EWS-05

STATE OF ARKANSAS

ARKANSAS GEOLOGICAL SURVEY
BEKKI WHITE, DIRECTOR AND STATE GEOLOGIST

EDUCATIONAL WORKSHOP SERIES 05

Karst "Old and New" along the Buffalo National River

Angela Chandler

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. The majority of information used in this guidebook was gathered through fieldwork conducted from July 2009 to April 2011 at the Arkansas Geological Survey through a contract with the National Park Service. Special thanks to the National Park Service and to Shepherd of the Ozarks for providing a spectacular lodge for the teachers.

Special thanks to the teachers throughout the state and Science Specialists in Arkadelphia for requesting this workshop. Without you, there would be no need for the workshop!

For information related to this manual please contact Angela Chandler: 501-683-0111

www.geology.arkansas.gov

Arkansas Geological Survey
3815 W Roosevelt Rd
Little Rock, AR 72204
501-296-1877

Front cover images: upper left – sinkhole in St. Peter sandstone, Buffalo Point, AR
upper right – Boiling Springs, Rush District, AR
lower left – St. Peter/Everton contact, Buffalo National River, Buffalo Point, AR
lower right – lead and zinc mine, Rush District, AR

Educational Workshop Series 05 – Karst Old and New along the Buffalo National River

This is a three day fieldtrip in the Buffalo National River area. The theme of this workshop is Karst – Old and New. The "old karst" is a reference to paleokarst at the contact of the St. Peter and Everton Formations and paleokarst breccias that host the lead and zinc mineralization. The "new karst" pertains to recent karst features and landforms in the area such as springs and sinkholes. The first day we will look at the historic Rush Mining District. The second day will feature a geologic float trip on the lower end of the Buffalo National River while the third day focuses on karst features along the Indian Rockhouse Trail at Buffalo Point. The following frameworks in Earth and Space Sciences will be addressed.

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

8.4.1 – Locate the Ozark Plateaus Region – specifically the Salem Plateau Region

9.4.1 – Analyze changes to the Earth's Surface through erosion and weathering of carbonate terrain – identify karst landforms such as sinkholes, springs and caves.

8.5.5: 8.5.6 – Identify the following minerals found in Arkansas – calcite, dolomite, galena and sphalerite.

8.8.7 – Use topographic maps to identify surface features of Earth

9.8.2 – Analyze how rock sequences may be disturbed by the following: erosion and deposition – paleokarst – lead and zinc bearing breccias etc.

Geologic Setting

This workshop is located in the Ozark Plateaus region, particularly the Salem Plateau region of north-central Arkansas. The Ozark Plateaus region is located on the edge of a broad, asymmetrical dome (or uplift), with the center of the dome (oldest rocks; Precambrian basement) located 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 this dome.

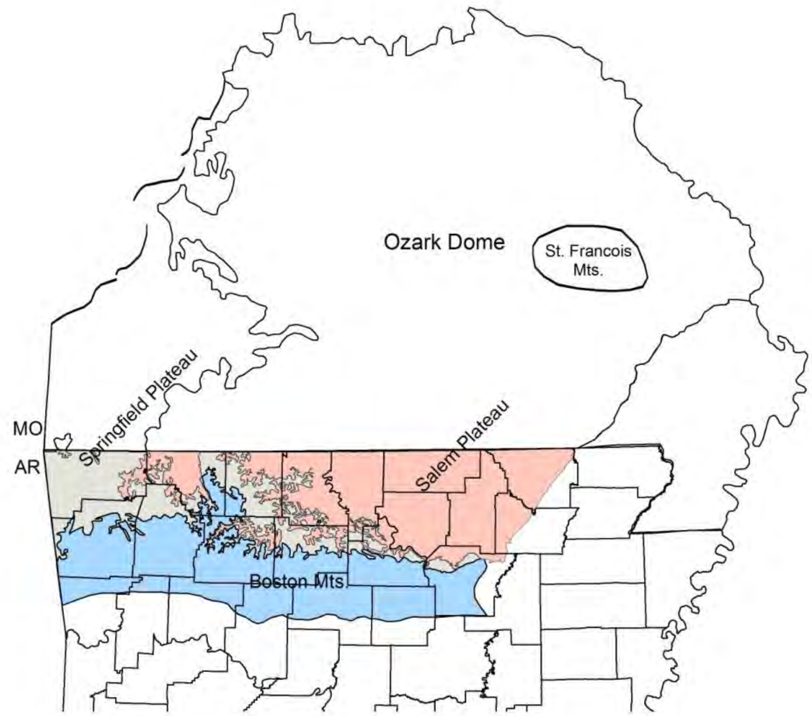

Figure 1. Plateau surfaces in the Ozark Plateaus region showing location of Ozark Dome.

This part of the state was periodically covered by shallow marine seas from Ordovician through Mississippian geologic periods. Mostly carbonate rocks such as limestone and dolostones were deposited at this time. As the sea regressed during the Pennsylvanian period, mostly sandstones and shales were deposited. The rock layers in the Ozarks are only very weakly deformed and generally flat lying. The rocks in this portion of the state have been exposed to weathering and erosion for approximately 290 million years. The Ozark plateaus have been deeply dissected by stream erosion leaving erosional mountains. Streams display a dendritic drainage pattern.

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 age rocks, mostly dolostone*

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

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

The plateaus become progressively higher in elevation and expose younger rocks from north to south in the Ozarks of Arkansas.

Even though this workshop will focus mainly on the Salem Plateau region, the Springfield Plateau is also present on the higher hills in the area. The Salem Plateau is made up of Ordovician age rock formations called the Cotter and Jefferson City Dolomites, the Powell Dolomite, the Everton Formation and the St. Peter Sandstone. We will focus on the St. Peter Sandstone and Everton Formation (Fig. 2) on the Salem Plateau. These rock layers consist of dolostone, limestone and sandstone with minor amounts of chert. The Springfield Plateau surface is primarily the Mississippian-age rock formation called the Boone Formation (Fig. 2). The Boone Formation consists of interbedded chert and limestone. At the base of the Boone Formation is a red crinoidal limestone called the St. Joe Limestone Member. In the deep drainages in the area, along the escarpment between the two plateau surfaces, older rock formations such as the Plattin Limestone (Fig. 2) are exposed.

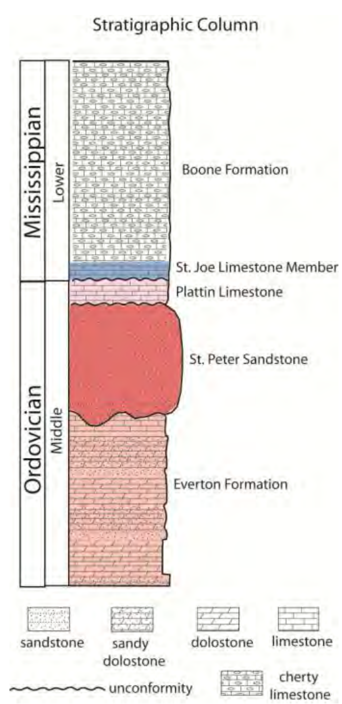

Figure 2. Stratigraphic column for fieldtrip area.

Deposition of rock formations - ***Middle Ordovician to Late Ordovician – 472-444 million years ago***

The Ordovician period is probably best known as a time of high sea level, although there were periods of relatively low sea level as can be seen by unconformable surfaces in the rock record. Carbonate deposits accumulated in shallow seas and on tidal flats over large areas of what is now the United States. There were areas west and north of Arkansas called the Canadian Shield (Fig. 3) and Transcontinental Arch (Fig. 5) where the continent was exposed and eroded. Deposition of the Everton Formation occurred on very low angle slopes in a shallow sea that was periodically exposed to create barrier islands, lagoons and intertidal to supratidal flats (Fig 4). The tidal flats consisted of broad lime mud sand several feet above mean high tide and were usually covered by stromatolites. Quartz sand was brought into the sea by rivers from the Canadian Shield to the north (Fig. 3). It was distributed by long-shore currents which built barrier islands much like the present-day Gulf Coast barrier islands.

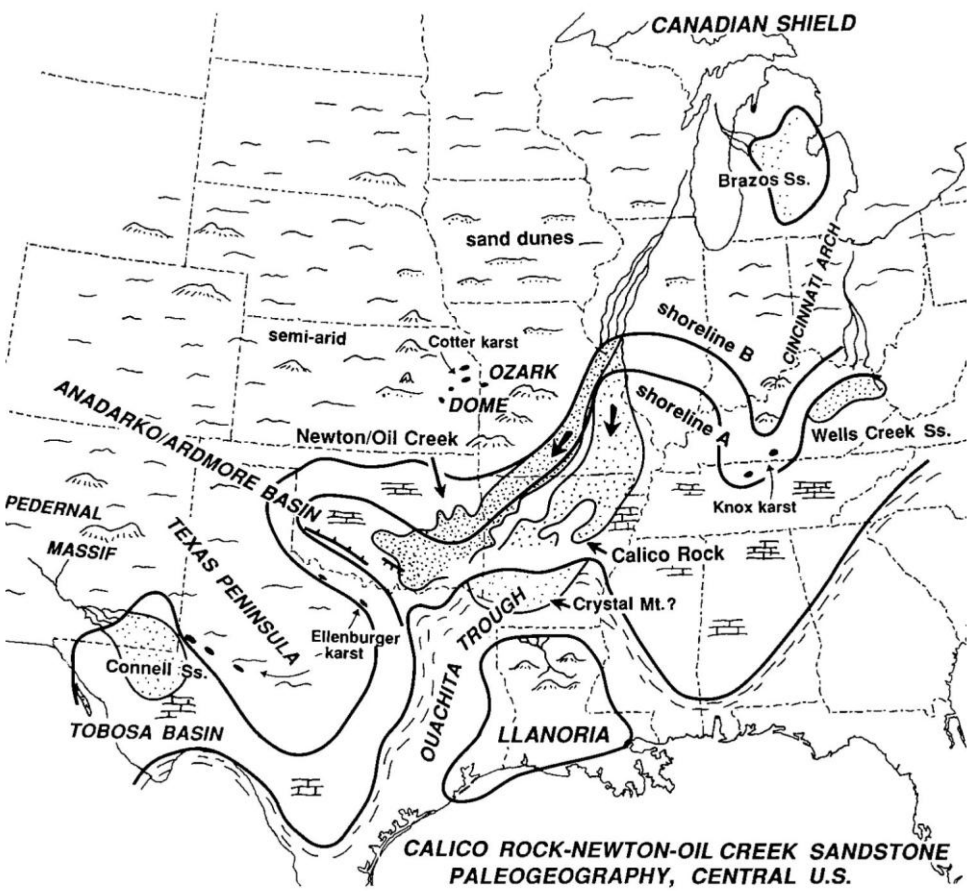

Figure 3. Paleogeographic map showing source of sands for Calico Rock Sandstone Member of the Everton Formation. *From Suhm, 1977.*

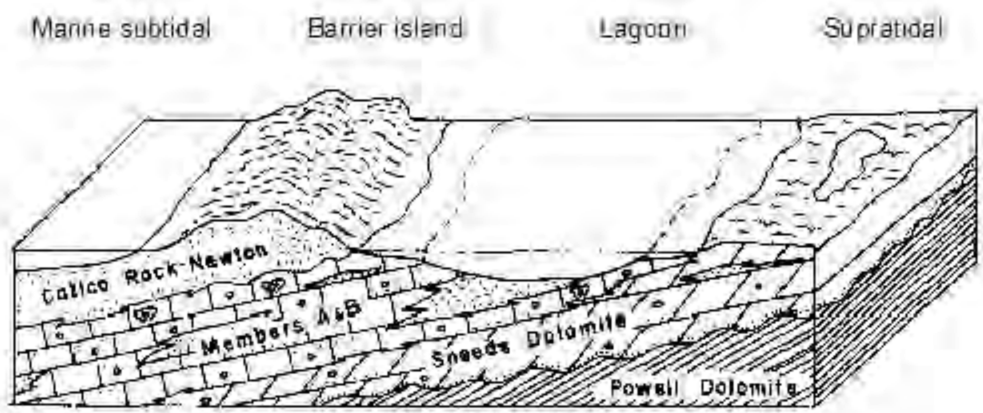

Figure 4. Sedimentary sequence showing environments of deposition, oceanward (left) to continent (right) for Everton Formation. *From Suhm, 1977.*

Description of rock formations

Plattin Limestone – This limestone is named for exposures near Plattin Creek, Jefferson County, Missouri (Keroher et al., 1966). It is a thin- to thick-bedded micritic (fine-grained) limestone. The Plattin Limestone is unconformable with the underlying St. Peter Sandstone in this area.

St. Peter Sandstone – This sandstone is named for exposures on the St. Peter River, now called Minnesota River, in southern Minnesota (Keroher et al., 1966). It is mostly a fine- to medium-grained clean sandstone with rounded quartz grains. It is thin- to medium-bedded and is commonly friable. The sandstone contains vertical trace fossils referred to as *Scolithos* by Adams et al. (1904), that weather to resemble icicles in cross-section view. The St. Peter Sandstone forms a prominent bluff-line in the area and is unconformable with the underlying Everton Formation.

Everton Formation – The Everton Formation is named for exposures near the town of Everton in Boone County, Arkansas. This formation consists of interbedded sandy dolostone, sandstone and limestone. A stromatolitic very thin-bedded fine-grained limestone is present at the top of the formation throughout the fieldtrip area. Springs are abundant in this unit.

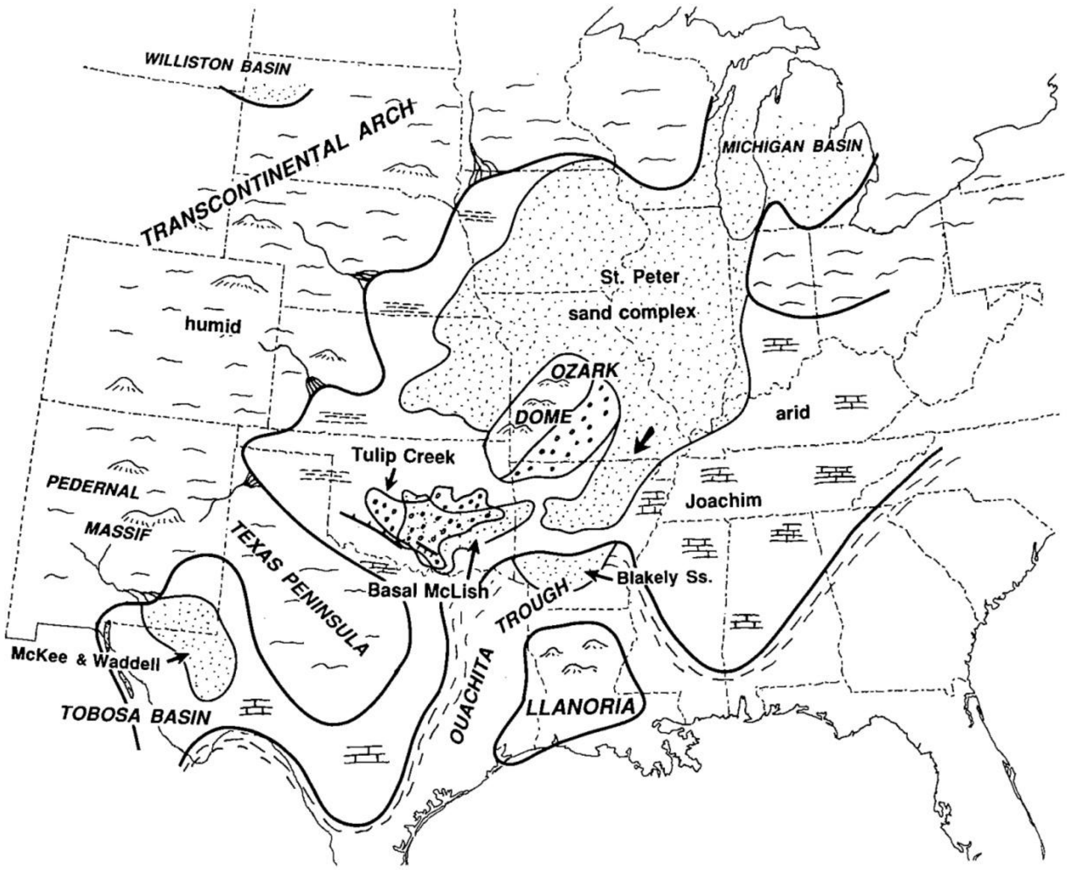

Figure 5. Paleogeographic map showing deposition area of St. Peter Sandstone. *From Suhm, 1977.*

Formation of paleokarst and regional unconformities – Middle Ordovician

Paleokarst is a rock or area that has been karstified and subsequently buried under sediments. At the contact of the St. Peter Sandstone and the Everton Formation an unconformity is present. This unconformity is regionally exposed in the central United States from the Great Lakes area to Texas. After deposition of the Everton Formation the sea that covered much of what is now the central part of the United States retreated and exposed the limestones that had been deposited. These limestones were exposed to erosion for up to tens of millions of years, during which an extensive karst surface developed (Palmer, 2011). This is evidenced by the tens of feet of relief at the unconformable contact and paleokarst that is present at various localities. Other paleokarst features include breccias within the Everton Formation that contain the lead and zinc mineralization. It is thought that these breccias formed by solution collapse of cave systems within the formation.

Another unconformity exists above the St. Peter Sandstone. At various localities the Middle Ordovician Plattin Limestone is present above the St. Peter Sandstone while at other localities the Mississippian St. Joe Limestone is present. When the St. Joe Limestone is present directly above the St. Peter Sandstone there is a major unconformity present with the Upper Ordovician, Silurian and Devonian formations missing. These formations are missing either due to erosion or non-deposition.

Deposition of rock formations - Lower Mississippian-359-345 million years ago

During the Mississippian Period northern Arkansas was covered by shallow marine seas on a southward gently sloping shelf. The St. Joe Limestone Member was deposited in fairly shallow water where abundant marine animals such as crinoids and bryozoa lived. The Boone Formation was deposited farther down the shelf in deeper water conditions. It is thought the origin of the chert is from remains of siliceous radiolarians and sponges.

Description of rock formations

Boone Formation – The Boone Limestone was named by J.C. Branner for Boone County, Arkansas where cherts and cherty limestones form the dominant rock types in the region (Penrose, 1891). The Boone Limestone consists of coarse-grained fossiliferous and fine-grained gray limestones interbedded with anastomosing and bedded chert. The chert varies in color from white to light gray in the upper portion to dark gray or blue gray in the lower portion. Fairly chert-free sections are petroliferous and contain brachiopods, corals and crinoids.

St. Joe Limestone Member - The St. Joe Limestone was named for the village of St. Joe, Arkansas by J.C. Branner, where it was first studied by the Arkansas Geological Survey (Hopkins, 1893). It consists of medium to coarsely crystalline and fine-grained thin-bedded limestone. The limestone is usually reddish gray in color and contains abundant crinoid columnals. This limestone varies from 2-15 feet in the area.

Lead and zinc mineralization – Pennsylvanian to Permian

During the Pennsylvanian Period the majority of northern Arkansas was exposed to weathering. At that time, around 310 million years ago, plate tectonics began to shape what is now Arkansas (Fig.6). The continents of Laurasia and Llanoria began to collide, pushing together a large mass of material. This collision lasted well into the Permian Period and caused the rocks to be folded, faulted and uplifted in the Ouachita Mountains region. It is thought that migration of warm mineral-rich fluids expelled by the pressure of the orogenic event is responsible for the mineralization in northern Arkansas.

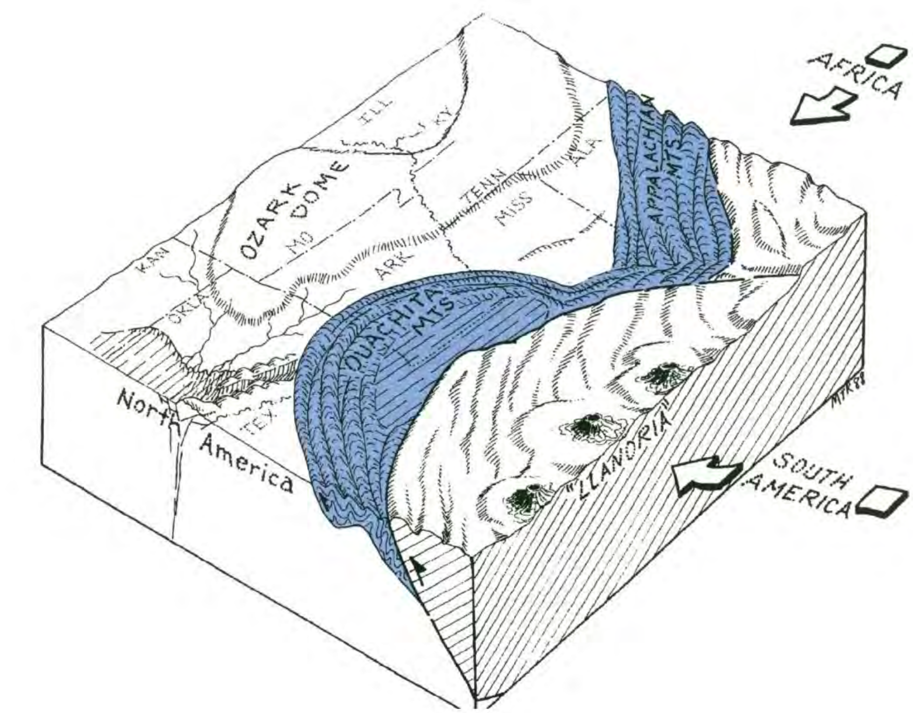

Figure 6. Middle Pennsylvanian paleogeography of Arkansas showing the collision of Laurasia and Llanoria and formation of the Ouachita Mountains. *From Guccione, 1993*.

Introduction and following paragraphs from Zinc and lead deposits of northern Arkansas by Edwin T. McKnight, 1935:

"Zinc and lead ores occur in the northern counties of Arkansas from the Arkansas-Oklahoma line on the west to the Coastal Plain, in Lawrence County, on the east, but are concentrated chiefly in Marion, Boone, Newton, Searcy, Sharp and Lawrence Counties. Lead ore was reported in the region as early as 1818, and small reduction plants were built in the vicinity of Lead Hill in 1851 or 1852. The Confederate forces obtained lead from northern Arkansas during the Civil War. Zinc mining began at a somewhat later date and reached its peak between 1914 and 1917, but since that time mining has been at a low ebb. The later history of lead mining in the region has closely paralleled that of zinc. The production from the region since 1907, according to statistics compiled by the United States Geological Survey, has been in round numbers, 1900 tons of lead sulphide concentrates, 11500 tons of zinc sulphide concentrates and 51300 tons of zinc carbonate and silicate concentrates."

The deposits in the Rush Creek district occur mainly in limestone and dolostone in the Everton Formation. The majority of the mines lie at the same stratigraphic position – approximately 160 feet below the St. Peter Sandstone. The ore shipped from the district has been mainly carbonate. Statistics on production of the district are incomplete but an estimate of 26,000 tons was considered conservative in 1935. The Rush Creek District produced far more than any other district in northern Arkansas.

The Morning Star mine was the first zinc property developed west of Sharp and Lawrence Counties. Prospecting began in 1880. After several months of developing the ore an assay was made which erroneously reported the ore to carry silver. Two smeltermen were brought in and a small rock smelter was built in 1882. The restored remains of the smelter still stand at Stop 1 as described in the Rush Historic District pamphlet published by the Buffalo National River.

The Morning Star mine was famous for the large masses of botryoidal smithsonite that came from it. A specimen weighing 12,750 pounds was displayed at the Chicago Worlds's Fair in 1893. The specimen was hauled by team from the mine to Buffalo City on the White River where it was taken by barge to the railroad at Batesville.

Formation of karst – present day (from Encyclopedia of Arkansas)

Karst Topography

Karst topography refers to natural features produced on a land surface due to the chemical weathering or slow dissolving of limestone, dolostone, marble or evaporite deposits such as halite and gypsum. The chemical weathering agent is slightly acidic groundwater that begins as rainwater. 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 now acidic groundwater, moves through fractures (cracks) and open spaces within rocks. Solution occurs as carbonic acid in groundwater dissolves calcite, which is the principal mineral in limestone and marble and an important mineral in dolostone. Halite and gypsum are easily dissolved in water alone. The region in Arkansas most well known for karst topography is the Ozark Plateaus (sometimes called the Ozark Mountains).

Features of karst landscapes include caves, springs, disappearing streams and dry valleys and sinkholes. Acidic groundwater moves through fractures and spaces within the rock, slowly dissolving and enlarging spaces to create larger openings and connected passages. Caves occur as natural open spaces underground, generally with a connection to the surface and large enough for a person to enter. Underground passages allow groundwater to travel long distances and re-appear as springs. Springs occur where ground water flows naturally from bedrock or soil onto the land surface or into a body of surface water. On the surface a stream can disappear into the subsurface through fractures and passageways and travel underground for some distance before re-appearing downstream or discharging as a spring elsewhere. These streams are called disappearing streams. In areas where the stream is mostly dry year round the valley is called a dry valley. Dry valleys are valleys devoid or almost devoid of running water and are common in areas underlain by carbonate rock with underground drainage. Sinkholes commonly occur as bowl or funnel-shaped depressions and usually are the surface expression of underground drainage. Sinkholes form by solution, solution subsidence and collapse. Solution sinkholes form as water infiltrates fractures in rock dissolving and enlarging them. A gradual settling or lowering of the surface takes place forming a depression. When carbonate rock is overlain by an insoluble rock such as sandstone, the underlying carbonate rock can undergo solution producing a void. This causes the overlying sandstone to subside into the void producing solution subsidence sinkholes. Collapse sinkholes form when strata overlying a cave chamber collapse into the chamber.

The majority of surface rocks in the Ozark Plateaus region of northern Arkansas are limestone and dolostone, and the region contains all of the features typical of a karst landscape. Thousands of caves and hundreds of springs are present in this region. Disappearing streams and dry valleys are common in the Salem and Springfield Plateau regions. The Salem Plateau surface is primarily underlain by dolostone in the Everton, Cotter and Powell Formations. Located in this region is the largest spring in Arkansas – Mammoth Spring, with an average discharge rate of 150,000 gallons per minute. Solution sinkholes occur in dolostones in the Cotter, Powell and Everton Formations. Solution subsidence and collapse sinkholes are present where a thin veneer of the St. Peter Sandstone overlies the Everton Formation. Approximately twenty percent of the caves in Arkansas occur in this region. The Springfield Plateau surface is underlain by limestone in the Boone Formation. The Boone Formation contains the majority of karst features throughout the Ozark Plateaus region and contains more than fifty percent of the caves in the state. Solution and collapse sinkholes are abundant in the Boone Formation. Solution subsidence and collapse sinkholes are also present where a thin covering of Batesville Sandstone overlies the Boone Formation. The Joachim Dolostone and Plattin, Kimmswick, and Fernvale Limestones are present along the escarpment between the Springfield and the Salem Plateau surfaces. Approximately five percent of the caves in Arkansas occur in these formations combined. The Boston Mountains Plateau surface consists of mostly sandstone and shale in the Atoka Formation which is not susceptible to karst features. Approximately ten percent of the caves in the state occur in the Brentwood Limestone and the Prairie Grove Member of the Hale Formation in this region. In deep drainages and along the escarpment of the plateau, the Pitkin Limestone is present and contains hundreds of caves and springs.

A portion of the West Gulf Coastal Plain is underlain by thin beds of limestone, chalk, a variety of limestone, and gypsum. Numerous springs are present and one cave is reported from this region.

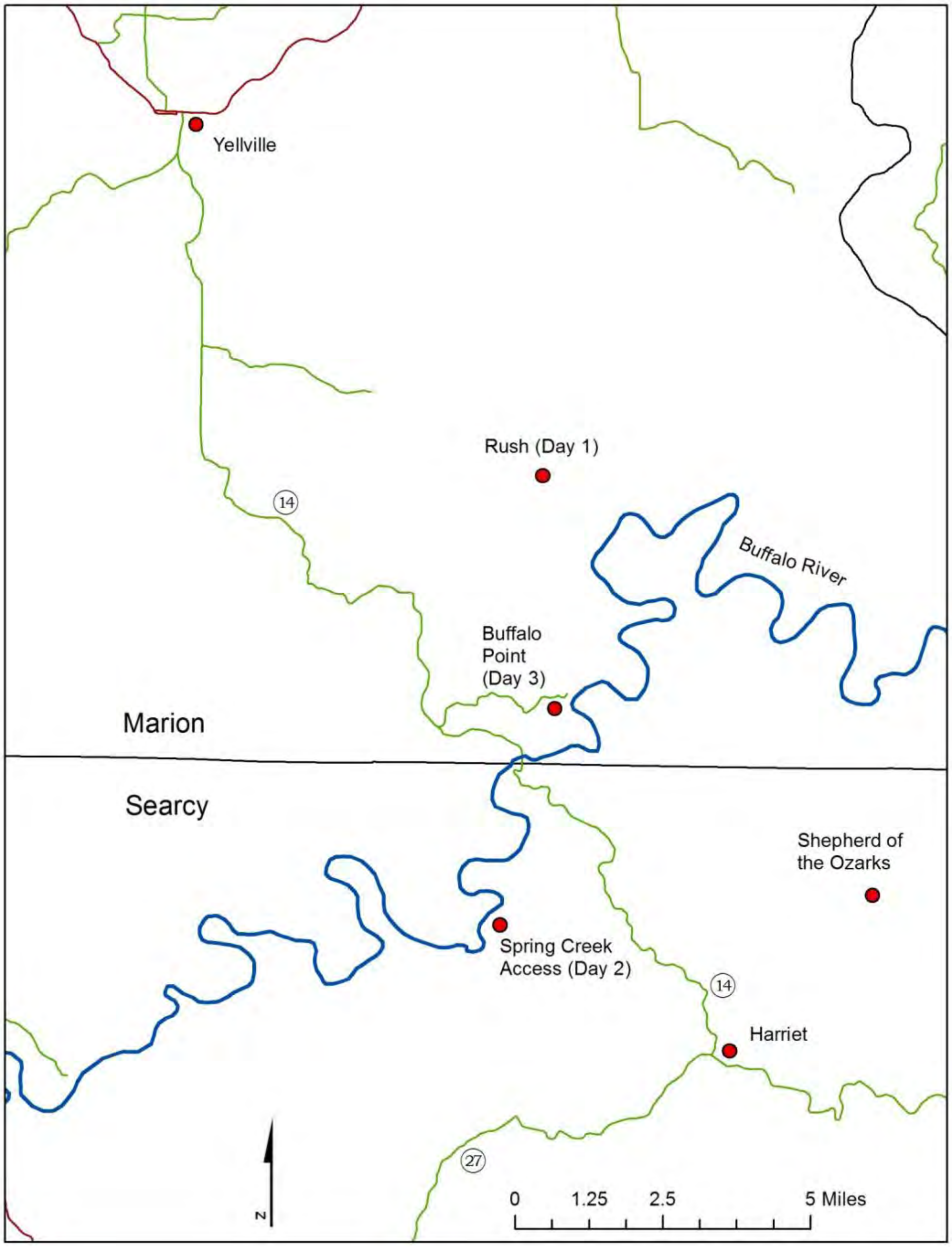

Figure. 7. Map showing locations for fieldtrip.

DAY 1 – Rush – Lead and Zinc Historic Mining District

Figure 8. Sphalerite (left), the ore of zinc and dolomite (right) can be found in the old mines.

Use the Rush Historic District Tour Pamphlet for this day.

Stop 1 – Lead and Zinc Mines (Site 5 in Rush Historic District Tour Pamphlet)

We will start off by walking the hiking trail up to the mine level above the Morning Star Area. As we walk up to the mine level you will see tailings from a processing mill that was once located here. All of the mines are located in the Everton Formation. Note the rock type in which the mines are located. Look around for minerals such as sphalerite, quartz and dolomite.

Figure 9. Zinc mine in Rush, Arkansas.

Figure 10. Quartz mineralization at zinc mine.

Stop 2 – Stromatolites in Everton Formation (Along Mine Level Trail)

Stromatolites are laminated structures built by blue green algae (also called cyanobacteria); one of the simplest and earliest known life forms. Basically, each layer of algae contains sticky cells that trap sediment when washed over its surface. As sediment accumulates the algal layer grows through and over the sediment to the top to trap more sediment. Stromatolites form small or large round structures called "heads". They can also form vertically stacked flat or wavy sheets (layers) depending on the amount of water energy in the environment. Stromatolites are abundant in the Everton Formation and indicate a shallow intertidal environment of deposition.

Figure 11. Wavy stromatolites (left) in cross section and stromatolite heads (right) from above.

Stop 3 – Boiling Springs along Rush Creek (Site 10 in Rush Historic District Tour Pamphlet)

A spring is a place where ground water flows naturally from a rock or soil onto the land surface or into a body of water. Its occurrence depends on the nature and relationship of three main variables: the permeability of the rock, the position of the water table and the topogaphy of the area. The main spring is located next to the road to Rush Landing. Although the volume of the spring varies, flow is constant. That along with the "bubbling or boiling" aspect suggests this spring has artesian flow. An artesian spring is a spring that flows through a fissure or other opening in a confining body of rock from an underlying aquifer.

This spring is located in the Everton Formation. There is a fault that passes just south of this spring that may allow a passageway for the confined water to travel to the surface at this location.

Follow the trail to the creek and look for more artesian springs in the creek.

Figure 12. Boiling spring (Site 10) along road. The spring flows into Rush Creek.

DAY 2 – Geologic Float from Spring Creek to Buffalo Point

Figure 12. Locality map for Buffalo River float trip.

Stop 1 – St. Peter/Everton contact in bluff line above river.

At this location we will look at the rock formations forming the steep bluffs along the river. The base of the St. Peter Sandstone is approximately 220 feet up from river level. As we travel downstream pay attention to the elevation of the St. Peter Sandstone and note that eventually we will see it at river level. We will also compare the lithologies in the gravel bar at this stop.

Figure 14. St. Peter bluff line above Buffalo River downstream from Spring Creek.

Stop 2 – Stromatolites in Everton Formation

What type of stromatolites are located at this stop? Note the rock type.

Figure 15. Stromatolites in the Everton Formation along the Buffalo National River.

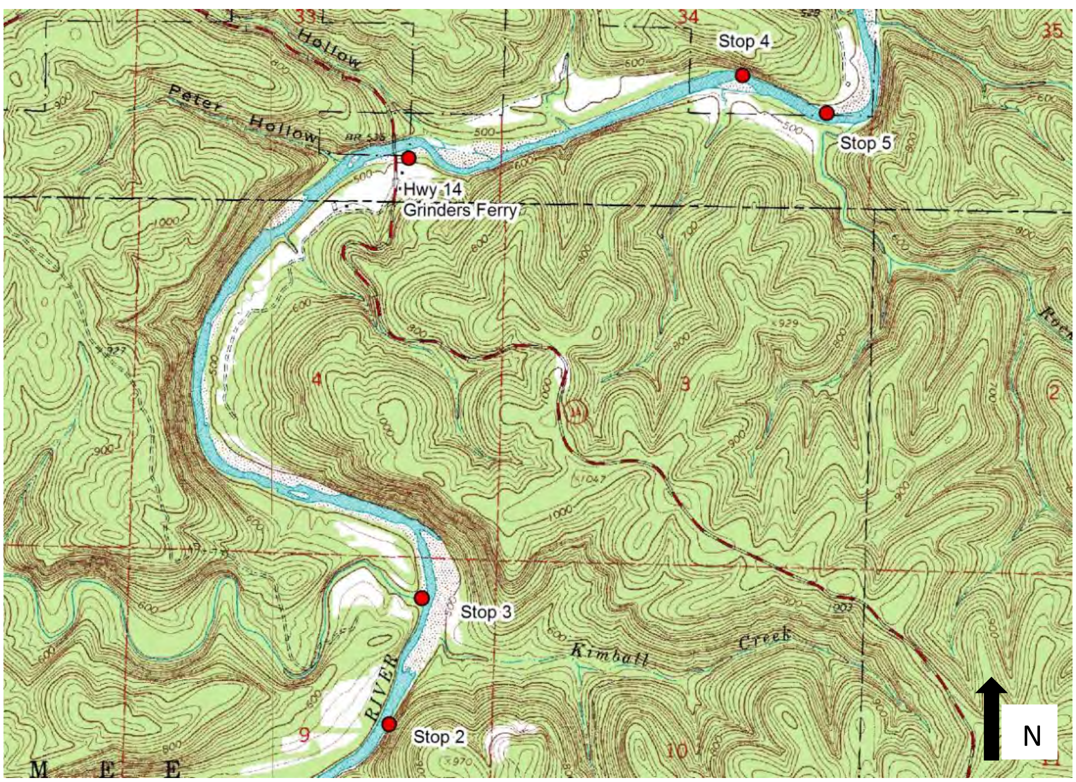

Figure 16. Fieldtrip stops 2-5 on Buffalo River float trip.

Stop 3 – Water Creek gravel bar and Everton exposures up mouth of creek

At this locality we will conduct the gravel bar experiment. This activity is located in Appendix 1.

Next we will examine Everton outcrops along the mouth of the creek. Notice the rock types at this location as well as the cross-bedding. What appear to be diagonal lines within sandstone beds is called cross-bedding. They represent the downstream movement of ripples and indicate the direction the river once flowed. Cross-beds are very abundant in sandstones and sandy carbonates that were deposited in tidal environments or by river systems.

Figure 17. Everton dolostone in Water Creek. Notice cross-bedding.

As you walk upstream in Water Creek also note the karst features present as open holes and tubes in the rock. The majority of surface rocks in the Ozark Plateaus region of northern Arkansas are limestone and dolostone and contain features typical of a karst landscape. Karst refers to natural features produced on a land surface due to the chemical weathering or slow dissolving of limestone, dolostone, marble or evaporite deposits such as halite and gypsum. Features of karst landscapes include caves, sinkholes, springs, disappearing streams and dry valleys. Thousands of caves and hundreds of springs are present in this region. Approximately 12 percent of the caves in Arkansas occur in the St. Peter and Everton Formations combined.

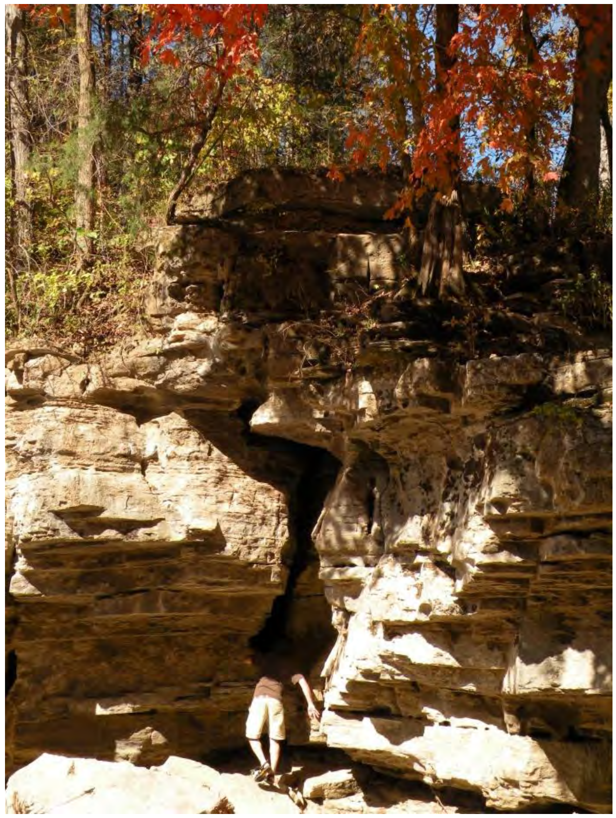
Figure 18. Solution features in Everton Dolostone in Water Creek.

Stop 4 – St. Peter /Everton unconformity above river.

We are now a few miles downstream. Notice the elevation of the St. Peter /Everton contact. Why is it so much lower here? What was the attitude of the rocks upstream? What does this imply?

Next, look at the unconformity between the two formations. An unconformity is a rock surface that represents a gap in the geologic record. An unconformity can be a surface on which no sediment was deposited or a surface where sediment has been eroded away. Unconformities range from local to worldwide. What caused this unconformity? Think about the rock type and the topography that can form on carbonate rocks.

Figure 19. St. Peter/Everton unconformity downstream from Highway 14 bridge.

Stop 5 – Skull Rock – Take out point.

This is an excellent outcrop to look at the St. Peter/Everton unconformable surface up close and personal. Examine the lithology of each formation. What are the fossils in the top of the Everton? Notice the vertical tubes in the St. Peter Sandstone. This is a good example of trace fossils called *Skolithos.* At various localities the surrounding sand will weather away leaving the tube to appear as an icicle. These trace fossils are abundant in the St. Peter Sandstone in northern Arkansas and are indicative of shallow marine deposits.


Figure 20. (left) Stromatolites in upper Everton Dolostone. (right) Vertical trace fossils in St. Peter Sandstone at Skull Rock.

Figure 21. St. Peter/Everton unconformity at Skull Rock, Buffalo Point, Arkansas.

DAY 3 – Buffalo Point – Indian Rockhouse Trail

The trailhead and the Rockhouse have about 400 ft. elevation change between them; therefore, be prepared for a steady incline/decline on the trail, with several steep sections. Allot 3 hours for this 3.5 mile hike, and make sure to bring plenty of drinking water (*from NPS Indian Rockhouse trail brochure*).

Stop 1 – Sinkhole Icebox

The first stop along the trail is a sinkhole in the Plattin Limestone. Notice the recent landslide (red clay scarp). Look around at the topography and nature of the rock. Can you determine why a sinkhole formed at this location? What processes assisted in the formation of the sinkhole?

Figure 22. Devil's Icebox along Indian Rockhouse trail at Buffalo Point.

__Stop 2 – Top of St. Peter Formation- Sandstone pipe tube__

At this locality is the contact of the Plattin Formation with the St. Peter Sandstone. Does the topography or vegetation change? Notice the small vertical depression forming. This is the beginning of the development of a sinkhole. Look for natural fractures for water to enhance the process. We will see a much larger sinkhole at Stop 5.

Figure 23. Geologist looking into small sinkhole.

Figure 24. Small sinkhole in St. Peter Sandstone, Buffalo City quadrangle.

Stop 3 – Waterfall

The contact between the St. Peter and Everton Formations is exposed at this location. What type of contact is this and why is it such an irregular surface? What are the rock types at this location?

Figure 25. St. Peter/Everton unconformity at waterfall.

Stop 4 – Old Zinc Mine

Notice the rock type and formation. In which rock formation is the old zinc mine located? What mineral is the ore of zinc?

Figure 26. Old zinc mine in Everton Formation.

Stop 5 – Sinkhole

This is an example of a sinkhole in sandstone. Sinkholes such as this are fairly common in the St. Peter Sandstone in northern Arkansas. What is geologic feature is exposed in the bluff shelter underneath the sinkhole? Hint: What are the two formations and type of contact?

Figure 27. Sinkhole in St. Peter Sandstone

Stop 6 – Pebble Springs

From which formation is this spring flowing? Since you cannot see the flow into the spring pool where is the water coming from? What geologic features can you see at this location? Look for ripple marks.

Figure 28. Pebble Springs along Indian Rockhouse Trail.

Stop 7 – Sculpted Bedrock

The sculpted bedrock occurs in the Everton Formation. What is the rock type at this location? What caused the rock to be sculpted? Think about the rock type and the interaction between water and rock and fractures. Walk around the outcrop here. What other features do you see in the outcrop? What probably caused them?

Figure 29. Sculpted bedrock along Indian Rockhouse Trail.

Stop 8 – Indian Rockhouse

Figure 30. Front of Indian Rockhouse.

What two formations create the bluff shelter at the Rockhouse? What type of karst features are present here? Notice the tunnel levels. Where is the water level now? Where does the water go? In which formation does the water flow? Look around for cave features. What types of cave deposits do you see?

Stop 9 – Rock Quarry

The formation exposed in the quarry is the St. Joe Member of the Boone Limestone. Look at the rock type. Notice the color. What are the white round pieces in the limestone? What other features do you notice in the quarry wall? Why would this rock make a good building stone? It is a very decorative stone that was used in the Washington Monument and Lincoln's Tomb.

Figure 31. St. Joe Limestone exposed in rock quarry.

For additional information:

For a list of Caving Grottos in Arkansas visit National Speleological Society, www.nssio.org.

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APPENDIX 1

GRAVEL BAR EXPERIMENT

Ozark Plateaus Region
Gravel Bar Learning Activity

Objective:

Students will work together to characterize the geology of a gravel bar by conducting their own scientific experiment.

Materials:

One towel per team
One laminated copy of rock identification sheet
A small bottle of acid per group (vinegar)
One data entry sheet
One bar graph template
Several permanent markers
One measuring tape per group *optional*

Methods Used:

Data collection
Rock identification
Graphing data – Creating a bar graph
Calculating percentage of rock types
Analyzing rocks by shape and size
Critical analysis

Time: Allow close to one hour, depending on class size and age. This includes the time to discuss findings.

Gravel Bar Lesson

The gravel found in a stream bed is derived from the bedrock in the stream's drainage basin upstream. Once detached from bedrock's outcrop, erosion, both mechanical and chemical, will reduce the rock fragments to gravel and smaller particles with time and distance of transport. Rocks that are mechanically weak or chemically unstable will be quickly reduced, whereas, more durable rocks will be more resistant to weathering.

Gravel Bar Lesson Plan

Directions:

Divide your students into groups of 3 to 5 members. Have each team come up with a team name relating to geology. This makes it more fun for students and gives them team spirit! Assign each group member a job. Jobs include: Rock gatherers, sorters, counters, and a recorder to collect data and draw graph.

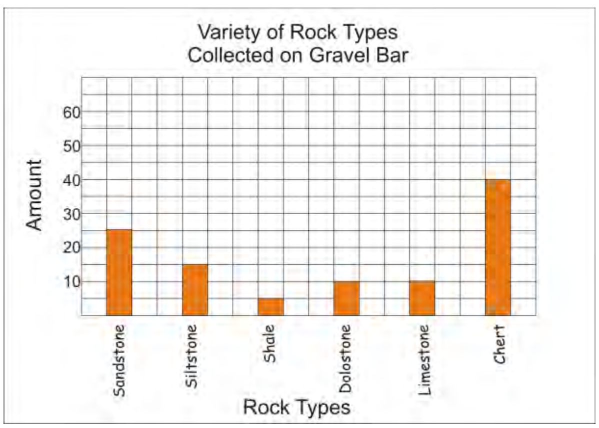
Ozark Plateaus Region
Gravel Bar Learning Activity

Step 1. Have rock gatherers from each team collect 100 gravel particles from the gravel bar at random and place on towel.

Here are some suggestions for getting a random sample:
One way is to mark off a grid (this does not need to be a large area, 10 feet by 10 feet); this can be quickly done with measuring tapes. Mark off corners using water bottles or other objects at hand. Or, have gatherers take 2 steps, close eyes and reach down to pick up a rock. Continue until enough samples are collected. Make sure that gatherers are instructed to collect the first piece they touch each time.

Step 2. Once 100 rocks are gathered and placed on the towel, finish sorting using the rock identification sheet provided. All team members can participate in the rock identification. *Hint* Remember to use properties such as hardness and reaction to acid, when identifying rocks types. Sort like rocks into individual piles.

Step 3. Once the rocks are properly sorted, team members will count the number of rocks in each pile. The recorder writes this data down in the data entry sheet.



Step 4. Once all rocks have been identified, sorted and counted, it is time to construct a bar graph. Use a permanent marker to record data on the laminated graph sheet on the next page to record results.

Further Analysis:
After the graph is completed, instruct team to sort all rocks by size and roundness. Record these observations.

Experiment Summary: You can have a group discussion of findings and compare groups' results.

Results and Discussion:
Gravel deposits found in the stream will reflect the erosional processes that brought them here. They will be enriched in the more durable rocks and impoverished in the weaker rocks. So, even though a stream's drainage basin may be dominated by one rock type, that rock type may not be the dominate type in the gravels of the stream.

Ozark Plateaus Region
Gravel Bar Learning Activity

Rock Types:

Most of the rocks in Arkansas are one of 6 types: sandstone, siltstone, shale, limestone, dolostone, and chert.

1. **Sandstone-** is nothing more than sand sized particles, mostly grains of quartz, cemented together. Sandstone is generally durable and frequently occurs as one of the more common rock types found in the gravel bars along a river bed.

2. **Siltstone**- is the halfway rock between sandstone and shale. It is generally composed of quartz and clay minerals. It is normally not as durable as sandstone, so not as common in gravel deposits.

3. **Shale**- is mud that has become stone. It is basically clay, often with trace amounts of fine sand and silt. Shale is not very durable and hardly found in gravel deposits unless an outcrop is nearby.

4. **Limestone**- Calcite (calcium carbonate) is the dominate mineral in limestone. A limestone is frequently nothing more than a layer of seashell fragments cemented together. Limestone normally erodes more rapidly than many sandstones or cherts in a gravel environment mostly because of dissolution. Therefore, you will generally not find as much limestone in the gravel bars.

5. **Dolostone**- Dolomite (calcium magnesium carbonate) is the dominant mineral in dolostone. Dolostone has durability in a gravel environment similar to limestone, again due to dissolutioning.

6. **Chert**- is an amorphous form of quartz with no obvious crystalline texture. Chert is frequently the most common constituent of gravel bars in Arkansas streams due to its durability. Chert is often fossiliferous, displaying molds and impressions of various creatures. It typically forms angular fragments.

Ozark Plateaus Region
Gravel Bar Learning Activity

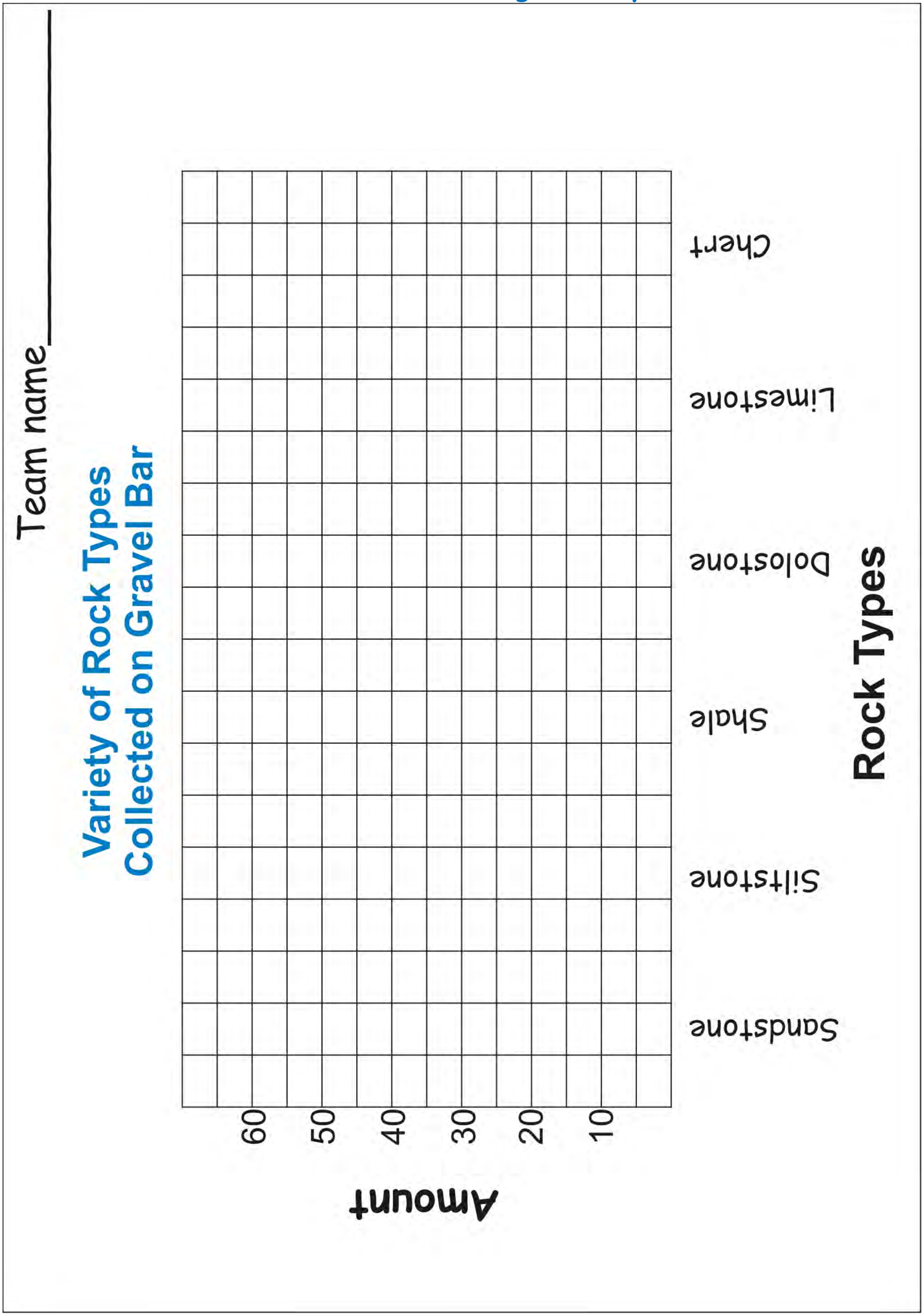
Roundness: is a measure of the amount of abrasion that has caused smoothing and rounding of edges, corners and faces of the gravels..

<u>Angular</u>: gravels show little or no effects of abrasion. The edges and corners are sharp and angular to very slightly worn.

<u>Sub-Angular/ Rounded</u>: gravels show definite to considerable wear; the edges and corners are rounded sometimes to smooth curves.

<u>Rounded</u>: Most surfaces of the gravel show considerable wear. Edges and corners are reduced to broad curves.

Ozark Plateaus Region
Gravel Bar Learning Activity



Gravel Bar Identification Chart

Sandstone

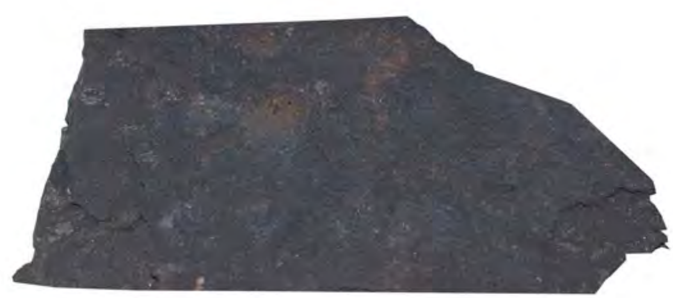
Chert

Siltstone

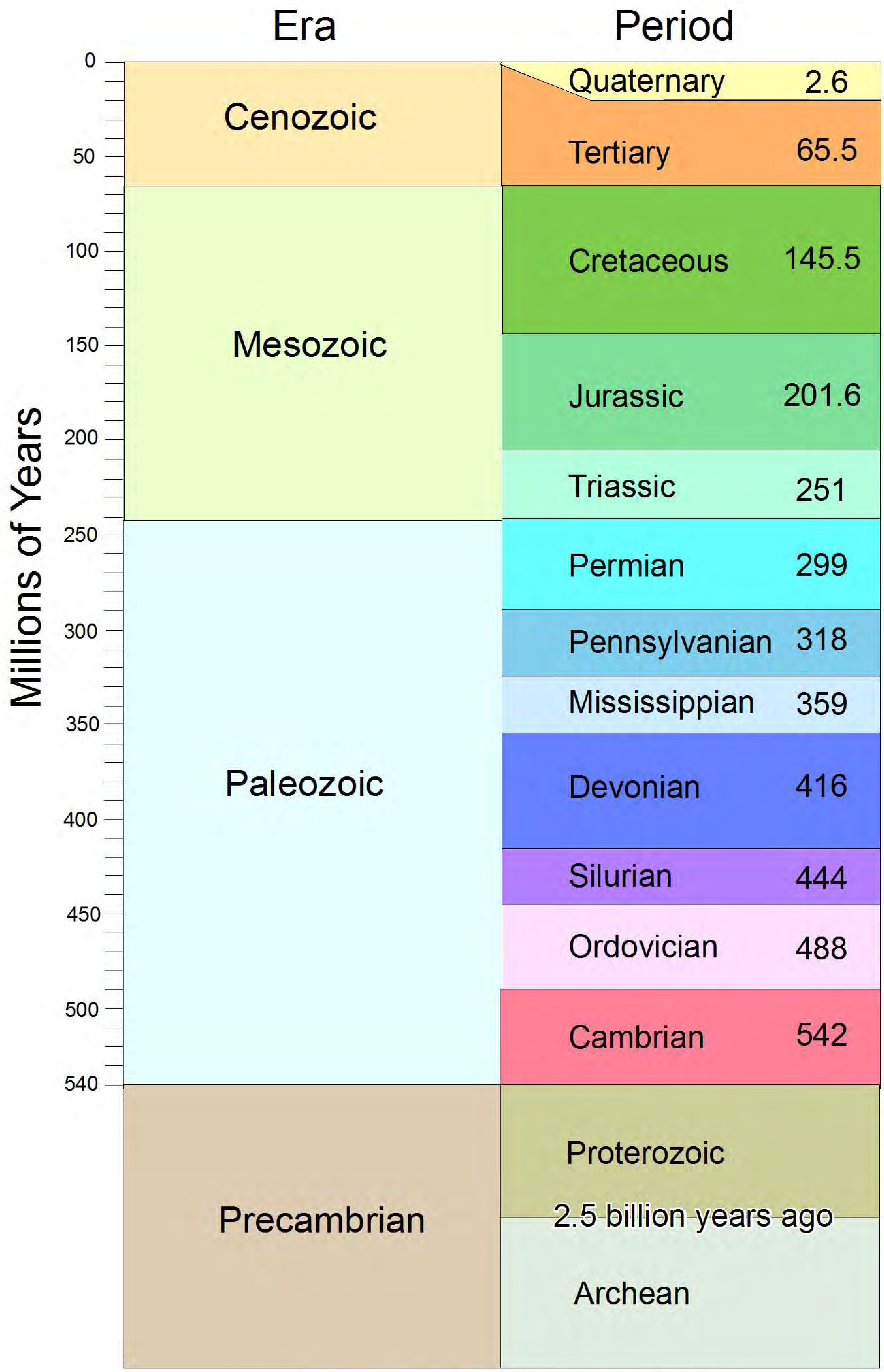
Limestone/Dolostone

Phosphate Nodule

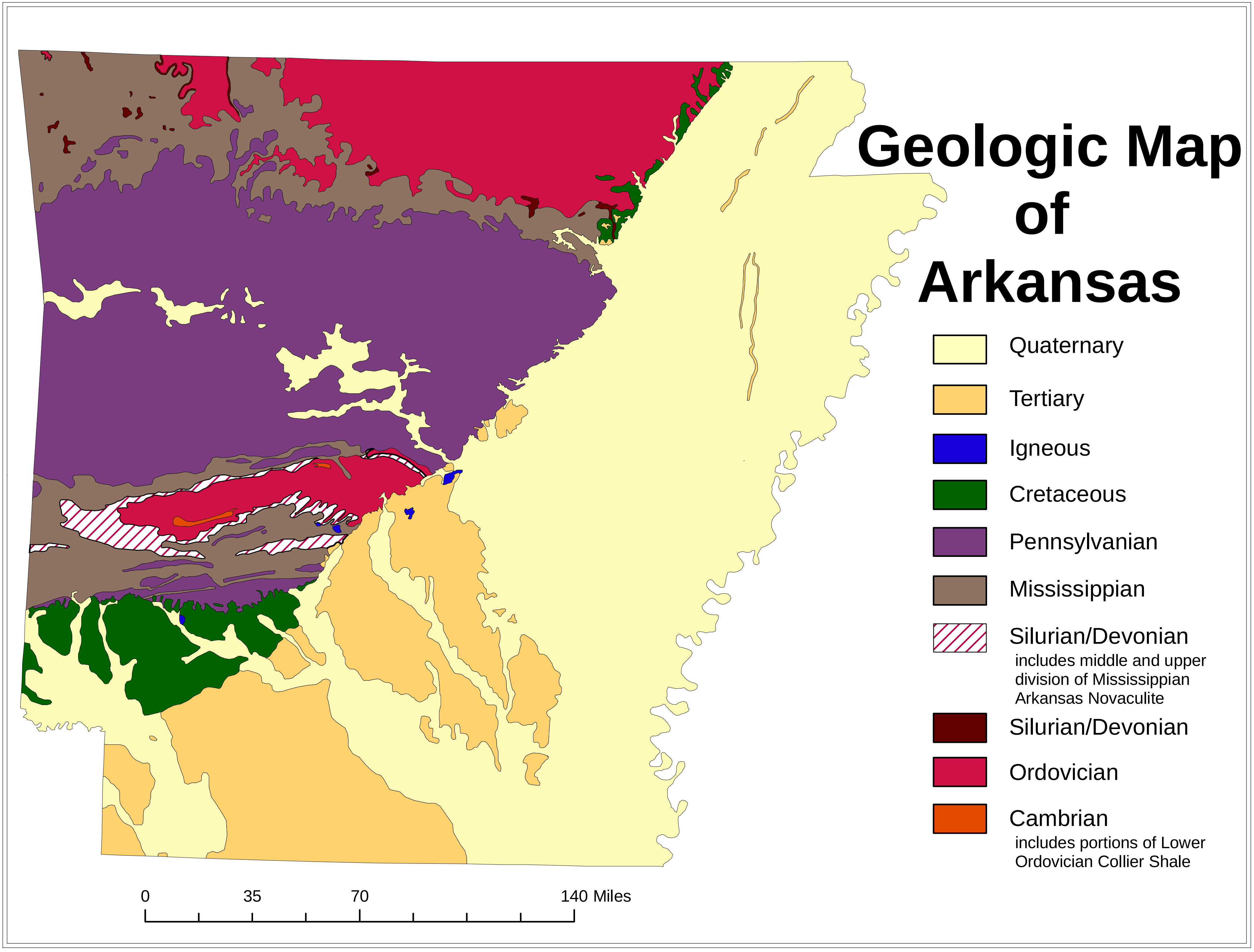
Shale

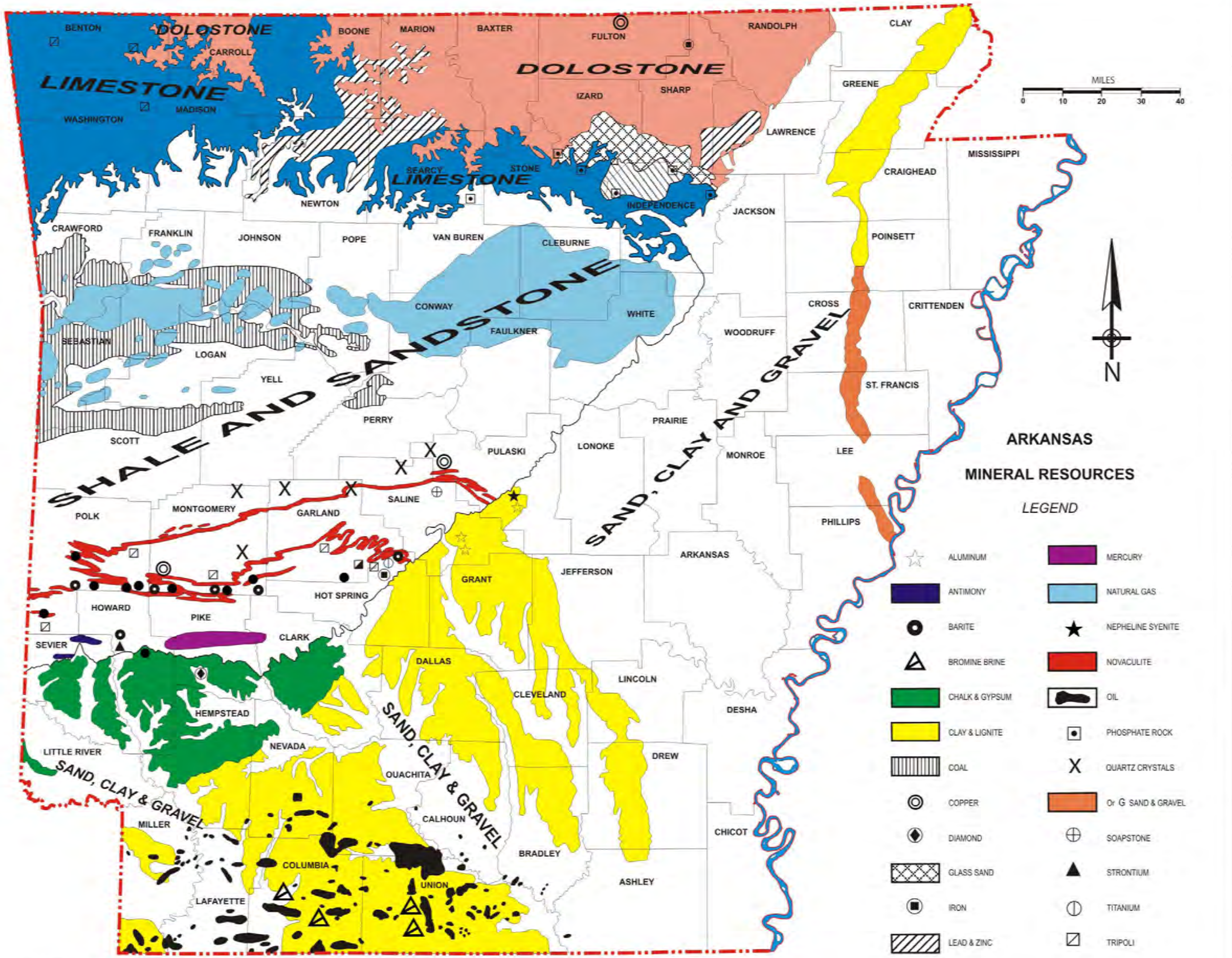


Geologic Time Scale



Based on 2009 Geologic Time Scale
Geological Society of America


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
0
35
70
140 Miles



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