Guidebook

Association of Desk and Derrick Clubs

ASSOCIATION OF DESK AND DERRICK CLUBS

Petit Jean and Mount Magazine Geological Tour

Sept. 24th and 26th, 2007

Prepared by
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Arkansas Geological Survey
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Guidebook

For
2007 ADDC Convention

Petit Jean and Mount Magazine Geological Tour

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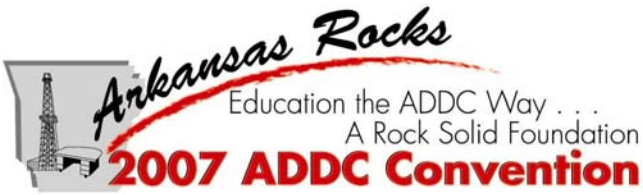

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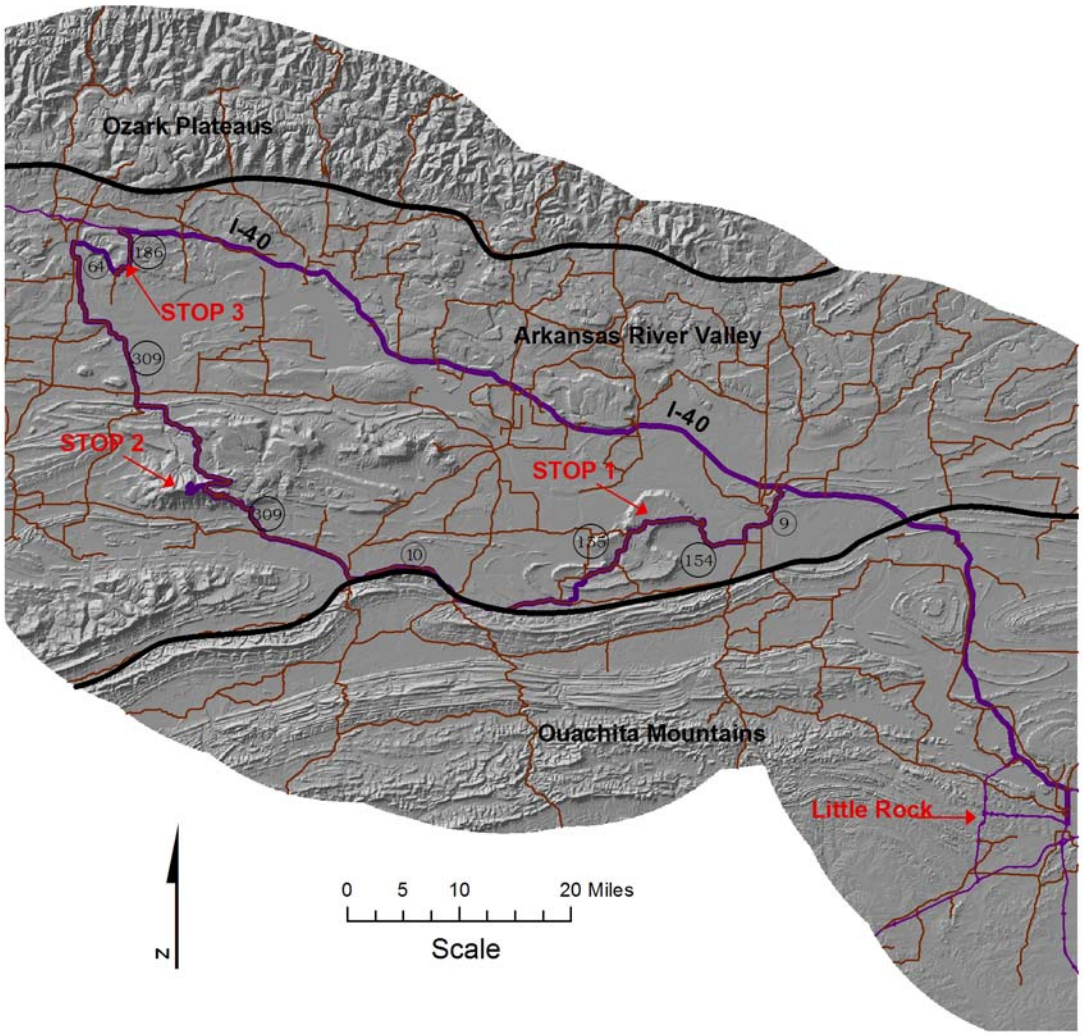
Fieldtrip Route

Refer to the map below for the geological tour route. The tour route is marked as a purple line with the field stops labeled in red. The physiographic regions are divided by a bold black line and labeled in black. The gray map base is a shaded relief map showing the topography of each region. Notice the difference in each region and the rounded structures in the River Valley. These are the surface expressions of the anticlines and synclines we will be seeing on our tour.



Location

Petit Jean and Mount Magazine State Parks are located in the central portion of the Arkansas River Valley. This region is a rather narrow and typically low-lying area surrounding the valley of the Arkansas River and its major tributaries. The Arkansas River Valley is bordered to the north by the Ozark Plateaus and to the south by the Ouachita Mountains. This region is characterized by gently tilted sedimentary rocks. In contrast are the flat-lying rocks of the Ozarks, and the steeply tilted and folded rocks of the Ouachita Mountains.

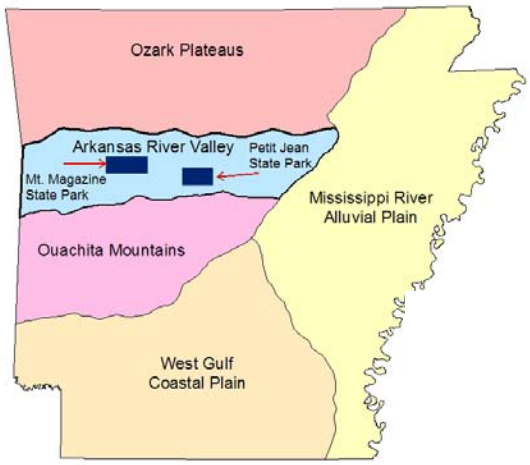


Figure 1. Physiographic Provinces of Arkansas

Geologic History

The rocks exposed in Petit Jean and Mount Magazine State Parks formed during the Pennsylvanian Period around 315-290 million years ago. Underneath these sandstones and shales are older rocks, predominantly limestones and dolostones that formed during the Cambrian through Mississippian Periods. The area known as the Arkansas River Valley has been above sea level and eroding since the beginning of the Permian Period.

During the Pennsylvanian Period, the area now known as the Arkansas River Valley was a basin sitting between the slightly uplifted Ozarks to the north and the slowly rising Ouachita Mountains to the south. These higher areas from the surrounding regions supplied sand, silt and clay that was carried into the basin by ancient river systems coming from the northeast creating deltas. Periodically, much of the basin was covered by a deepening ocean. Swamplands populated by ferns and trees unlike any today developed around bays and inlets. Sea level fluctuated during this time and as sediment subsided in the basin, sea water spread into the area covering the bays and inlets burying the swamplands. Several cycles of deposition created layers of clay and sand which contained thin layers of plant material. These layers became buried and compressed by overlying deposits to form shales and sandstones with an occasional thin coal bed. These layers of rock are known as the Atoka Formation.

After deposition of the Atoka Formation a large river flowing from the east deposited a sandstone called the Hartshorne Sandstone. This river was comparable to the present day size of the Mississippi River and extended from Conway, Arkansas to eastern Oklahoma. Following deposition of the Hartshorne Formation were more delta systems creating the McAlester and the Savanna Formations, similar to the environment of deposition that created the Atoka Formation.

Continents Collide

The continents as we know them today looked much different in the past. Since Cambrian time they have been shifting and colliding so that around 365 million years ago, North America was attached to the continents now known as Greenland and Europe to form one large landmass called Laurasia situated along the equator. South of the equator a

larger continent called Gondwana, made up of the continents now known as South America, Africa, Antarctica and Australia, had formed. These two landmasses moved toward each other and finally collided around 340 million years ago. During this collision some of the continental rocks of Gondwana became attached to the southeastern portion of Laurasia in what is now Arkansas.

This collision first affected the sequence of rocks in what is now known as the Ouachita Mountains. These once flat-lying rocks were compressed into tight folds, downwarps and upwarps, called synclines and anticlines. Eventually deformation spread to the flat-lying shales and sandstones of what is now called the Arkansas River Valley. These rocks were compressed into more gentle folds that extended far above the current land surface. During the last 250 million years these rocks have eroded to form the present landscapes within the Arkansas River Valley

The area now known as Petit Jean Mountain and Magazine Mountain were compressed into a downwarp or syncline. The limbs and younger rocks that would have existed on top of the mountains have been eroded. The lowest portion of each syncline has been preserved as a mountain today.

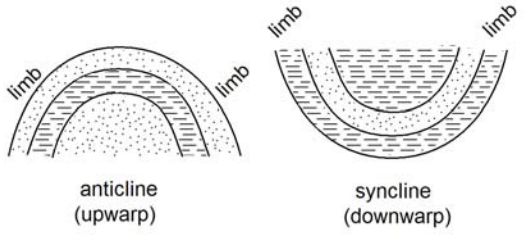


Figure 2. Diagrams showing folded geologic structures.

Description of Field Trip Stops

STOP 1 – Petit Jean State Park

After a stop at the Visitors Center we will proceed to regular field trip stops.

Directions: From Little Rock travel on I-40 to exit 108 Highway 9. Travel south to Oppelo and take a right on Highway 154 to Petit Jean State Park.

Geologic formations present within the park.

Petit Jean Mountain is underlain by shales and sandstones in the Atoka Formation and the Hartshorne Sandstone. The Atoka Formation is divided into upper, middle and lower members based on regionally mappable shale or sandstone intervals. Only the upper member is exposed in the park. In some areas fossiliferous beds containing mostly gastropods and bivalves are present. The upper member of the Atoka Formation can be seen when beginning the climb to the top of the mountain from either direction on Highway 154. The best exposures are found along the highway on the east side of the mountain beneath Stouts Point. At this location dark gray to black shales are interbedded with thin layers of tan to gray sandstone. Thicker sandstones appear along the road at the top of the mountain. These sandstones are part of a different rock formation called the Hartshorne Sandstone.

Figure 3. The Atoka Formation along Highway 154.

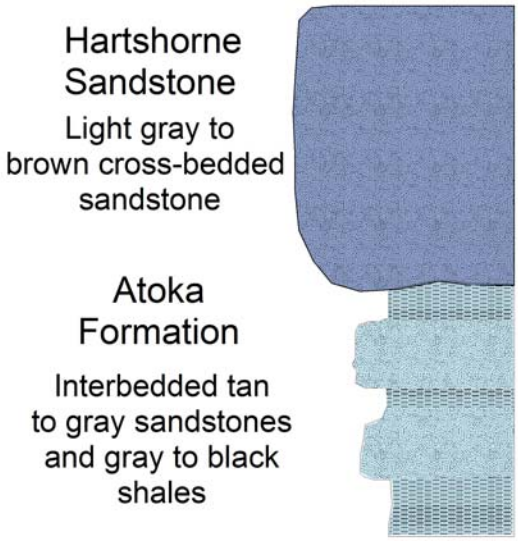


Figure. 4. Columnar section showing sequence of rock formations within the park.

The Hartshorne Sandstone caps Petit Jean Mountain and forms the near vertical ledges and bluffs around the top of the mountain. This rock formation also contains most of the geologic curiosities including Rock House Cave and Bear Cave. The sandstone is brown to light gray, forms thick beds, and is usually cross-bedded. Scenic exposures of this sandstone are found behind Mather Lodge and many of the cabins. This formation is easily viewed at any of the overlooks for Cedar Falls and the canyon formed by Cedar Creek.

Figure 5. Hartshorne Sandstone capping Petit Jean Mountain.

STOP 1A – Cedar Falls Overlook

Directions: Turn right off of Highway 154 into the parking area for Cedar Falls Overlook when heading east/southeast toward Mather Lodge.

This is a very short walk to a magnificent view of the canyon cut by Cedar Creek and Cedar Creek Falls. Walk underneath the stairway and around to the left to see great liesegang banding sometimes called box-work and "carpet rock"**.**

Figure 6. View of Cedar Falls from overlook.

Carpet Rocks

Box-shaped and triangular patterns are abundant in the sandstones on top of Petit Jean Mountain. These patterns form when iron present in the rock is oxidized. Iron exists as the minerals siderite, magnetite, hematite and some clay minerals that are present in the Hartshorne Sandstone. At some point in geologic history water filled the pore spaces of the rock formation and came into contact with minerals made up of iron. This caused the iron to go into solution. If the rock becomes exposed to air then oxygen is added to the solution and causes the iron to oxidize and precipitate out along exposed joints in the rock formation. Sometimes color bands result from

the different oxidation states of iron. These bands are also referred to as Liesegang banding or box work by the scientific community. Often the joints form interesting triangles referred to as "carpet rock" by the park community.

Figure 7. "Carpet rocks" along Cedar Creek Trail.

STOP 1B – Turtle Rocks area near Mather Lodge

Directions: Veer right off of Highway 154 onto lane toward Mather Lodge. Stop near first rock outcropping on right side of road.

Figure 8. Box work near Cedar Falls overlook.

Turtle Rocks

Some of the most unique features seen around the park are those called "turtle rocks". Mounded polygonal structures resembling a turtle shell were carved in thick sandstones of the Hartshorne Sandstone. These features are unique to this sandstone but not to the mountain itself. More turtle rocks can be found throughout the Arkansas River Valley where the Hartshorne Sandstone is exposed. Turtle rocks also exist on Pleasant View Mountain and London Mountain near Russellville and Cove Mountain south of Petit Jean State Park.

The exact processes that create "turtle rocks" are poorly understood. One explanation involves spheroidal weathering. This process occurs when water percolating through cracks and between individual grains in the rock loosens and separates layers of the rock. The weathering acts more rapidly on the corners and edges of the rock producing a rounded shape. Another theory concerns the amount of calcite present in the matrix of the rock holding the grains together along with the size of the grains that allow for this type of weathering. Either way the weathering of the rocks is strongly influenced by the polygonal joint pattern seen in all "turtle rocks".

Figure 9. Turtle rocks near Mather Lodge.

Other areas of interest

If time allows we may walk down to Rock House Cave. Start at the Rock House Cave Trail and walk down to a excellent exposure of "turtle rocks". This is a good area to examine the joints around each "turtle back". Follow the trail off of the outcrop and down to the rock shelter. See what Cedar Creek carved out long ago!

Figure 10. Turtle rocks near Rock House Cave

Figure 11. Rock House Cave

STOP 2 – Mount Magazine State Park

Directions: From Petit Jean State Park travel west on Highway 154 to Highway 155. Travel south to Hwy 10. Take a right on Highway 10 and continue west to Ola. Continue on Highway 10 turning left in Ola to Danville. Take a right in Danville continuing on Highway 10 pass the town of Bellville. The next town is Havana. Take a right in Havana on Highway 309. Proceed north to Mount Magazine State Park.

After a stop at the Visitors Center we will proceed to regular fieldtrip stops.

Geologic formations present within the park.

Mount Magazine State Park is underlain by sandstones and shales in the Atoka Formation, Hartshorne Sandstone, McAlester Formation and the Savanna Formation. All of these formations can be seen when beginning the climb to the top of Magazine Mountain from Havana on Highway 309. For purposes of this field trip, the geologic descriptions of the area will start approximately 3 miles north of Havana on Highway 309. At this location good exposures of the upper part of the Atoka Formation can be seen.

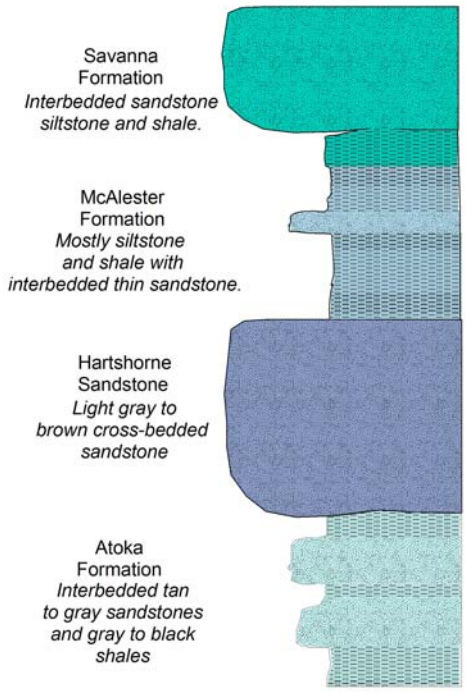


Figure 12. Columnar section showing rock formations within the park.

Atoka Formation

The Atoka Formation is divided into upper, middle and lower members based on regionally mappable shale or sandstone intervals. The upper part of the formation generally contains a higher proportion of gray black shale than other parts of the Atoka Formation (Cohoon and Vere, 1988). Ironstone concretions and small coal seams occur in some intervals. Along Highway 309 the Atoka consists of gray to black shales that are less resistant than the overlying Hartshorne Sandstone. The contact between the two formations is very sharp and well exposed along the highway.

Figure. 13. Shale in the Atoka Formation along Highway 309.

Hartshorne Sandstone

The Hartshorne Sandstone is one of the most persistent sandstone units in Arkansas (Haley, 1961). This unit is a prominent ledge former in the area and consists of gray to brown fine- to medium-grained sandstone. Sometimes an occasional shale bed is interbedded within the sandstone and in some areas it has a thin coal bed at its base.

Figure 14. Contact between Hartshorne Sandstone and Atoka Formation along Highway 309.

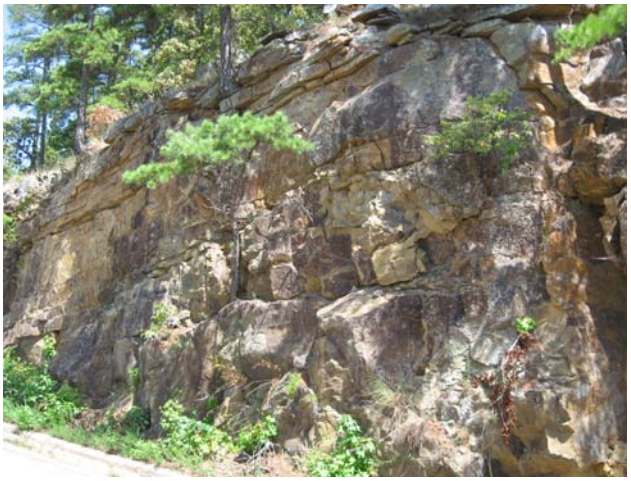


Figure 15. Hartshorne Sandstone along Highway 309.

McAlester Formation

The McAlester Formation consists of mostly a shale sequence that can contain three or more coal beds, in particular the Lower Hartshorne coal bed which is near the base of the formation (Haley, 1961). This unit is mostly covered along Highway 309, but some shale with interbedded thin sandstones is seen approximately 4-5 miles north of Havana.

Figure 16. McAlester Formation along Highway 309.

Savanna Formation

The Savanna Formation consists of both shale and sandstone, however the most noted portion of the unit is the sandstone capping the mountain and forming the bluff line that is viewed at the overlooks.

A good exposure of the Savanna Sandstone occurs at the last sharp curve climbing the mountain just before the Petit Jean Valley Overlook on Highway 309.

Figure 17. Savanna Formation along Highway 309.

STOP 2A – Mount Magazine Lodge/Lunch

Directions: Turn left off of Highway 309 in front of Visitor Center. Follow signs to Lodge at Mount Magazine

The Lodge at Mount Magazine State Park

This resort mountain lodge uses local stone work throughout the building and in the landscaping on the grounds. Swartz Stone Company in Paris, Arkansas provided a large supply of ornamental stone especially those used for the rockwall in front of the lodge. Some stone also came from a quarry in the Danville area (Don Simonds, Mount Magazine State Park, personal communication). Most likely the rock was quarried from the Hartshorne Sandstone and the Atoka Formation. Notice the decorative stone throughout the interior of the lodge as well. Be sure to take a stroll on the backside of the lodge and see the view of Blue Mountain Lake. The large mountain beyond the lake is Poteau Mountain and the axis of the Poteau Syncline.

Figure 18. The Lodge at Mount Magazine State Park.

Figure. 19. Rock wall made of Arkansas stone.

STOP 2B – Signal Hill – Highest Point in Arkansas

Signal Hill

The highest point in Arkansas is located at Mount Magazine State Park, specifically on Signal Hill with an elevation of 2,753 ft. The hike to this point is a short one – only 15-20 minutes one way and well worth it. There are three different trails to this point. I suggest taking either the one nearest the lodge which is .6 miles or the trail starting at the entrance to Cameron Bluff Campground which is .4 miles. Once you reach the summit, a rock "patio" (highpoint monument) in the shape or Arkansas sits below a sign announcing the highest point. Be sure to sign the guest book!

STOP 2C – Cameron Bluff Overlook Drive

Cameron Bluff Drive provides spectacular views north of the mountain into the river valley. Notice some of the structures typical of the river valley called anticlines and synclines. The Savanna formation is well exposed creating a bluff line viewed at several of the overlooks on this drive.

Figure 20. Signal Hill – Highest point in Arkansas. Notice the rock monument.

Figure 21. The Savanna Formation along the bluff line of Overlook Drive.

STOP 3 – Wiederkehr Village

Directions: From Magazine Mountain proceed north on Highway 309 to Paris. Take a left and travel west on Highway 369 to Caulksville. Take a right onto Highway 23 and travel to Ozark. Take a right and travel east on Highway 64 to the town of Altus. Turn left and travel north on Highway 186 for three miles to the village.

Vineyard Geology

Wiederkehr Wine Cellars is located in the Arkansas River Valley on top of St. Marys Mountain. According to the history of the winery, the microclimate atop the mountain resembles the grape-growing climates in Europe's finest wine regions. The winery and vineyards are located on the Hartshorne Sandstone.

Economic Geology

Coal

There are coal beds present in each of the formations exposed at Petit Jean and Mount Magazine State Parks but not in the park themselves. The coal seams occur in various places in the River Valley, averaging from two inches to 6 feet thick. Major coal beds occur in the McAlester Formation and the Savanna Formation. Coal production in Arkansas started in the late 1800's mostly from underground mines. In the 1950's surface mining began and became the dominant form of mining well into the 1970's (Haley, 1978). The only coal mined in Arkansas at this time is from the Lower Hartshorne Coal in the McAlester Formation. There are two active mines in Sebastian County. The coal has several uses: in a coating for pipelines; as charcoal briquettes; as a heat source for blacksmiths; and coking used in steel-making and power generation.

Coal Bed Natural Gas

There is the potential for some of the coal beds in Arkansas to produce gas. Methane is absorbed on the internal surface of the coal itself and can be produced from the coal bed. This potential has not yet been quantified and is dependent upon many factors. However, coal bed production began in Arkansas in 2002 and currently there are four coal bed natural gas fields which contain approximately 53 wells in Sebastian County. These wells are producing from the Lower Hartshorne Coal in the McAlester Formation.

Annual coal bed natural gas production is estimated at 1.8 billion cubic feet as of 2006.

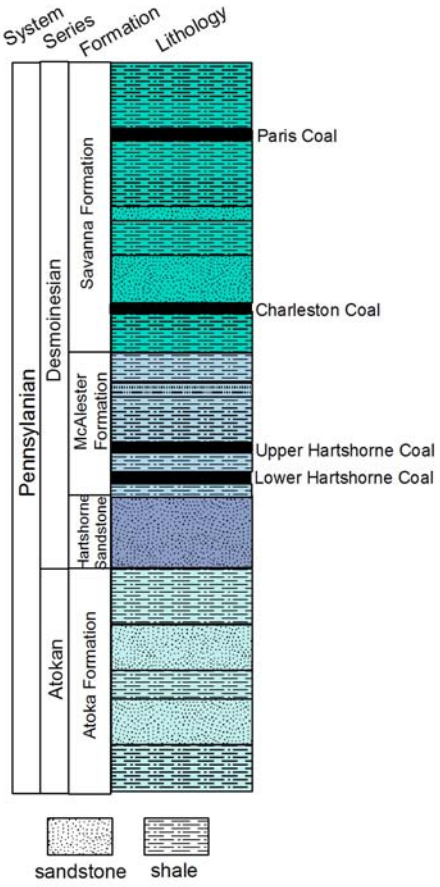


Figure 22. Generalized stratigraphic column showing named coal beds.

Natural Gas

Commercial development of natural gas in Arkansas began in 1902 in Sebastian County. The principal gas producing formation in the Arkoma Basin is the Atoka Formation that contains numerous sandstone beds (reservoirs) throughout the unit. The Hartshorne Sandstone was exploited prior to the 1930's but because of low pressure and low

production this unit is of little commercial interest (Storm, 1998). There is only one well in Arkansas producing gas from the Hartshorne Sandstone in Arkansas. The McAlester and Savanna Formations are not considered gas producers in Arkansas because they are present only at the surface or if buried would be too shallow and provide no overburden pressure for gas production.

The Arkoma Basin contains 104 gas fields but only 99 of the fields are actively producing gas. Annual production is estimated at 150 million cubic feet as of October 2006.

Building Stone and Aggregate

Most of the sandstone quarried in Arkansas is crushed and used for aggregate in concrete and asphalt. Large blocks (riprap) are used for fill and in dike and jetty construction. Rough, weathered sandstone blocks and boulders (fieldstone) have been used for years as facing stone on homes and other buildings, and to build other structures such as fireplaces, walls, and walkways. Much flaggy sandstone has been produced from the Hartshorne Sandstone (Pennsylvanian) near Midway in Logan County. Other counties in west-central Arkansas that occasionally produce this type of material are Logan, Sebastian, and Franklin. A substantial tonnage of thin flagstone and dimension stone has been produced in the state since the early 1950's.

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Notes