EWS-04

STATE OF ARKANSAS

ARKANSAS GEOLOGICAL SURVEY
BEKKI WHITE, DIRECTOR AND STATE GEOLOGIST

EDUCATIONAL WORKSHOP SERIES 04

Geologic float on Lake Ouachita
from Lake Ouachita State Park

Angela Chandler and Erica Doerr

Little Rock, Arkansas
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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. Special thanks go to Charles Stone for his invaluable assistance on the geology of Lake Ouachita.

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Lake Ouachita Geologic Float

Deposition of rock formations (Middle Ordovician 472-461 million years ago)

The following geologic float allows us to inspect some of the older rock formations present in the core of the Ouachita Mountains. The two rock formations seen on this float are the Middle Ordovician aged Blakely Sandstone and Womble Shale (Fig. 3). This sequence of rocks was formed in a deep ocean basin (Fig. 1) that periodically received sediment from the north and east in the form of submarine fans (underwater/submerged deltas) and turbidity currents. A turbidity current is a bottom-flowing current that contains suspended sediment and moves rapidly down a subaqueous slope or submarine canyon. They can be caused by storm waves, tsunamis, earthquakes and tectonic movement.

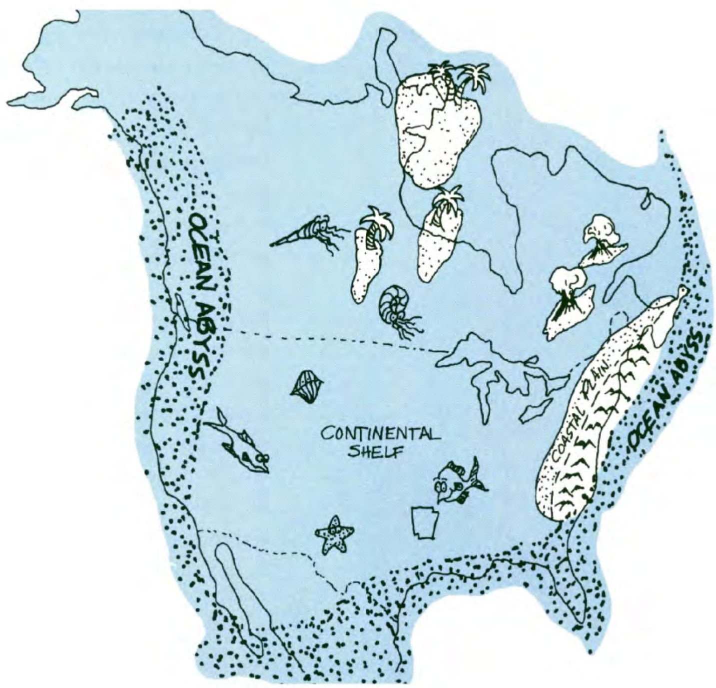

Figure 1. Late Ordovician paleogeography of North America. Ocean covered areas are depicted in blue. *From Guccione, 1993*.

The following descriptions are taken from *Stratigraphic Summary of Arkansas* by J.D. McFarland, 1998.

Womble Shale – This shale is named for the town of Womble that is now called Norman, north of Caddo Gap, Arkansas. The Womble is mostly black shale with thin layers of limestone, silty sandstone and some chert. Local green shales are interbedded with the black shales but less so than the Mazarn. Cleavage at an angle to bedding frequently displays a ribboned cleavage surface. The sandstones are dark gray, compact, fine-grained though occasionally conglomeratic and may be phosphatic. These sandstones are generally found in the lower part of the formation. The dense blue-gray limestones usually occur near the top of the formation in thin to medium beds. The chert is black and found as thin layers also at the top of the formation. Large milky quartz veins often fill fractures in the formation. Graptolite and conodont fossils have been noted from the Womble. The Womble rests conformably on the underlying Blakely Sandstone. The Womble ranges from 500 to 1200 feet thick.

Blakely Sandstone – This sandstone is named for Blakely Mountain, Garland County, Arkansas. The formation consists of black and green shale in alternating layers with hard gray sandstone and some bluish gray limestone. Although the shale may locally make up 50-70% of the sequence it is the sandstone that stands out. The sandstones are light gray to blue, medium-grained, well cemented and form thin to thick beds. Both silica and calcite have noted as cement. Where the cement is silica, the sandstone is quartzite and is quite resistant to weathering. Erratic meta-arkose boulders and pebbles occur in some of the conglomeratic sandstones. The shales of the Blakely are sometimes ribboned much like the Mazarn shales. Graptolites and conodonts are reported from the formation. The lower contact is considered conformable. The thickness ranges from a few feet to about 700 feet.

Ouachita Mountain Building Event (Pennsylvanian 318-299 million years ago)

The rocks exposed along the lake are no longer flat-lying as they were originally deposited. They are steeply inclined and have been folded into anticlines and synclines. Various folds that are present in this area are shown in Figure 2. Compare the attitude of the rocks in the Ouachita Mountains region with those in the Arkansas River Valley and the Ozark Plateaus Regions.

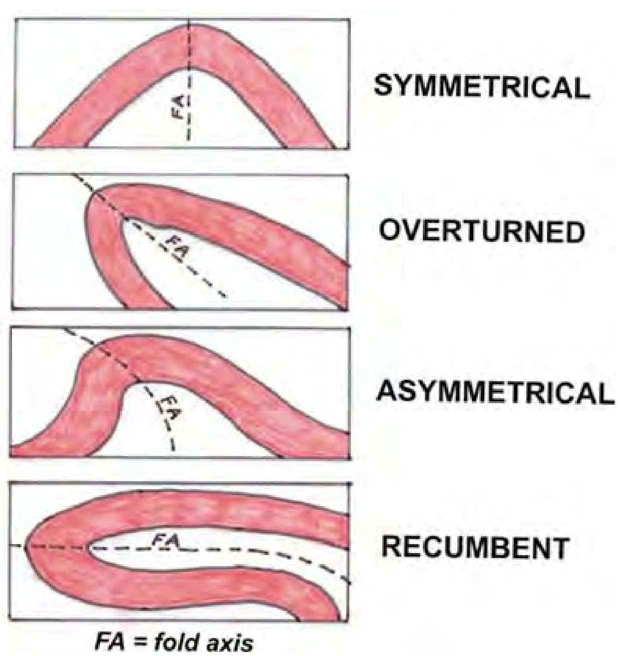

Figure 2. This figure displays an anticline that has been distorted due to folding. Look for these types of folds in the outcrops around the lake.

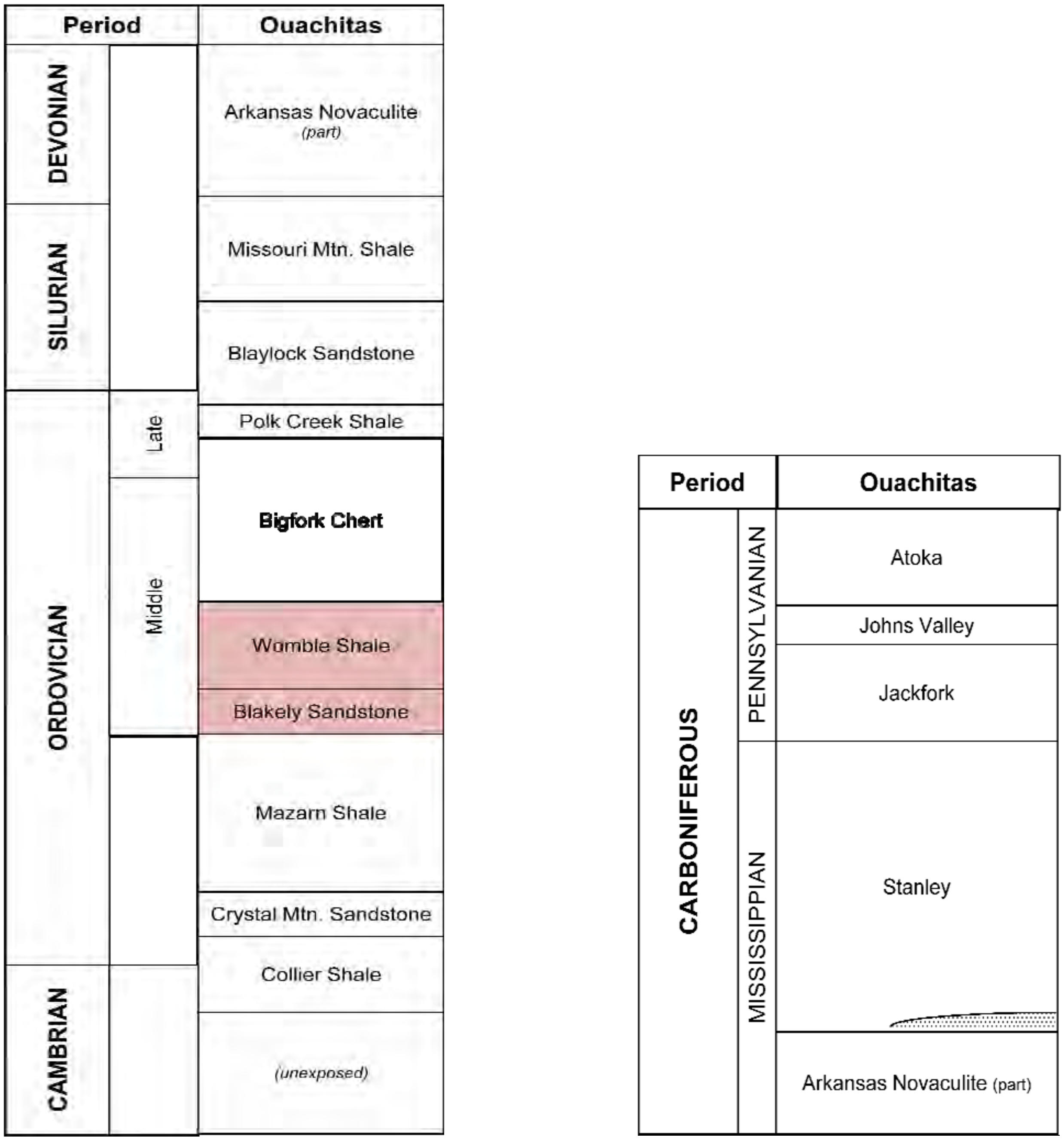

Figure 3. Stratigraphic columns of rocks in the Ouachita Mountains showing the two formations (highlighted) seen on the geologic float trip. *Modified from McFarland, 1998.*

To understand why the rocks are no longer flat-lying we need to look back in geologic time. By the Middle Pennsylvanian Period, geologists believe that there was approximately 50,000 feet of rock that had been deposited in the deep Ouachita ocean basin (Stone and Haley, 1982). At this time, around 310 million years ago, plate tectonics began to shape what is now Arkansas (Fig.4). The continents of Laurasia and Llanoria began to collide, pushing together this large mass of material. This collision caused the rocks to be folded, faulted and uplifted into the Ouachita Mountains that we see today. Deformation of the rocks increases as one travels from south to north with more complex folds, thrust faults and sizeable quartz veins in the northern region.

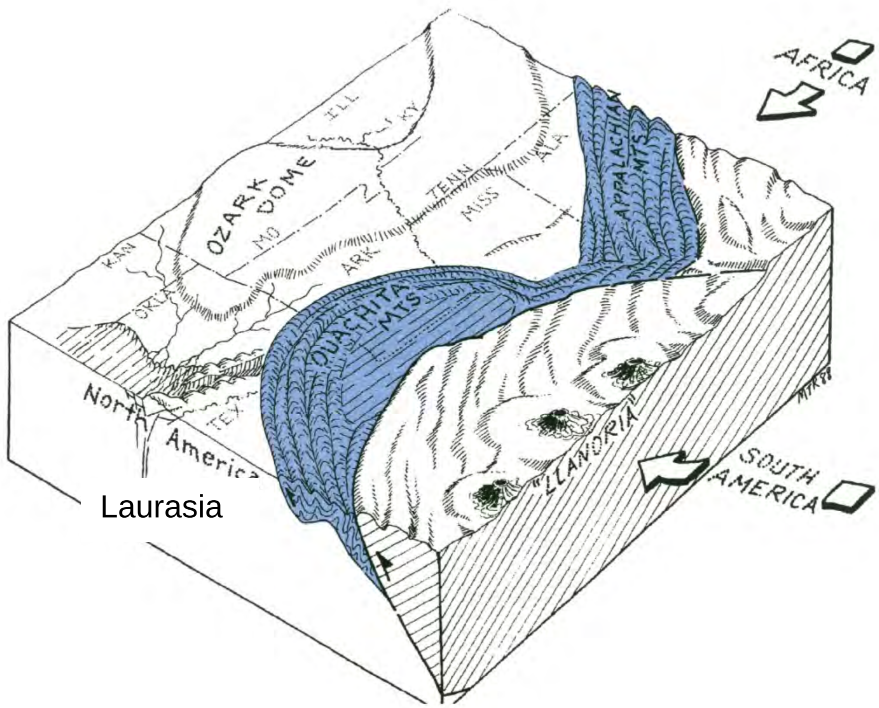

Figure 4. Middle Pennsylvanina paleogeography of Arkansas showing the collision of Laurasia and Llanoria and formation of the Ouachita Mountains. *From Guccione, 1993*.

Erosion and igneous intrusives (Cretaceous 145.5-65.5 million years ago)

Since the beginning of the uplift in late Pennsylvanian time the Ouachita Mountains area has been exposed and undergone erosion with approximately 20,000 feet of rock being removed. During the Cretaceous the Gulf of Mexico reached it's highest level and covered southern and eastern Arkansas (Fig. 5). Along the southern boundary of the Ouachita Mountains, Early to Lake Cretaceous strata overlie deformed Mississippian and Pennsylvanian aged rocks.

During the Cretaceous Period all of the igneous rocks in Arkansas were implaced as dikes (cuts across bedding) or sills (parallel to bedding), (Howard, 2010, Arkansas Geological Survey in-house data). It is thought that reactivation of the Reelfoot Rift caused the mobilization of magma from a deep-seated source (Brewer, 1986). The Reelfoot Rift is the term used for the late Precambrian to early Cambrian rifting event which caused the continent to stretch or extend along the "fall line" separating the Interior Highlands from the Gulf Coastal Plain. This rifting event led to deep fractures in the earth's crust that allowed igneous masses to rise to the surface.

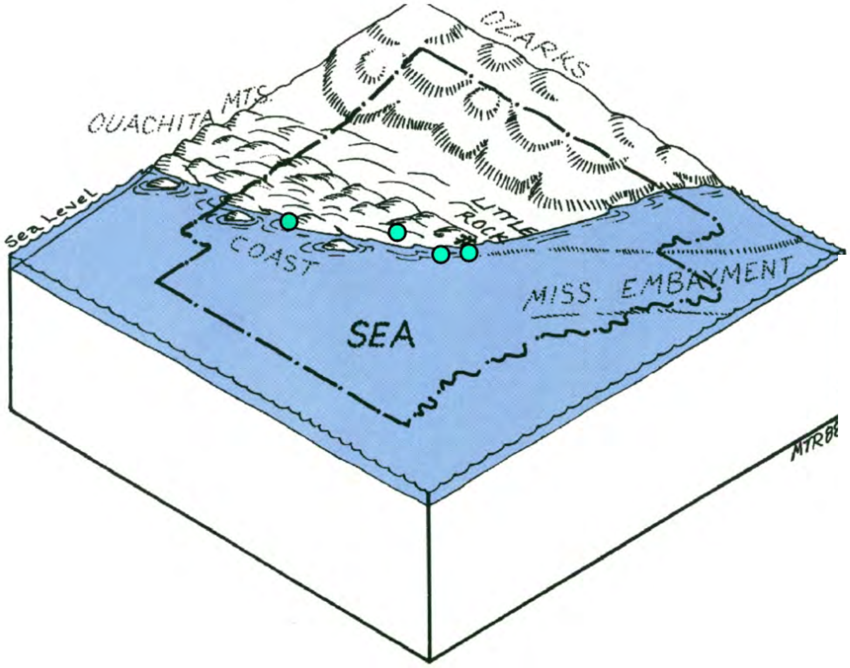

Figure 5. Late Cretaceous paleogeography of Arkansas showing major igneous intrusions. *Modified from Guccione, 1993.*

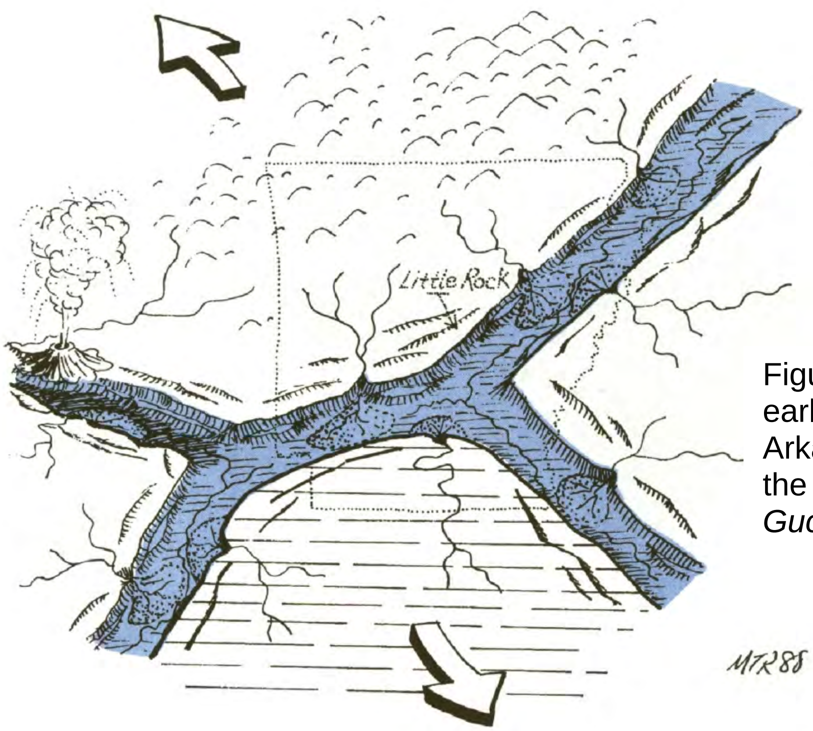

Figure 6. Late Precambrian to early Cambrian rifting in Arkansas that was reactivated in the Cretaceous. *From Guccione, 1993.*

Geologic Float Stops

Refer to the figure below for locations on this geologic float. For purposes of this float the boat leaves from the marina at Lake Ouachita State Park.

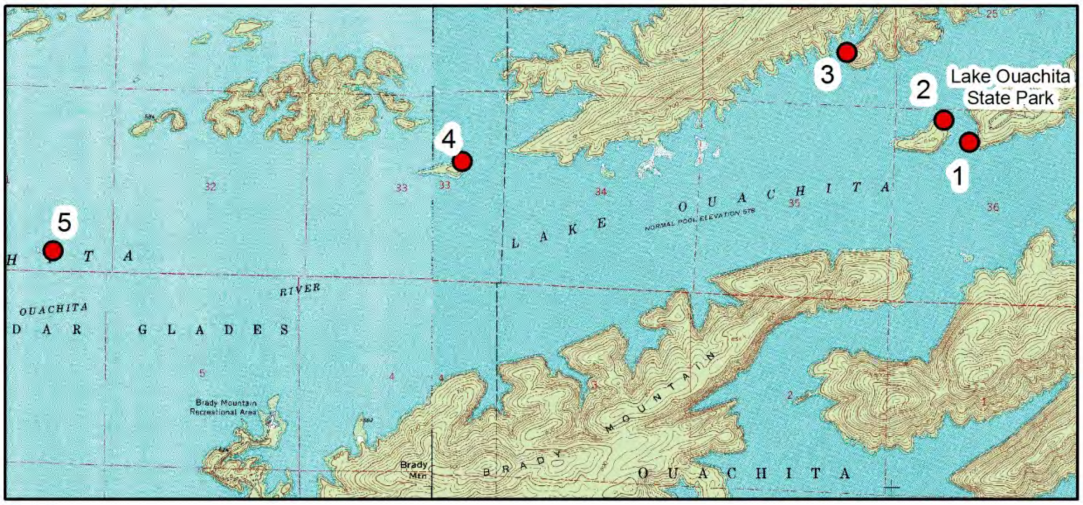

Figure 7. Location of stops for geologic float on Lake Ouachita.

Stop 1 – Submarine Slide in Blakely Formation

The small finger of land on which the State Park is located is an anticline. On the northern edge or limb the rocks dip to the north. At our stop location, interbedded sandstone and shale in the Blakely Formation dip approximately 15 degrees to the south. At the southern end of the point the rocks increase in dip to 50 degrees. The rocks are slightly folded on this southern limb and contain fractures that are filled with quartz.

Notice the large gray masses of rock sitting on the hill above the tilted rock at lake level. These gray rounded masses look very distinct from the underlying rocks. They weather and erode differently because they are a conglomerate made up of boulders, cobbles and pebbles of sedimentary rocks. These masses are called exotics because the pieces of rock that make up the mass were broken off the shelf and carried down the slope of the continental shelf to their current position. The exact mechanism that brought the material down the slope is unknown, however we can postulate that there was possibly an earthquake that broke the rocks off the shelf and caused them to slide down the slope.

Figure 8. Large exotic (outlined in red) in the Blakely Formation.

Figure 9a. Interbedded sandstone and shale with quartz filling fractures in the sandstone bed.

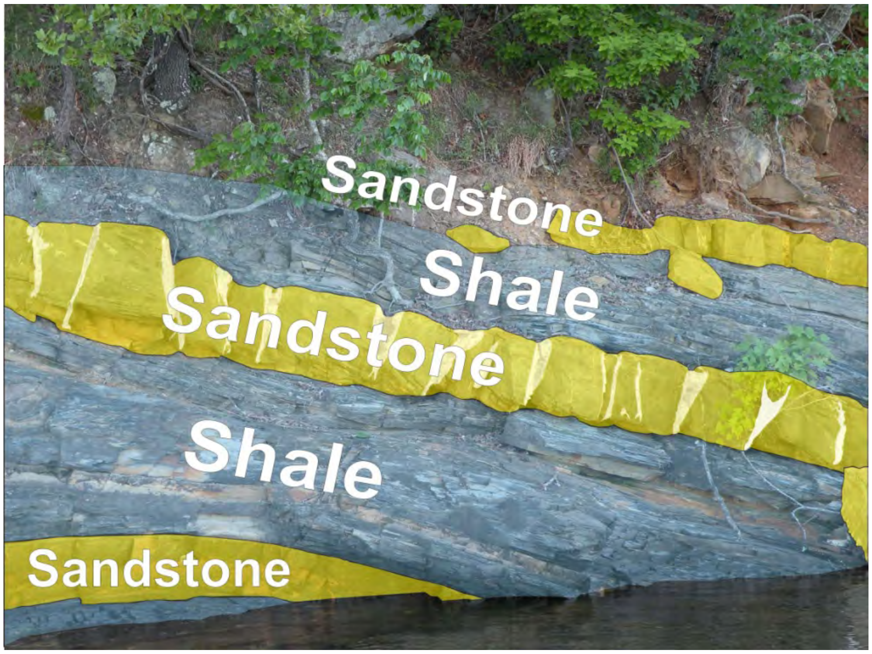

Figure 9b. Overlay of rock types on picture.

Stop 2 – Zebra Rock – Blakely Formation

This stop is known for its quartz veins which give the rock its striped or zebra appearance. Quartz veins are found in a wide belt extending from Little Rock, Arkansas to Broken Bow, Oklahoma in the central core area of the Ouachita Mountains (Stone and Haley, 1984). The quartz came from a solution of hot water formed during the Ouachita Mountain building event. There is a close association of quartz veins with fault zones. Faulting causes the adjacent rocks to become cracked and opens up fractures creating pathways for water to flow. The hot water solution was rich in silica and as it flowed through the open fractures quartz precipitated out of the solution.

This stop is located on the northern limb of the same anticline as Stop 1. Notice the rock layers dipping to the north.

Figure 10. Blakely sandstone containing quartz veins.

Stop 3 – Folding in the Womble Shale

The Womble Shale is mostly black shale that weathers to a brown color and contains some thin lenses and beds of limestone, sandstone and chert. At this location there is thin- to medium-bedded fine-grained dense blue- gray limestone exposed in the Womble along the lake. Also present are beds of conglomerate that are believed to have been transported to their current position as debris flows from a higher shelf to the northeast. All of these beds have been tightly folded and faulted in their current position along the lake. Try to find a recumbent fold in this area.

Figure 11. Faulted recumbent folds in limestones of the Womble Shale. Fault is located as red line.

Determine the relative ages of the folding in relation to the fault in Figure 11. Try to reconstruct the the formation of events from deposition to current position.

Figure 12. Overturned anticline with debris flow conglomerate (darker beds) interbedded with Womble limestones.

Stop 4 – Checkerboard Point – Blakely Sandstone

The sandstone at this location shows a well defined joint system that has allowed the rock to be more easily weathered and eroded to resemble a checkerboard pattern. A joint is a fracture or parting in the rock without displacement. Joints are present in most rock formations and provide a record of the stress and strain the rock has undergone. When two or more joints intersect it is called a joint system. The joint system at this location consists of a primary joint set in the N/S direction with a secondary joint set in the E/W direction. The primary joint set formed at right angles to the compression event that formed the Ouachita Mountains.

Figure 13. Joint system in the Blakely Sandstone at Checkerboard Rock.

Stop 5 – Small Island – Igneous Dike in Womble Shale

The Womble Shale is dipping to the southwest at this locality and contains an igneous dike (Fig. 14). The Womble Shale was deposited in the Middle Ordovician Period and folded and deformed in the Pennsylvanian to Permian Periods . The dike intruded into the Womble in the Cretaceous Period. Use the principal of cross-cutting to determine the relative age of the units in this outcrop. Try to reconstruct the formation of events from deposition to current position.

The Womble Shale contains graptolites. Take a minute to explore on this island and try to discover these fossils. Also, try to find the dike cutting through on the opposite side of the island.

Figure 14. Igneous dike (outlined in red) in Womble Shale.

Figure 15. Graptolites in the Womble Shale.

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McFarland, J.D., 1998, Stratigraphic summary of Arkansas: Arkansas Geological Commission Information Circular 36, 39 p.

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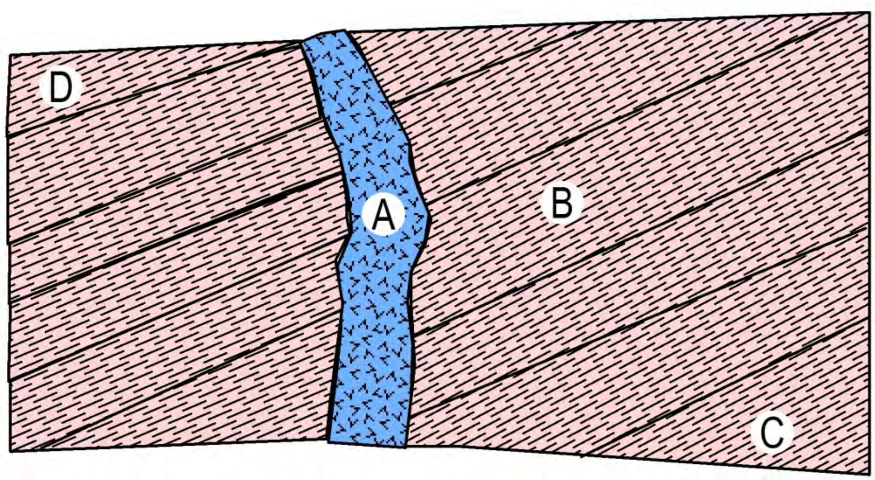
Exercise 1

Refer to the cross-section diagram below which corresponds to Stop 5, Figure 14. Determine the relative ages of the rock bodies and features marked with letters. Indicate their relative age relationships by writing their letters on the blanks from oldest to youngest. What caused the Womble Shale to be inclined or dipping? What caused the dike? What age is the Womble Shale? What age is the dike?



______ Youngest

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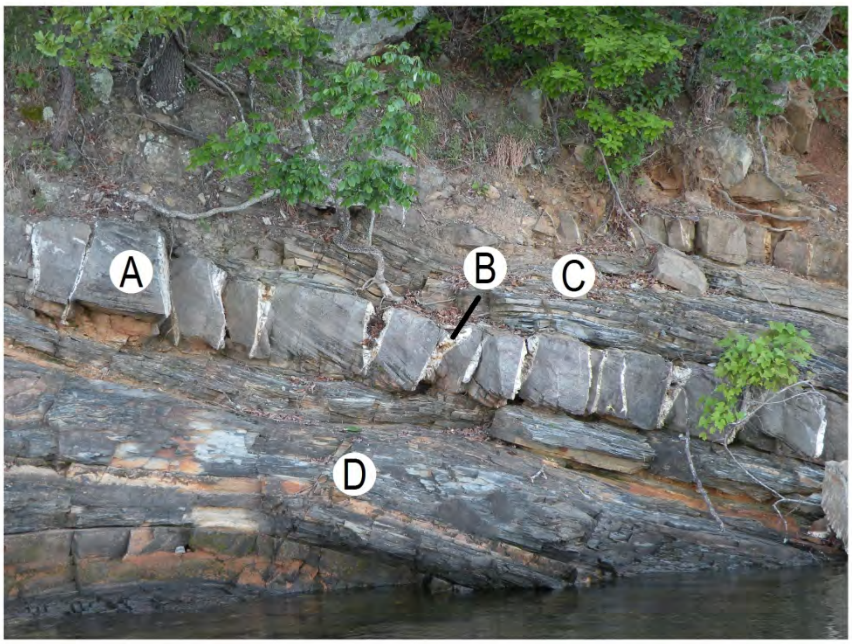
Exercise 2

Refer to the cross-section diagram below which corresponds to Stop 1, Figure 9. Determine the relative ages of the rock bodies and features marked with letters. Indicate their relative age relationships by writing their letters on the blanks from oldest to youngest. What age is the Blakely Sandstone? When did the quartz fill the fractures in the rock?



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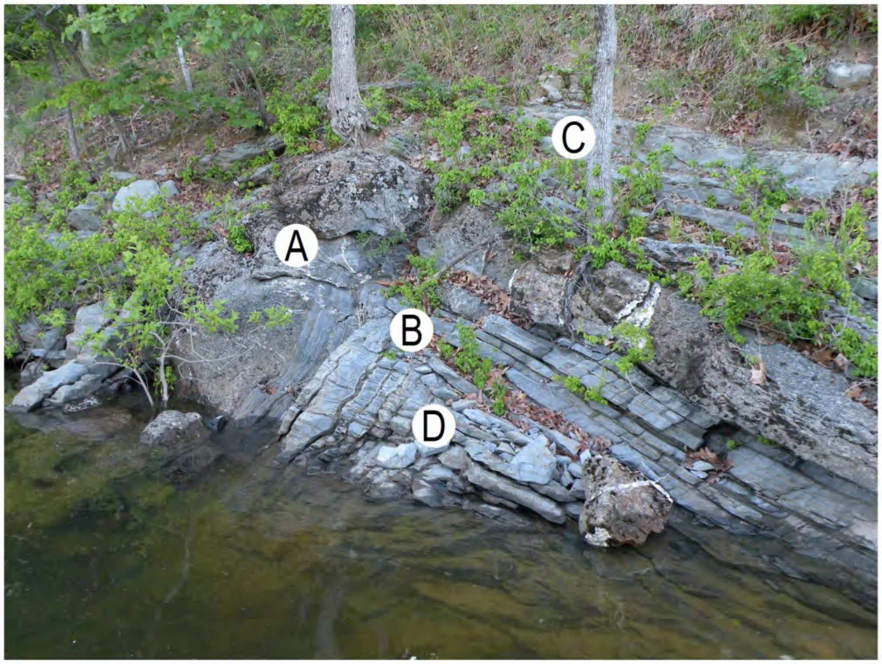
Exercise 3

Refer to the cross-section diagram below which corresponds to Stop 3, Figure 12. Determine the relative ages of the rock bodies and features marked with letters. Indicate their relative age relationships by writing their letters on the blanks from oldest to youngest. Is this an anticline or syncline? Is it symmetrical or overturned? What rock type is letter A? How did this rock type become interbedded with the Womble Limestones?



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