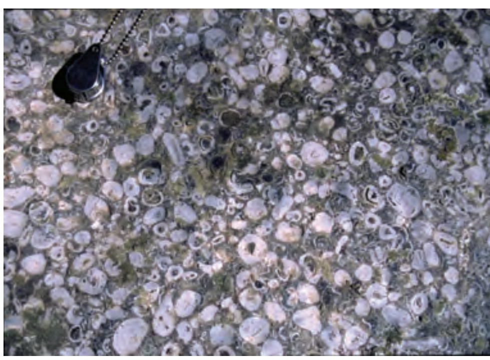
EWS - 08

STATE OF ARKANSAS

ARKANSAS GEOLOGICAL SURVEY
BEKKI WHITE, DIRECTOR AND STATE GEOLOGIST

EDUCATIONAL WORKSHOP SERIES 08

Arkansas Geology: Bluffs, Crevices, Pedestals, and Fossils



Angela Chandler

Little Rock, Arkansas
2015

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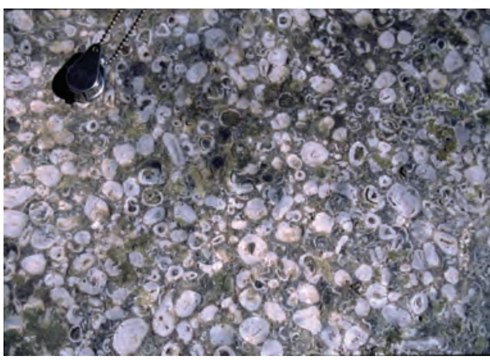

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STATE OF ARKANSAS
Mike Beebe, Governor

Arkansas Geological Survey
Bekki White, State Geologist and Director

Little Rock, Arkansas

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Acknowledgments

This workshop booklet is written for Arkansas teachers studying Earth Science. It is also written with the Arkansas Science Curriculum in mind so that students can meet the requirements and goals set for their age groups. This booklet is also a great fieldtrip guidebook to the interested public. Thanks to various staff members at the Arkansas Geological Survey for suggestions and edits to this booklet.

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Front cover images:
- left – oncolitic limestone in the Pitkin Limestone from Richland Creek
- middle – pedestal at Pedestal Rocks Scenic Area
- right – coral colonies in the Pitkin Limestone at Richland Creek

Arkansas Geology – Bluffs, Crevices, Pedestals, *and* Fossils

This is a two day workshop that explores features and fossils on the Boston Mountains Plateau in the Ozark National Forest. The first day of the workshop, we travel to Pedestal Rocks Scenic Area to look at a sandstone bluff that has weathered and eroded to create crevices and pedestals. Next, we move on to scenic Richland Creek to look for fossils. The second day we visit Long Pool Recreation area to look for more fossils. The following frameworks in Earth and Space Sciences and Environmental Science will be addressed:

ESS.8.3.1 – Distinguish among Earth's materials: rocks, minerals, fossils, soil

ESS.8.3.3 – Identify sedimentary rocks – differentiate between limestone, dolostone, and sandstone

ESS.8.4.1 – Locate the Ozark Plateaus Region and identify each plateau – Salem, Springfield, and Boston Mts.

ESS.8.8.7 – Use topographic maps to identify surface features of Earth

ESS.9.4.1 – Analyze changes to the Earth's Surface through erosion and weathering of sandstone terrain – identify landforms such as bluffs, fractures, pedestals

ESS.9.5.1 – Explain and give examples of how physical evidence from fossils supports the theory that Earth has changed over time

ESS.9.5.2 – Analyze fossil record evidence about plants and animals that lived long ago

ESS.9.5.3 – Infer the nature of ancient environments based on fossil record evidence

ESS.9.8.2 – Analyze how rock sequences may be disturbed by the following: erosion and deposition –

PD.1.ES.6. – Describe the processes of degradation by weathering and erosion

PD.1.ES.10 – Describe the characteristics of each of the natural divisions of Arkansas: Ozark Plateaus

Geologic Setting

This workshop is located in the Ozark National Forest of north-central Arkansas in the Ozark Plateaus Region. The Ozark Plateaus Region is located around a broad, asymmetrical dome (or uplift) with its center (oldest rocks; Precambrian basement) in the St. Francois Mountains of southeast Missouri (Fig. 1). The rock formations dip gently away from this area in all directions. The Ozarks of northern Arkansas form the southern flank of the Ozark dome.

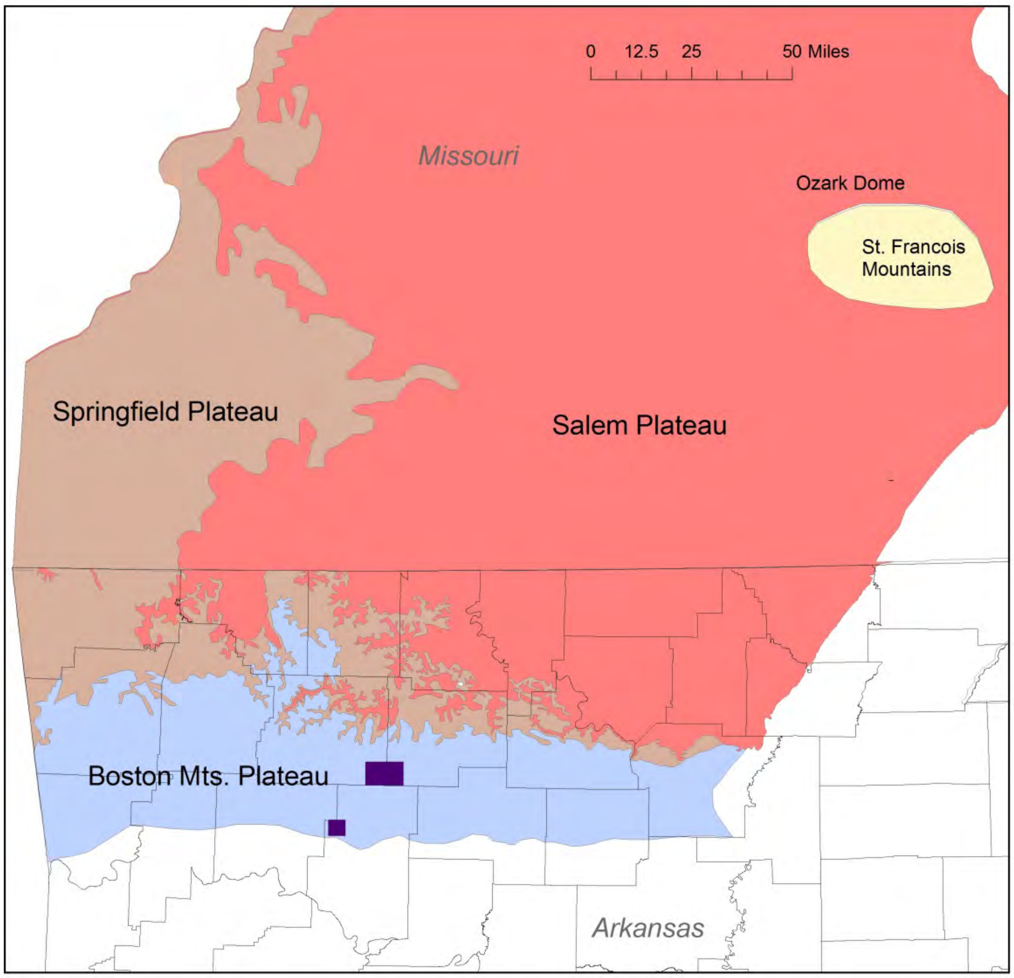


Figure 1. Map of the Ozark Plateaus region showing location of plateau surfaces in relation to Ozark Dome. Purple boxes show location of workshop stops.

The Ozarks can be divided into 3 plateaus (broad, flat-topped areas) that are separated from each other by steep slopes called escarpments.

1) *Salem Plateau – capped by Ordovician rocks, mostly dolostone*

2) *Springfield Plateau – capped by Mississippian rocks, mostly limestone*

3) Boston Mountains Plateau – capped by Pennsylvanian rocks, mostly sandstone

The plateaus become progressively higher in elevation and expose younger rocks from north to south in the Ozarks of Arkansas. This workshop focuses on the Boston Mountains Plateau surface. It is the youngest plateau surface and also the most rugged, with the highest elevations in the Ozarks.

This fieldtrip will traverse portions of the southern Boston Mountains Plateau in Newton, Searcy, and northern Pope Counties in north-central Arkansas (Fig.1). This area is underlain primarily by relatively flat-lying sandstones and shales that are inclined gently southward. Gentle folds and minor structural deformation are present near east-west trending faults. The surface geology consists of Pennsylvanian age rocks currently mapped as the Hale Formation and the Bloyd Formation (Fig. 2). The plateau surface is deeply dissected by streams in this area. The underlying Mississippian limestones crop out in the valleys, and the Pennsylvanian sandstones and shales are exposed on the hillsides. The focus of this fieldtrip is to look at an upper Mississippian limestone and lower Pennsylvanian sandstones in the southern portion of the Ozarks (Fig. 3).

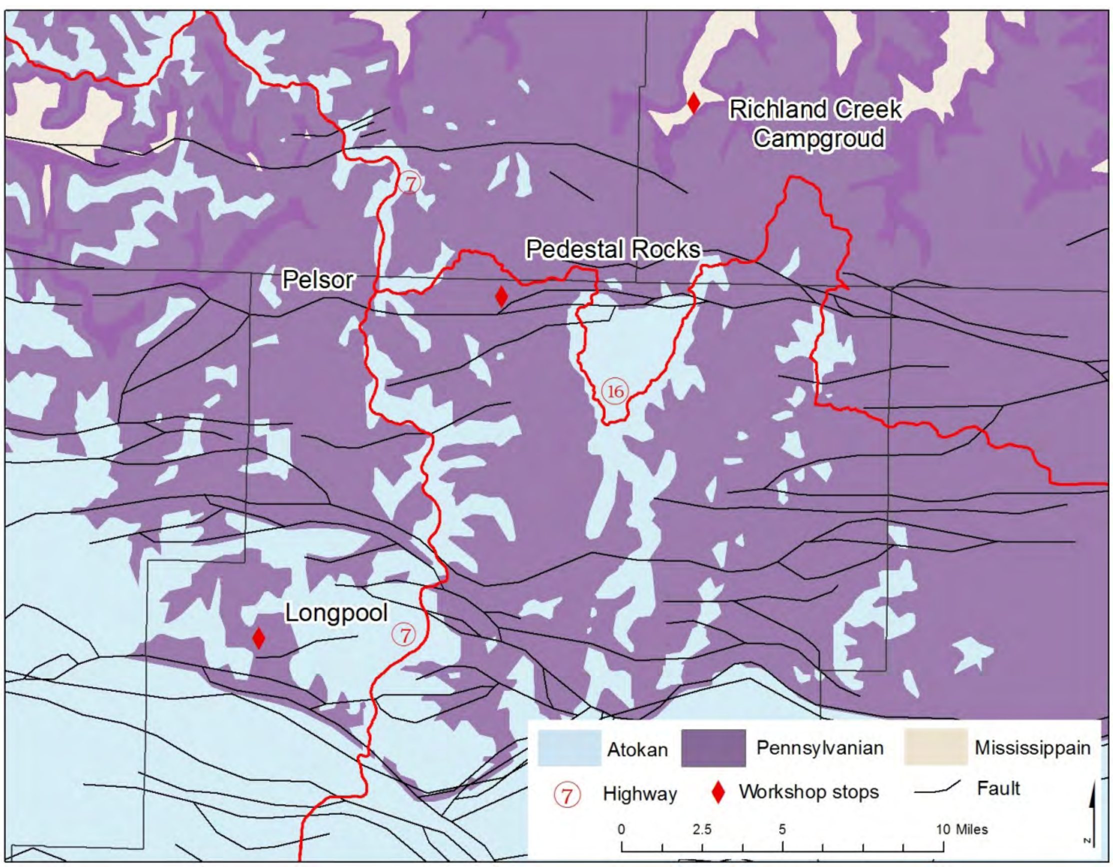


Figure 2. Geologic map of Arkansas illustrating age of rocks and location of workshop stops.

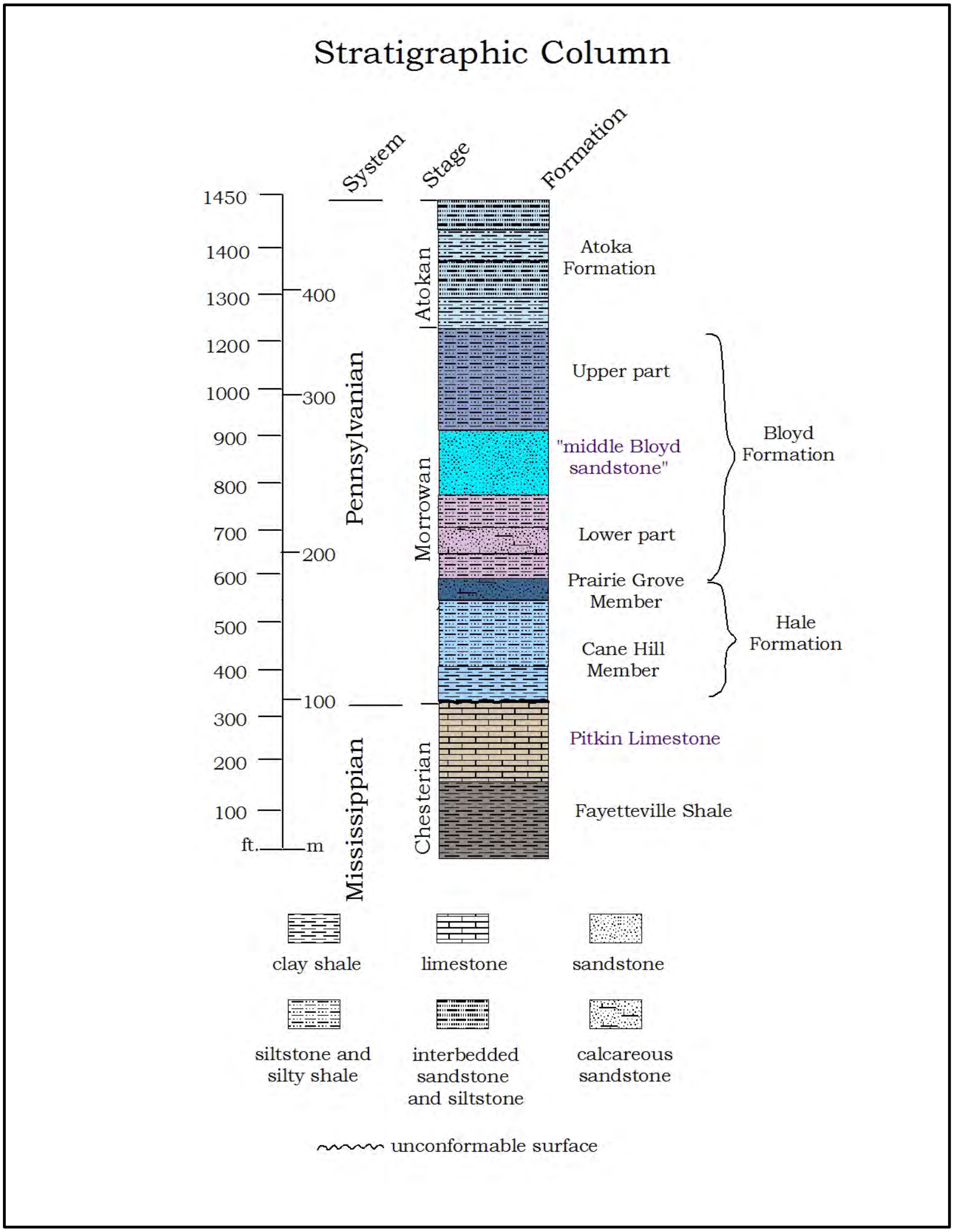


Figure 3. Stratigraphic column for area. The formations we will see on this workshop are in purple text.

Deposition of Pitkin Limestone: Upper Mississippian (331-323 million years ago)

Toward the end of the Mississippian Period, northern Arkansas was covered by shallow marine seas on a southward gently sloping continental platform or ramp. During this time the sea level rose (transgressed) and fell (regressed) multiple times. Pitkin Limestone was deposited on top of the Fayetteville Shale in water depths less than 20 feet. Waves moved near the shoreline or beach and created an environment where oolites formed. Many of the oolites were washed downslope through tidal channels on the ramp during storm events (Fig. 4). In some localities, carbonate mud accumulated as mounds. The mounds were good places for many animals such as bryozoans, crinoids, brachiopods, corals, bivalves, and sponges to live. Oncolites accumulated in quiet areas on the shallow shelf. The sea regressed at the end of the Mississippian Period, and the Pitkin Limestone was exposed. Some of the limestone was eroded before deposition of Pennsylvanian age sediments. This created an unconformity between Mississippian and Pennsylvanian age rocks.

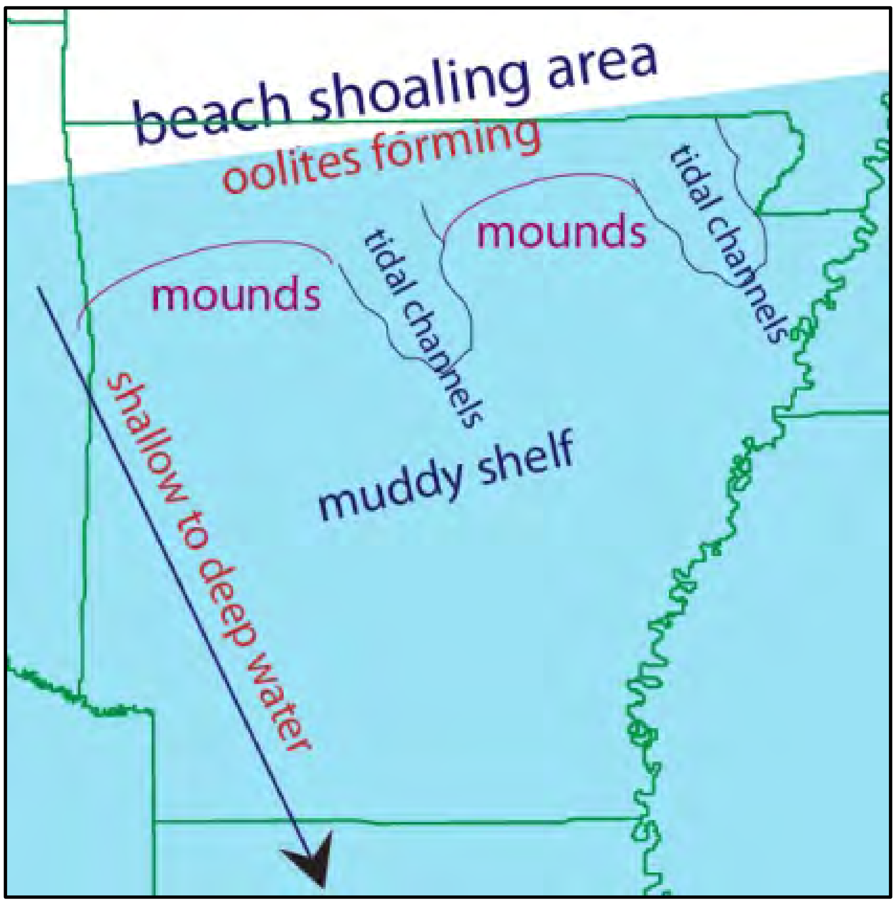


Figure 4. Depositional environment of the Mississippian Pitkin Limestone.
Blue represents water.

The Pitkin Limestone crops out along Richland Creek, at Richland Falls, and at Twin Falls.

Description of Pitkin Limestone – Boston Mountains Plateau

The Pitkin Limestone is a fine- to coarsely-crystalline, commonly fossiliferous limestone containing crinoidal fragments, *Archimedes* bryozoans, gastropods, coral (Rugose (single) and colonial), oncolites, and oolites. It varies in color from light-gray to dark-gray on fresh surfaces, but the limestone usually weathers light to medium-gray. The limestone is commonly medium- to massive-bedded and often has a petroliferous odor on freshly broken surfaces.

Oolites and oncolites are round features in sedimentary rocks, however oolites are much smaller then oncolites, and they are created in different environments by different mechanisms. Oolites are small (<2 mm), spherical, coated grains that consist of several concentric layers of calcite surrounding a central nucleus such as a shell fragment or sand grain. They form where strong bottom currents and wave action (beach/tidal area) move the fragment around to become coated with layers of calcite precipitated out of the sea water. Oncolites (>2 cm) also consist of concentric layers around a central nucleus; however, the concentric layers are made up of blue-green algae or cyanobacteria. Oncolites are very similar to stromatolites, but, instead of forming columns, they form spherical structures. Oncolites are indicators of warm waters in a stable shallow sea, lagoon, or bay.

Deposition of Bloyd Formation: Pennsylvanian (Morrowan) (323-300 million years ago)

At the end of the Mississippian Period, the sea had withdrawn from northern Arkansas for a period of time. The boundary between the Mississippian and Pennsylvanian Periods is unconformable because of this time of non-deposition. In Morrowan time, the ocean once again flooded the shallow shelf. Sea level rose and limestone interbedded with shale was deposited in the western part of the state during early Morrowan time (Fig. 5). During times of low sea level, sandstones were deposited as rivers brought sediment in from the north and northeast that mixed with shoreline deposits. In middle Morrowan time, the sea had retreated and a large stream system entering the state from the northeast deposited sand in a near shore environment, from Van Buren County as far west and south as Madison and Franklin Counties (Fig. 5).

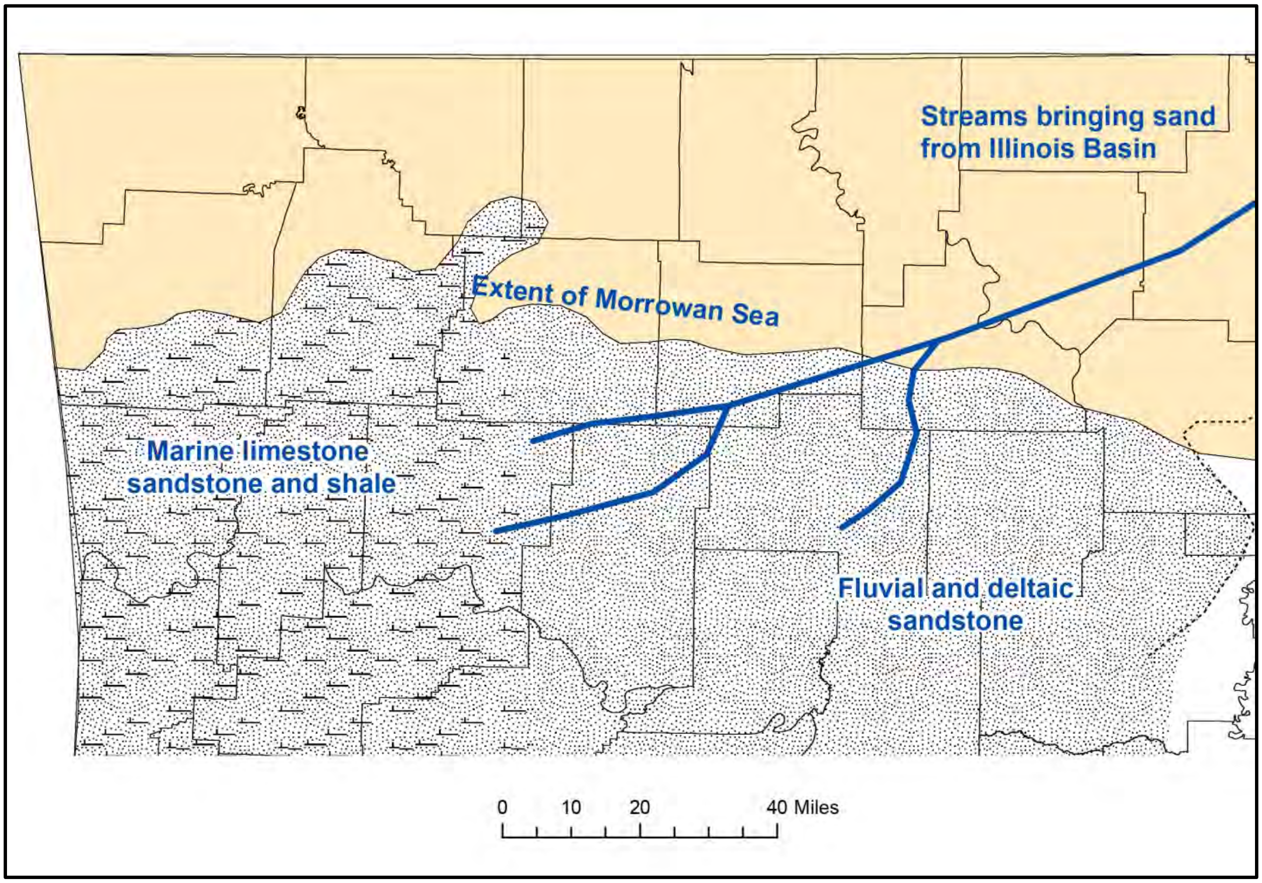


Figure 5. Diagram illustrating deposition of the “middle Bloyd sandstone” throughout north-central Arkansas.

Cross-bedding is an abundant sedimentary feature present in the “middle Bloyd sandstone”. Cross-beds appear as diagonal lines within a rock. They represent the downstream movement of ripples and indicate the direction the river once flowed. Cross-beds are very abundant in the thick sandstones that were deposited by ancient river systems. Paleocurrent measurements on large-scale, tabular cross-bed sets (Fig. 6) at localities along the outcrop belt in Carroll, Madison, and Newton Counties (Zachry, 1979) indicate unidirectional current systems flowing south and southwestward. Paleocurrent measurements are analyzed by taking the compass direction of cross-beds.

Figure 6. Cross-bed sets in the "middle Bloyd sandstone". Notice direction of flow from right to left.

Description of Bloyd Formation - Boston Mountains Plateau

Mostly sandstone and shale was deposited in northern Arkansas during the Pennsylvanian Period. Many of the sandstones are calcareous, contain fossils, and will fizz with dilute hydrochloric acid. The sandstones are usually resistant and are bluff-formers. We will focus on the "middle Bloyd sandstone".

The "middle Bloyd sandstone" is a thin- to massive-bedded, medium- to coarse-grained, cross-bedded calcite or iron-cemented sandstone. It can be reddish, gray, or light-tan on fresh surfaces but weathers brown to orange-brown due to iron content. The cross-bedded packages can be up to three feet thick and locally overturned. The sandstone contains abundant lycopod fossils and rounded quartz pebbles. It forms a prominent bluff throughout the north-central part of the state. A quartz pebble clast conglomerate is present at the base of this sandstone. The "middle Bloyd sandstone" is unconformable with the lower part of the Bloyd Formation.

Formation of crevices, pedestals, and other features in sandstone

Rocks on the surface of the earth have natural fractures or cracks called joints (Fig. 7). These fractures allow surface water to travel downward (vertically) below the ground surface due to gravitational flow. Rainwater becomes acidic by absorbing carbon dioxide to create carbonic acid as it falls through the atmosphere. It then passes through the soil horizon and becomes even more acidic. As it moves down through fractures and open spaces within the rock below, the carbonic acid in groundwater dissolves the calcite cement that holds quartz grains in the sandstone together. The process of dissolving the cement or the rock itself is called solution. Once the cement is dissolved from the sandstone, the rock falls apart and erodes away easily.

Figure 7. Natural cracks called joints in the sandstone bluff at Pedestal Rocks.

Erosion occurs on the bare outcrops as well. Water erodes small channels and basins (Fig. 8) into the sandstone. In the winter, during wet freezing periods, water can freeze and expand in fractures in the rock causing the fractures to enlarge. Pieces of sandstone also flake or spall off the outcrop during times of intense heat such as forest fires or prescribed burns.

Figure 8. Small basins developed by erosion in the “middle Bloyd sandstone” on top of the bluff.

Water seeping into the rock causes areas to be hollowed out by cavernous or honeycomb weathering. This type of weathering produces pits of varying size on a rock surface (Fig. 9). The pits vary in size from 1 inch up to 3 feet in diameter. The dominant process that forms these features is solution of the cement holding the sand grains together. In most instances, this forms patches where the cement is no longer present, allowing the rock to fall apart. Honeycomb weathering is abundant in the sandstones in the northern part of the state.

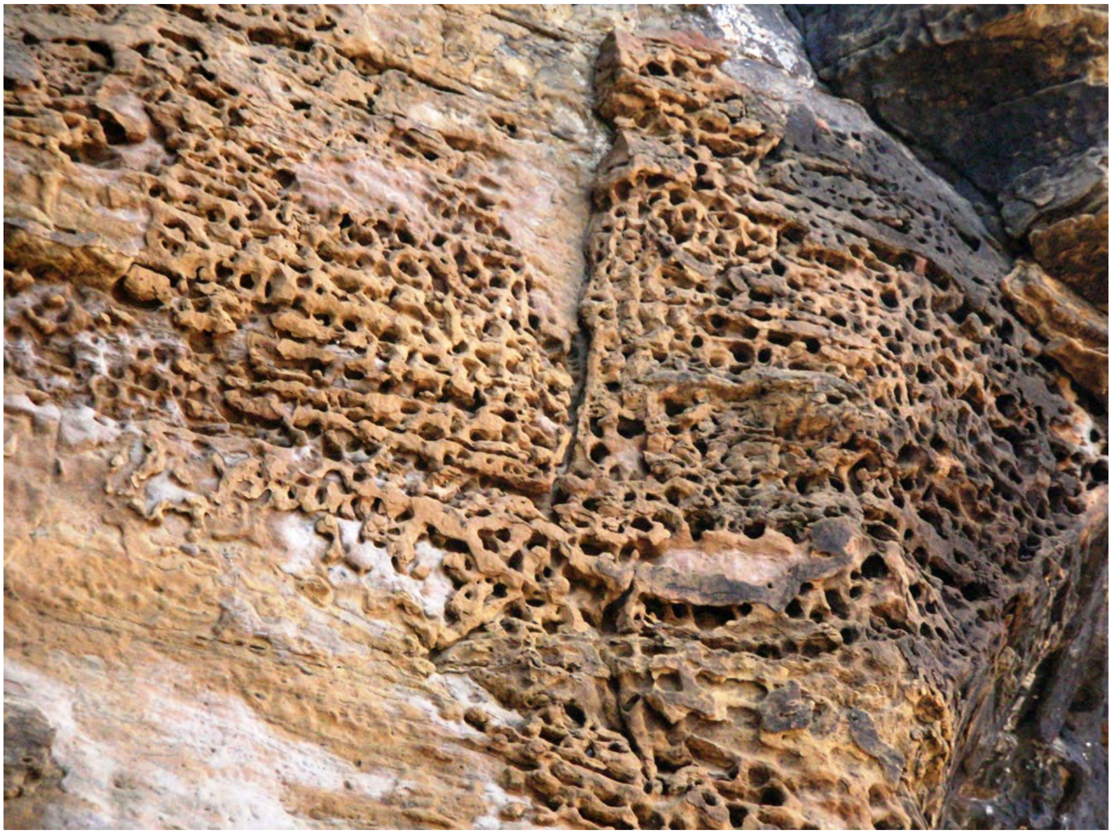
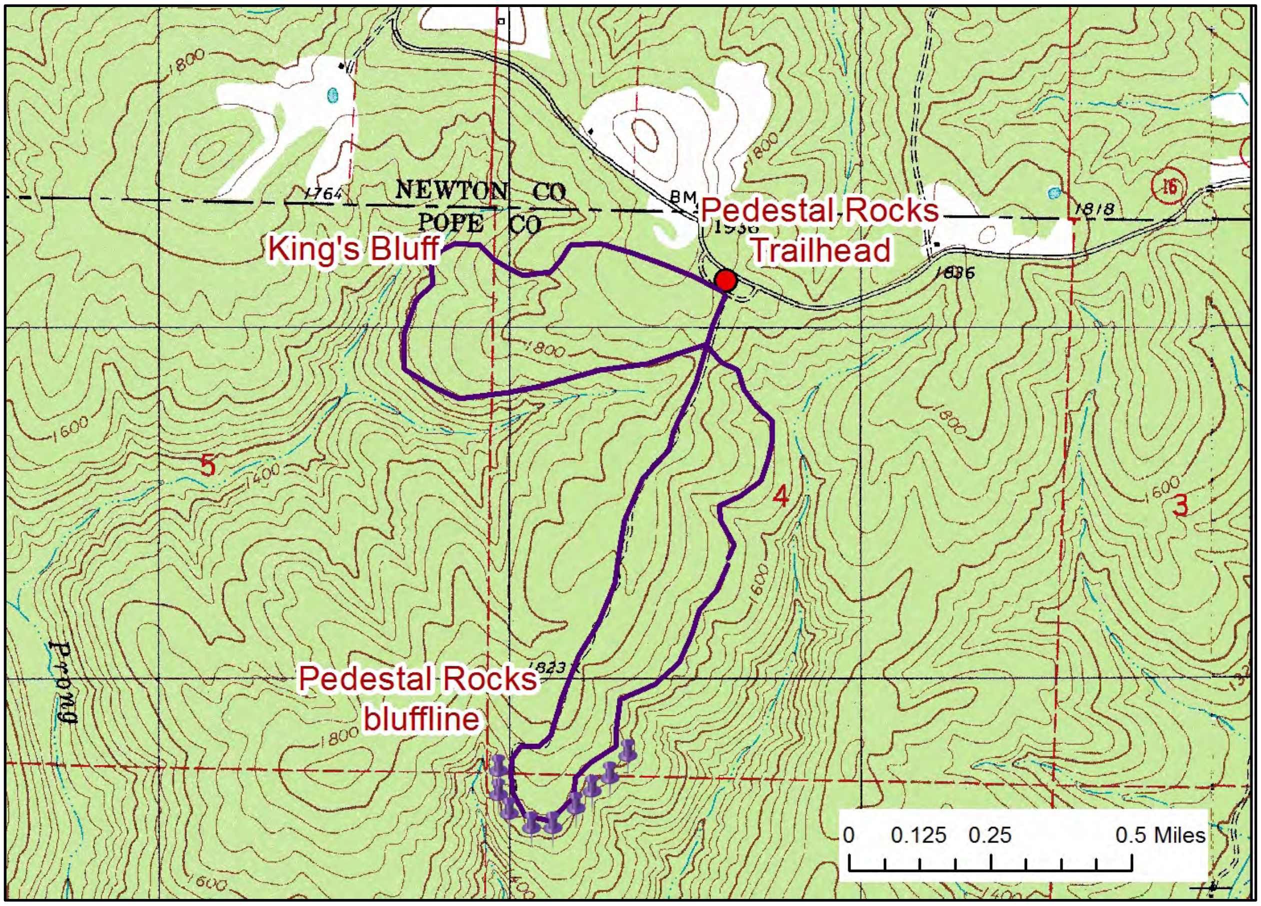


Figure 9. Honeycomb weathering in sandstone bluff at Pedestal Rocks Scenic Area.

As joints are deepened and widened, both by solution of the cement and erosion of the sand grains, the sandstone between them is shaped into pedestals of various shapes and sizes. Many pedestals are located a distance away from the bluff where they formed. They probably slid or glided to their current location. A rock will glide down slope when it is sitting on shale. Once shale gets wet, it forms a slick surface on which heavier rocks and materials slide.

Stop 1 – Pedestal Rocks Scenic Area

Location – Take Arkansas 7 to Pelsor and turn right (east) on Arkansas 16, and go 6 miles. The scenic area is located on the right (south) side of the highway. Lat: 35°43'25.573" Long: 93°0'56.216", Sand Gap quadrangle, Pope County, Arkansas.



Stop 1 – Location of Pedestal Rocks trailhead and bluff line, Pope County, Arkansas.

Description – There are two individual loop trails at this location: Pedestal Rocks and Kings Bluff. We will hike the Pedestal Rocks trail. This trail illustrates a unique bluff line in the "middle Bloyd sandstone" where we can see pedestals in the Boston Mountains Plateau. The topography is rugged which is typical of this plateau surface.

Once we reach the top of the bluff, look for joints or fractures in the sandstone. Look at the "mushroom" shape of the pedestals. Notice the capstone of the pedestal. It appears to be more resistant while the "stem" is more easily eroded. The capstone is protected by an outer layer of iron called case hardening that is hard to erode. The stem does not have this outer layer, and water is able to actively erode it by seeping underneath the capstone along the bedding plane and into fractures.

Stop 1 – Pedestal separated from main bluff along Pedestal Trail at Pedestal Rocks Scenic Area.

Look for interesting features in the sandstone as you follow the bluff trail. Box-shaped, triangular, and circular patterns are abundant in the sandstones of Arkansas. Though common, the process that forms these features is not well understood. Iron exists as the minerals pyrite, siderite, magnetite, hematite, and clay minerals that are present in the sandstone. Water once filled the pore spaces of the rock causing the iron to dissolve in the solution. Once the iron-rich water combined with oxygenated groundwater, iron precipitated along fractures and joints, cross-beds, bedding planes, and other areas of groundwater flow. These bands are referred to as liesegang banding or box-work by the scientific community.

Stop 1 – Box-work in the sandstone along Pedestal Rock trail at Pedestal Rock Scenic Area.

There are several examples of liesegang banding along the trail. Find these locations and take plenty of pictures.

Next, walk below the bluff to see pedestals and fracture caverns when accessible along the trail. Look for features such as:

- concentrations of iron in the form of banding or box-work
- quartz pebbles
- interesting weathering (honeycomb)
- fractures/joints

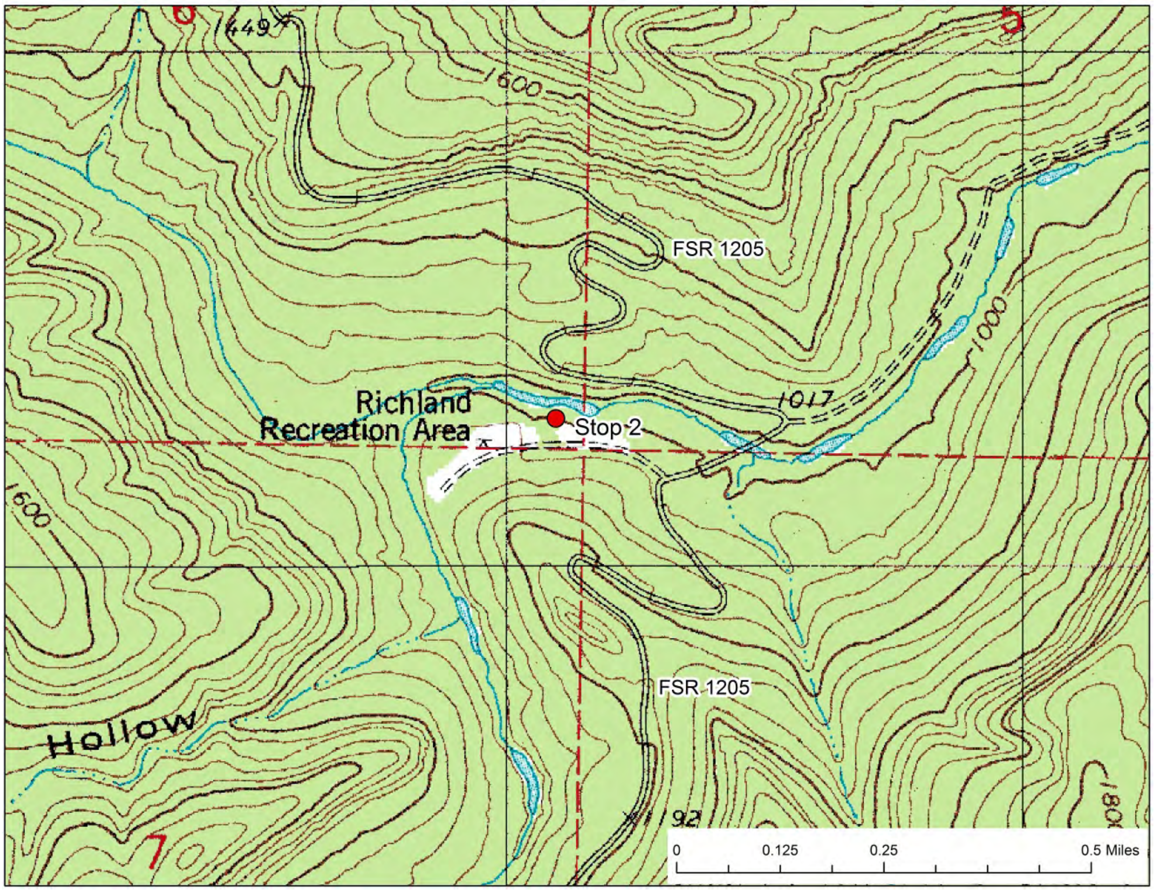
The bluff overlooks the headwaters of the North Fork of the Illinois Bayou. Take a moment to enjoy the view in all directions. What do you see? Notice these features:

- deeply dissected valleys characteristic of the Boston Mountains Plateau surface
- sandstone rimming the hills at the same elevation around you

It is important to note the continuity of the sandstone unit throughout the area. This illustrates the **Principle of Lateral Continuity** where sedimentary rocks extend in all directions until they reach their end or the edge of the sedimentary basin.

Stop 2 – Richland Creek Recreation Area

Location: Take Arkansas 7 north from Russellville for 37 miles to Pelsor. Turn right (east) on Arkansas 16, and go 10 miles. Then turn left (north) on Forest Service Road 1205 (gravel), which is located about 1.5 miles south of Ben Hur. Take Forest Service Road 1205 (gravel) north, 9 miles to Richland Creek campground. Lat: 35°47'51.191" Long: 92°55'58.306". Moore quadrangle, Searcy, County, Arkansas.

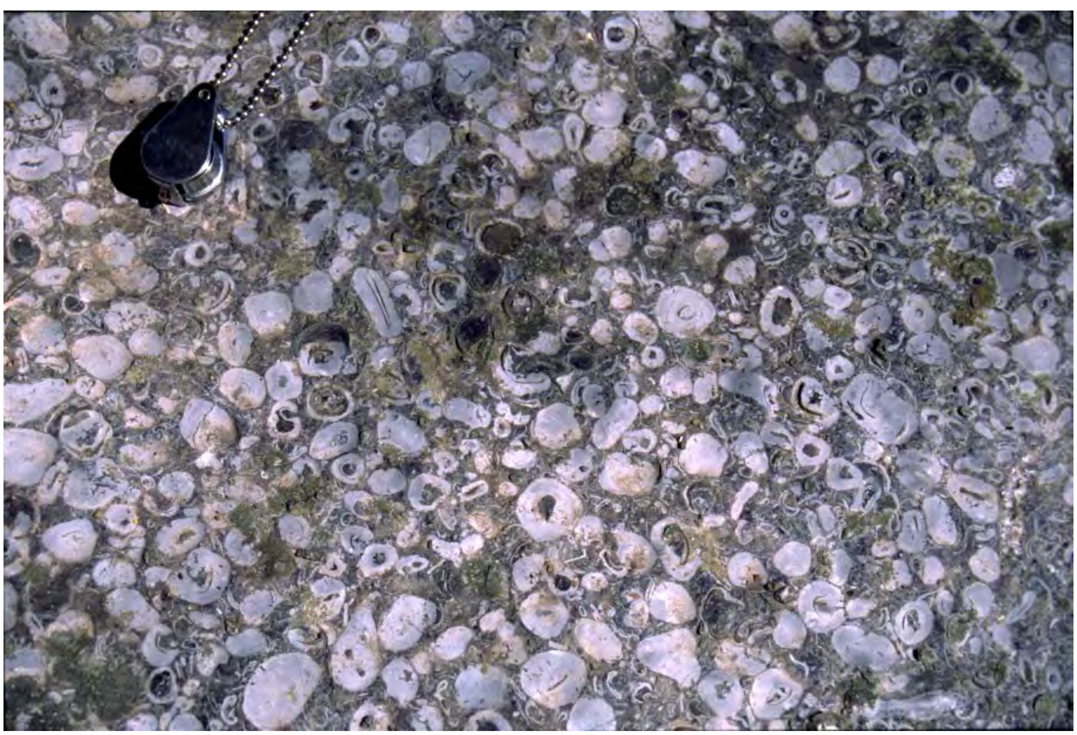


Stop 2 – Topographic map with location of Stop 2, Richland Creek Recreation Area.

Description – The Pitkin Limestone crops out in and along the banks of Richland Creek. This limestone is very fossiliferous and contains crinoids, bryozoans, corals, and trilobite fragments. Rock types that may have eroded upstream and been transported downstream to this location include oncolitic and oolitic limestone.

Look for interesting and varying types of limestone in the creek. Also, look for fossils!

Stop 2 – Oolitic limestone from the Pitkin Limestone, Richland Creek Recreation Area.



Stop 2 – Oncolitic limestone in the Pitkin Limestone at Richland Creek Recreation Area.

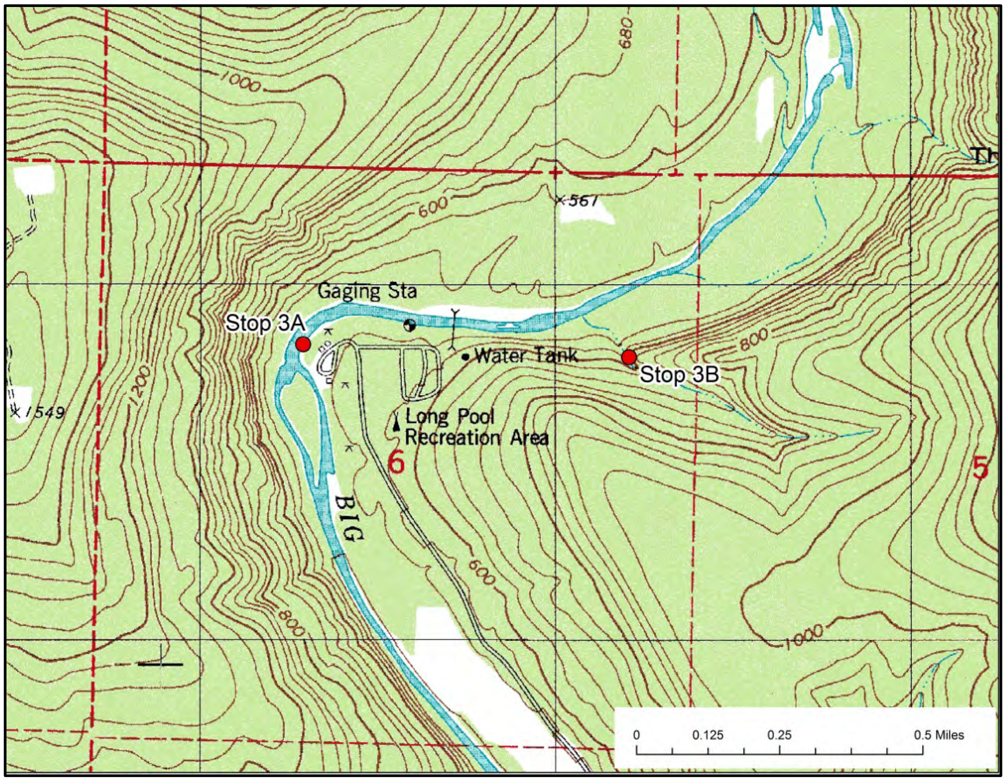
Stop 2 – Crinoidal limestone in the Pitkin Limestone at Richland Creek Recreation Area.

Stop 2 – *Archimedes* bryozoan, with fishing lure for scale, in the Pitkin Limestone, Richland Creek Recreation Area.

Stop 2 – Coral colony in the Pitkin Limestone, Richland Creek Recreation Area.

Day 2 – Long Pool Recreation Area

Location: From Dover, take Arkansas 7 north for 6 miles, turn left (west) on Arkansas 164, and go 3 miles. Turn right (northeast) on Forest Service Road 1801, and go 3 miles. Then turn left (northwest) on Forest Service Road 1804, and go 2 miles. Lat: 35°32'58.88", Long: 93°9'38.078". Treat quadrangle, Pope County, Arkansas.



Stop 3 – Topographic map showing location of Stop 3A-B at Long Pool Recreation Area.

Description: The Bloyd Formation crops out along Big Piney Creek and up the hillsides. The highest portions of the hills are capped by the Atoka Formation. Sandstone and shale are the most abundant rock types in this area, however, a distinctive limestone containing blastoids is present along the creek at various localities. Many of the sandstones are calcareous and contain fossils such as crinoids, ammonoids, and bryozoans.

Stop 3A – Fossiliferous sandstone along Big Piney Creek

Walk downstream from the put-in at Long Pool to see interbedded sandstone and shale. The sandstone is calcareous and conglomeratic. Look for fossils.

Stop 3A – Interbedded sandstone and shale in the lower part of the Bloyd Formation along Big Piney Creek at Long Pool Recreation Area.

Look for other features in the rock. Find the following:

- ripple marks
- joints or fractures
- conglomerate pieces
- fossils

Stop 3B – Waterfall Hollow

Waterfall Hollow is easily accessed by a trail that starts at the eastern end of Long Pool Campground. Starting there, follow the trail toward the creek and follow it to the mouth of Waterfall Hollow. As you start up the hollow, notice the fine detail in the cross-beds weathering out of the sandy limestone in the lower part of the Bloyd Formation. Water pouring over this waterfall has differentially solutioned the carbonate-rich beds in the outcrop, leaving the sandier beds in relief.

Stop 3 – Cross-bedding in sandy limestone of lower part of the Bloyd Formation.

Continue up the drainage toward the larger waterfall. Look around at the boulders in the streambed and the outcrops on the hillside. There is a fairly thick section of black shale in the lower part of the Bloyd Formation forming a large reentrant below the upper waterfall.

Stop 3 – Predominantly shale outcrop between lower waterfall and upper waterfall.

Thin-bedded siltstone interbedded with shale crops out near the base of the waterfall. The section becomes more thick-bedded and coarse-grained at the top. Above this is a sandstone ledge that is a small bluff-former in the lower part of the Bloyd Formation, pictured below.

Stop 3 – Thin- to thick-bedded sandstone in the lower part of the Bloyd Formation.

Trace fossils called *Asterosoma* are present in the interbedded siltstone/shale section. These impressions were made by an unknown Pennsylvanian-aged animal as it fanned out in a radial feeding pattern which left a star-shaped trace in the mud that was later filled by silty sediments. All these layers became buried then lithified over time. Here they have resurfaced because shales weathered away and left behind a cast of the original impression.

Stop 3 – *Asterosoma* trace fossils, approximately 2-3 inches in width.

References:

Chandler, A. and Hutto, R., 2010, Geologic float guide to Big Piney Creek, Helton's Farm to Twin Bridges, Pope County, Arkansas: Arkansas Geological Survey Guidebook 2010-1.

Manger, W.L., 2010, Introduction to the geology of the Boone-Pitkin interval in outcrop, southern Ozarks, northern Arkansas: Operations fieldtrip Southwestern Energy Company, Conway, Arkansas, November 16-17, 48 p.

Zachry, D.L., Jr., 1979, Early Pennsylvanian braided stream sedimentation, northwest Arkansas in Hyne, N.J. (ed.), Pennsylvanian sandstones in the mid-continent: Tulsa Geological Society, p. 269-282.

Appendix 1
Topographic Map Exercises

Topographic Map Exercises

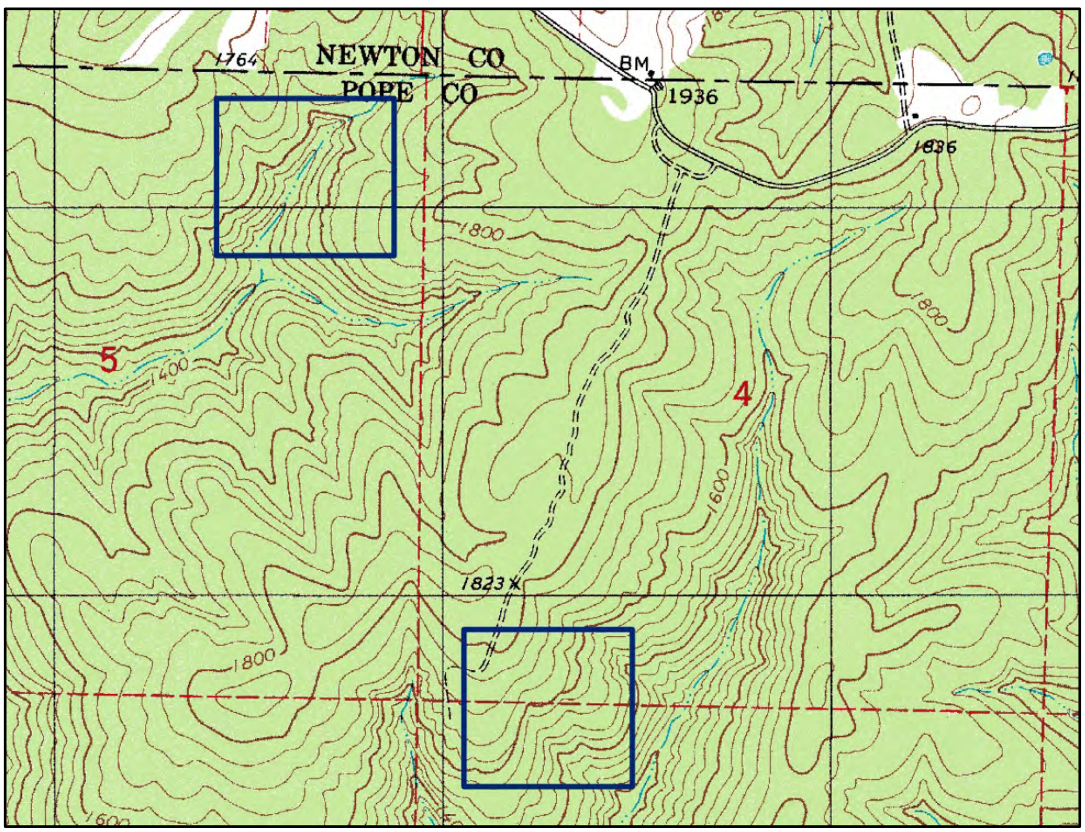
Exercise 1

Refer to the Sandgap Topographic Quadrangle to answer the following questions.

1. Determine the following:

   A. Contour Interval____________________
   B. Elevation between Index Contours_______________________
   C. What type of topography does this suggest?
   __________rugged _________gently rolling hills

2. Use the map below to answer this question. Follow the 1600 ft. contour in the boxed areas.

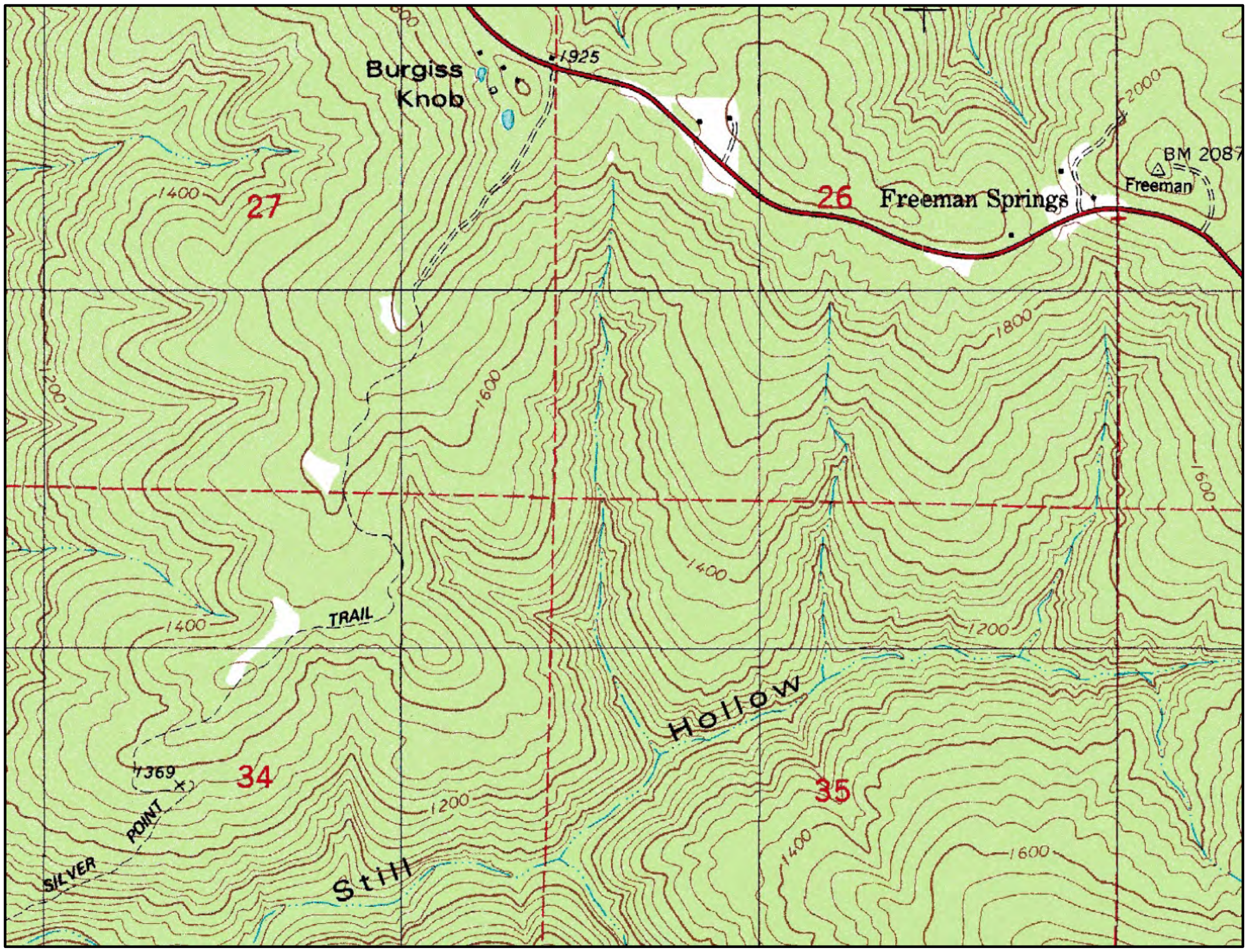


   A. What happens to the contour above and below the 1600 ft. contour?_______________________________________

   B. What kind of landform is present here?
   _______plain _______bluff ______lake

3. Locate a Radio Tower.
    A. What is the location in the Land Grid System?____
    B. What is the elevation of the tower?_____________________________
    C. Is this the highest elevation on the map?__________________________
    D. What is the symbol for a Radio Tower?___________________________

4. Locate Burgiss Knob. What is the relief from the top of Burgiss Knob south into Still Hollow?____



Contour interval = 40 ft.

Appendix 2
Sedimentary Rocks

Sedimentary Rocks

Sedimentary rocks are made up of materials derived from preexisting rocks by physical erosion or chemical weathering.

Physical erosion occurs by water, wind and ice and produces clay, silt, sand, and gravel which can become cemented together to form detrital or clastic sedimentary rocks.

Chemical weathering is the process of alteration of rocks by water which places certain elements and compounds in solution. In time, elements in solution can be precipitated to form chemical sedimentary rocks. Some clay minerals can be carried away to be deposited somewhere else as a detrital rock called shale.

Sedimentary rocks

Sedimentary rocks are classified according to the size and composition of their grains. Definitions of the grain sizes are listed below.

Gravel – grains are large and easily seen with the naked eye and consist of grains larger than sand such as pebble, granules or cobbles.

Sand – grains from the size of a match head and down to the size of a pinhead. Feels like sandpaper to the touch.

Silt – The upper size limit is approximately the smallest size that can be distinguished with the unaided eye. Gritty if chewed.

Clay – Cannot see grains with the unaided eye. Smooth, sticky when wet. Pasty if chewed.

Chemical and Biochemical or Organic Sedimentary rocks

Chemical sedimentary rocks are crystalline sedimentary rocks that form by precipitation of inorganic materials from water. Limestone forms from chemical precipitation of aragonite or calcite. A lime mud formed in shallow seas becomes a rock called micrite. Chert forms by precipitation of fibrous varieties of quartz or by chemical alteration of opal.

Biochemical or organic sedimentary rocks form as a result of organic processes. They include peat and coal made of plant fragments and skeletal limestone which is made up of animal shells or skeletons.

Sedimentary rocks in Arkansas

Conglomerate

Sandstone

Shale

Limestone

Novaculite

Chert

Bauxite

Dolostone

Chalk

Varieties of Limestone in Arkansas

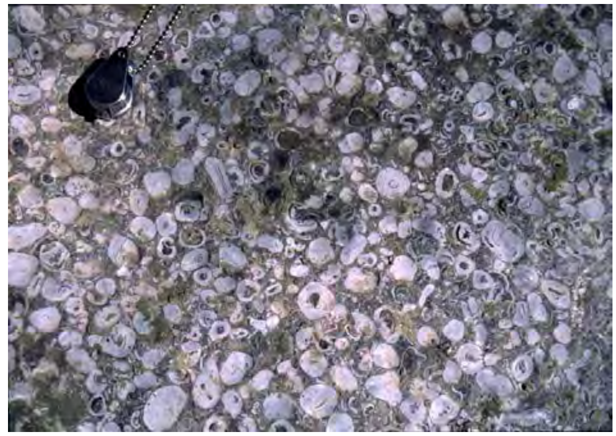
Coarsely crystalline limestone

Crinoid fragments in a fine grained matrix

Brachiopod limestone

Crinoidal limestone

Oolitic limestone



Oncolitic limestone

Fine-grained limestone also called a micrite

Sediments and sedimentary rocks make up 99.9 % of surface materials in Arkansas.

Uses of some sedimentary rocks

Bauxite – the principal commercial source of aluminum
Limestone – used as crushed stone and agricultural limestone; mined for cement and as a source of lime; quarried as a decorative stone.
Sandstone – used as rock aggregate and for building stone.
Novaculite – used as oilstones or whetstones and as a high silica source material.
Dolostone – used as rock aggregate and for building stone.
Coal – used to generate electricity. Other uses include coking coal for steel manufacturing and industrial process heating.

Classification of Chemical and Organic Sedimentary Rocks

(rocks in red are from Arkansas)

Composition	Comments	Grain-size	Name
Mainly calcium carbonate, $CaCO_3$	shells or shell fragments well cemented to form dense rock	gravel	Calcirudite
		sand	Calcarenite
		silt	Calcisiltite
		clay	Micrite
	shells or shell fragments poorly cemented to form porous, earthy rock	gravel	Coquina
		sand	Calcarenite
		silt and clay	Chalk
	spherical grains with concentric laminations	<2mm	Oolitic Limestone
	crystals formed as inorganic chemical precipitates	coarse-grained to fine-grained	Crystalline Limestone
		very fine-grained	Micrite
Mainly dolomite $CaMg\ (CO)_3$	commonly altered from limestone	all sizes	Dolostone
Mainly varieties of quartz (flint, jasper, etc.)	layers, lenses or nodules	microcrystalline or amorphous	Chert
	very hard and brittle	sub-microcrystalline	Novaculite
Mainly halite	crystals formed as inorganic chemical precipitates	all sizes	Rock Salt
Mainly gypsum	crystals formed as inorganic chemical precipitates	all sizes	Rock Gypsum
Mainly plant fragments	brown and porous	all sizes	Peat
	black and non porous	all sizes or dense with conchoidal fracture	Bituminous Coal
Mainly gibbsite and boehmite	contains round grains called pisolites	varies in size	Bauxite

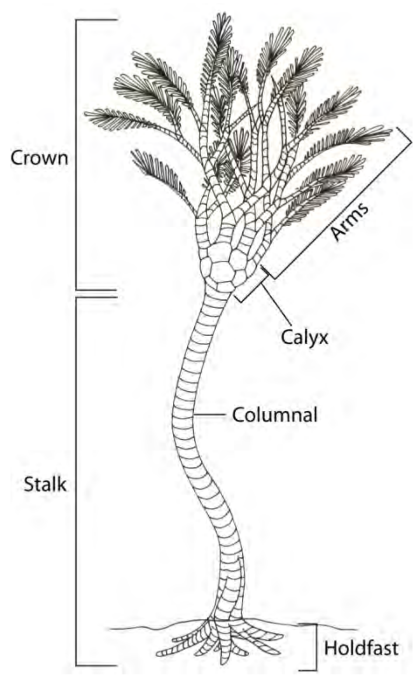
Classification of Detrital Sedimentary Rocks (samples in red are from Arkansas)				
Composition	Grain-size Class	Comments	Name	
Mainly quartz feldspar, rock fragments, and clay minerals	gravel (>2mm)	rounded grains	Conglomerate	
		angular grains	Breccia	
	sand (0.0625 - 2.00, or 1/16 - 2,mm)	mostly quartz grains	Quartz Sandstone	Sandstone
		mostly feldspar grains	Arkose	
		mostly rock fragments	Lithic Sandstone	
		mixed with much silt and clay	Wacke	
	silt 1/256-1/16 mm	nonfissile (compact)	Siltstone	Mudstone
		fissile (splits easily)	Shale	
	clay 1/256 mm	nonfissile (compact)	Claystone	
		fissile (splits easily)	Shale	

Appendix 3
Fossil Description
And
Fossil Exercise

Crinoids

The most common fossil found at this locality is the crinoid.

Crinoids are a group of marine invertebrates in the Echinoderm Phylum. These animals are organized in patterns of five so that crinoids may have as few as five arms but they usually have arms in multiples of five. Crinoids resemble plants and are sometimes called “sea lilies” (Fig. 2). Most of today’s living forms are stemless and live in clear shallow water down to about 200 m (sublittoral zone), although some are attached by a stem and live in quiet deep water, from 200 to 4000 m, in the bathyal zone. Crinoids are most common in Paleozoic rocks worldwide and in Arkansas are abundant in Late Ordovician and Mississippian age rocks. It is unusual to find a complete crinoid fossil; however, pieces of the stalk (commonly called stem or column) are abundantly preserved in the rocks in Arkansas.

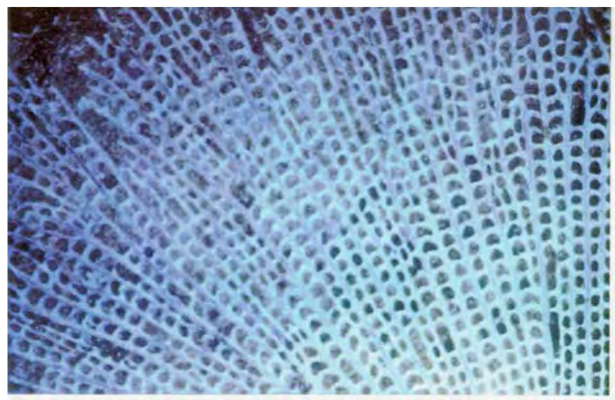


The crinoid animal. Illustration by Sherrie Shepherd.

Bryozoans

Bryozoans are tiny colonial marine animals that are also present in marine and fresh water today. They are sessile benthonic animals (fixed to seabed) and prefer shallow seas, living fairly close to shore (neritic). One bryozoan called *Archimedes* (see picture below) is abundant in Mississippian age rocks in Arkansas and is so plentiful that one of the rock formations now called the Pitkin Limestone was once referred to as the "*Archimedes* Limestone". Generally, only small pieces of bryozoans that resemble "fronds" are preserved in Mississippian and Pennsylvanian age rocks in the Ozark Plateaus Region. Bryozoans are commonly associated with reef structures.

Archimedes bryozoa

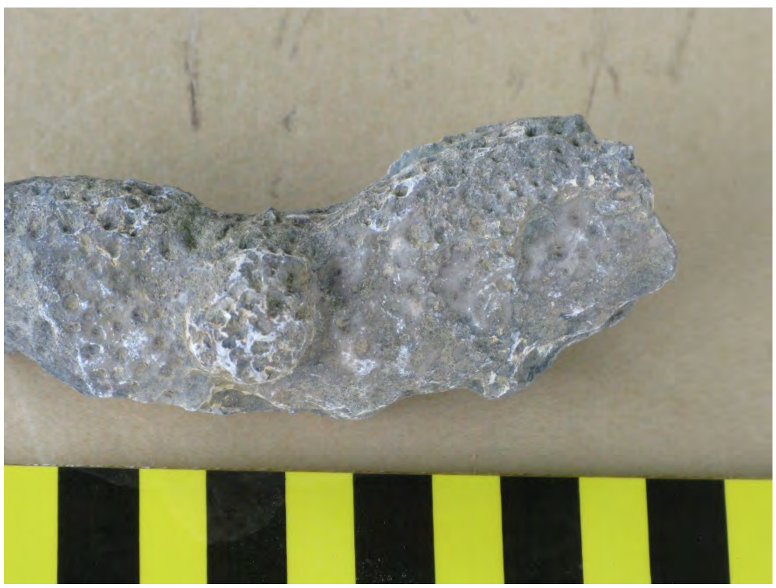


Bryozoan "fronds".

Corals

Corals are marine animals that live either in colonies or alone (solitary). In the colonial corals, numerous polyps (individual animals) construct and inhabit a common skeleton, whereas in the solitary corals each polyp constructs its own individual skeleton. In either case each polyp's "house" (or *corallite*) may be partitioned radially by *septa*, or transversely by *tabulae*. Corals grow attached to the sea floor, and many have been and continue to be, important reef builders. Colonial corals are present in Ordovician through Pennsylvanian formations in north Arkansas.

Rugose coral (left) and tabulate coral colony (right) from the Mississippian Pitkin Limestone.



Michelina, a colonial coral, from the Pennsylvanian Brentwood Limestone.

Nautiloids

Nautiloids are cephalopods that built a hard outer shell like that of the modern chambered Nautilus. They can have straight or coiled shells. Nautiloids have an inner chamber called a siphuncle that is positioned in the center or sub-center of the animal. The siphuncle was used to empty water from the chambers as the animal grew. The animal could also maintain buoyancy in the water by emptying water from the chambers. This allowed it to swim with less effort. The majority of nautiloids are preserved in Ordovician through Mississippian age rocks in Arkansas. The only living representative of this group is the genus Nautilus which lives in the deep slopes along coral reefs in tropical waters of the Indo-Pacific.

Ordovician nautiloid from the Fernvale Limestone (left). Mississippian nautiloid from the Fayetteville Shale (right).

Mississippian nautiloid showing central siphuncle.

The following fossils may be discovered from Richland Creek, Arkansas.

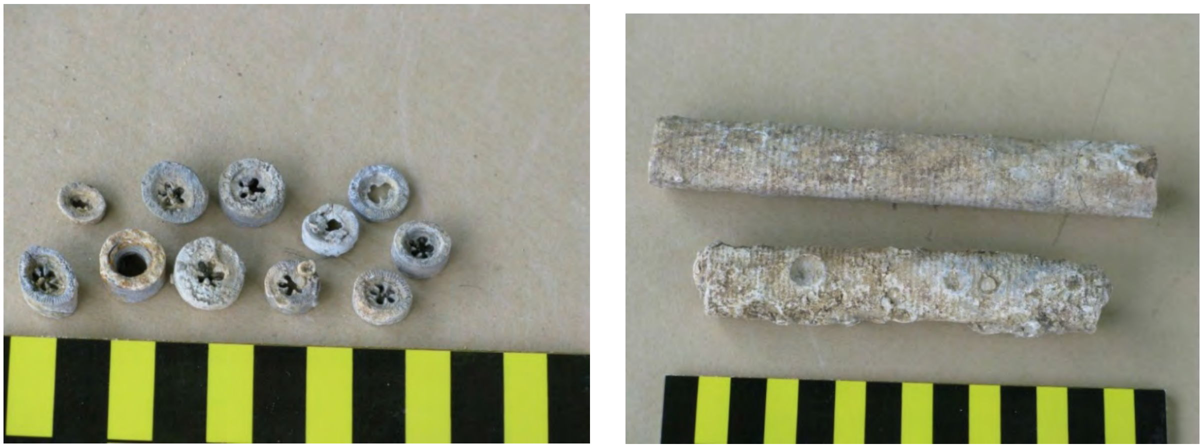


Figure 4. Crinoid "buttons" (left) and columnals from Huff, Arkansas (right).

Figure 5. Rugose coral (left) and the bryozoan *Archimedes* (right).

Figure 6. Rugose corals (left) and nautiloids (right).

Data to be recorded when collecting fossils:

Date:______________________________

Location:____

Geologic formation:____

Fossils: ____

NOTES____

Date:

Location:

Geologic formation:

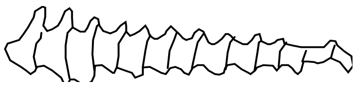
Fossils:

NOTES

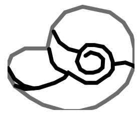
Fossils and Geologic Time Exercise

Use the fossil symbols, descriptions and geologic time scale to answer the questions in the Activities section.

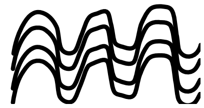
Fossil list



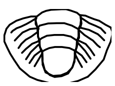
A. This *Archimedes* bryozoan is abundant in the Pitkin Formation and is Upper Mississippian age.



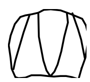
B. This goniatite ammonoid is present in the Fayetteville Formation and is Middle Mississippian age.



C. These stromatolites are present in the Everton Formation and are Middle Ordovician age.

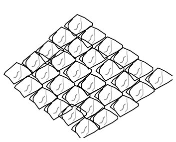


D. This trilobite is present in the Collier Formation and is Cambrian age.

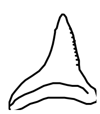


E. This blastoid is present in the Brentwood Limestone and is Lower Pennsylvanian age.

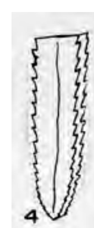
F. Crinoids like this are abundant in the St. Joe Limestone and are Lower Mississippian age.



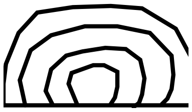
G. *Lepidodendron* fossils like this one are present in the Hartshorne Sandstone and are Middle Pennsylvanian age.



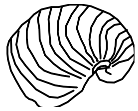
H. Shark teeth are present in the Midway Group and are Tertiary age.



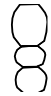
I. Graptolites are present in the Mazarn Shale and are Lower Ordovician age.



J. Small algal “rounds” like these are found in the Lafferty Limestone and are Silurian age.



K. Oysters like this *Exogyra ponderosa* are found in the Marlbrook Marl and are Cretaceous age.



L. These unique barrel shaped crinoid columnals are present in the Fernvale Limestone and are Upper Ordovician age.

Activity 1

Using the Geologic Time Scale put the letter of the fossils from the fossil list in order by relative age from oldest to youngest.

_________ youngest

____

____

____

____

____

____

____

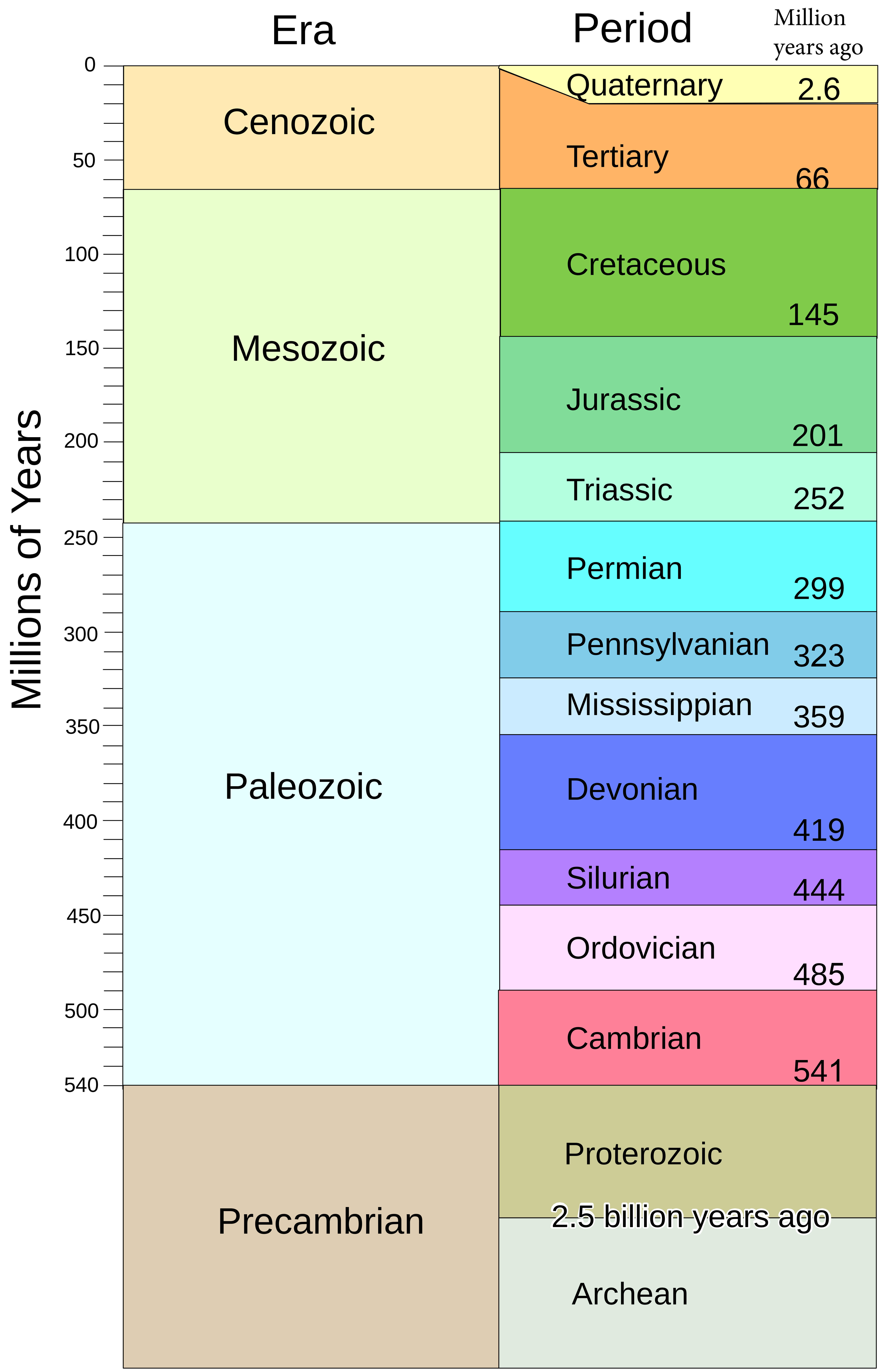
____

____

____

_________ oldest

Geologic Time Scale



Based on 2012 Geologic Time Scale
Geological Society of America