Middle and Late Paleozoic Organic-Rich Gas Shales of the North American Midcontinent*

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Search and Discovery Article #110069 (2008)
Posted September 13, 2008

*Prepared for oral presentation at AAPG Annual Convention, San Antonio, Texas, April 20-23, 2008

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Abstract

Black organic-rich gas producing shales are abundant in outcrop and subsurface in the North American Midcontinent. The middle Paleozoic Woodford and Chattanooga black shales (Frasnian-Tournisian) consist of fissile black shales in shelfal settings, abundant chert and black shale interbeds in distal shelf and slope settings, and novaculite with black shale interbeds in basinal settings. Faunal elements consist of pelagic forms including radiolarians, conodonts, ammonoids, and fish debris and are largely devoid of any benthic organisms.

Midcontinent Upper Mississippian black shales (Visean-Serpukhovian) include the Barnett Shale of Texas, Caney Shale of central and southern Oklahoma, and Fayetteville Shale of Arkansas and northeast Oklahoma. These shales differ from those of the Woodford and Chattanooga in lacking significant chert beds or novaculite but are similar in containing black fissile organic-rich shale and localized phosphate. Ammonoid-bearing diagenetic carbonate concretions (bullion) typify these black shales. Faunal elements include both pelagic and benthic components. The pelagic components include radiolarians, conodonts, ammonoids, and fish, whereas the benthic faunas of low diversity include acrotretids and Leiorhynchoidea brachiopods, bivalves (*Caneyella*), and gastropods (archaeogastropods). These suggest that times of anoxia and dysoxia alternated, possibly related to water-masses changes related to the onset of Gondwana glaciation.

Upper Carboniferous (Moscovian-Gzhelian) and Lower Permian (Asselian) black fissile organic-rich phosphatic shales are numerous (>30) in the Midcontinent and are typified by being thin (1-2 meters) and associated with maximum marine flooding during cyclothemic sedimentation. These black shales are overlain and underlain by gray dysoxic shales.

MIDDLE AND LATE PALEOZOIC ORGANIC-RICH GAS SHALES OF THE NORTH AMERICAN MIDCONTINENT

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Acknowledgements

- We would like to acknowledge Devon Energy (Barnett Shale) -
  - Bill Coffee & Jeff Hall

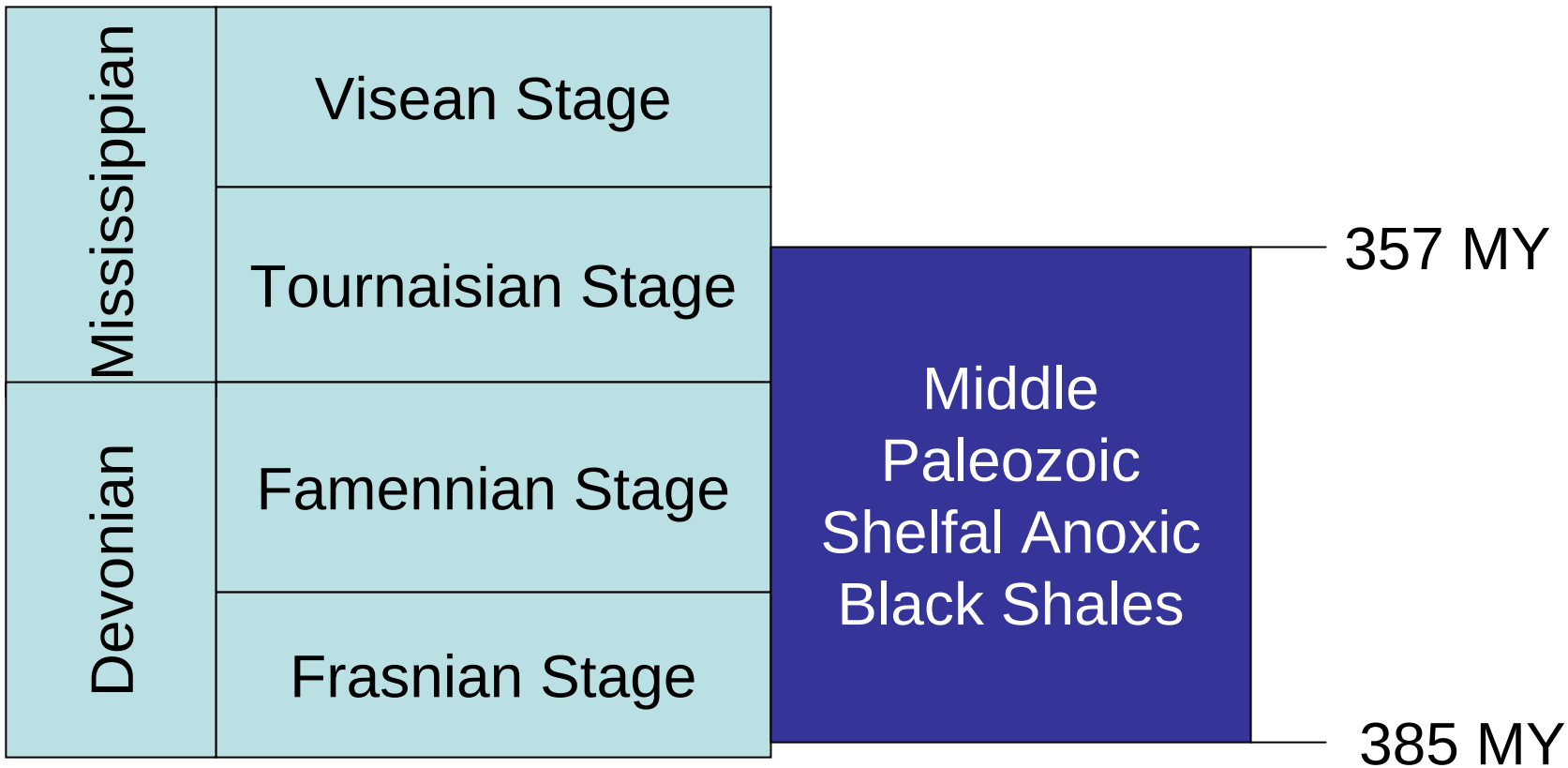
  Newfield Exploration (Woodford)

  -Jack Breig

Methodology

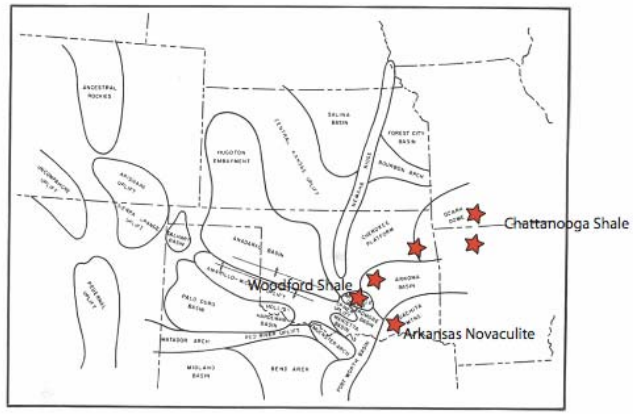
- 1. Detailed Measured Sections from Outcrop
- 2. Core Analysis
- 3. Spectral Gamma Ray of Outcrops
- 4. Thin Sections
- 5. Clay Mineralogy
- 6. Geochemistry
- 7. Microscopic Analysis of Microfossils

Woodford Shale



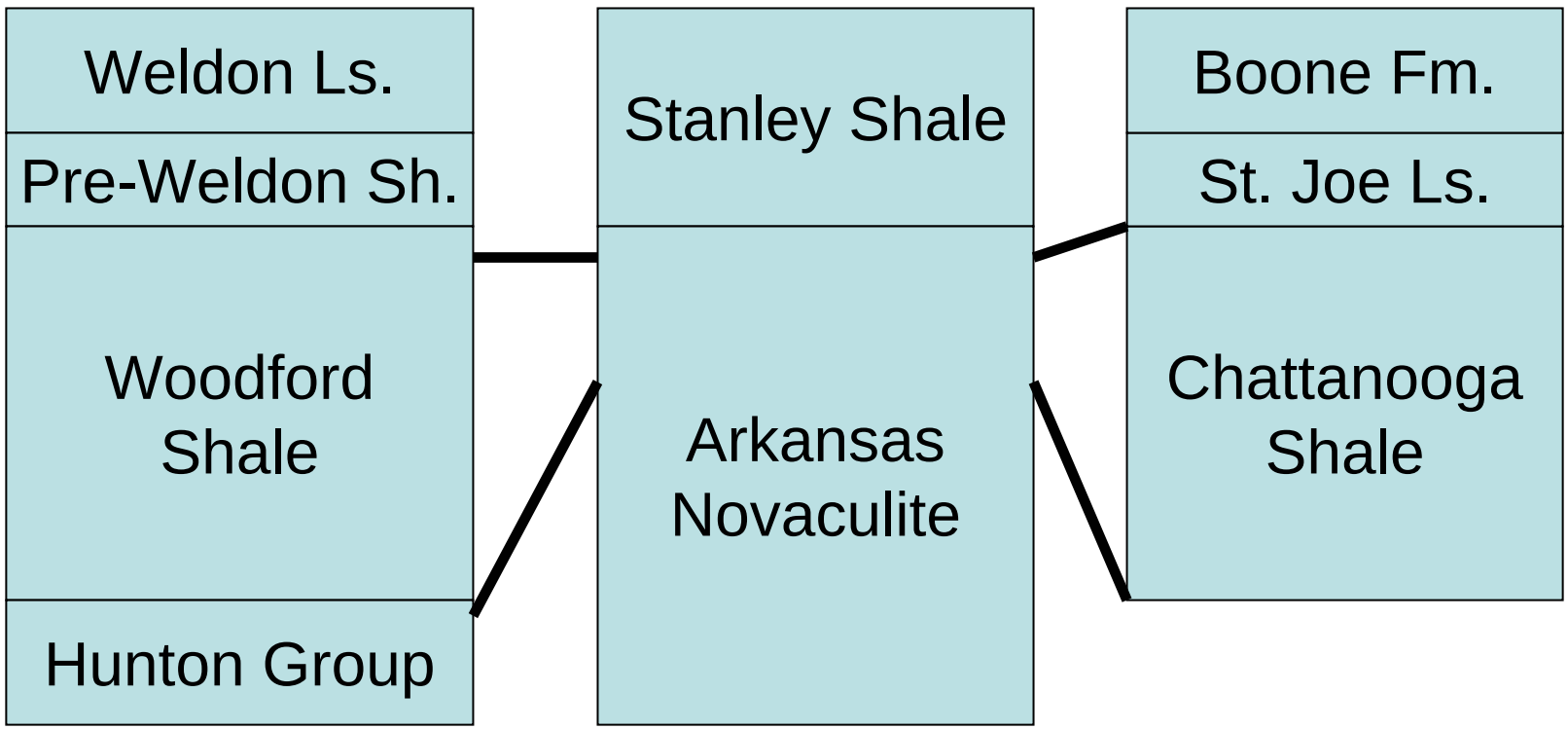
Woodford Shale

- Location Map



Woodford Shale

- Arbuckles



Woodford Shale

- Lawrence Uplift (Haas G)

Welden Limestone

pre-Welden shale

Woodford Shale

Woodford Shale

- Base of Woodford-US 77-D (I-35 North area)

Woodford Shale

- Top Woodford (I-35 North)

Woodford Shale

- Chert and Black Shale Interbeds
- I-35 South

Woodford Shale

- Woodford Criner Hills (McAlester Shale Pit)
- PO4 Nodules

Woodford Shale

- Woodford
- Criner Hills

Chattanooga Shale

- Jane, Missouri

Arkansas Novaculite

- Base Arkansas Novaculite

Arkansas Novaculite

- Middle & Upper
- Arkansas Novaculite

Arkansas Novaculite

- Top Arkansas Novaculite

Woodford Shale

- Regional Distribution

  High Shelf Northeastern Oklahoma-Southwestern Missouri, Northwestern Arkansas “Chattanooga Shale” (Black, Fissile, Shale)

  Low Shelf/Distal Shelf (Arbuckle Mountains) Interbeds of Radiolarian-bearing bedded cherts and black, fissile, phosphatic shale, very localized early carbonate concretions [Bullion, Criner Hills]

  Basinal (Arkoma Basin) Interbeds of Radiolarian bearing Novaculite with black fissile shale Black Shale percentage reduced compared to Shelf as well as variegated and red shales

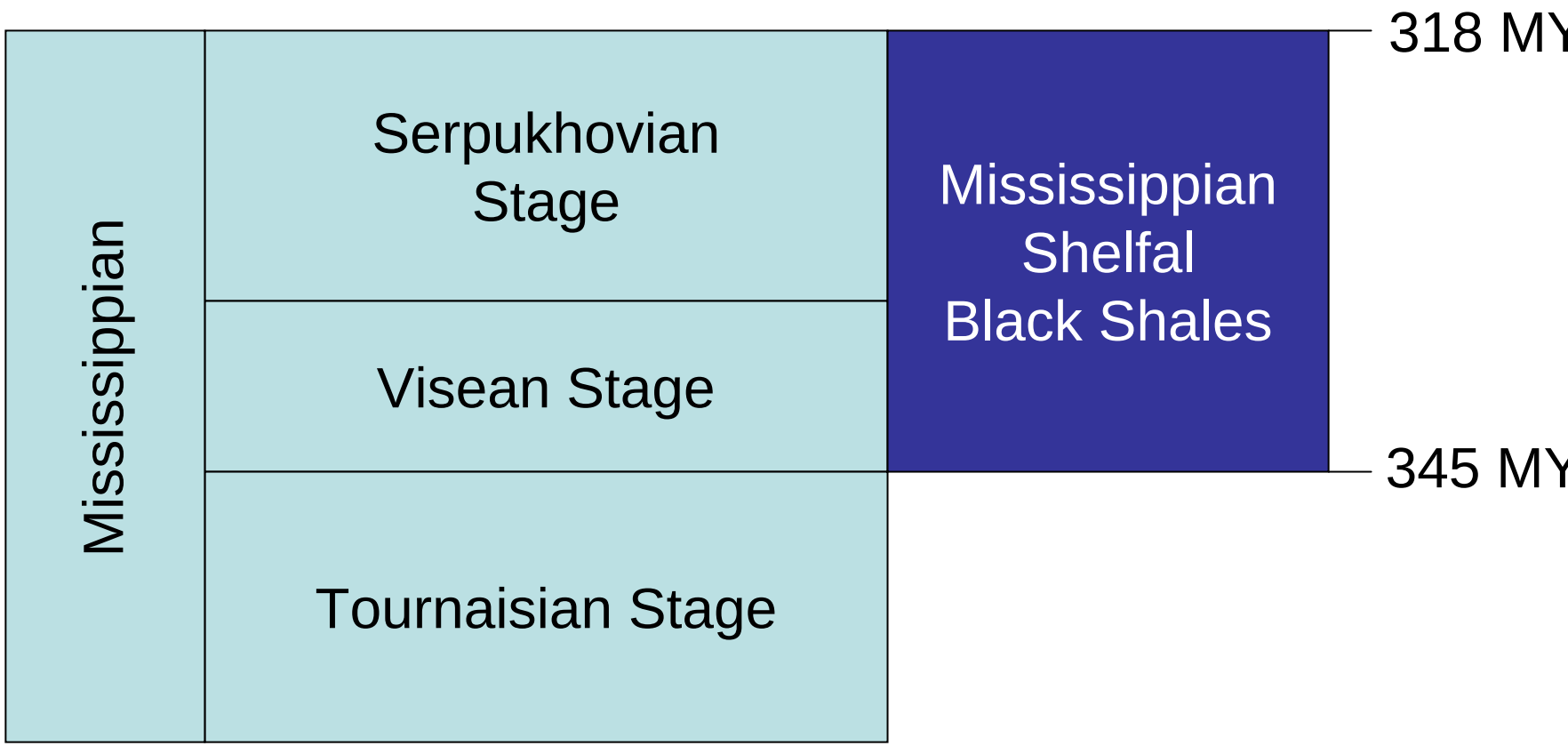
Woodford Shale

- Fossil Content (All Pelagic)
  - Conodonts
  - Ammonoids
  - Fish & Shark Debris
  - Fossil Wood (Transported)
  - Radiolarians

Woodford Shale

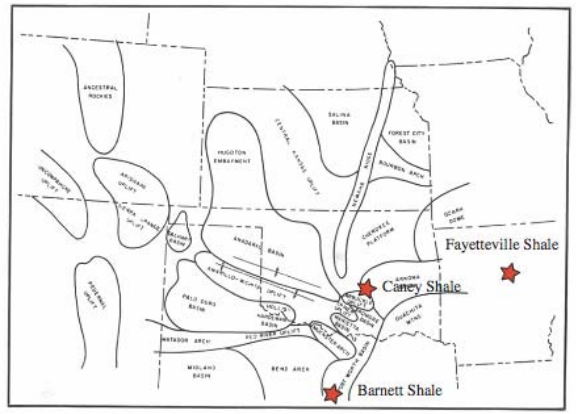
- Oxygen Levels
  - Widespread shelfal anoxia
  - No evidence of benthic invertebrates
  - No evidence of well developed anoxic, with transitional dysoxic and oxic environments

Mississippian Black Shales



Mississippian Black Shales

- Location Map

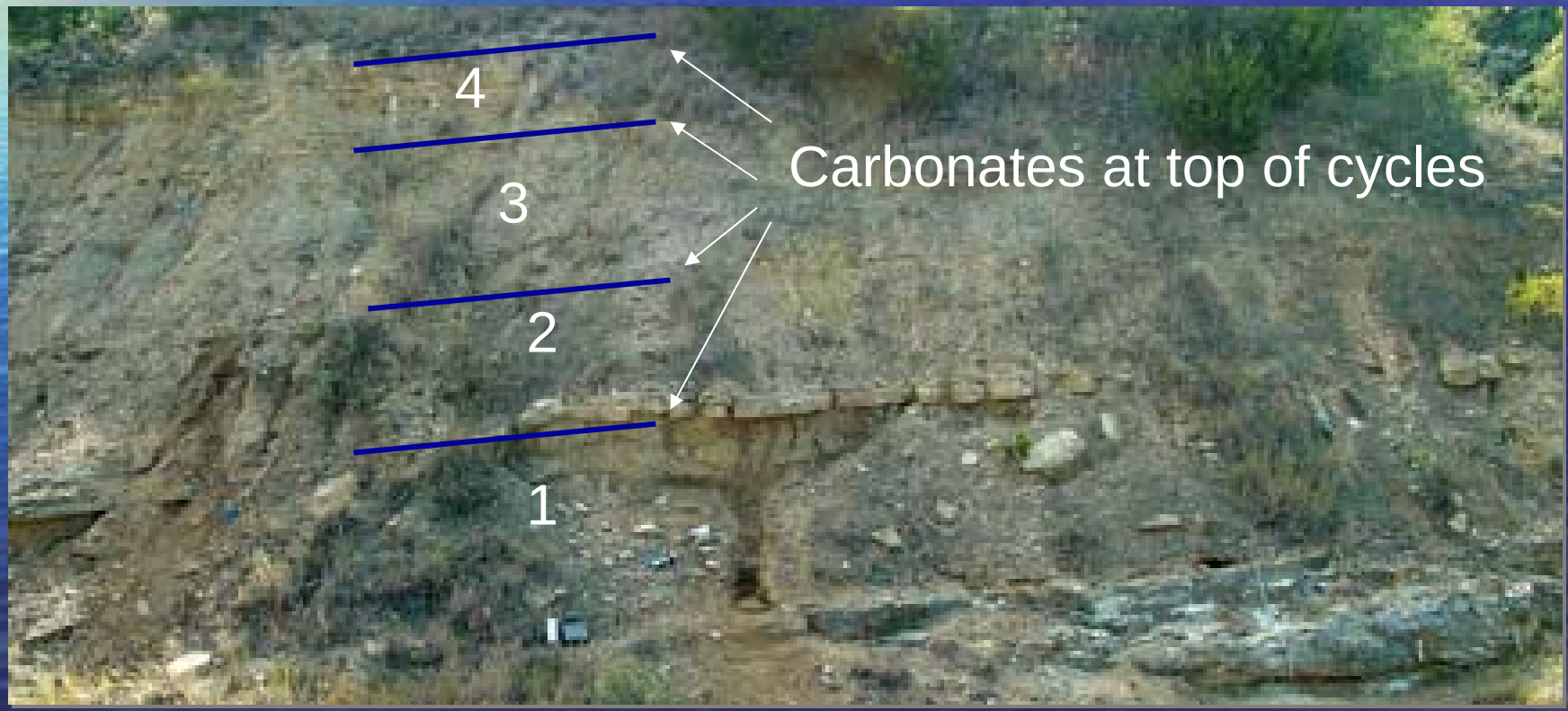


Mississippian Black Shales

- Llano Uplift Lawrence Uplift NW Arkansas

Llano Uplift	Lawrence Uplift	NW Arkansas
Marble Falls Ls	Rhoda Creek Sh	Imo Fm.
Barnett Shale	Sand Branch Mb Caney Fm.	Fayetteville Sh
White's Crossing Ls	Delaware Creek Caney Fm.	Batesville Ss
Chappel Ls	Alohoso Mb Caney Fm.	Moorefield Fm.
	Weldon Ls.	Boone Fm.
	Pre-Weldon Sh	St. Joe Ls.

Barnett Shale Showing Cyclicity



Barnett Shale

- Regional Distribution
  - Black Fissile Phosphatic Shale
  - Thin 1-2 meter cyclicity with glauconitic, phosphatic (granular) condensed sections
  - Early diagenetic carbonate nodules with ammonoids, conodonts, radiolarians
  - Rare intervals with benthonic invertebrates (Inarticulate brachiopods, Leiorhynchoidea, Caneyella bivalves, Archaeogastropods)
  -

Caney Shale-Lower Caney Ahloso Member

Middle Caney Shale (Delaware Creek Member)

Upper Caney Shale Member (Sand Branch Member)

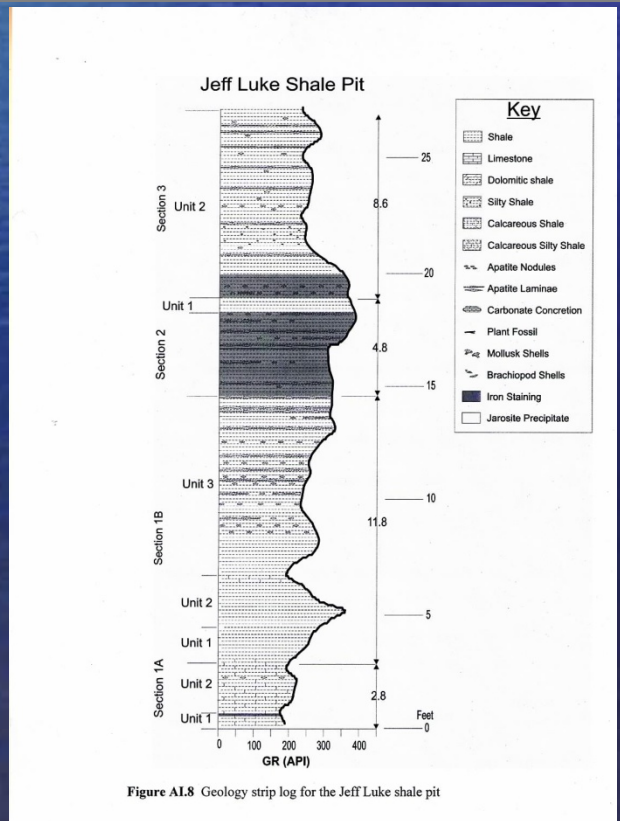


Figure AI.8 Geology strip log for the Jeff Luke shale pit

Caney Shale

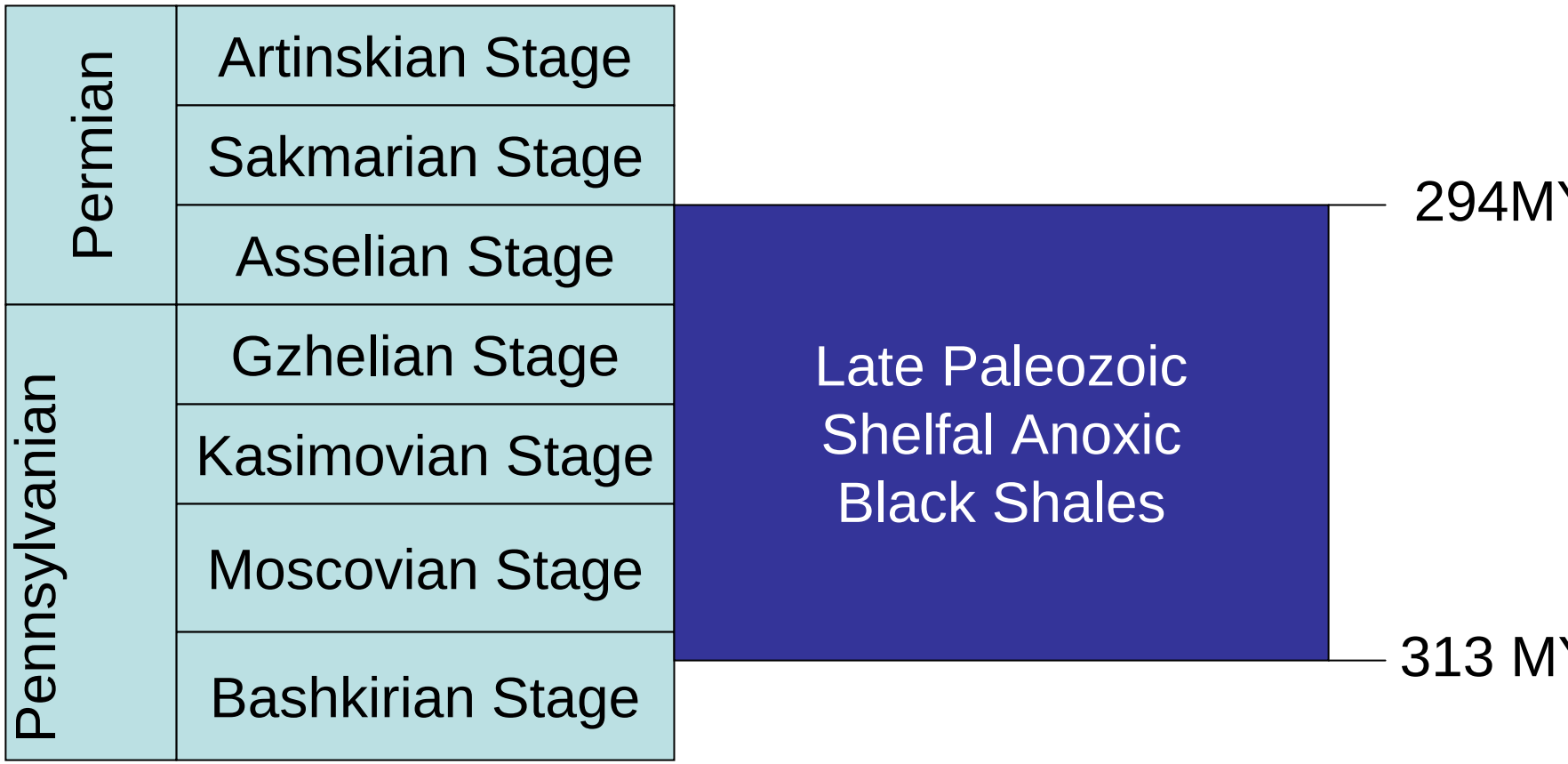
- Regional Distribution
  - Basal Caney Shale (Ahloso Member)-Characterized by Silt Content [Equivalent to Sycamore Limestone]
  - Middle Caney Shale (Delaware Creek Member), Characterized by loss of silt, addition of Carbonate Concretions [Bullion]
  - Upper Caney Shale (Sand Branch Member), Characterized by Black Fissile Shale, Abundant Phosphate, minor carbonate concretions

Fayetteville Shale

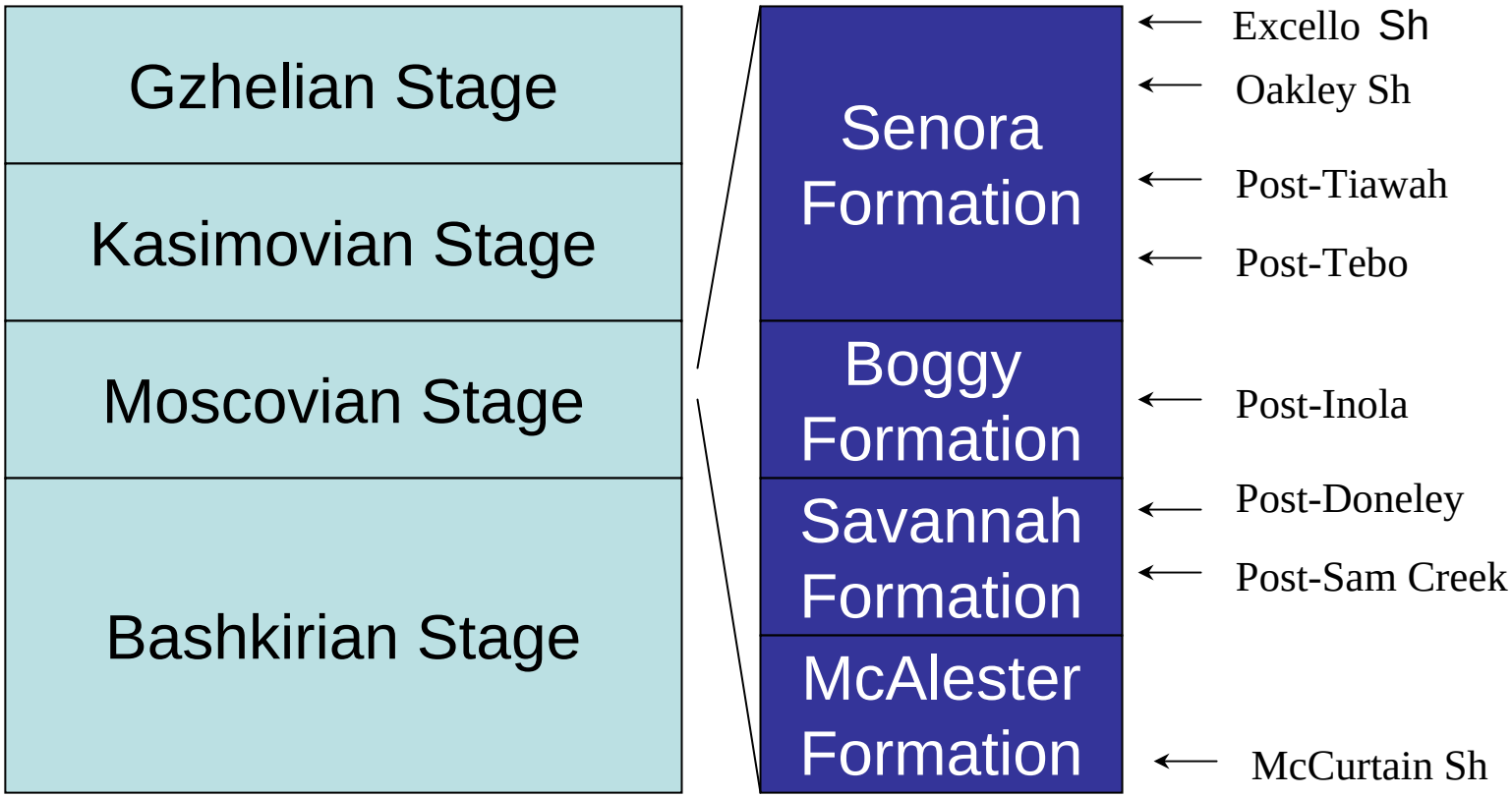
- Upper Fayetteville Shale
- Marshall, Arkansas

Pennsylvanian and Permian Black Shales

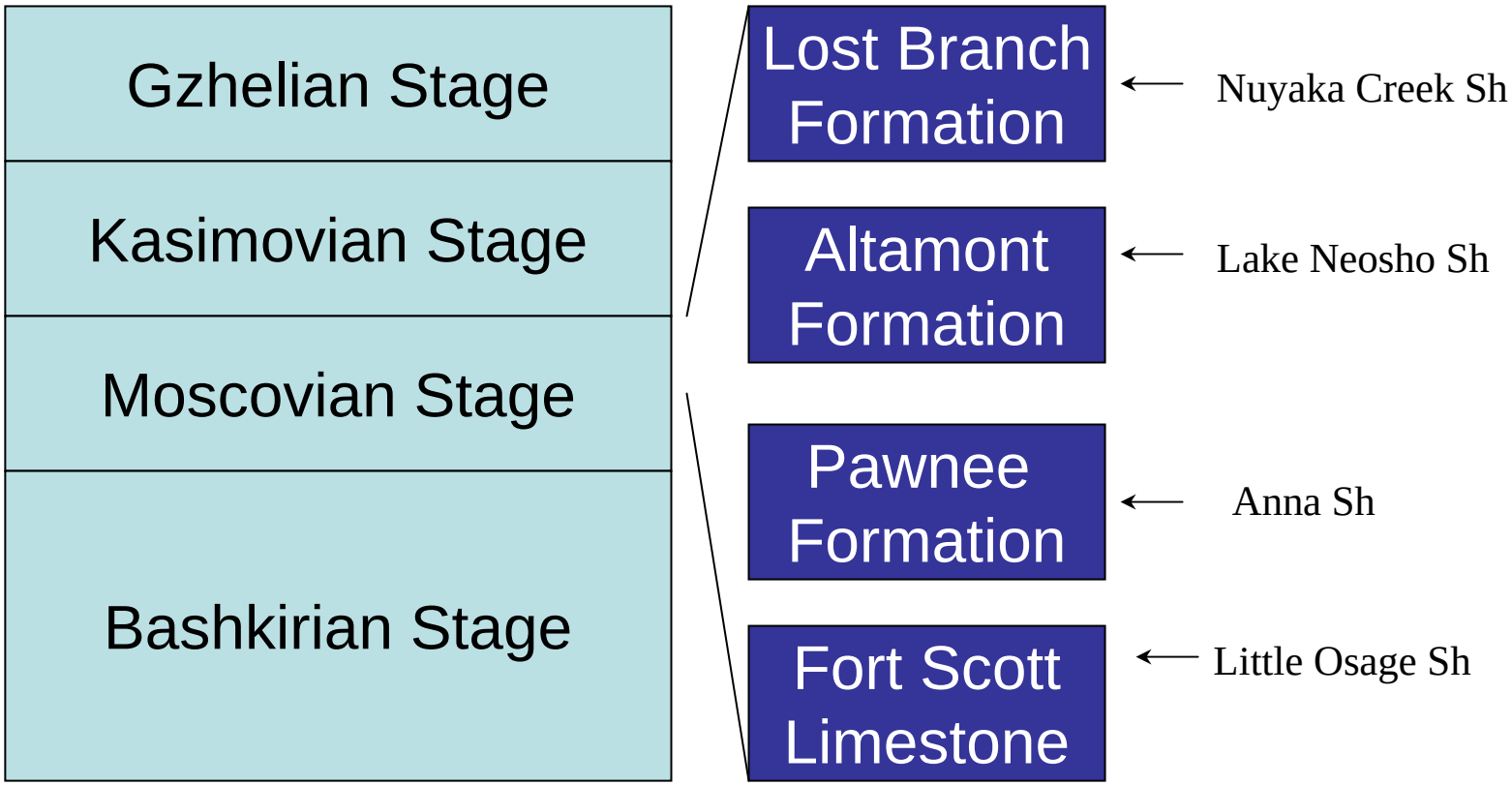
Pennsylvanian and Permian Black Shales



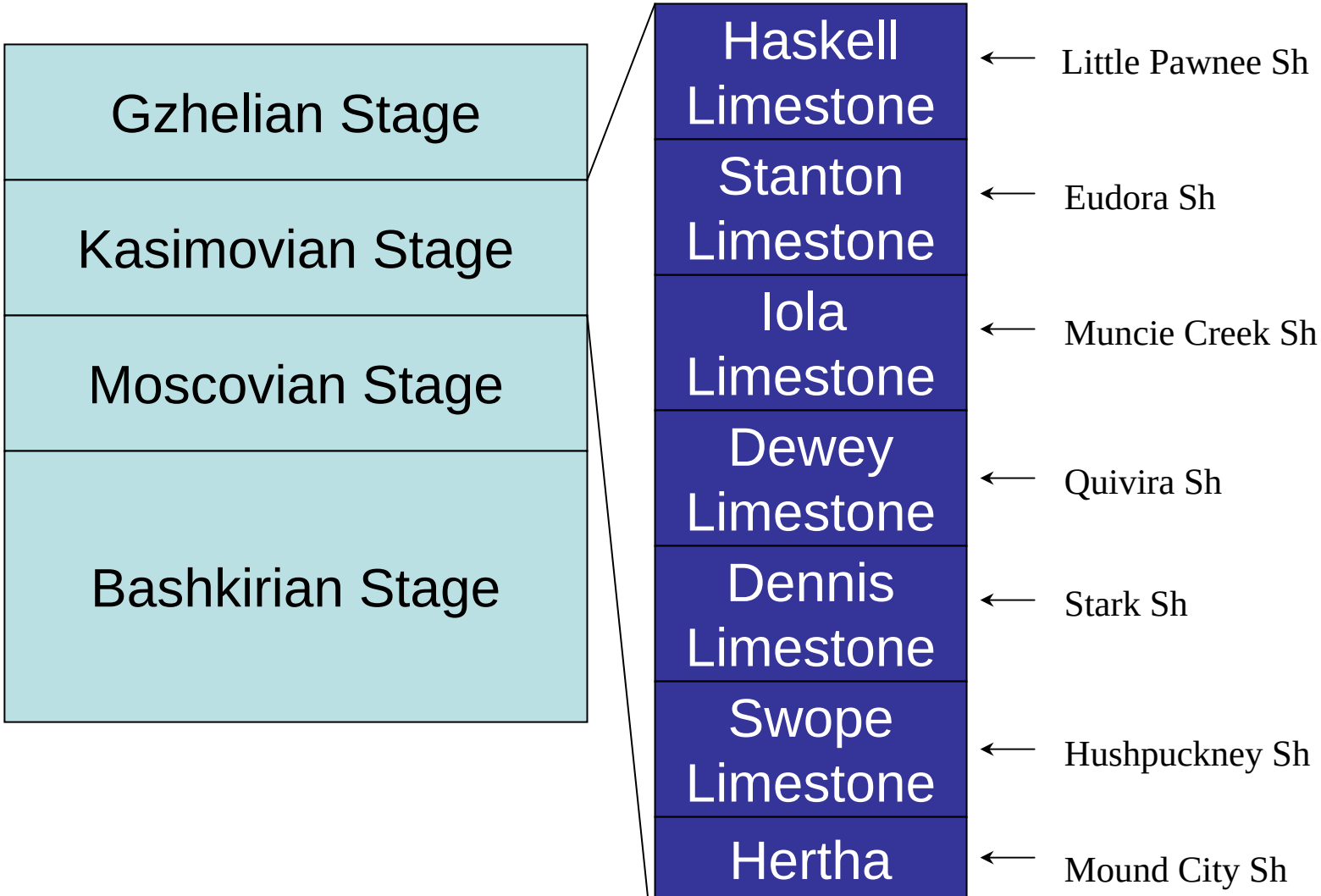
Pennsylvanian Black Shales-Cherokee Group (Moscovian)



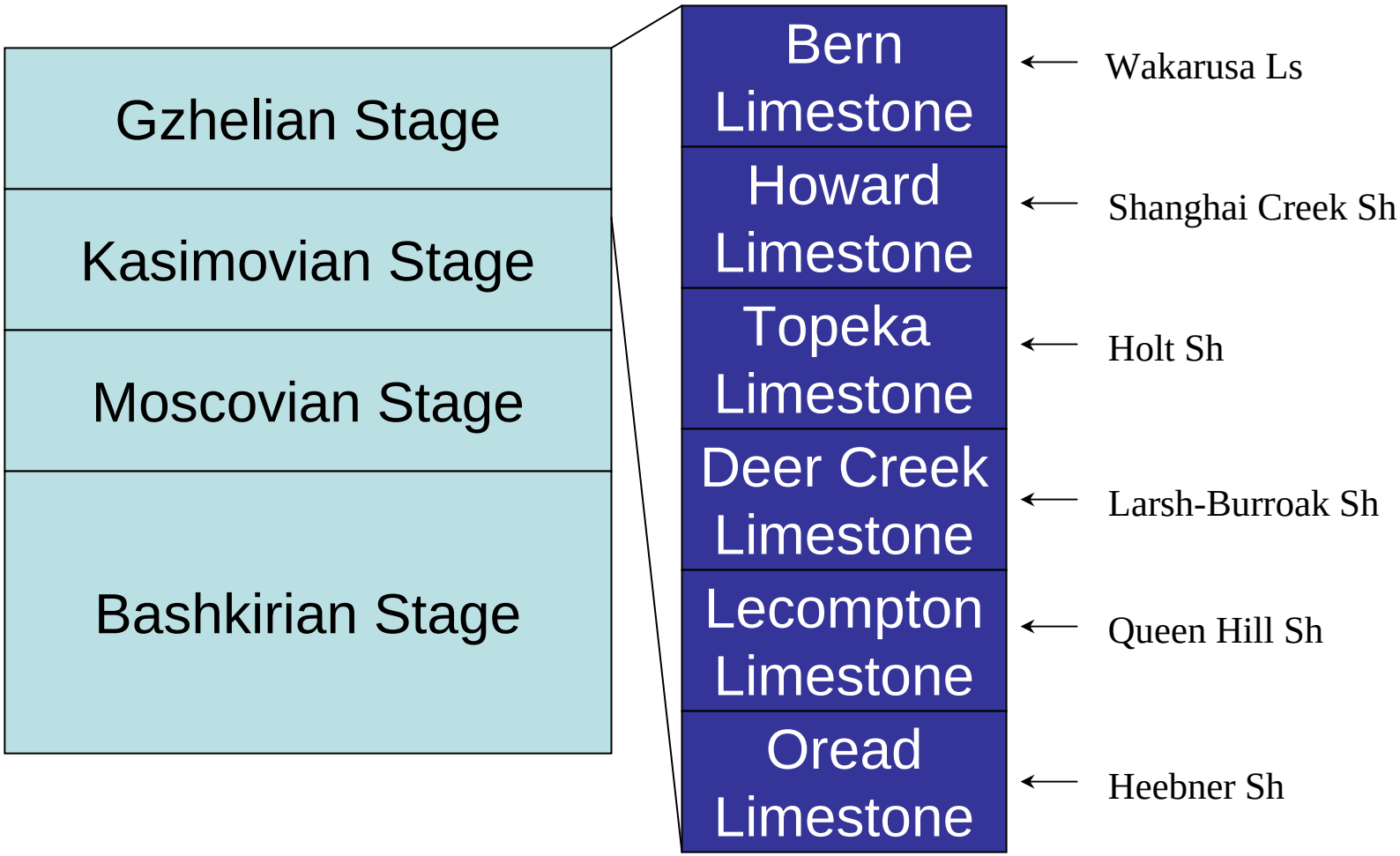
Pennsylvanian Black Shales-Marmaton Group (Moscovian)



Pennsylvanian Black Shales-Kasimovian



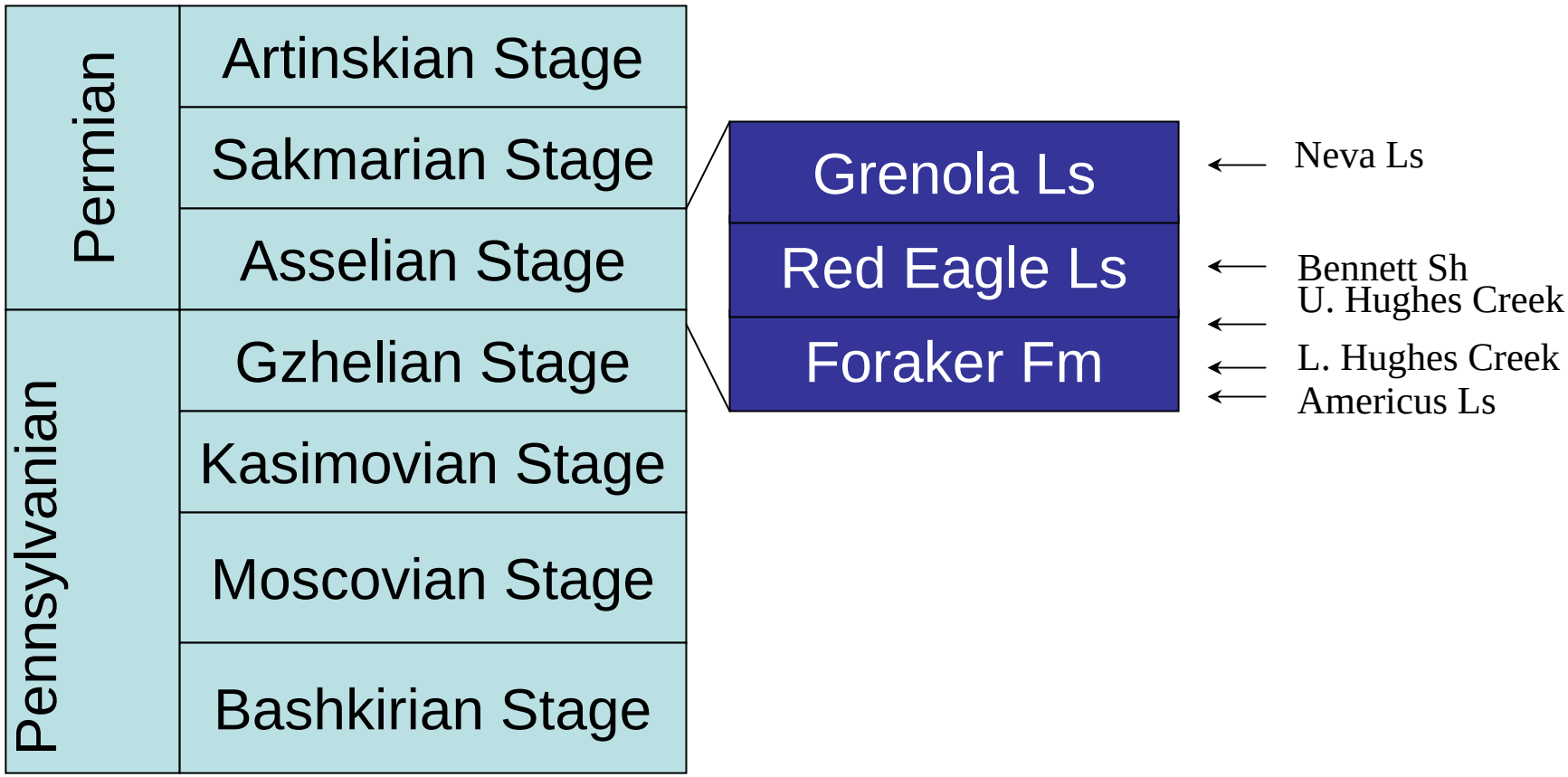
Pennsylvanian Black Shales-Gzhelian



Pennsylvanian

- Gzhelian-Heebner Shale

Pennsylvanian and Permian Black Shales



Pennsylvanian Black Shales

- Black, Fissile Phosphatic Shales (29 from Desmoinesian-Virgilian)
  - Black, Fissile Phosphatic Shales contain rare carbonate concretions [bullions]
  - Black Shales are sandwiched between gray non-fissile dysoxic shales with benthonic invertebrates
  - Black Shales form from upwelling from the Anadarko Basin during maximum transgression
  - Shelfal anoxia is established but short-lived
  - The black shales thicken from Kansas to Oklahoma and correspond to progressively thicker marine condensed sections at the base of high-stand deltaic sediments

Permian Black Shales

- Latest Gzhelian-Early Asselian black, shales are less fissile and contain greater percentages of silt
  - These black shales are only moderately fissile,contain rare small phosphate concretions due to reduction in rate of basin subsidence and a reduction in upwelling
  - Gray dysoxic shales also sandwich the black shales
  - Thickness of black shales increases northward, a trend opposite to those of Virgilian and earlier deposits. Source of clastics is likely aeolian-derived contrasted to high-stand deltaic source of earlier black shales.

Conclusions

- Differences in Midcontinent Black Shales are believed to reflect changing tectonic and eustatic influences
- Devonian/Mississippian Woodford Black Shale remained essentially anoxic in all settings. Regional tectonism was minimal, siliciclastic sources distal
- Mississippian Barnett, Caney and Fayetteville are cyclic but fail to develop strong patterns evident in the Pennsylvanian and Permian.

- Pennsylvanian Black Shales represent shorter periods of anoxia, maximum flooding, and marine condensed sections
- Black Shales occur at predictable positions in cycles. Shales thicken southward toward subsiding basins
- Permian Black Shales are less developed than Pennsylvanian ones. Permian shales thicken northward as southerly subsidence slowed and sources shifted to south and east