Introduction

This road guide was developed for those in the general public who are curious about our natural environment. Arkansas has a fascinating geologic history that spans approximately 500 million years. A road trip on Scenic 7 provides an opportunity to do what many have dreamed of for ages, that is, travel through time.

This narrative is somewhat technical, but a Glossary of Terms is provided at the end of the road guide and it is hoped that the road log descriptions will provide the reader with an overview of the rock types, structural framework, and geologic history of Arkansas. The road logs are written as if one were travelling from north to south; however, each physiographic province is treated as a unit and the entire trip does not have to be completed to learn about a particular area.

Arkansas is divided into five distinct physiographic regions and Scenic 7 crosses four of the regions in a north-south direction from Missouri to Louisiana over a distance of almost 300 miles. From north to south the regions are as follows: Ozark Plateaus, Arkansas River Valley, Ouachita Mountains, and West Gulf Coastal Plain. The fifth region, the Mississippi River Alluvial Plain, lies to the east of the others (Fig. 1).

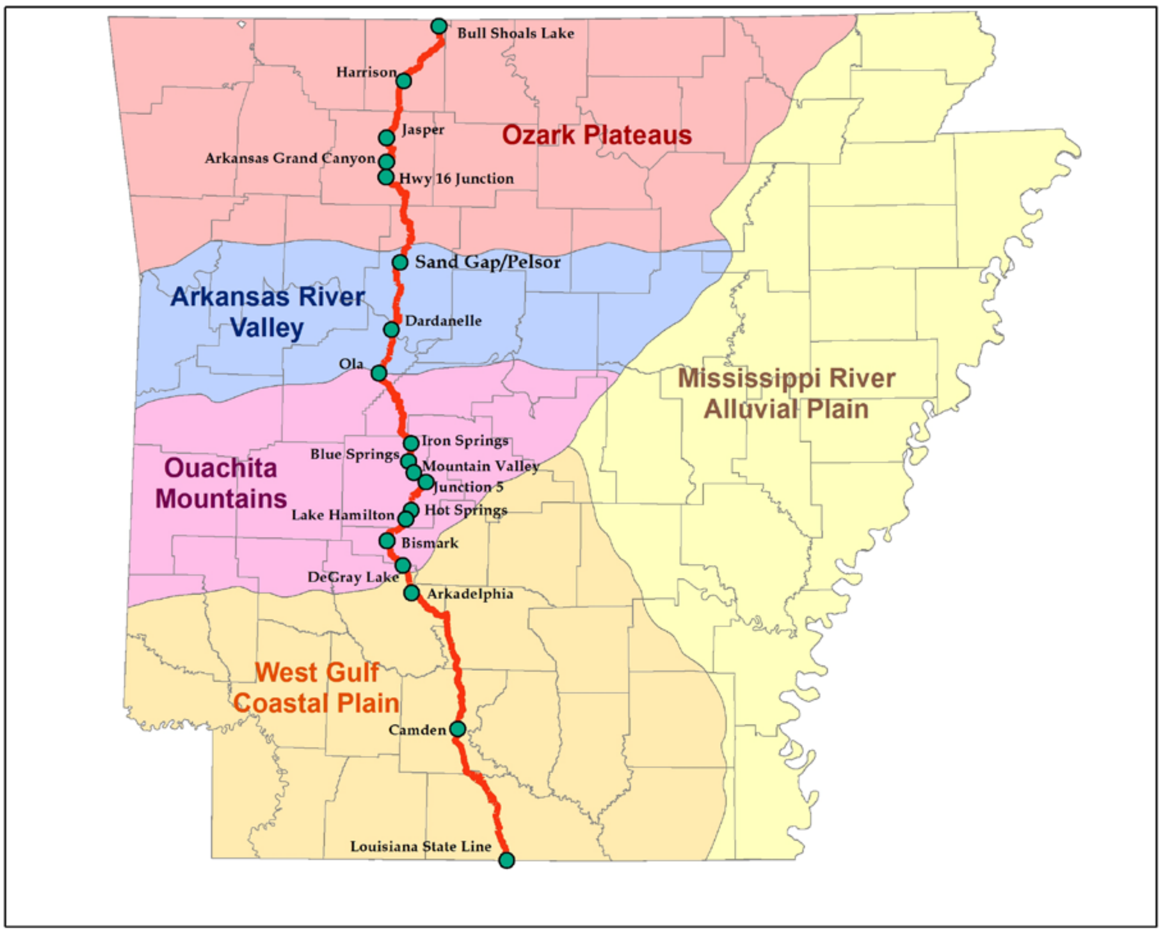

Figure 1. Scenic 7 route map across Arkansas' physiographic regions

Geologic Time

Geologists consider time much as astronomers think about space. "Deep time" (geologic time) is similar to "deep space". Both concepts, one dealing with enormous amounts of time and the other with vast distances, describe quantities that are difficult to comprehend.

Over many years simple observations and common sense led to the development of a relative geologic time scale that shows the order of deposition of sedimentary strata and the relative time of intrusion of igneous rocks. After 1900, it was discovered that decay rates of certain radioactive elements in rocks are measurable and constant. Thus, a natural clock mechanism is operating in some rocks of the Earth's crust and their absolute ages can be measured. Radiometric dating was used to corroborate and refine the relative time scale based on the order in which sedimentary rocks were deposited. The result of this combination of dating methods is known as the geologic time scale.

Geologic Time Scale

(Periods/subperiods in millions of years ago, epochs in years)
(Source, U. S. Geological Survey, GIP 141)

Periods	Eras	Years
	Cenozoic	
Quaternary		**present to 2.6**
Holocene Epoch		**present to 11,700 yr**
Pleistocene Epoch		**11,700 to 2,600,000 yr**
Tertiary		**2.6 to 65**
	Mesozoic	
Cretaceous		**65 to 145**
Jurassic		**145 to 199**
Triassic		**199 to 251**
	Paleozoic	
Permian		**251 to 299**
Carboniferous		**299 to 359**
Pennsylvanian		**299 to 318**
Mississippian		**318 to 359**
Devonian		**359 to 416**
Silurian		**416 to 443**
Ordovician		**443 to 488**
Cambrian		**488 to 542**
	Eon	
	Precambrian	**542 to 4,600**

Geologic Maps

A geologic map depicts the ages of rocks and alluvial sediments exposed at the Earth's surface. Detailed geologic maps also include the position of the sedimentary strata. In many areas strata are in their original horizontal position, as they were deposited; however, some have been disturbed by tectonic forces causing the strata to become warped, folded, or broken by faulting. The Geologic Map of Arkansas (Fig. 2) displays broad patterns of sedimentary rock outcrops deposited during various geologic periods. The location of the larger igneous intrusions in the state are also shown.

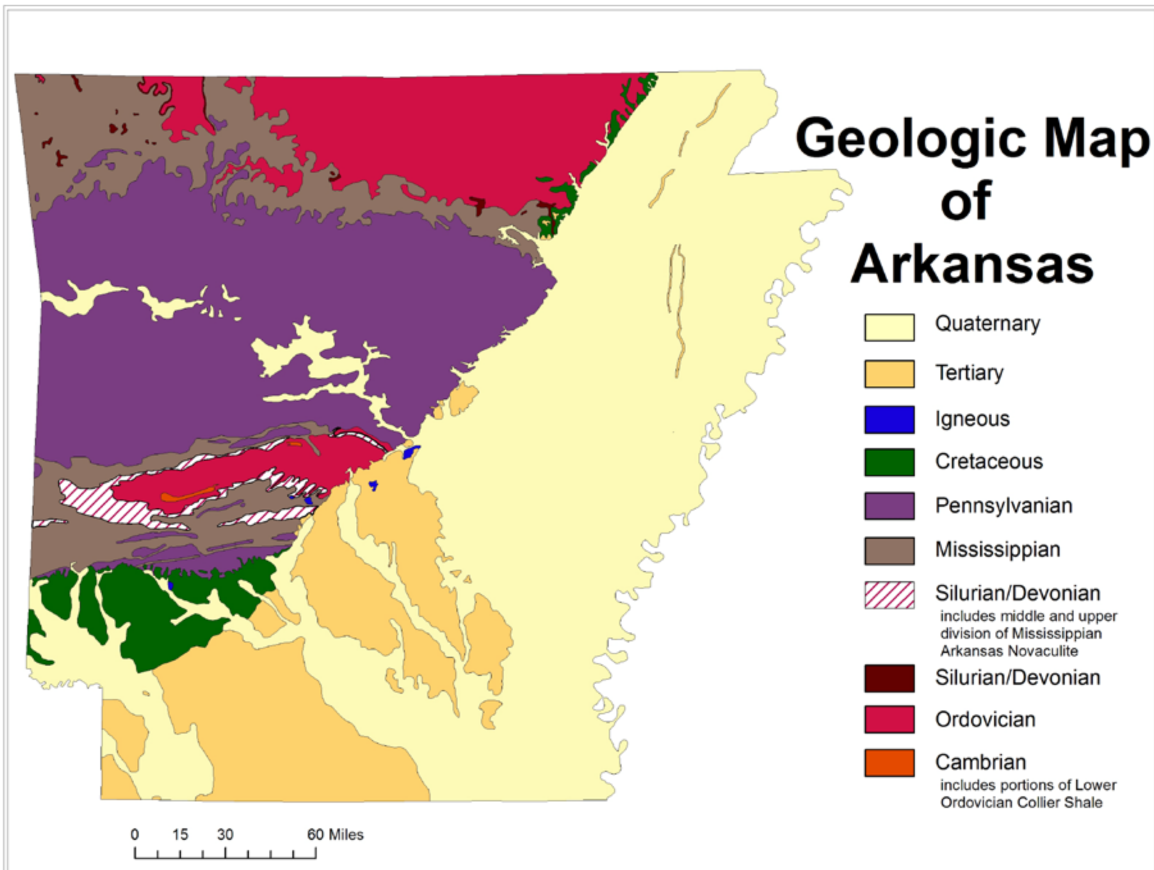

Figure 2. Geologic map of Arkansas
(Source, Arkansas Geological Survey)

Correlation Charts

Correlation charts are necessary in the study of geology because sedimentary rocks deposited in different areas during a geologic period will generally have different chemical and physical characteristics. The strata may be sandstone, shale, limestone, conglomerate, or some hybrid combination of sediments. This is because of differences in the source of sediments and a variation in the type of depositional environment. For example in the Ozark Plateaus the Boone

Formation was deposited during the Mississippian Period; however, during the same time period the Arkansas Novaculite (bedded chert) was deposited in the Ouachita Mountains. The depositional environment in the Ozarks was that of a shallow warm sea, while the Ouachita sediments forming at the same time had a different source and were deposited in a deep marine trough.

Rock units (formations) are often named for a geographic feature present in the area where the rock unit was first described. The formations are mapped across a region by reference to their fossil content and/or similar physical and chemical characteristics.

The correlation charts (Fig. 3) list the name and stratigraphic position (geologic age) of the geologic formations (sedimentary rock units) present in Arkansas. Also, detailed descriptions of the rock units encountered during the trip are included in the overview statement for each physiographic region.

Ozark Plateaus

Overview

The Ozark Plateaus cover an area of approximately 47,000 square miles in southern Missouri, northern Arkansas, eastern Oklahoma, and the extreme southeastern corner of Kansas (Fig. 4). These high plateaus (2,200 to 2,500 feet elevation), cut by deep valleys (500 to 1,500 feet deep), are underlain by a broad dome-like structure in the Earth's crust. This feature, known as the Ozark Dome, formed about 1.5 billion years ago and is part of the early North American continent. Pre-Cambrian-aged (1,350 to 1,485 million years ago) granites and rhyolites form the igneous rock core of the dome. These rocks are exposed at the surface in the St. Francois Mountains in southeastern Missouri. Rocks of this age are not exposed at the surface in Arkansas, but are present below the sedimentary strata.

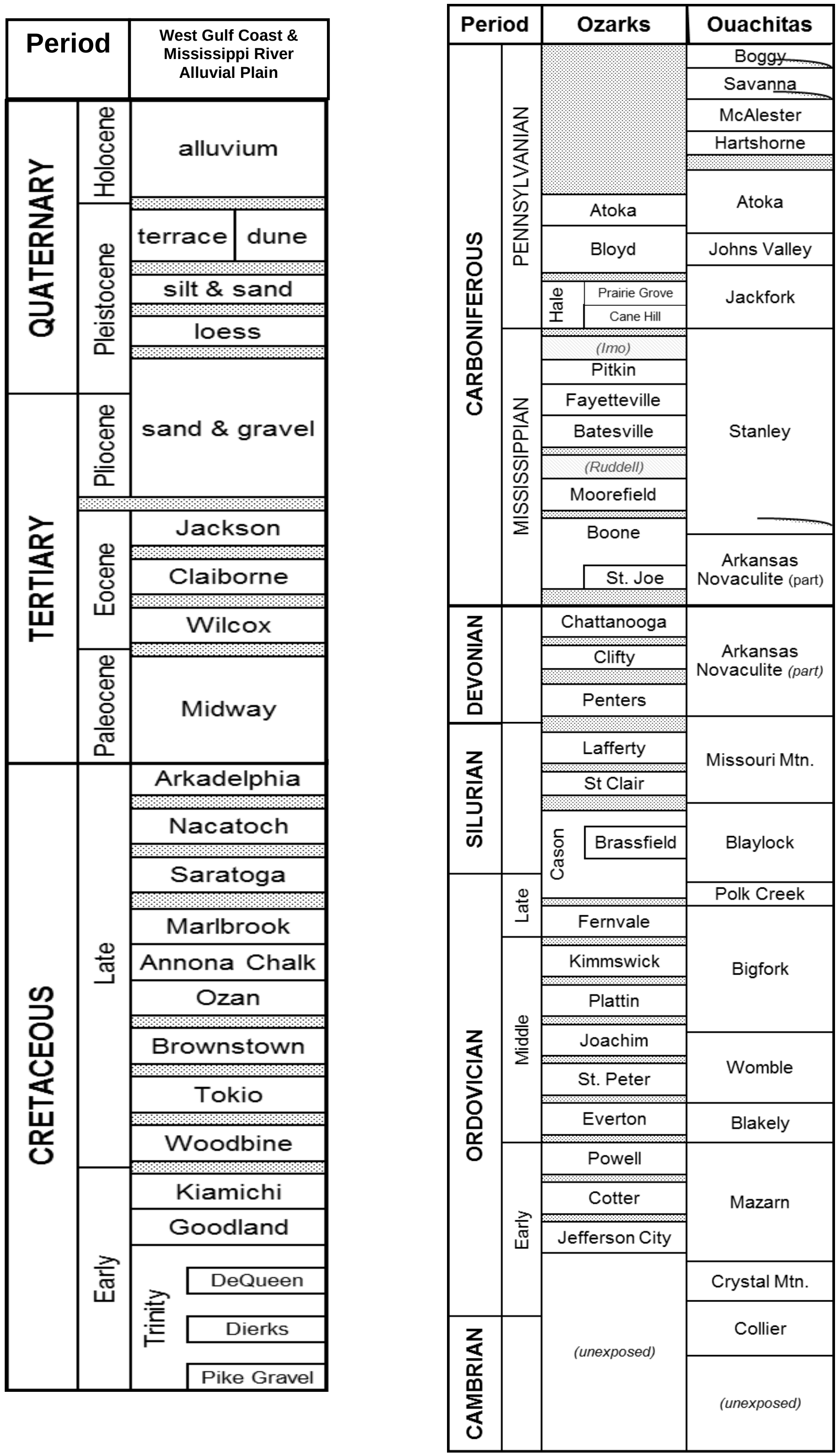

Figure 3. Correlation charts of Arkansas stratigraphic nomenclature
(McFarland, 2004)

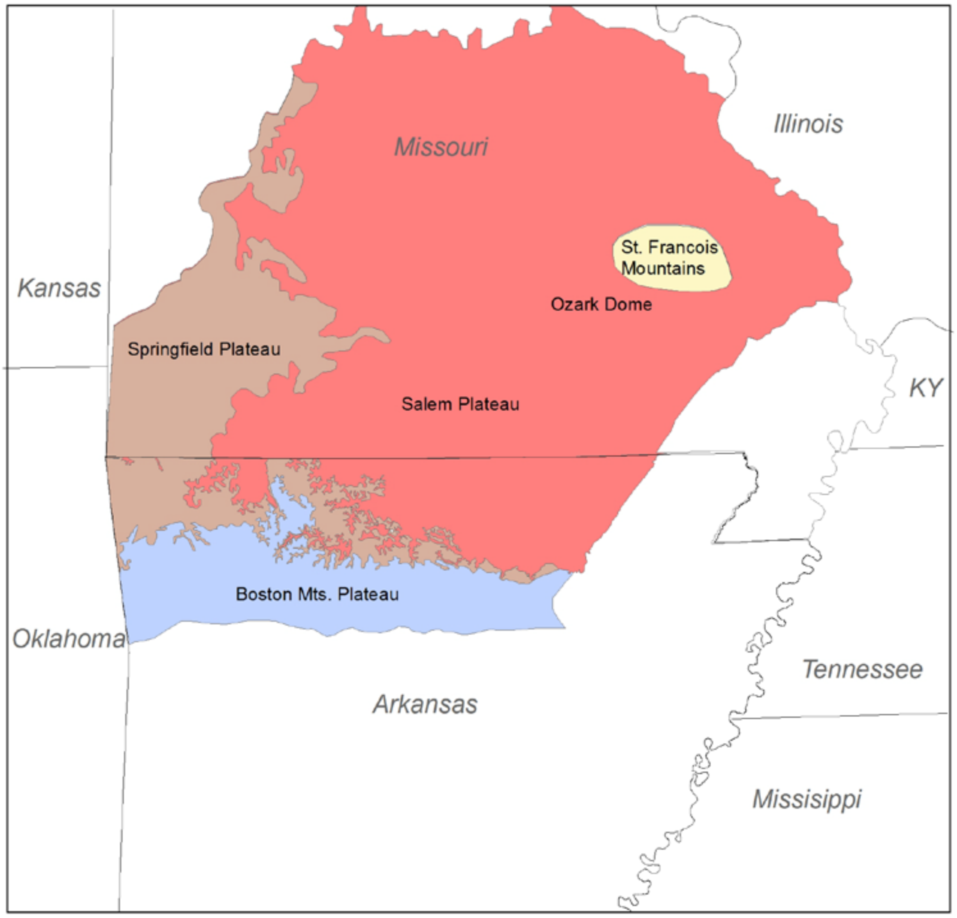

Figure 4. Location map for the Ozark Plateaus and Ozark Dome
(source, Arkansas Geological Survey)

Ozark Plateaus and Highlands

During most of the Paleozoic Era (251 to 542 million years ago), shallow seas deposited almost horizontal layers of sand, silt, clay, and calcareous mud across the southern and western flanks of the Ozark Dome. These sediments became rock after deep burial by a process known as lithification. This process involves compaction, loss of water, and crystallization of minerals resulting in cementation of granular sediment or the formation of crystalline sedimentary rocks.

The geologic rock record is not complete because there are many time gaps (unconformities) between sedimentary rock units. Periodic sea level changes interrupted the depositional process and exposed rocks to erosional processes over this nearly 290 million year span of time. Numerous types of marine fossils are present in these rocks, especially in the limestone that was deposited in warm, relatively shallow seas on the continental shelf. These fossils are often utilized as time markers for the various rock units.

The Ozarks are considered to be the most significant “Interior Highlands” between the Appalachian and Rocky Mountains. The region can be divided into the Salem Plateau, Springfield Plateau, and the Boston Mountains Plateau (Fig. 4). The rocks exposed in the Ozark Plateaus range in age from Early Ordovician (460 million years ago) to Middle Pennsylvanian (310 million years ago). The Salem Plateau consists of Ordovician-aged dolostone, sandstone, and limestone. The slightly higher Springfield Plateau is composed of Late Mississippian-aged (320 million years ago) limestone and chert. Arkansas’ highest part of the Ozarks is the Boston Mountains Plateau which is composed of shale, siltstone, and sandstone of Pennsylvanian-aged strata (299 to 318 million years ago).

The rate of sedimentation was relatively slow from Ordovician to Early Pennsylvanian time; however, the rate dramatically increased as highlands began to develop to the south due to the early stages of the Ouachita orogeny. It began in Mississippian (359 million years ago) and culminated in Late Pennsylvanian – Early Permian time (290 million years ago). The Orogeny was a result of the collision of ancestral South America-Africa with ancestral North America. This continent-changing event will be discussed later as we approach the Ouachita Mountains on our trip.

Structurally, the Ozark Plateaus are composed of nearly horizontal strata that are slightly folded (monoclines) in some areas and broken by normal (gravity) faults and numerous fractures (joints). The crustal blocks on the south side of most faults in the Ozarks moved down as a result of gravitational forces.

Rock Types Exposed Along Scenic 7 in the Ozark Plateaus

(Based on McFarland, 2004 and Braden and Smith, 2004)

(Rock types are listed from youngest to oldest and map symbols are included following the formation name.)

Atoka Formation (ℙa)

Age: Pennsylvanian (299 to 318 million years ago)

Description: tan to gray, silt-containing sandstone, silty gray-black shale with fragmented plant fossils, and a few thin coal beds. The Atoka has the largest area of surface exposure in the state. Thickness varies from a few tens of feet to over 300 feet in the Ozarks.

Environment of deposition: shallow marine and coastal swamp.

Bloyd Formation / Shale (ℙbh)

Age: Early Pennsylvanian (299 to 318 million years ago)

Description: various limestone, calcareous shale, siltstone, sandstone, and thin coal members. Thickness ranges from 175 to 200 feet.

Environment of deposition: shallow marine, coastal swamp and delta.

Hale Formation (ℙbh)

Age: Early Pennsylvanian (299 to 318 million years ago)

Description: Cane Hill Member – dark gray silty shale interbedded with siltstone and fine-grained sandstone. Prairie Grove Member – calcareous sandstone or sandy limestone with lenses of fossiliferous limestone. Thickness of the Hale is not well established due to the difficulty in

determining the position of the upper and lower boundaries; however, it is estimated to be from 200 to over 300 feet.
Environment of deposition: shallow marine.

Pitkin Formation (Mp)
Age: Late Mississippian (304-318 million years ago)
Description: fine to coarse-grained, fossil-bearing limestone with minor amounts of black shale, chert, and sandstone in some areas. A wide variety of marine invertebrate fossils may be present. Thickness ranges from 50 to 200 feet.
Environment of deposition: shallow marine

Fayetteville Shale (Mf)
Age: Late Mississippian (304-318 million years ago)
Description: black, fissile shale with minor amounts of gray, fine-grained limestone. Fossils preserved by the iron sulfide mineral pyrite (fool's gold) may be present. Thickness ranges from 10 to 400 feet.
Environment of deposition: marine in an oxygen-poor region due to limited current and wave action, such as in a coastal swamp or isolated basin.

Batesville Formation (Mbv)
Age: Late Mississippian (304-318 million years ago)
Description: fine to coarse-grained, light brown to brown sandstone with thin shales. Western outcrops may contain a fossiliferous limestone. Thickness ranges from very thin to over 200 feet.
Environment of deposition: shallow marine.

Boone Formation (Mb)
Age: Early and Middle Mississippian (318 to 344 million years ago)
Description: gray fossiliferous limestone with interbedded chert and irregular-shaped chert nodules. The Boone contains numerous crinoid fragments, as well as bryozoa, mollucks, corals, trilobites, shark's teeth, and conodonts. Thickness ranges from 300 to 400 feet. The limestone is the host-rock for karst topographic features such as sinkholes and caverns.
Environment of deposition: shallow marine.

St. Joe Member of the Boone Formation (Mbs)
Age: Early Mississippian (318 to 330 million years ago)
Description: fine-grained, crinoid-rich limestone that may be gray, red, pink, purple, brown, or amber in color. The St. Joe often forms bluffs in the landscape. Fossils that may be contained in the limestone include the following: crinoids, brachiopods, bryzoa, conodonts, blastoids, ostracods, and horn corals. Thickness ranges from a few inches to over 100 feet.
Environment of deposition: shallow marine.

Major Unconformity Early Mississippian to Middle Ordovician (time gap of 150 million years).

Everton Formation (Oe)
Age: Middle Ordovician (458 to 473 million years ago)
Description: a mixture of dolostone (rock dolomite), sandstone, and limestone. The limestone is light-gray to brownish gray, and may contain sand. The dolostone shows a range of shades of gray and also is sandy. Bedding may be thin to massive. Thickness varies from 300 to 650 feet.
Environment of deposition: shallow marine.

Powell Dolomite (Op)
Age: Early Ordovician (473 to 488 million years ago)
Description: Fine-grained, light gray to greenish gray dolostone containing thin beds of shale, sandstone, sandy dolostone, and minor amounts of chert. The thickness ranges from thin to over 200 feet.
Environment of deposition: shallow marine.

Jefferson City – Cotter Dolomite Formation (Ocjc)
Age: Early Ordovician (473 to 488 million years ago)
Description: Dolostones of this age have not been mapped separately in Arkansas, as they have in Missouri, due to the lower contact of the Jefferson City not being exposed in Arkansas. The Cotter is a fine-grained, white to tan or gray dolostone. It may be soft (cotton rock), or a massive-bedded gray dolostone that weathers to a rough surface. The Cotter may contain chert nodules. Fossils are rare in the Cotter.
Environment of deposition: shallow marine.

Karst Topography

Karst topography is a type of landscape in which sinkholes and caverns are well developed. The term was coined by European geologists after studying the Kras Plateau in Slovinia of south central Europe. The formation of karst landscape requires the presence of soluble bedrock, usually limestone or dolostone. In the Arkansas Ozarks, karst landscape features, consisting of sinkholes, caverns, springs, and blind (box canyon) valleys, are developed mostly in limestone, a rock composed of the mineral calcite (calcium carbonate). Other conditions that must be present during the development of karst features include the following: rock fractures and sedimentary bedding planes along which ground water can move, adequate rainfall to provide slightly acidic surface and ground water to dissolve the limestone, and the passage of much time.

The second stage of cavern development begins as deeply eroded stream valleys allow drainage of the caverns and air to enter the voids. During this stage, dripstones (speleothems) develop. The water dripping into the cavern is slightly acidified due to the presence of dissolved carbon dioxide derived from the interaction of water with the atmosphere and overlying soil. As it travels through the rock, the acidic water dissolves limestone and becomes supersaturated with calcium carbonate. Upon entering the air-filled cavern, some of the carbon dioxide evaporates resulting in the recrystallization of calcium carbonate (calcite) to form the speleothems.

A great variety of speleothems may form depending on the manner in which water enters the void (Fig. 5). Stalactites form attached to the cave's ceiling and stalagmites build upwards from the cavern floor. When these two forms join, columns result. Flowstones and rimstone basins may form on the cave floor, and ribbon stone forms along ceiling fractures. The variety of forms is almost endless contributing to the uniqueness of each cavern.

Figure 5. Speleothems
(Crystal Dome Cavern, northern Newton County, 36°07′10″N 93°07′37″W)

Arkansas’ tour caves include the following: Blanchard Springs Cavern, Bull Shoals Caverns, Cosmic Caverns, Hurricane River Cave, Mystic Caverns and Crystal Dome, Onyx Cave, Old Spanish Treasure Cave, and War Eagle Cavern.

For more information on the caves of the Arkansas Ozarks check out the following website: www.Arkansas.com/places-to-go/caves-caverns/.

Rock and Mineral Resources

Boone County

The main rock and mineral resources in the county are limestone, dolostone, sandstone, sand, and gravel. However, over the years, more than 30 zinc and lead prospects or mines have been active (Fig. 6). It is estimated that approximately 9,800 tons of zinc ores and a small amount of lead ore were produced, mostly during World War I, from three districts located as follows: east of Harrison along Crooked Creek, west of Lead Hill, and surrounding the Zinc community (Stroud, et al., 1969, p. 193).

The Fayetteville Shale, which has received so much attention as a natural gas producer in Arkansas since 2004, is exposed on the slopes of the deeper valleys in the County; however, it is not considered a viable gas producer in this area because of its exposure at the surface. The center of the producing area lies about 70 miles southeast of Harrison where the Fayetteville is several thousand feet below the surface. The main counties where Fayetteville production has developed are Van Buren, Cleburne, Conway, Faulkner, and White.

Newton County

Limestone, dolostone, and sandstone are present in many localities in the county, so there are significant dimension stone and crushed stone resources available. Also, sand and gravel deposits are present along the Buffalo River and its tributaries.

Zinc and lead mineral deposits were mined in six districts in the northern half of the county located as follows: Ponca-Boxley, Little Buffalo River, Upper Cave Creek, Mount Hersey-Lower Cave Creek, Mill Creek, and Davis Creek-Hurricane Branch.

Veins of ore minerals are present in fractures associated with faults and joints in the Boone Formation, the Everton Formation, and the Batesville Sandstone (Stroud, et al., 1969, p. 307). Galena (lead sulfide), the chief ore of lead, was mined in the county as early as 1864. After 1900, especially during World War I, zinc ores became the chief mineral mined. Not much mining or prospecting occurred in the area after 1920. Total amounts of ore produced are approximately 1,700 tons of sphalerite (zinc sulfide), 7,000 tons of zinc carbonate and silicate minerals, and 2,800 tons of galena (Stroud, et al., 1969, p. 307).

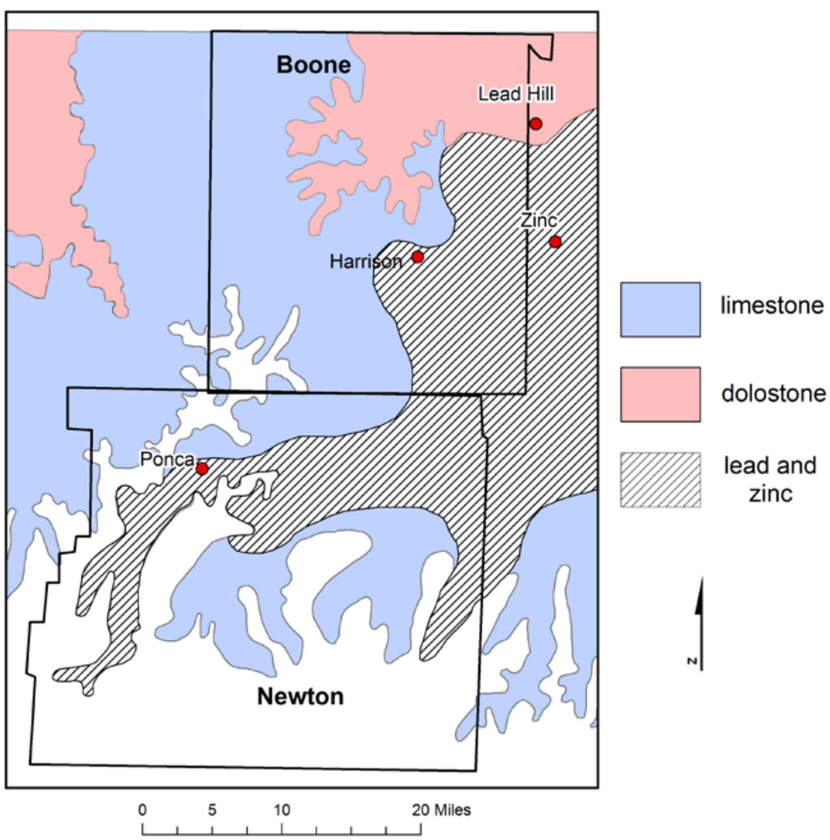

Figure 6. Rock and mineral resources of Boone and Newton County
(from Arkansas Mineral Resources, page size map)

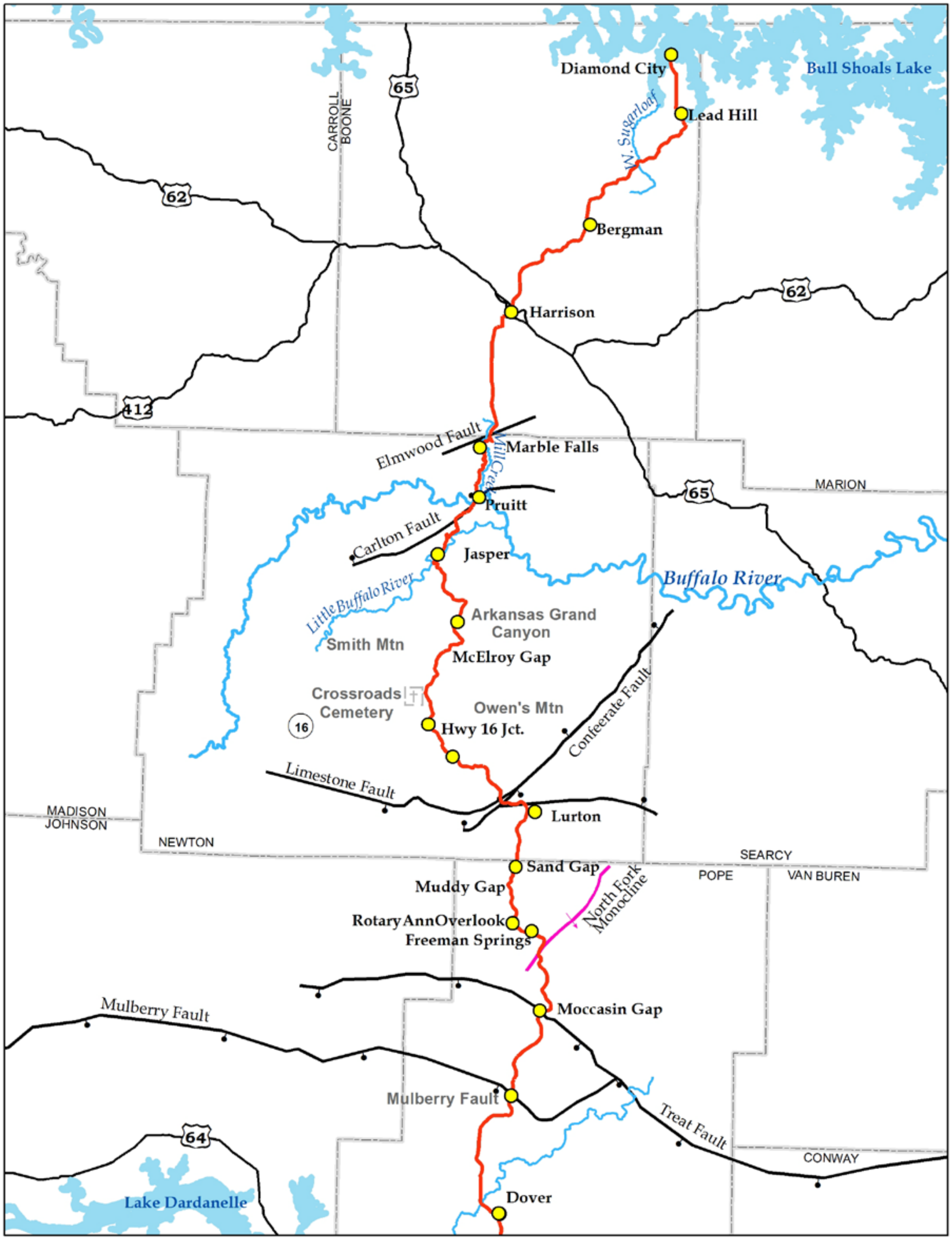

Figure 7. Scenic 7 route map from Bull Shoals Lake to Dover
(Major faults and monoclinal axes are shown, black dots are located on the downthrown side of the fault)

Road Log – Bull Shoals Lake to Harrison

Scenic 7 begins or ends, depending on your approach, in Boone County at Bull Shoals Lake on the border of Missouri and Arkansas (Fig.7). The northernmost community on the highway, Diamond City, is located on the Salem Plateau. The sedimentary rock formations exposed in this vicinity are the Jefferson City and Cotter Dolomite (Fig. 8). These two formations are mapped as a single unit in Arkansas. The Jefferson City Dolomite was originally defined at Jefferson City, Missouri, while the Cotter Dolomite was first described in the White River Valley near Cotter, Arkansas. Each formation is Early Ordovician Period (473 to 488 million years ago) in age. Both formations consist of white to tan or gray dolostone (calcium-magnesium carbonate) containing chert nodules that are irregularly-shaped masses of silicon dioxide. Fossils are rare; however, gastropods, cephalopods, and algae occur in the Cotter (McFarland, 2004).

From Diamond City to Lead Hill, Scenic 7 continues to cross the Jefferson City-Cotter Dolomite. Approximately 2.6 miles southwest of the South Lead Hill community, the road curves and passes between two hills that rise about 80 feet above the road. They are composed of the Powell Dolomite, the next younger rock unit that overlies the Jefferson City-Cotter Dolomite. The road continues across the Jefferson City-Cotter for approximately another 4.8 miles. After following a branch of West Sugar Loaf Creek in Cook Hollow, Scenic 7 leaves the Salem Plateau and enters the Springfield Plateau after crossing the Powell Dolomite for about 0.4 mile.

A major unconformity lies between the Powell Dolomite (Early Ordovician Period, 473 to 488 million years ago) and the Boone Formation (Early to Middle Mississippian Period, 318 to 338 million years ago) that forms the surface of the Springfield Plateau. The missing rock strata reflect a 150 million-year gap in the stratigraphic record! What happened? Where did the rocks go or did they ever exist?

These are the kinds of questions that geologists must deal with. We will never know the absolute truth about the missing rock record. However, we have reasonable explanations (hypotheses) to offer. Either the sediments were deposited in a shallow marine setting then eroded away after sea level dropped, or the continental shelf was uplifted above sea level, and possibly this portion of the continent remained above sea level and sediments were never deposited. We do know that there are sedimentary rocks of similar age preserved elsewhere in the Ozarks and in the Ouachita Mountains approximately 140 miles southwest of this area. However, the Ouachita rocks were deposited in a deep-water marine setting, not on a continental shelf. So, the margin of the continent during this time gap was somewhere between the Ozarks and the Ouachitas. Hopefully, a better understanding of this question will be developed as we follow Scenic 7 across the Arkansas River Valley and into the Ouachita Mountains.

From Bergman to Harrison, Scenic 7 crosses the mostly horizontally-bedded Boone Formation. The Boone consists of a fossil-rich gray limestone that often contains chert beds and nodules. The Boone is well known as a host rock of karst topographic features.

While not on Scenic 7, a drive of a few miles on U.S. 65 from Harrison toward the Missouri border is worthwhile. The large road cuts north of Harrison along U.S. 65 display the Boone Formation in a spectacular manner. You will see that the horizontally-bedded gray limestone is interbedded with numerous nearly white chert beds (Fig. 9).

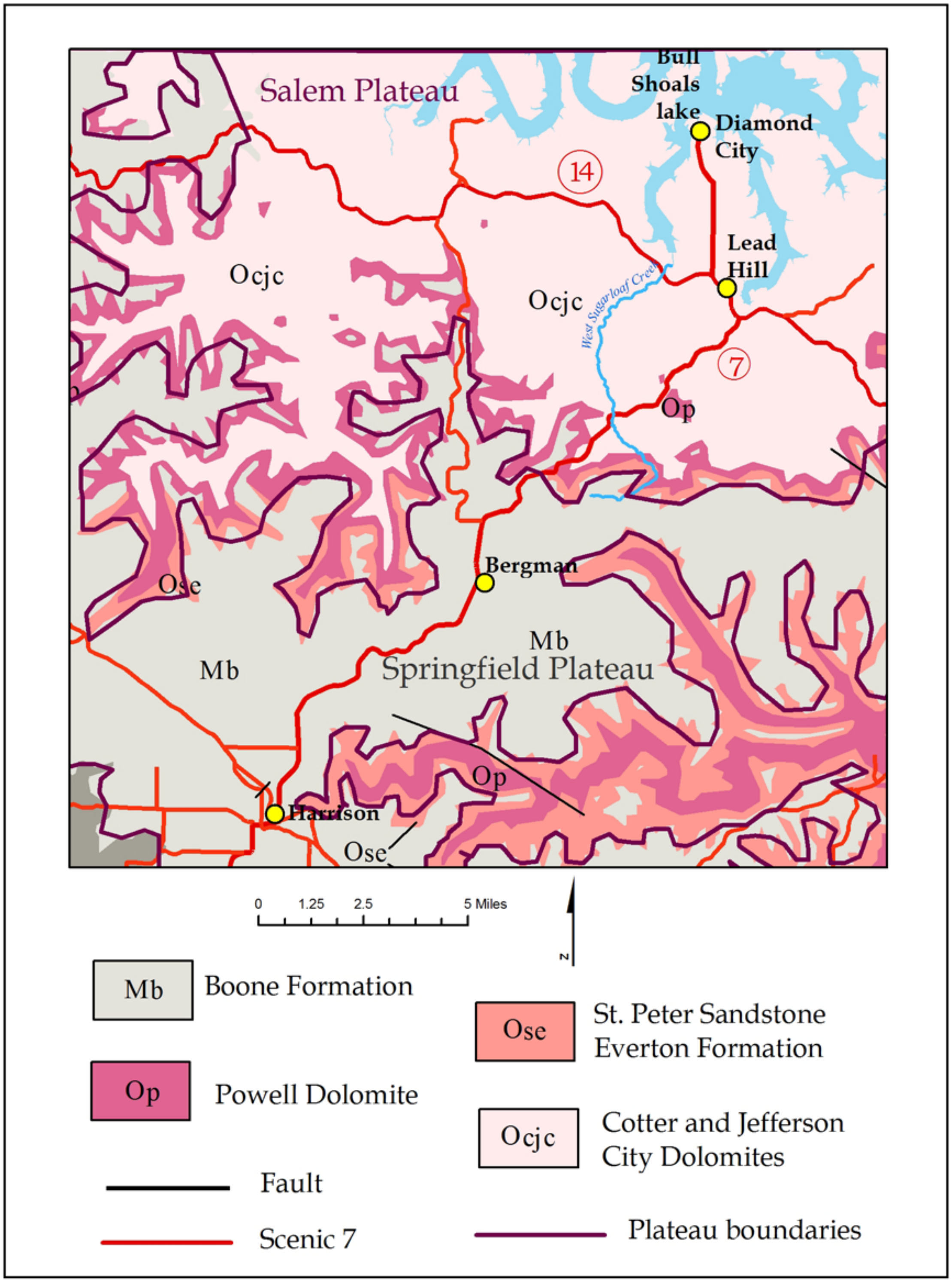

Figure 8. Geologic map from Bull Shoals (Diamond City) to Harrison
(from the Geologic Map of Arkansas, 1:500,000 scale)

Figure. 9. Boone Limestone with bedded chert
(North of Harrison on U.S. 65, 36°25′35″N 93°13′43″W)

The rolling, hilly surface of the Springfield Plateau is a few hundred feet higher in elevation than the Salem Plateau. The plateau surface reaches an elevation of 1,800 feet above sea level in several localities, but is dissected by deep ravines where stream systems have entrenched themselves. As, we return to Harrison, the hilly surface is well exposed (Fig. 10A).

(A) **(B)**

Figure 10. Springfield Plateau (A) north of Harrison (36°24′56″ N, 93°13′57″) **on U.S. 65 and (B) south of Harrison on Scenic 7** (36°09′20″ N, 93°07′18″ W)

Road Log – Harrison to Jasper

Heading south from Harrison, Scenic 7 continues to cross the Boone Formation and the broad rolling landscape typical of the Springfield Plateau (Fig. 10B). Approximately 8 miles south of Harrison, the road crosses the Elmwood Fault Zone (Fig. 11). The rocks of this region display mild structural deformation, as shown by the presence of broad domes, monoclines, and low displacement normal faults (Hudson, et al., 2001). These structures may represent gravitational settling in response to faults in the deeper igneous basement rocks.

The road roughly parallels the fault zone for approximately 0.6 mile before turning sharply to the southeast at Dogpatch (Marble Falls, Newton County), where it begins to follow the valley of Mill Creek for several miles. In this area, the St. Joe Limestone Member is exposed at the base of the Boone Formation.

Limestone from this area was quarried in 1836 for use in the Washington Monument. In 1954 the Newton County Historical Society erected a roadside marker at Marble Falls in commemoration of the donation. For more historical information please check out the following website: www.arkansasroadstories.com/washmon.

The St. Joe is exposed on the west side of Scenic 7 for approximately 1.7 miles before encountering the Everton Formation (Middle Ordovician Period, 458 to 473 million years ago). The Everton is an interbedded dolostone, sandstone, and limestone up to 230 feet thick where a complete section is present (Hudson, et al., 2001). Approximately 0.1 mile north of the Buffalo River, the road crosses the Carlton Fault Zone (Fig. 12) before splaying (dividing) into a graben structure that continues to the east. Scenic 7 crosses the Carlton fault again approximately 3.7 miles north of Jasper.

Massive sandstone of the Everton Formation is dramatically exposed in the bluff along the north bank of the Buffalo River near Pruitt (Fig. 13). A stop at the river access point and picnic area at the south end of the bridge is a must to just appreciate the beautiful scenery and marvel at the massiveness of the sandstone.

Leaving the picnic area, the road climbs from an elevation of 820 feet to about 1,400 feet above sea level over a distance of approximately 1.4 miles. In this distance, Scenic 7 crosses the Everton Formation and the St. Joe Limestone Member of the Boone Formation. For the next 0.5 mile the road runs parallel to the Carlton Fault Zone which brings the Everton into contact with the Boone, thus creating a 150 million year gap in the geologic record. As the road turns from southwesterly to a more southeasterly direction, the Everton and St. Joe Limestone are exposed again in the valley of a tributary of the Little Buffalo River.

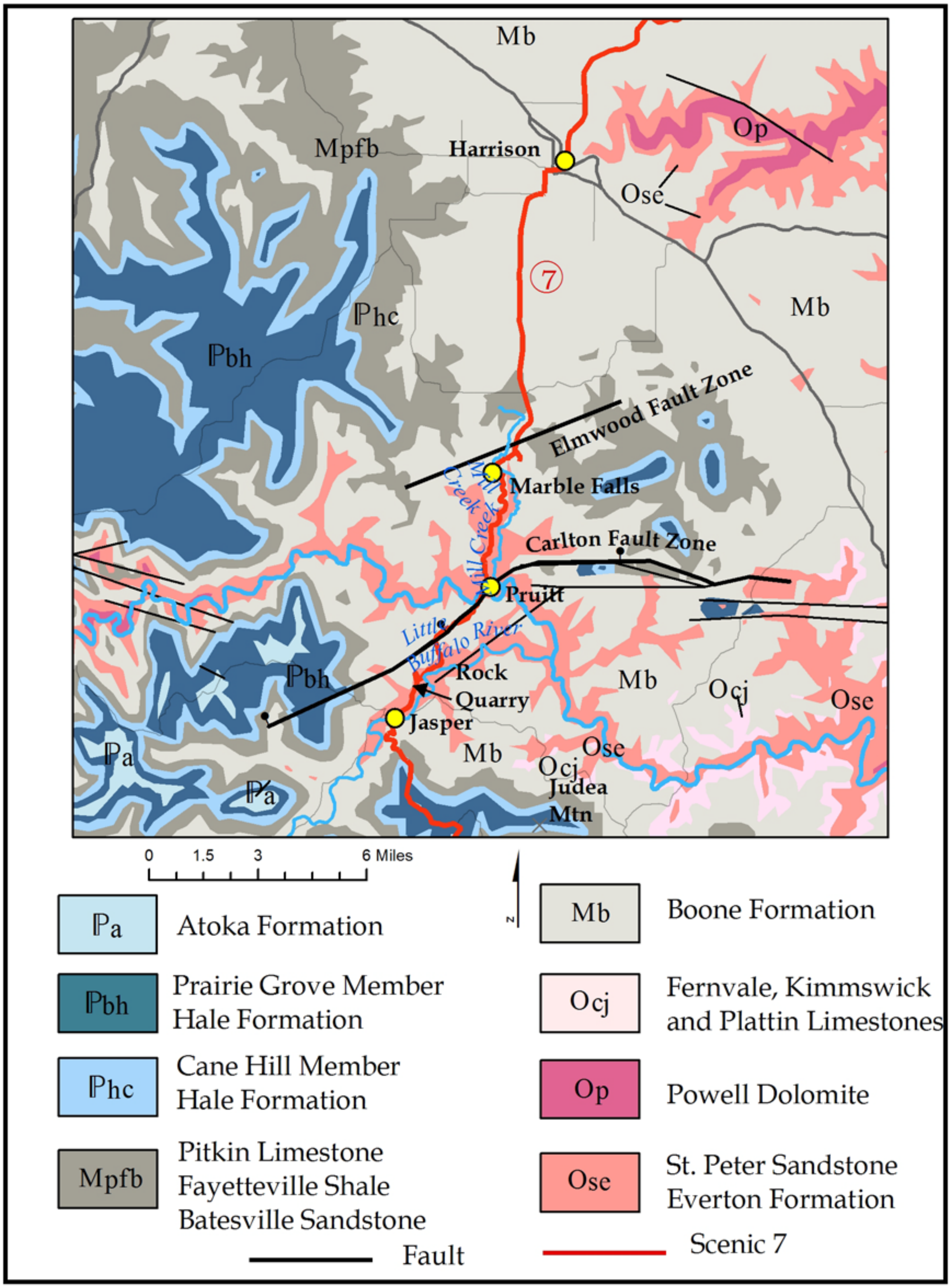

Figure 11. Geologic map from Harrison to Jasper
(from Geologic Map of Arkansas, 1:500,000 scale)

Figure 12. Carlton Fault Zone (3.7 miles north of Jasper, 36°02′42″N 93°09′31″W)

Figure 13. Everton Sandstone (Buffalo River near Pruitt, 36°03′40″N 93°08′17″W)

Figure 14. Little Buffalo River Landscape
(North of Jasper, 36°01′31″N 93°10′19″W)

Figure 15. Boone-St. Joe Limestone
(North of Jasper, 36°01′31″N 93°10′19″W)

Three miles south of Pruitt, Scenic 7 enters the valley of the Little Buffalo River (Fig. 14) and runs parallel to it on the Everton Formation and the St. Joe Limestone before reaching the Little Buffalo River Bridge. Approximately 3.7 miles south of Pruitt (1.6 miles north of Jasper), there is an abandoned rock quarry on the west side of the Scenic 7 roadway (Fig. 15). This is an easy pull-off area where you may collect limestone from the St. Joe and chert fragments from the Boone. There are many small fragments of white to gray chert and gray to red limestone containing numerous fossil crinoid column fragments. Other marine invertebrate fossils typical of the Boone may also be present.

After crossing the Little Buffalo River Bridge we arrive in downtown Jasper, the quaint county seat of Newton County. The town of Jasper is built on the Everton and Boone Formations

Road Log – Jasper to Arkansas Grand Canyon Overlook

As we leave Jasper on Scenic 7 there are excellent exposures of the Boone in roadcuts on the left (east) side of the road 1.9 miles from the Newton County Courthouse**.** The limestone contains numerous chert nodules, but not as much bedded chert as we saw north of Harrison. Heading south, the road begins a dramatic 3.6 mile climb from an elevation of 834 feet at Jasper to the summit of Judea Mountain, considered to be the beginning of the Boston Mountain Plateau, at 2,154 feet above sea level. During this drive, we will be travelling "upsection", as geologists say, that is, crossing all of the progressively younger sedimentary formations between the Everton and Bloyd, including a landslide deposit (Fig. 16).

The steep slopes of the Boston Mountains Plateau are especially prone to mass wasting (landsliding). Geologic maps of the region show numerous landslide deposit areas of Quaternary age (Recent to 2.6 million years ago). For example the "Geologic Map of the Parthenon Quadrangle, Newton County, Arkansas", the map that includes Judea Mountain, shows five landslide deposit areas. Such slope instability is especially likely during rainy periods in areas where shale underlies sandstone or limestone. The guilty parties triggering slope failure in this region are the Cane Hill Member (interbedded silty shale, siltstone, and thin sandstone) of the Hale Formation and the interbedded finely crystalline limestone and shale of the Fayetteville. Periodically, Scenic 7 and other roads in the Springfield and Boston Mountain Plateaus are affected by slope failure.

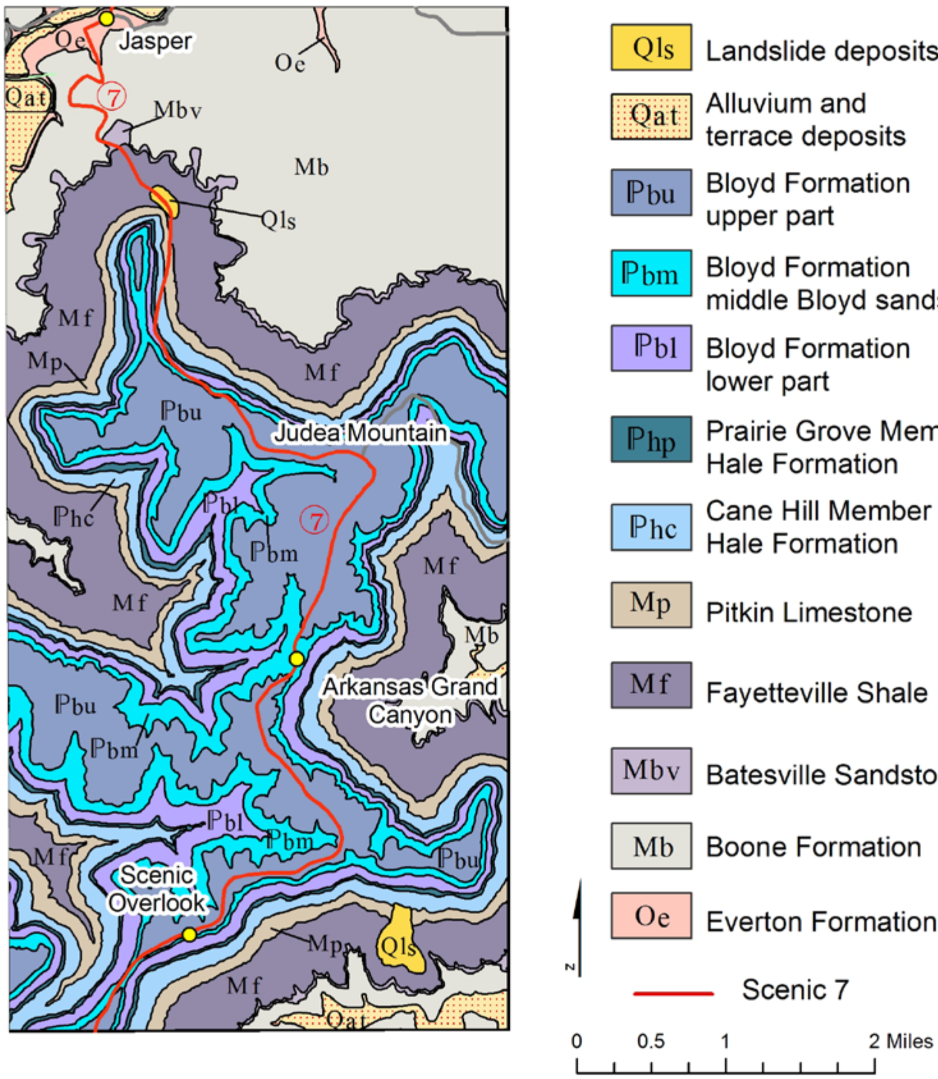

Figure 16. Geologic map from Jasper to Arkansas Grand Canyon
(from Geologic map of the Parthenon quadrangle, 1:24,000 scale)

Once you reach the summit of Judea Mountain, there are spectacular views of the surrounding landscape to the north, east, and southeast. Be sure to take advantage of these scenic opportunities by stopping at Scenic Point at the top of the uphill climb 3.6 miles south of Jasper and at Cliff House Inn 5.4 miles south from Scenic Point to view the Arkansas Grand Canyon (Fig. 17).

The valley between Judea Mountain and the highlands to the east was carved out by Big Creek and its tributaries. The valley floor elevation is about 800 feet while the mountain tops are generally 2,000 to 2,200 feet above sea level.

Figure 17. Arkansas Grand Canyon
(35°54′25″N 93°11′12″W)

If one were to hike from Big Creek to the summit of one of the surrounding mountain tops, you would cross six or seven geologic formations separated by about the same number of unconformities. The geologic ages encountered, in such a challenging climb, would range from the Middle Ordovician to the Middle Pennsylvanian Periods, spanning approximately 150 million years. These unconformities indicate that sea level fluctuated many times. When the Ozark Dome and its surrounding continental shelf were above sea level, erosion occurred. When sea level rose shallow-water marine limestone**,** sandstone, and shale were deposited.

Judea Mountain is capped by sandstone and shale of the upper and middle Bloyd Formation (Early Pennsylvanian Period, 312 to 318 million years ago). The Bloyd (Fig. 18) consists mostly of interbedded sandstone and shale that ranges from light-brown to gray on fresh surfaces, but weathers to a darker gray (Braden and Ausbrooks, 2003).

Trace fossils (feeding burrows and tracks of bottom-dwelling organisms) and lycopod (plant) fossils indicate that portions of the Bloyd were deposited in relatively shallow water in a non-marine setting. It should be noted that lycopod fossils are evidence of the first plant life on land in Arkansas rocks, and should be recognized as marking a significant step toward the development of more complex land-dwelling organisms. So far, all of the remains of life that we have encountered during our trip through time have been sea-dwelling creatures.

Figure 18. Bloyd Formation
(Judea Mountain Scenic Overlook, 35°55′10″N 93°10′31″W)

Road Log – Arkansas Grand Canyon Overlook to State Highway (SH) 16 (Road to Deer) Junction

Heading south again after stopping at the last scenic overlook, we pass through McElroy Gap where a side road winds downhill into the valley of the Left Fork of Big Creek flowing between Smith Mountain and Owens Mountain. One of the rare structural folds in rocks of the Boston Mountains Plateau is crossed 0.7 mile south of McElroy Gap. Red Rock Monocline, a step-like fold lying between Moss Mountain and Smith Mountain, trends northwest-southeast and dips toward the northeast (Fig. 19). The flexure is present probably because of normal faulting in deeper rocks. This type of structure is not caused by compressive mountain-building forces, it probably is a gravitational response of the sedimentary strata to normal faulting in the underlying igneous basement rock.

Continuing south, Scenic 7 leaves the upper Bloyd Formation and encounters the younger Atoka Formation 2.4 miles south of McElroy Gap. In this area, the Atoka consists of black to tan-colored shale, mica-bearing siltstone, and tan sandstone (Braden and Ausbrooks, 2003). Scenic 7 reaches an elevation of approximately 2,260 feet as it passes Crossroads Cemetery. The road continues south and the Bloyd Formation is exposed again as the hilly landscape makes a series of dips and rises. The Atoka is crossed again before reaching the intersection with SH 16.

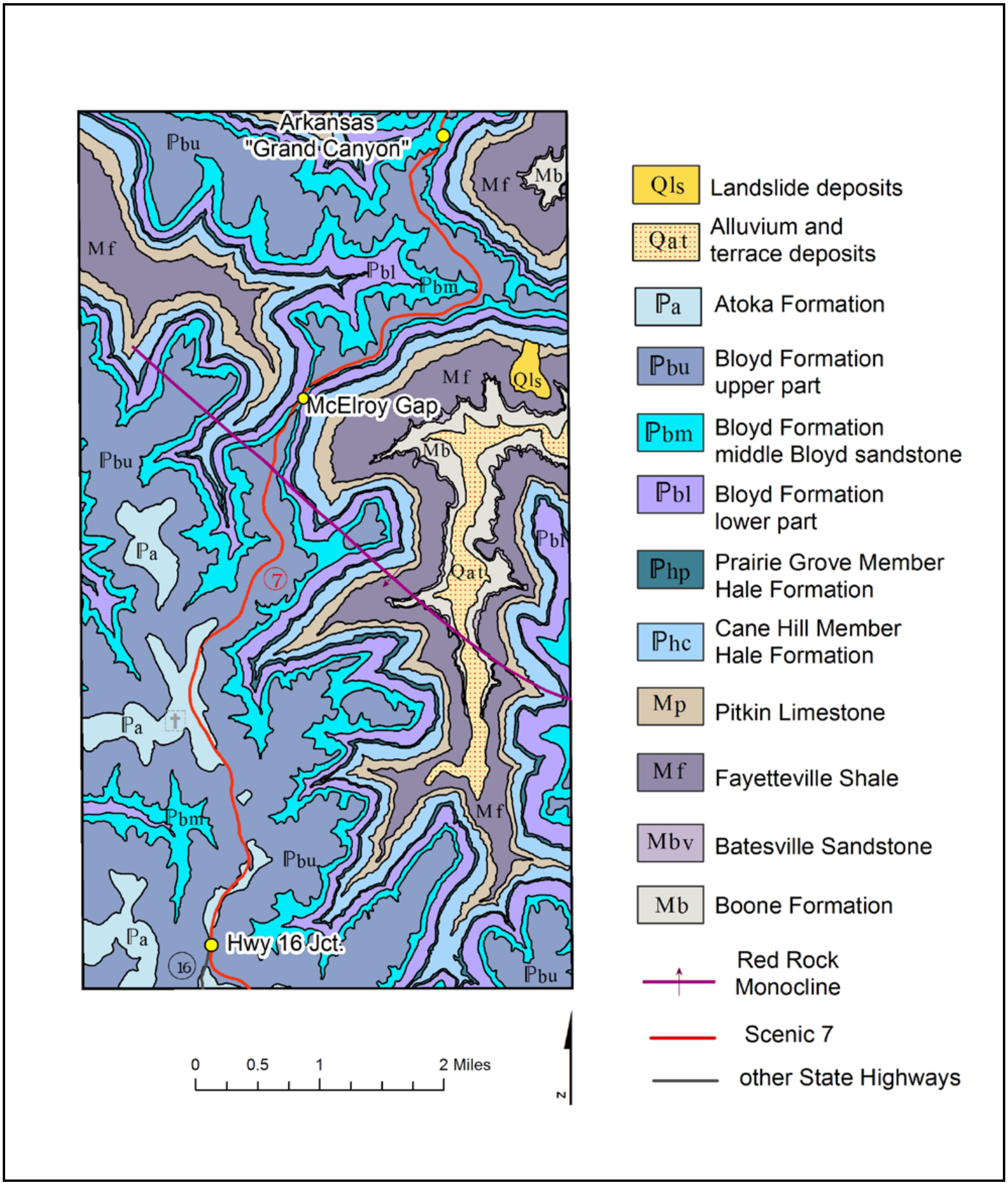

Figure 19. Geologic map from Arkansas Grand Canyon to State Highway 16
(from Geologic map of the Parthenon quadrangle, 1:24,000 scale)

Road Log – SH 16 Junction to Mulberry Fault

From the SH16 Junction to the Cowell community Scenic 7 remains on the Bloyd Formation, but in this area the Atoka caps the higher elevations, which may reach 2,230 feet above sea level.

Approximately 5 miles south of Cowell, Scenic 7 crosses a normal fault leading into a graben structure 0.3 mile wide at this point. The Atoka Formation is exposed between the normal faults that define the margins of the graben. The faults that bound the graben are the Limestone Fault on the north and the Confederate Fault on the south (Fig. 20). These two faults are considered to be major regional structures. Downward displacement of strata within the graben is approximately 200 feet (Braden and Smith, 2004). Faults are recognized in this area by the once nearly horizontal strata displaying dips up to 40 degrees near a fault. Also, faulting causes older strata to be brought into contact with younger strata at the surface and may cause offset in their outcrop patterns.

South of Muddy Gap, located 2 miles south of Sand Gap (Pelsor), the Atoka Formation is dipping an average of 5 degrees to the south. As you remember, this is unusual in the Ozark Plateaus since most of the strata are in a nearly horizontal position except where disturbed by faulting or folding. It is assumed that this monocline was caused by deeper normal faults in igneous basement rocks causing strata overlying the fault to fold due to the force of gravity. Between the Lurton area and Sand Gap (4.3 miles) the road remains on the Atoka Formation (Fig. 20).

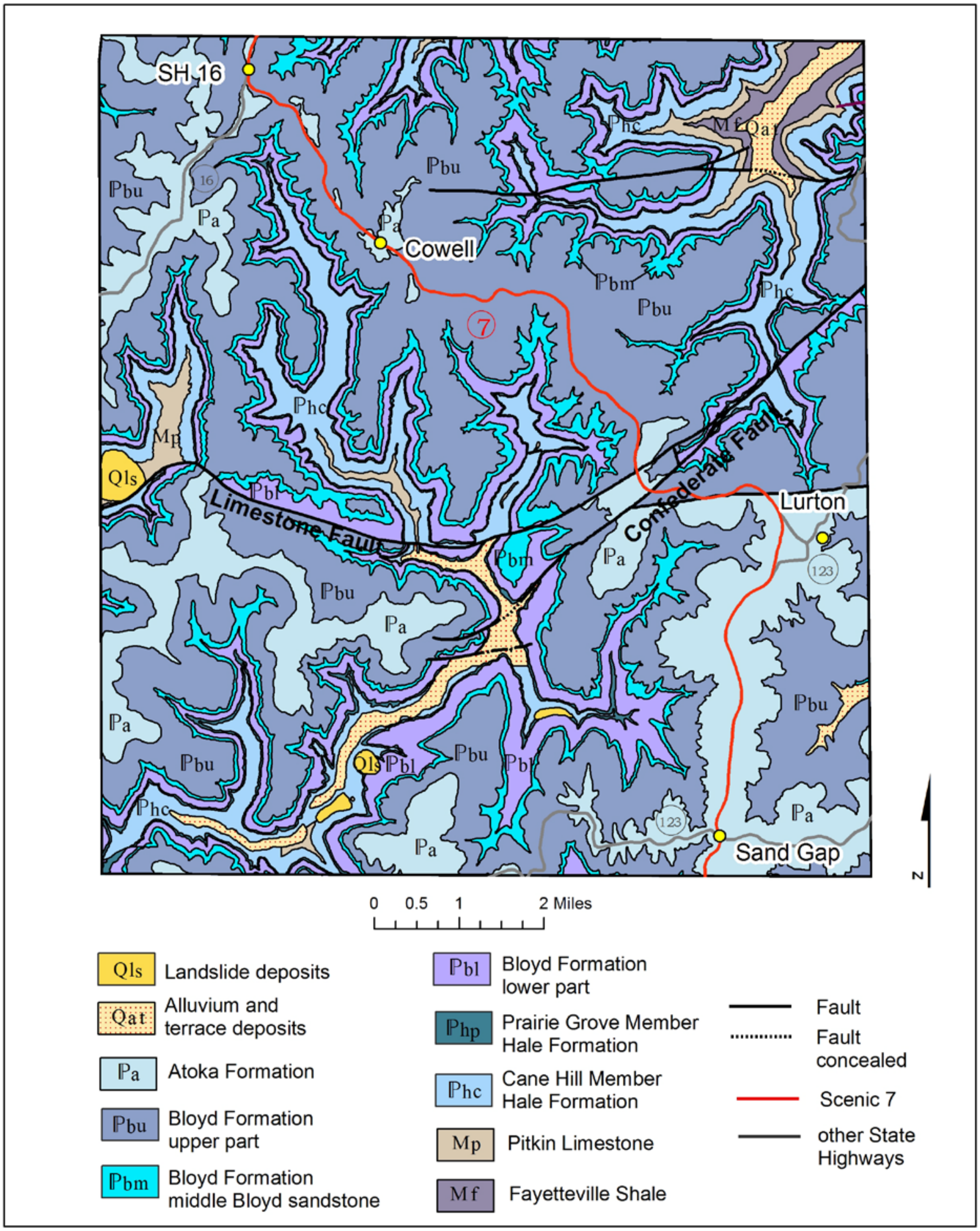

Figure 20. Geologic map from SH 16 Junction to Sand Gap
(from Geologic maps of the Deer, Lurton, and Sand Gap quadrangles, 1:24,000)

Figure 21. Rotary Ann Overlook
(Pope County, 35°40′10″N 93°05′56″W)

Rotary Ann Overlook, maintained by the U.S. Forest Service, is an excellent rest stop where we can view many square miles of the Boston Mountains which are actually a deeply-eroded plateau. Notice how the "knobs", as the summits of the distant hill tops are labeled on the "Lay of the Land" signboard, are essentially at the same elevation (Fig. 21). The Boston Mountains Plateau is the highest part of the Arkansas Ozarks, reaching over 2,500 feet above sea level at some locations.

These higher elevations are topped by outcroppings of Pennsylvanian-aged sandstone of the Atoka and Bloyd Formations. The plateau has been eroded, as deeply as 500 to 1,500 feet, by numerous streams that have developed a dendritic (tree-like branching) drainage pattern over thousands of years because of the uniform hardness and mostly horizontal orientation of the sedimentary strata. However, some rectangular and trellis drainage patterns formed locally because of the presence of tilted strata due to minor folds and faults, especially along faults with a northeast-southwest trend.

After leaving Rotary Ann Overlook, Scenic 7 continues south (1.3 miles) to the Freeman Springs community. Two miles south of Freeman Springs, the road crosses the North Fork Monocline that trends northeast and dips toward the southeast (Fig. 22). Continuing south on the Atoka Formation, the road passes through the Simpson community and 1.8 miles farther is Moccasin Gap where we encounter the Treat Fault. A branch of this normal (gravity) fault is well exposed on the west side of the road - you can't miss it (Fig. 23).

The Atoka Formation strata dip toward the south about 28 degrees, while the fault plane dips north 29 degrees. Along the outcrop the strata are offset approximately 46 feet to the north. The shales and siltstones in contact with the fault plane show drag. Drag is folding that indicates the direction of motion of the hanging wall (block above the fault plane) with respect to the footwall (block below the fault plane).

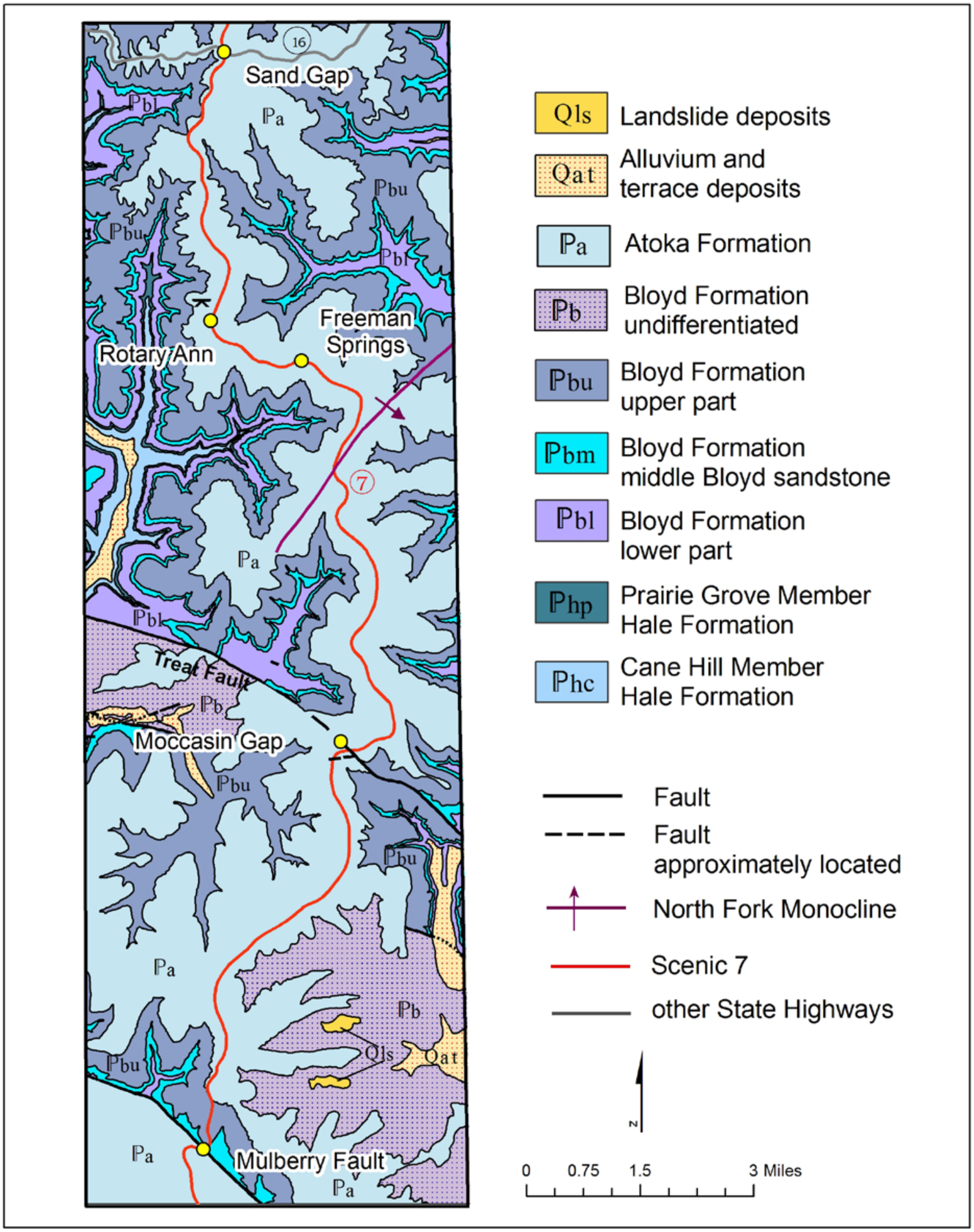

Figure 22. Geologic map from Sand Gap to the Mulberry Fault
(from Geologic maps of the Sand Gap and Simpson quadrangles, 1:24,000 scale)

From Moccasin Gap, Scenic 7 continues south on the Atoka Formation at an elevation over 1,400 feet above sea level. Approximately 4.9 miles from the fault, the road begins a downhill run and about 0.5 mile from the beginning of the descent we cross back onto the upper part of the Bloyd Formation. From this point Scenic 7 continues its descent and approximately 0.6 mile from the upper Bloyd contact, the middle Bloyd is crossed as the road curves sharply to the west and crosses the Mulberry Fault (35°29″32′N 93°06″14′W).

The Mulberry Fault is a major fault zone, forming the southern boundary of the Boston Mountains Plateau and the beginning of the Arkansas River Valley Physiographic Province (Fig. 24). Tensional forces in the Earth's crust caused the Mulberry and similar normal faults to develop in the igneous basement rocks and overlying sedimentary strata. Fault blocks (hanging walls), lying above the south-dipping fault surfaces, moved downward with respect to the blocks that underlie the fault (footwall). Most of the faults in this region are of this type and are known by oil and gas geologists as "down to the south" faults meaning that the hanging wall moved down on the south side of the fault surface.

Data gained from the drilling of natural gas wells indicate that the Mulberry Fault caused the Atoka and underlying strata to drop approximately 3,500 feet (Bill Cains, personal communication, 2011). Such displacements along major faults, like the Mulberry and associated cross-faults, caused numerous structural traps to form in the sedimentary strata, resulting in the natural gas accumulations characteristic of the Arkansas River Valley Province (aka Arkoma Basin).

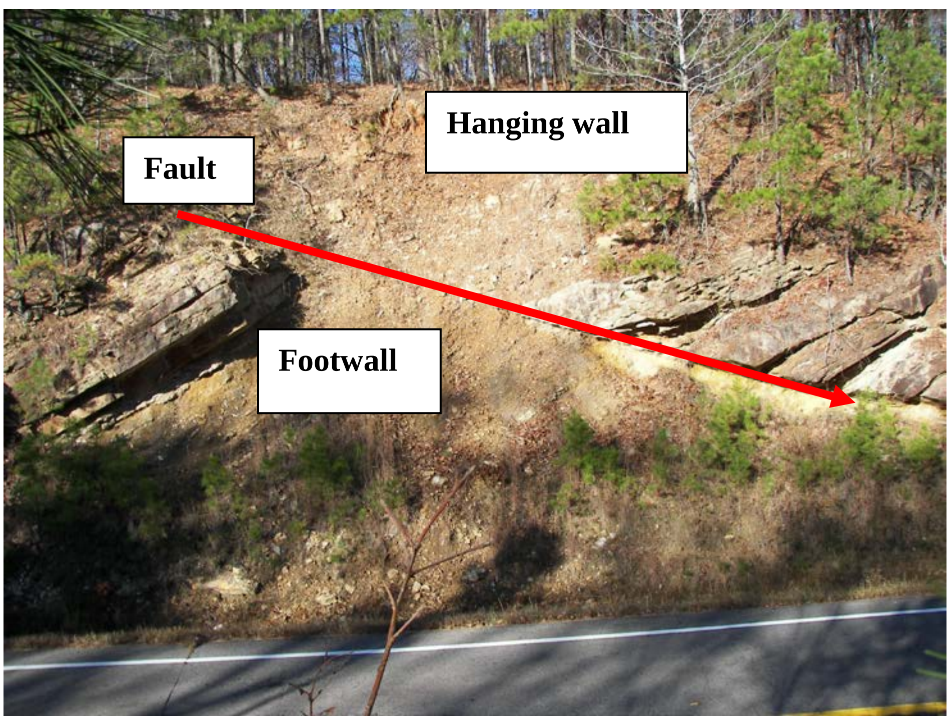

Figure 23. Branch of the Treat Fault at Moccasin Gap
(Pope County, 35°35′10″ N 93°04′09″W)

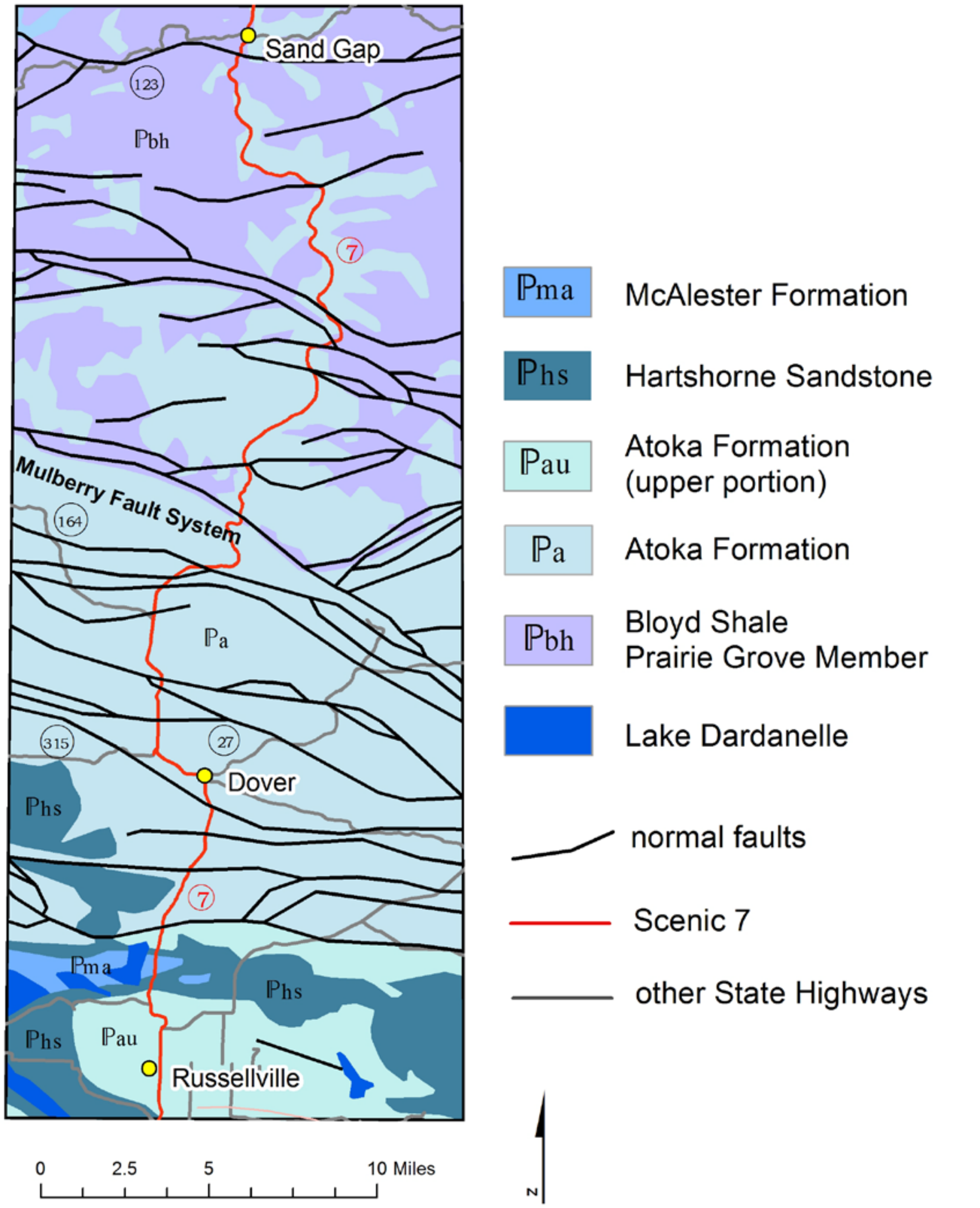

Figure 24. Geologic map of normal faults between Sand Gap and Russellville
(Source, Geologic Map of Arkansas, 1993)