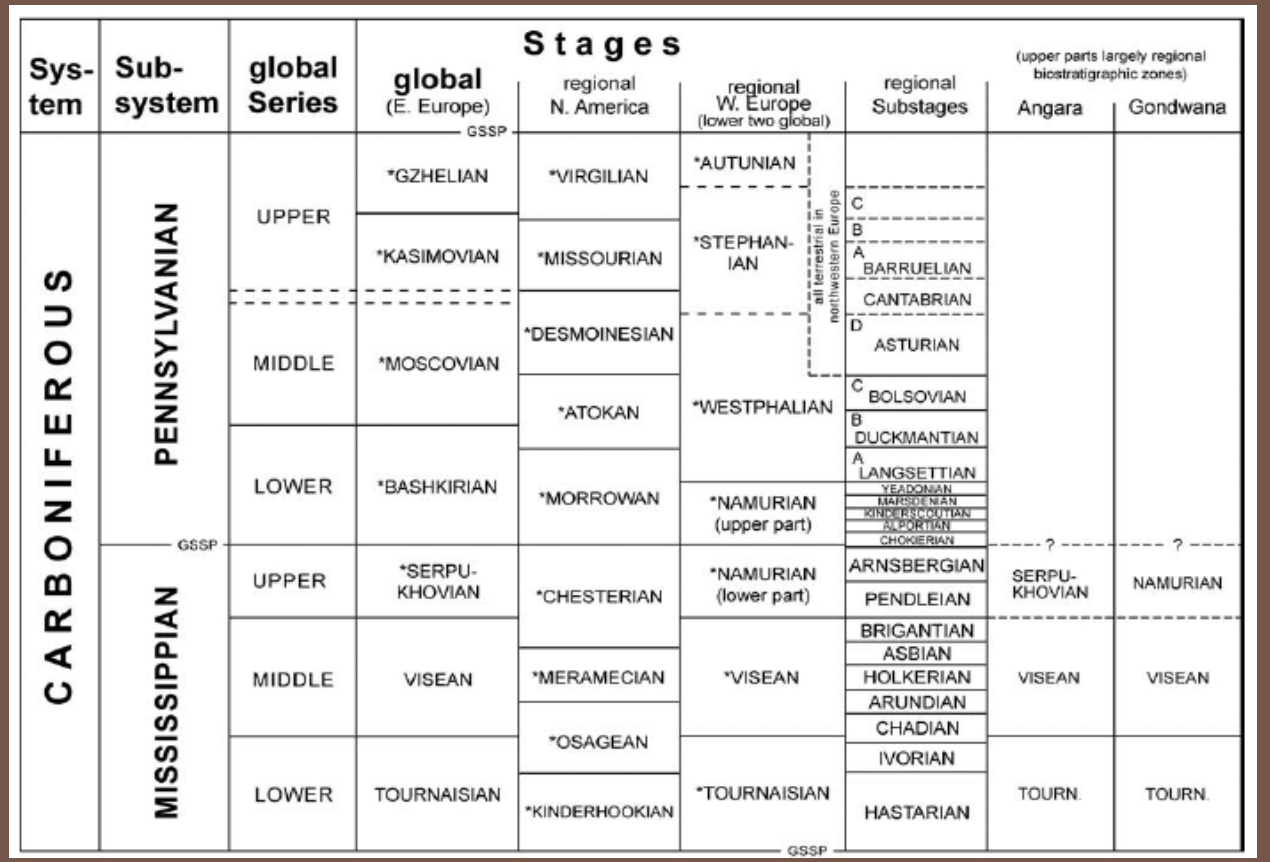
This action does not change the classification of Carboniferous systems used in the official nomenclature to include Mississippian system and Pennsylvanian system, as provided for in my memorandum of May 14, 1953.[3]

[3] "Use of Mississippian, Pennsylvanian, and Carboniferous in Official Reports," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 37, No. 6 (June, 1953), p. 1533.

Bradley, 1956

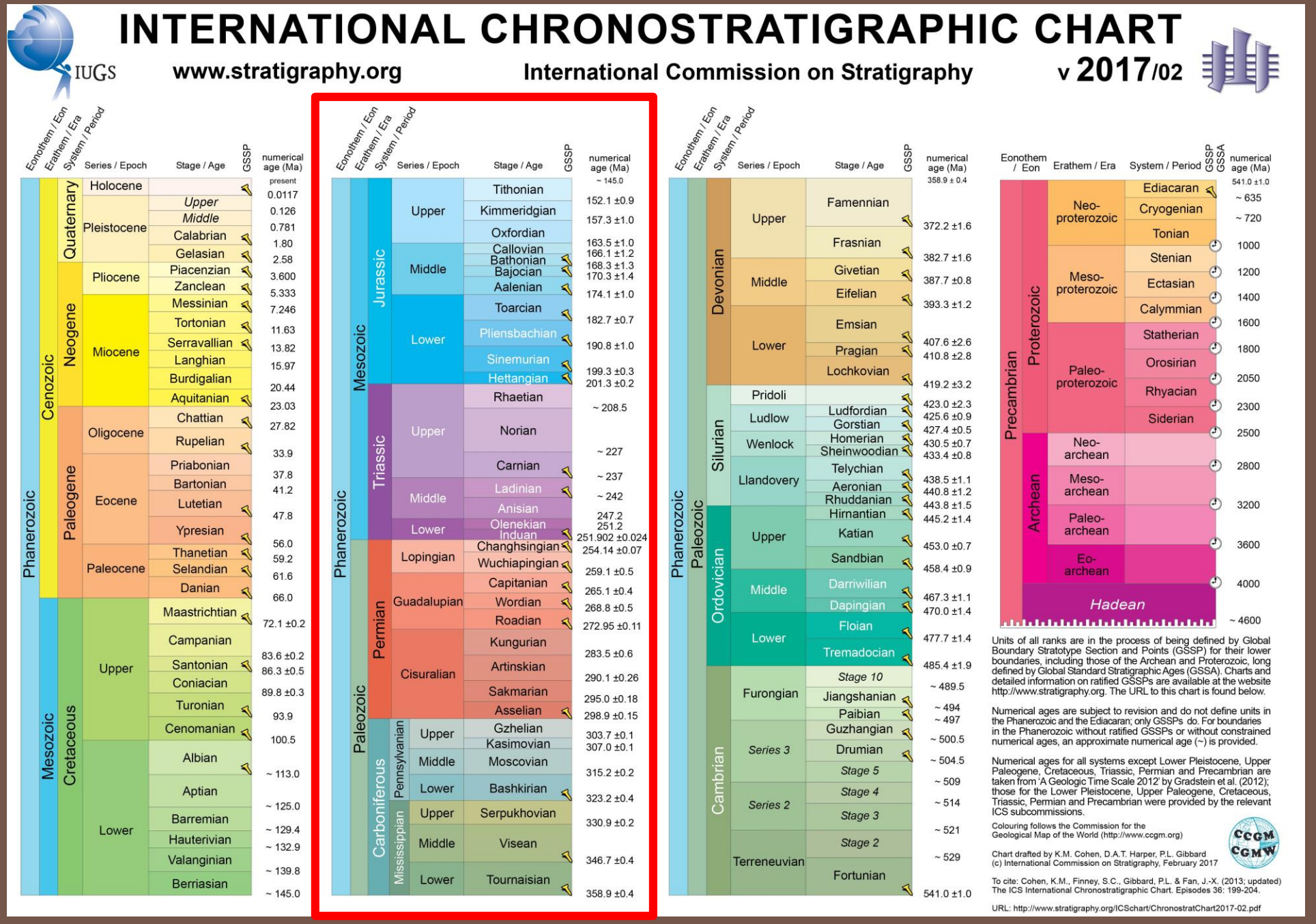
21st Century

- 2004: Int'l Committee on Stratigraphy establishes the Mississippian and Pennsylvanian as global "**Subsystems**" of the Carboniferous System



System	Subsystem	global Series	Stages: global (E. Europe)	Stages: regional N. America	Stages: regional W. Europe (lower two global)	Stages: regional Substages	(upper parts largely regional biostratigraphic zones): Angara	(upper parts largely regional biostratigraphic zones): Gondwana
CARBONIFEROUS	PENNSYLVANIAN	UPPER	*GZHELIAN	*VIRGILIAN	*AUTUNIAN			
					*STEPHAN-IAN	C		
			*KASIMOVIAN	*MISSOURIAN		B		
						A BARRUELIAN		
						CANTABRIAN		
		MIDDLE	*MOSCOVIAN	*DESMOINESIAN		D ASTURIAN		
				*ATOKAN	*WESTPHALIAN	C BOLSOVIAN		
		LOWER	*BASHKIRIAN	*MORROWAN		B DUCKMANTIAN		
						A LANGSETTIAN		
					*NAMURIAN (upper part)	YEADONIAN MARSDENIAN KINDERSCOUTIAN ALPORTIAN CHOKIERIAN	?	?
	MISSISSIPPIAN	UPPER	*SERPU-KHOVIAN	*CHESTERIAN	*NAMURIAN (lower part)	ARNSBERGIAN PENDLEIAN	SERPU-KHOVIAN	NAMURIAN
		MIDDLE	VISEAN	*MERAMECIAN	*VISEAN	BRIGANTIAN ASBIAN HOLKERIAN ARUNDIAN CHADIAN	VISEAN	VISEAN
				*OSAGEAN				
		LOWER	TOURNAISIAN	*KINDERHOOKIAN	*TOURNAISIAN	IVORIAN HASTARIAN	TOURN.	TOURN.

Heckel and Clayton, 2006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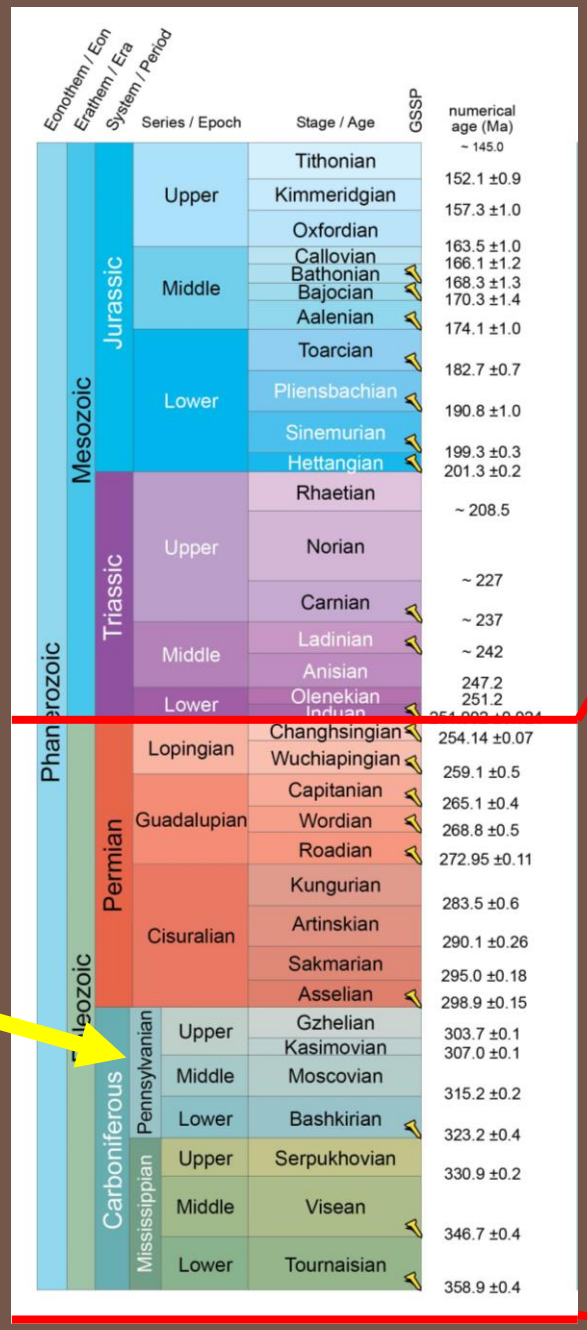
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315.2 ±0.2
Bashkirian
323.2 ±0.4
Serpukhovian
330.9 ±0.2
Visean
346.7 ±0.4
Tournaisian
358.9 ±0.4
Phanerozoic
Paleozoic
Mesozoic
Jurassic
Triassic
Permian
Carboniferous
Pennsylvanian
Mississippian
Upper
Middle
Lower

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