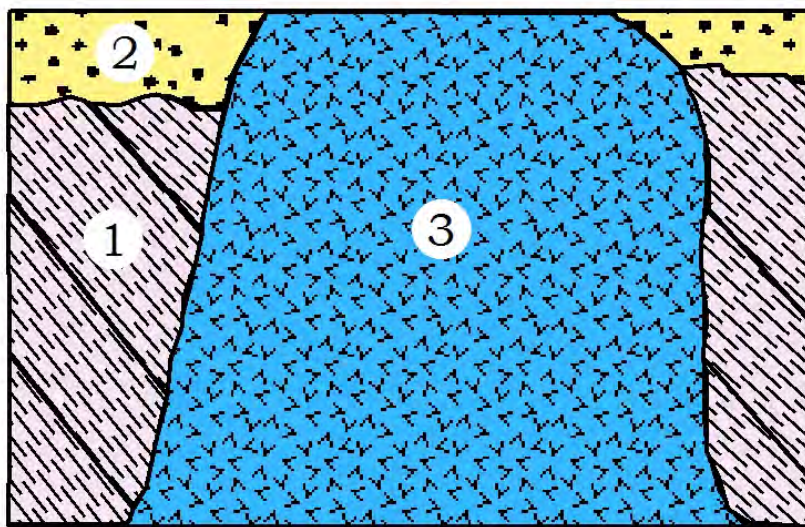


STATE OF ARKANSAS

ARKANSAS GEOLOGICAL SURVEY
BEKKI WHITE, DIRECTOR AND STATE GEOLOGIST

EDUCATIONAL WORKSHOP SERIES 02

Relative Age Dating
(with special emphasis on Arkansas materials)



Angela Chandler



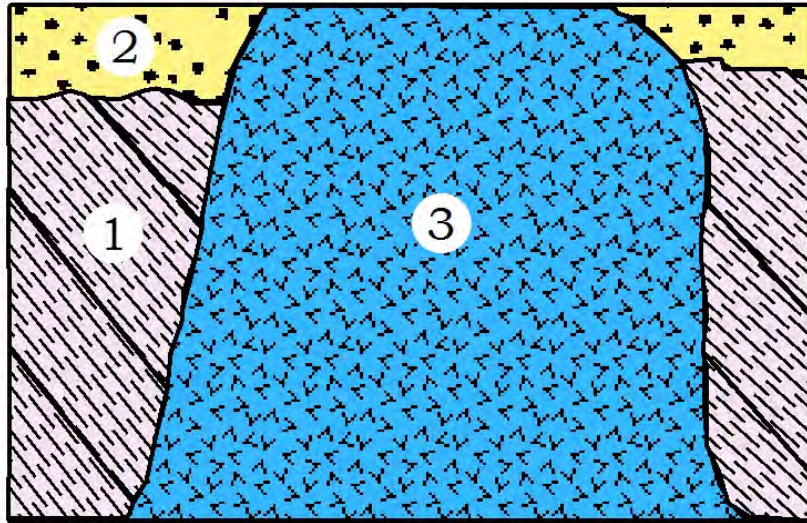
Little Rock, Arkansas
2009

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Acknowledgments

This laboratory manual is written for Arkansas teachers studying earth science. This was also written with the Arkansas Science Curriculum in mind so that students can meet the requirements and goals set for their age groups. Various staff at the Arkansas Geological Survey contributed material to this manual.

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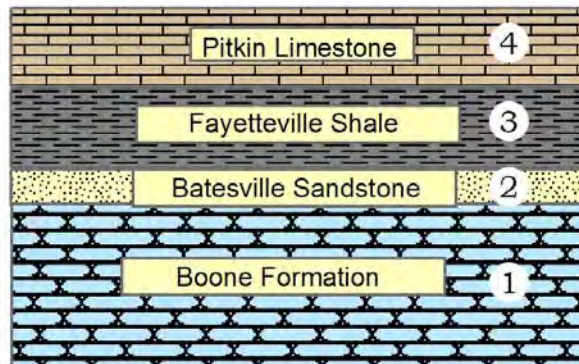
Little Rock, Arkansas
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THE RELATIVE AGE OF ROCKS

Geologists study rock layers exposed along roads, in quarries, along hill sides and in stream beds. All of the rock layers exposed at the surface in Arkansas have been named and are called formations. Sometimes the formations are divided into members. Both formations and members are named from geographical localities. For example: The Boone Formation, which consists mostly of limestone and chert and is wide spread in northern Arkansas, is named for exposures in Boone County. Another example is the Fayetteville Shale which is named for exposures in Fayetteville, Arkansas. Several formations in Arkansas are mentioned in this lab exercise and other exercises.

In order to study the depositional history of rock layers, we first have to learn certain rules or principles. There are two basic principles for determining relative age in sedimentary rocks: the Principle of Original Horizontality and the Principle of Superposition. These two principles and others discovered by geologists are as follows:

Principle of Superposition – In any *undisturbed* sequence of strata, the oldest stratum is at the bottom of the sequence, and the youngest stratum is at the top.

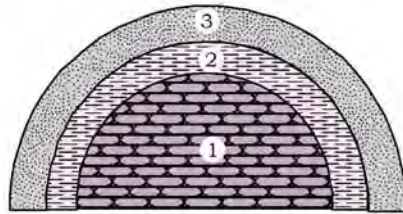


The figure above illustrates generally flat lying strata (formations) in the Ozark Plateaus physiographic region. The formations are numbered in order from oldest (1) to youngest (4).

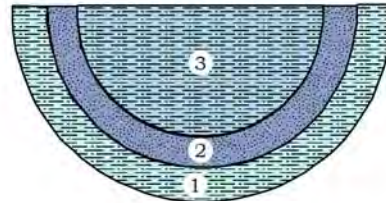
Principle of Original Horizontality – Sedimentary rock layers (strata) originally were deposited as horizontal layers of sediment. If strata are no longer horizontal, it is because they have been displaced by movements in the Earth's crust.

Strata in the Ozark physiographic region are basically horizontal or flat-lying. The rocks in the Arkansas River Valley and the Ouachita Mountains physiographic regions are not

horizontal. They have been compressed to form folds. The two basic forms of folds are shown below in cross-section view like you may see in a road outcrop.



Anticline



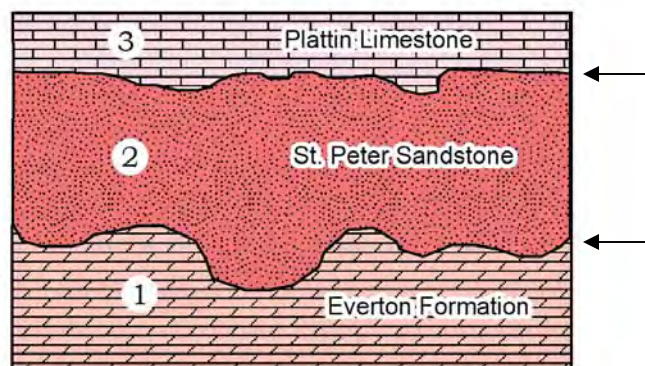
Syncline

In each of the structures above, the rocks are labeled from oldest (1) to youngest (3). Notice the oldest rocks are in the center of the anticline while the youngest rocks are in the center of the syncline.

Principle of Original Lateral Continuity – Sedimentary rock layers, and lava flows, extend laterally in all directions until they thin to their termination (pinch out) or reach the edges of their basins of deposition.

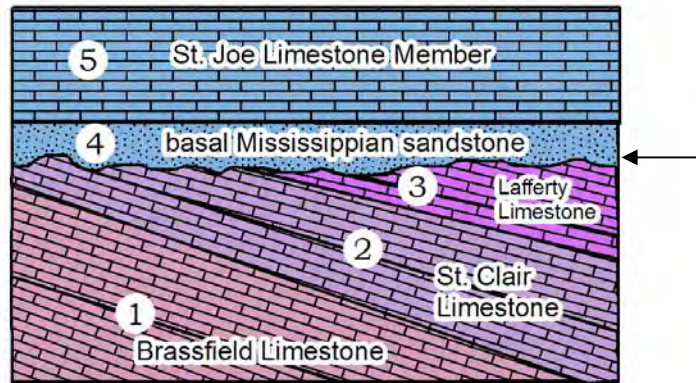
Principle of Unconformities – An unconformity is a rock surface that represents a gap in the geologic record. An unconformity can be a buried surface on which no sediment was deposited for a while or a buried surface that was first eroded. Unconformities range from local to worldwide. There are three *common* types:

Disconformity – an unconformity between parallel strata. The disconformity itself may be a very irregular surface. There are many disconformities in the fairly flat lying rock strata in the Ozarks.



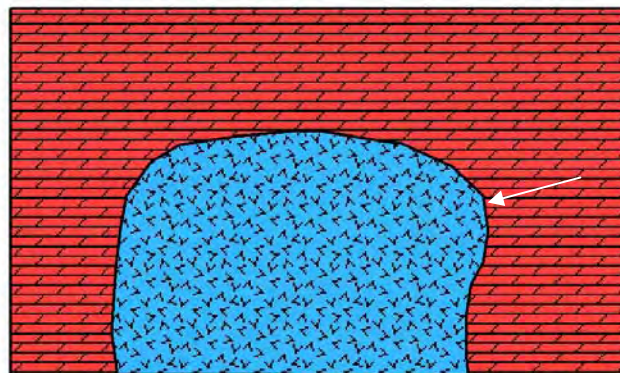
The diagram above shows Ordovician age formations in the Ozarks that have disconformities between the strata. The units are labeled with the oldest (1) on the bottom. The arrows are pointing to the disconformable surfaces.

Angular unconformity – an unconformity between nonparallel strata. Since most of the strata in the Ozarks are flat-lying there are few angular unconformities. However, they do exist usually above or within the dipping strata of Ordovician age.



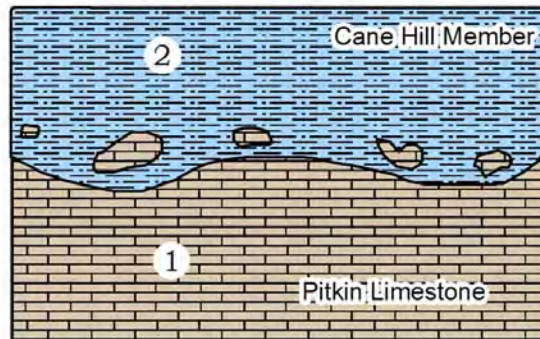
The diagram above shows an angular unconformity (arrow) between Mississippian age strata and Ordovician age strata. This relationship exists in the rock formations exposed along the Buffalo National River at various localities.

Nonconformity – an unconformity between sedimentary rock/sediment and non-sedimentary rock.



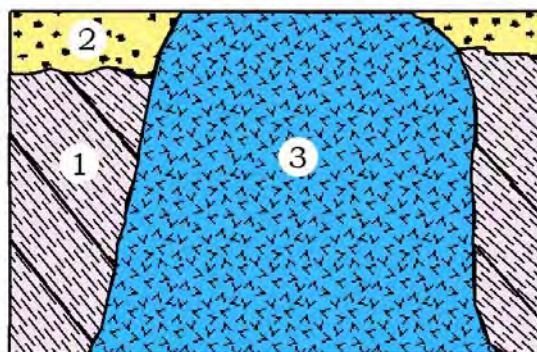
The diagram above illustrates a nonconformity (arrow) between an igneous intrusion and surrounding dolostones. This relationship possibly occurs in the subsurface in northeastern Arkansas near the Newport area. Igneous rock is exposed at the surface at Granite Mountain Quarries in southwestern Little Rock, near Hot Springs, and at Murfreesboro, Arkansas.

Principle of Inclusions – Any piece of rock (clast) that has become included in another rock or in sediment must be *older* than the rock or sediment into which it has been incorporated. Such a clast (commonly a rock fragment, crystal, or fossil) is an inclusion. The surrounding body of rock/sediment is the matrix or groundmass. Thus, an inclusion is older than its matrix.



The diagram above illustrates the unconformable relationship between the Cane Hill Member of the Hale Formation and the Pitkin Limestone (Formation) in northern Arkansas. At various localities, pebbles of the Pitkin have been eroded from the unit and included in the basal portion of the Cane Hill Member.

Principle of Cross Cutting – Any geologic feature that *cuts across* a rock or sediment must be *younger* than the rock or sediment it cuts across. Such cross-cutting features include a fracture (a crack in the rock), a fault (a fracture along which movement has occurred), or an intrusive mass of rock.



The diagram above illustrates a cross-cutting relationship between an igneous rock body and the rock that it intruded. The strata are numbered in order from oldest (1) to youngest (2). Notice angular unconformity between units (1) and (2).

Faults

A fault is a break or fracture in the rock along which there has been movement and displacement of one side relative to the other. It is difficult to determine which side has actually moved or whether both sides have moved. However, after faulting has occurred, it can be said that one side has moved with respect to the other.

In order to determine the fault movement we must first look at the *fault plane*, label the *hanging wall* in relation to the *foot wall*, then determine the *upthrown* and *downthrown sides*. Refer to the definitions below:

Fault plane – the break along which the slipping or movement occurs.

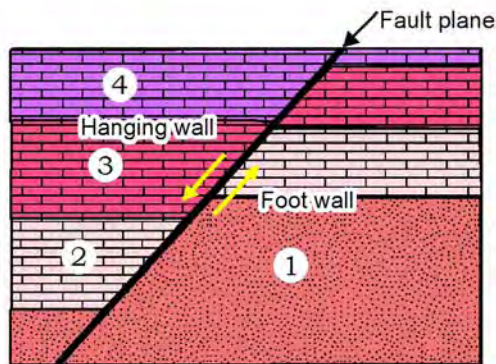
Hanging wall – the rock which overhangs or rests on the fault plane.

Foot wall – the rock which supports the hanging wall and faces obliquely upward.

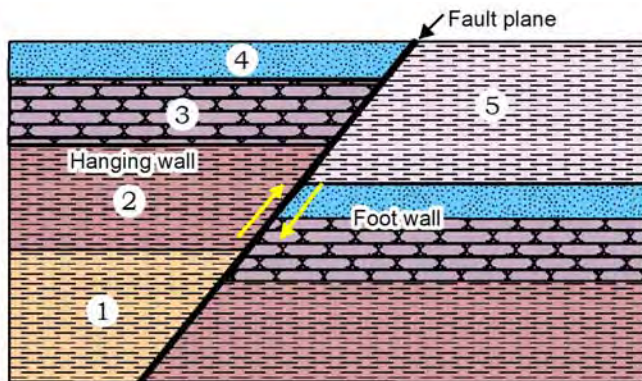
The *upthrown side* is the side which moves upward relative to the other side.

The *downthrown side* is the side that moves downward relative to the other side.

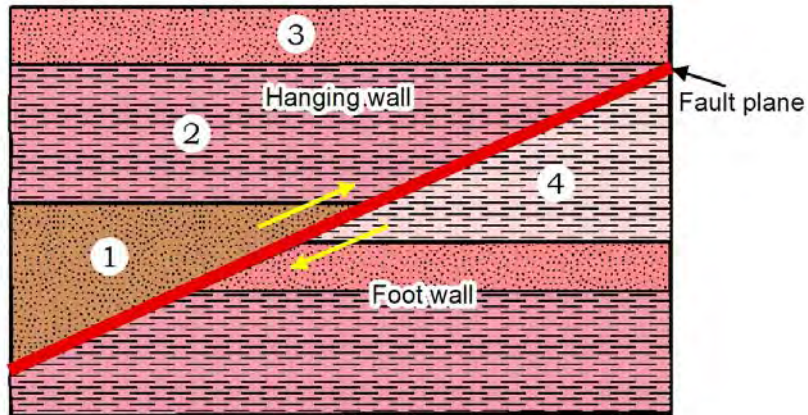
After we determine the relative movement along the fault then we can label the fault as *normal*, *reverse*, *thrust*, or *strike-slip*. Refer to cross-sections below for examples of each type of fault.



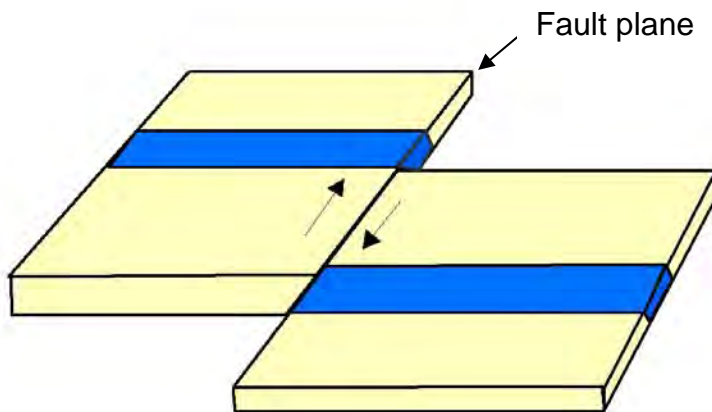
This diagram illustrates a normal fault in which the hanging wall has moved down relative to the footwall. The hanging wall is the downthrown side while the foot wall is the upthrown side. The strata are numbered from oldest (1) to youngest (4).



This diagram illustrates a reverse fault in which the hanging wall has moved up relative to the footwall. Note the fault plane is 45° or greater from horizontal. The hanging wall is the upthrown side while the footwall is the downthrown side. The strata are numbered from oldest (1) to youngest (5).



This diagram illustrates a special type of reverse fault called a thrust fault. Note the fault plane is less than 45° . Thrust faults occur at lower angles than reverse faults. The strata are numbered from oldest (1) to youngest (4).

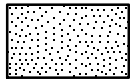


This diagram illustrates in map view a strike-slip fault. Note the horizontal movement of the fault. If you stand on one side of the fault and look across, the rocks on the opposite side appear to have moved to the right. This is called a right-lateral fault.

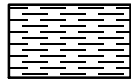
There are many faults in the surface rocks of Arkansas. Generally, you will find mostly normal faults in the Ozark Plateaus Region and northern portion of the Arkansas River Valley Region while thrust faults dominate the Ouachita Mountain Region.

Basic Symbol Sheet

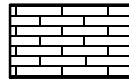
Geologists use lithology symbols as a quick reference tool to communicate easily through drawings. Shown below are basic lithology symbols to use when creating drawings for your students. These symbols are easily created if you have the option of using ArcView ArcGIS. Each geologic formation in Arkansas is also represented on a map by a certain color. Igneous intrusions are represented in blue. For other colors refer to the Geologic Map of Arkansas.



sandstone



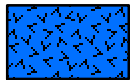
shale



limestone



chert or
novaculite



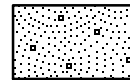
igneous
intrusion



coal



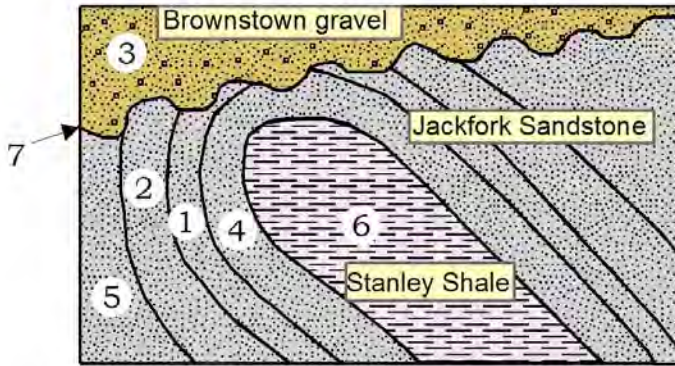
dolostone



gravel or
conglomerate

Exercise 1

Refer to the cross-section diagram below. Determine the relative ages of the rock bodies and features marked with numbers. Indicate their relative age relationships by writing their numbers on the blanks from oldest to youngest. The relationship below exists where the Ouachita Mountains Region meets the West Gulf Coastal Plain.

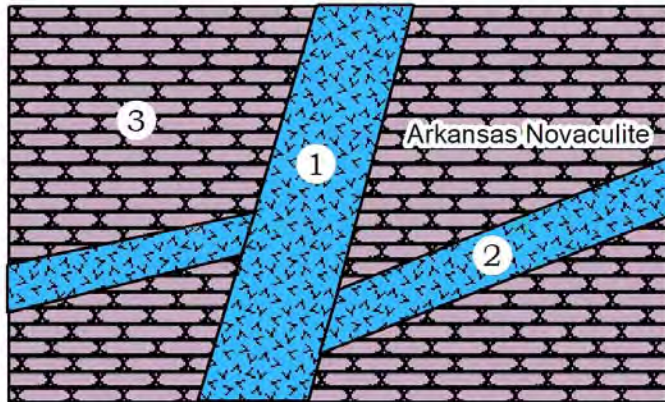


____ youngest

____ oldest

Exercise 2

Refer to the cross-section diagram below. Determine the relative ages of the rock bodies and features marked with numbers. Indicate their relative age relationships by writing their numbers on the blanks from oldest to youngest. The geologic scenario below exists near Magnet Cove, Arkansas.



____ youngest

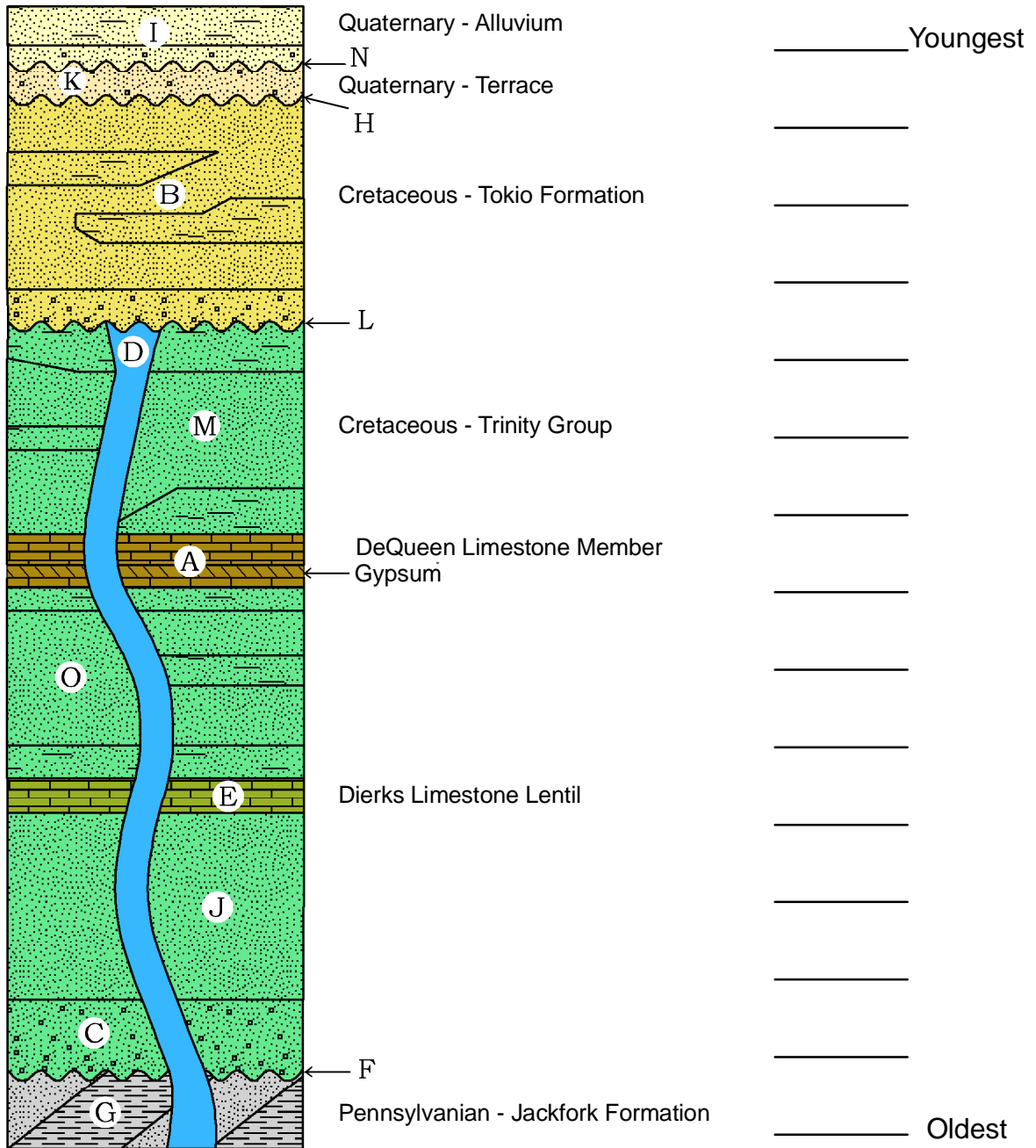
____ oldest

Exercise 3

Shown below is a geologic cross section for Cretaceous through Pennsylvanian rocks that were deposited near Crater of Diamonds State Park. Note the gypsum. It occurs in the DeQueen Limestone Member of the Trinity Group.

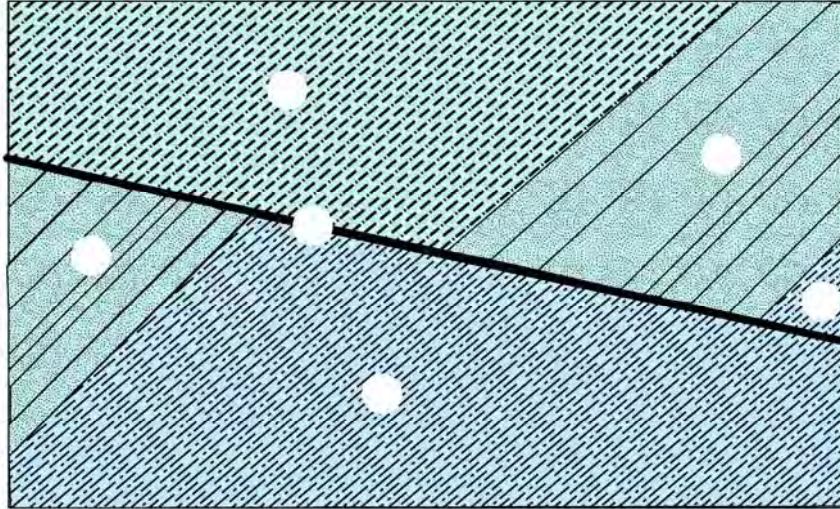
Examine the cross section and determine the relative ages of the rock formations and features marked with letters. Indicate their relative age relationships by writing their letters in the blanks from oldest to youngest.

What event caused the rocks in letter G to be tilted or dipping (inclined)?



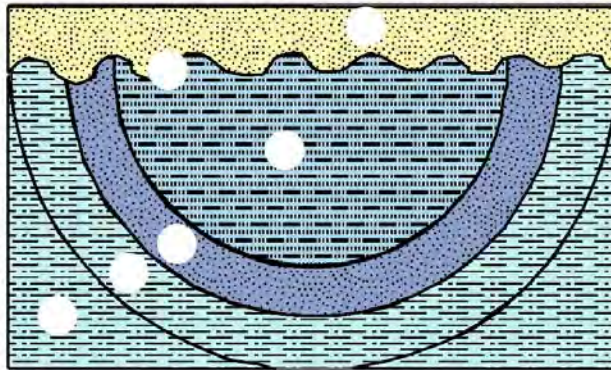
Exercise 4

Refer to the cross-section diagram below. Determine the relative age of the fault and the rock units, from oldest (1) to youngest (4) by writing these numbers in the circles below. Label the Hanging Wall and the Foot Wall. What type of fault is depicted in this diagram? This fault exists in sandstones and shales of the Atoka Formation in north Arkansas along Highway 7 north near Moccasin Gap.

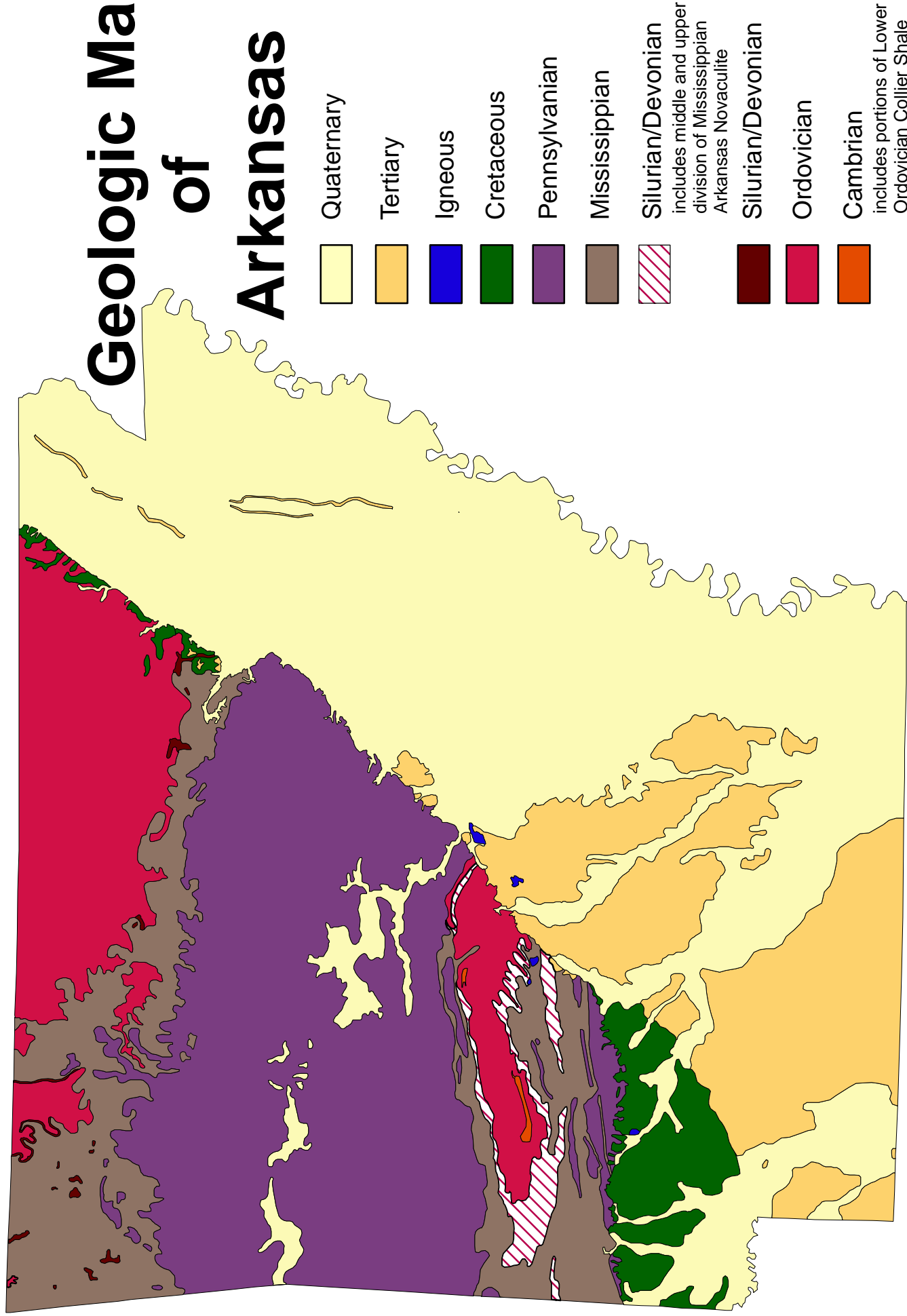


Exercise 5

Refer to the cross-section diagram below. Determine the relative ages of the rock units and the unconformity by labeling them in order from oldest (1) to the youngest (6) in the blank circles. What type of fold is shown in the diagram below? This structure exists at Petit Jean Mountain in the Arkansas River Valley.



Geologic Map of Arkansas



Quaternary

Tertiary

Igneous

Cretaceous

Pennsylvanian

Mississippian

Silurian/Devonian

includes middle and upper
division of Mississippian
Arkansas Novaculite

Silurian/Devonian

Ordovician

Cambrian

includes portions of Lower
Ordovician Collier Shale

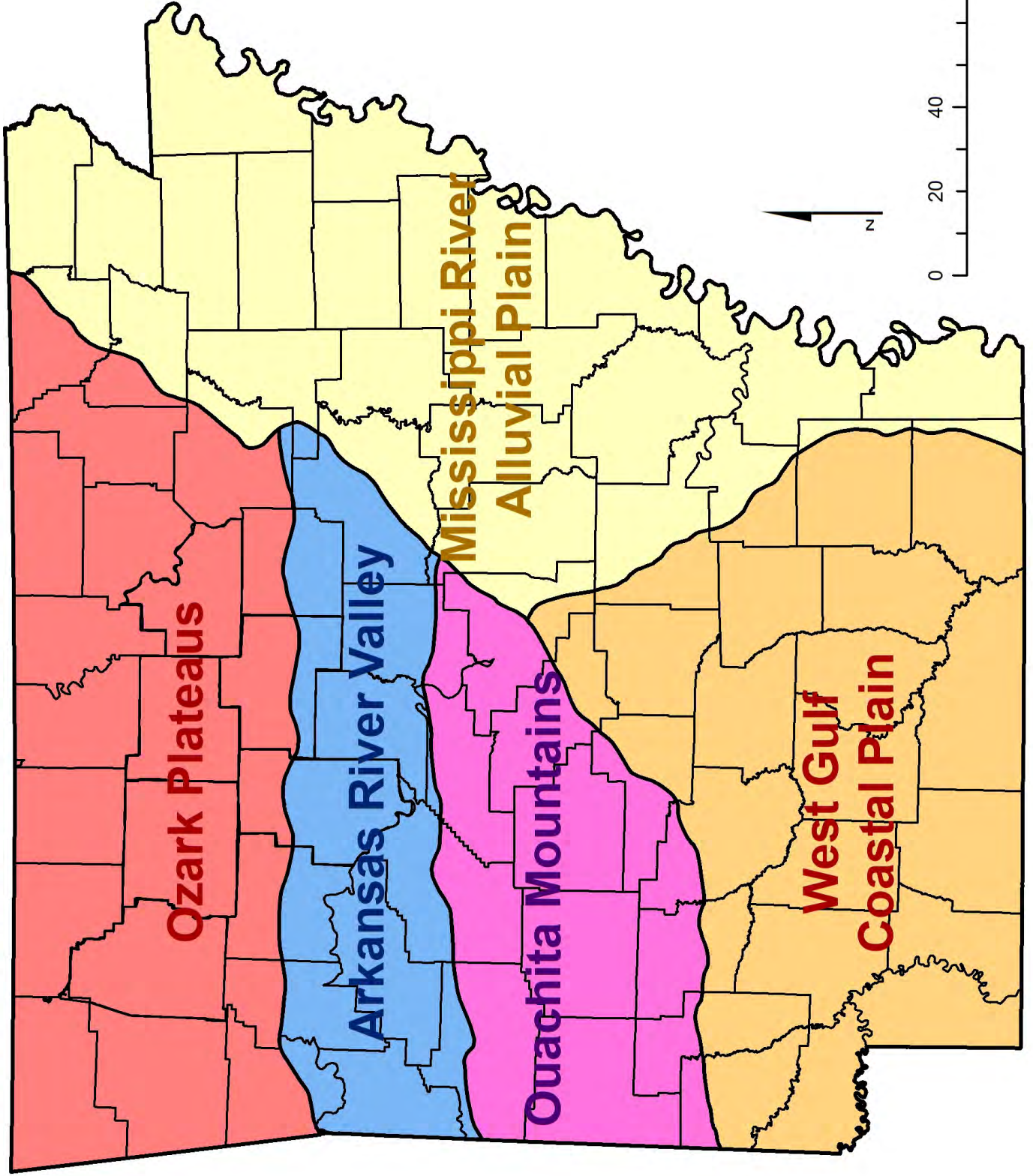
140 Miles

70

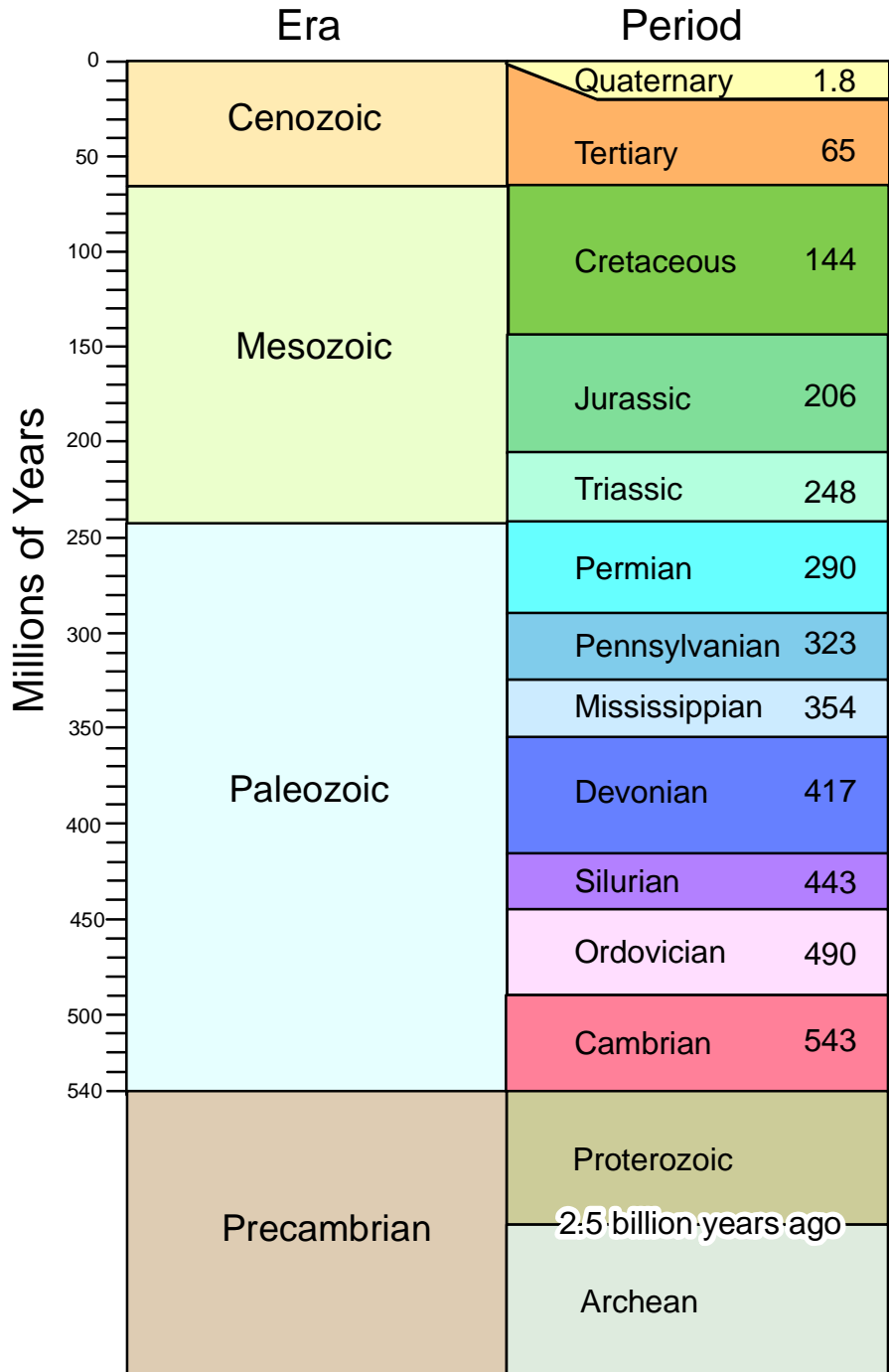
35

0

Physiographic Regions of Arkansas



Geologic Time Scale



Based on 1999 Geologic Time Scale
Geological Society of America

Stratigraphic Columns

Period		Ozarks	Ouachitas
CARBONIFEROUS	PENNSYLVANIAN		Boggy
			Savanna
			McAlester
			Hartshorne
		Atoka	Atoka
		Bloyd	Johns Valley
	Hale	Prairie Grove	Jackfork
		Cane Hill	
		(Imo)	Stanley
		Pitkin	
		Fayetteville	
		Batesville	
	(Ruddell)		
	Moorefield		
	MISSISSIPPIAN	Boone	Arkansas Novaculite (part)
		St. Joe	

Period	Ozarks	Ouachitas	
DEVONIAN	Chattanooga	Arkansas Novaculite (part)	
	Clifty		
	Penters		
SILURIAN	Lafferty	Missouri Mtn.	
	St Clair		
	Cason	Brassfield	Blaylock
ORDOVICIAN	Late		Polk Creek
	Middle	Fernvale	Bigfork
		Kimmswick	
		Plattin	
		Joachim	Womble
		St. Peter	
		Everton	Blakely
	Early	Powell	Mazam
		Cotter	
		Jefferson City	
	CAMBRIAN	(unexposed)	Crystal Mtn.
		Collier	
		(unexposed)	

Stratigraphic Columns

TERTIARY		QUATERNARY		
Paleocene	Midway	Pliocene	sand & gravel	
				Eocene
Holocene	alluvium			
		Pleistocene	terrace	dune sand
			silt & sand	loess

CRETACEOUS		
Late	Arkadelphia	
	Nacatoch	
	Saratoga	
	Marlbrook	
	Annona Chalk	
	Ozan	
	Brownstown	
	Tokio	
	Woodbine	
	Kiamichi	
Early	Goodland	
	Trinity	DeQueen
		Dierks
		Pike Gravel