Mount Nebo Geology Fieldtrip

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Introduction

Rock exposures at Mount Nebo State Park west of Dardanelle, Arkansas, show excellent examples of the rock formations that crops out throughout the Arkansas River Valley Region. Numerous outcrops are accessible along the connecting system of trails that ring the summit and "bench" of the mountain. The outcrops feature rocks that formed as accumulations of sediment in the geological past during a period of time referred to as the Paleozoic (roughly 325 million years before the present). Minerals, fossils, and other sedimentary features used in the interpretation of ancient environments of sediment accumulation are common. Groups and individual hikers, then, are familiarized with typical rocks of the area and with the features that allow for the interpretation of sedimentary rocks in general.

Two formations, the Atoka Formation and the Hartshorne Sandstone, will be examined during the fieldtrip. The strata of the Atoka Formation are believed to have formed along the front of a delta in an offshore marine setting. The strata preserve features indicative of quieter offshore settings: fine grained sediments in the silt and clay range, thin continuous layering, slightly wavy bedding, and rare marine fossils. The Hartshorne Sandstone, the younger of the two formations, is believed to represent an ancient river system. Features present in the Hartshorne Sandstone suggestive of a delta coastal system include: medium to large sand grains, distinctive ripple marks, cross-bedding, plant fossil casts, and channel features.

Field Trip Stops

Stop 1: Bench Overlook
Mount Nebo is located seven miles west of Dardanelle on Arkansas Highway 155. The Arkansas Highway 155 turnoff is located approximately one-quarter mile northwest of the intersection of Arkansas highways Seven and Twenty-two on the west side of Dardanelle. The field trip begins at the Bench Overlook roughly one-half of a mile from the mountain's summit (see Figure 1. Map of Mountain Nebo from the Mount Nebo State Park brochure). The viewing deck overlooks the valley of the meandering Arkansas River and its floodplain. To the northeast lies Lake Dardanelle. Several mountains dot the landscape: Norristown Mountain adjacent to Lake Dardanelle, Carrion Crow Mountain to the east, and Petit Jean Mountain to the southeast. These mountains are all eroded remnants of broad down folds (synclines) in the Atoka and Hartshorne Formations. The Arkansas River as it winds eastward occupies the eroded center of a long nearly east-west trending up fold (anticline).

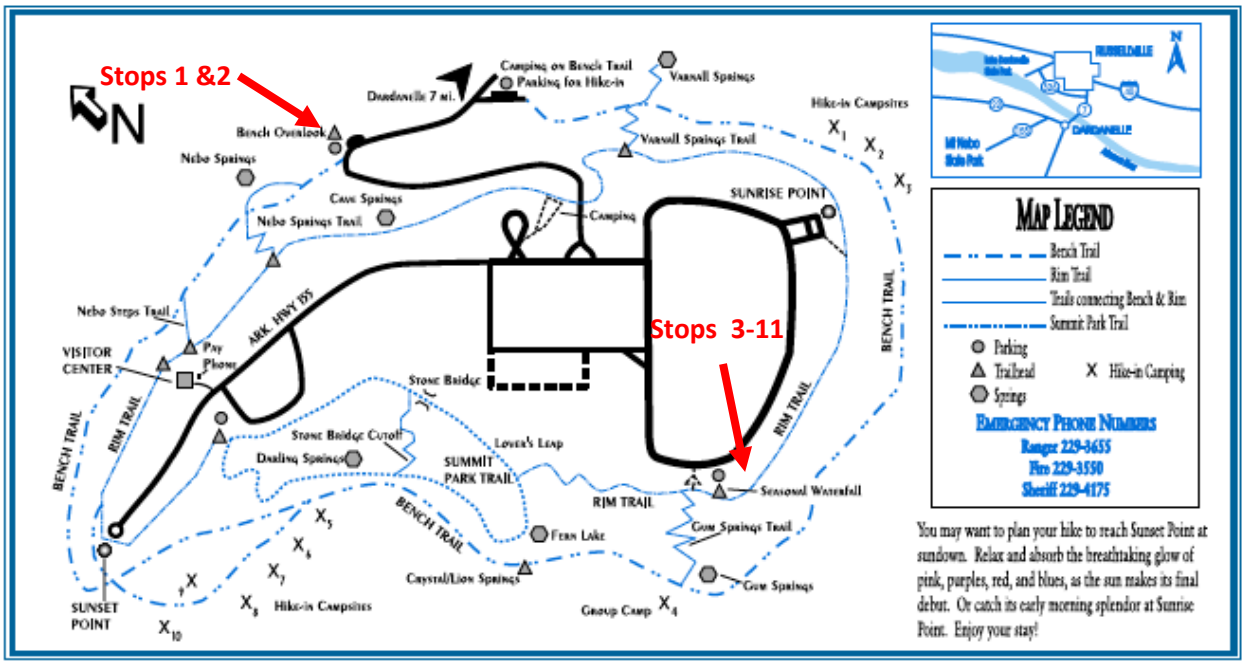

Figure 1. Mount Nebo State Park map (courtesy of Arkansas State Parks)

Stop 2. Bench Shale Pit: Atoka Formation

Proceeding north along the bench trail from the Bench Overlook, the Atoka Formation is exposed in a shale pit roughly 300 yards from the overlook parking lot (Fig. 2). The Atoka Formation along the flanks of Mount Nebo is comprised of dark gray silty shales composed of clay minerals and quartz and thin quartz sandstone layers. The layers are thinly bedded to almost laminated in appearance. Large fractures known as joints criss-cross the face of the exposure. Concentrations of iron oxide minerals are visible along the joint surfaces. The fractures are heavily weathered and, where undercut by erosion, create landslides.

Weathering shales usually produce large amounts of small plate-like fragments and clay forming a large talus slope. Shale talus hillsides tend to be moderate in slope. Most Atoka Formation outcrops above the bench of Mountain Nebo are covered by sandstone boulders that have fallen from bluffs above; however, the moderate slopes below the bluffs are indicative of the shales present beneath.

The small grain sizes of the shale, the thin even bedding, and lack of oxidation along fresh surfaces suggest a quiet offshore marine setting with abundant sediment. Comparable environments exists today along the margins of large deltas such as the delta formed along the Gulf of Mexico by the Mississippi River.

Figure 2. Atoka Formation exposure at Stop 2 on the Mount Nebo Bench Trail (photo courtesy of Amber Johnson, Arkansas Tech University geology major).

Stop 3. Seasonal Waterfall Overlook

Continue to the top of the mountain on Arkansas State Highway 155. At the junction at the mountain summit, turn left. Proceed south approximately one-tenth of a mile to another junction. At the junction turn right (west) and proceed west on County Road 102 to the parking lot for the Seasonal Waterfall Overlook and Gum Springs Trail

The Seasonal Waterfall Overlook features an excellent view of Spring Mountain to the west (Fig. 3). Spring Mountain, like Mount Nebo, is capped and ringed by impressive bluffs of the Hartshorne Sandstone. The lower slopes are comprised of the Atoka Formation, similar to the rocks of the Atoka seen at Stop 2. The broad, mesa-like mountain is, in fact, a broad down-warp/down-fold in the earth's crust. Such large-scale down-folds are known as synclines. Careful scrutiny of Spring Mountain shows that the north and south ends of the mountain are subtly inclined toward the mountain's center. Strata inclined "toward" each other are indicative of a syncline.

Figure 3. Spring Mountain: synclinal mountain located west of Mount Nebo. The summit of Spring Mountain, like Mount Nebo, is comprised of bluffs of the Hartshorne Sandstone.

When viewing Mount Nebo from Dardanelle, there are similar dips in the slopes of the mountain identifying Mount Nebo as a syncline as well. The gentler slopes below the bluff-line of Spring Mountain are comprised of shales and thinly bedded sandstones of the Atoka Formation similar to the strata observed at Stop 2.

Stops 4-7: Mount Nebo Rim Trail

The following four stops of the fieldtrip are along the Mount Nebo Rim Trail, a trail blazed by mountain residents during the last century. The stops of the field trip are highlighted in red in Figure 4.

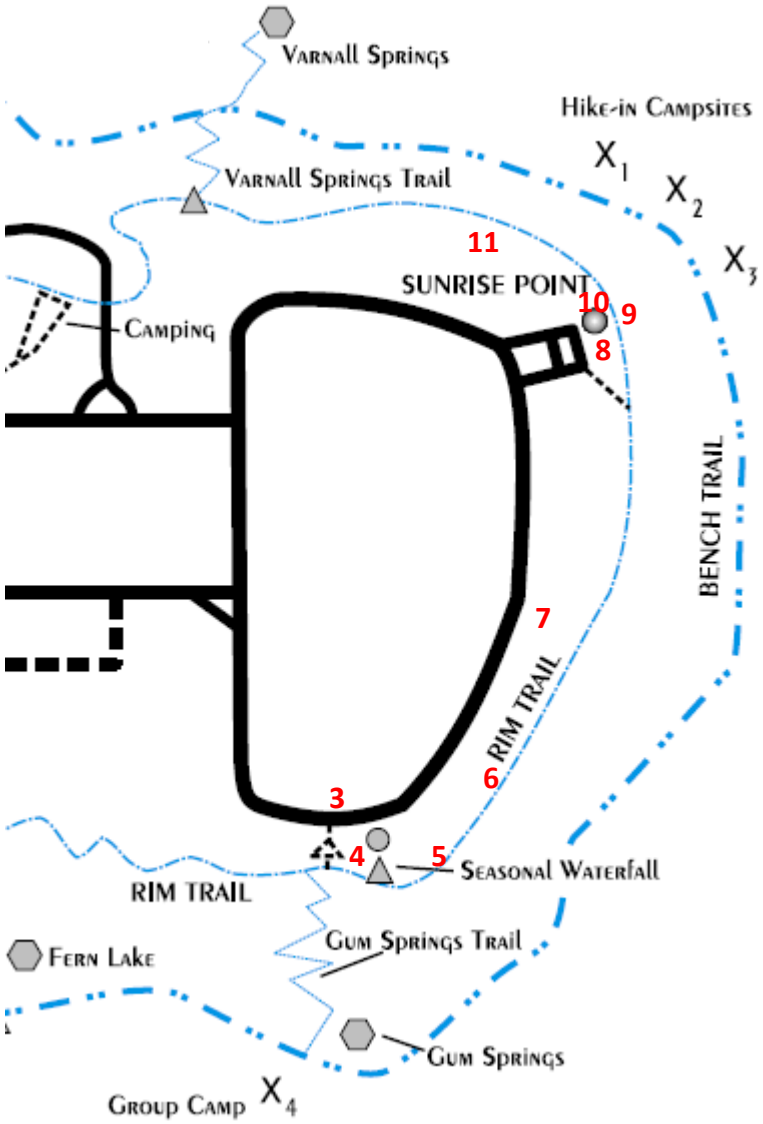

Figure 4. Stops 3-11 of the Mount Nebo Geology Fieldtrip (courtesy of Arkansas State Parks)

Stop 4: Gum Springs Trail

A few steps to the left will take you to the beginning of the Gum Springs Trail. The trail consists of a steep series of steps which should be carefully negotiated. The small stream leading to the waterfall descends along a narrow channel of moderately weathered rock. Reviews of aerial photographs of Mount Nebo suggest that a large nearly east-west running lineament may be responsible for weakness along which preferential weathering and erosion occurred (Fig. 5).

Figure 5. View along Gum Springs Trail upstream from seasonal waterfall.

The sandstones of the Hartshorne are primarily comprised of quartz grains that on a sunny day sparkle like tiny diamonds. Most of the rocks along the trail are stained by iron oxides ranging from a dark red color to shades of yellow and orange. Sedimentary features indicative of a river system are common along the trail. Ripple marks may be seen, but cross-bedding is most common. The cross-bedding is a criss-cross pattern in the sandstones that resulted as sand bars shifted with current flow in channels. These cross-beds probably originated in ancient stream channels.

As the trail winds along the stream channel large rock falls are visible to the right (Fig. 6). These massive sandstone rock falls are believed to be the result of collapse of large columns of weathered sandstone. Later in the trip, a large weathered sandstone column on the verge of failure will be examined.

Figure 6. Sandstone boulder "stream" along Gum Springs Trail

The Seasonal Waterfall is located at the base of the bluff line. Rocks at the base of the bluff are more heavily weathered creating an overhang responsible for the waterfall. Close examination of the heavily weathered zone shows fracturing that would have accelerated deterioration of the rock.

During winter months the waterfall can be quite striking with the development of long ice "draperies" (Fig. 7).

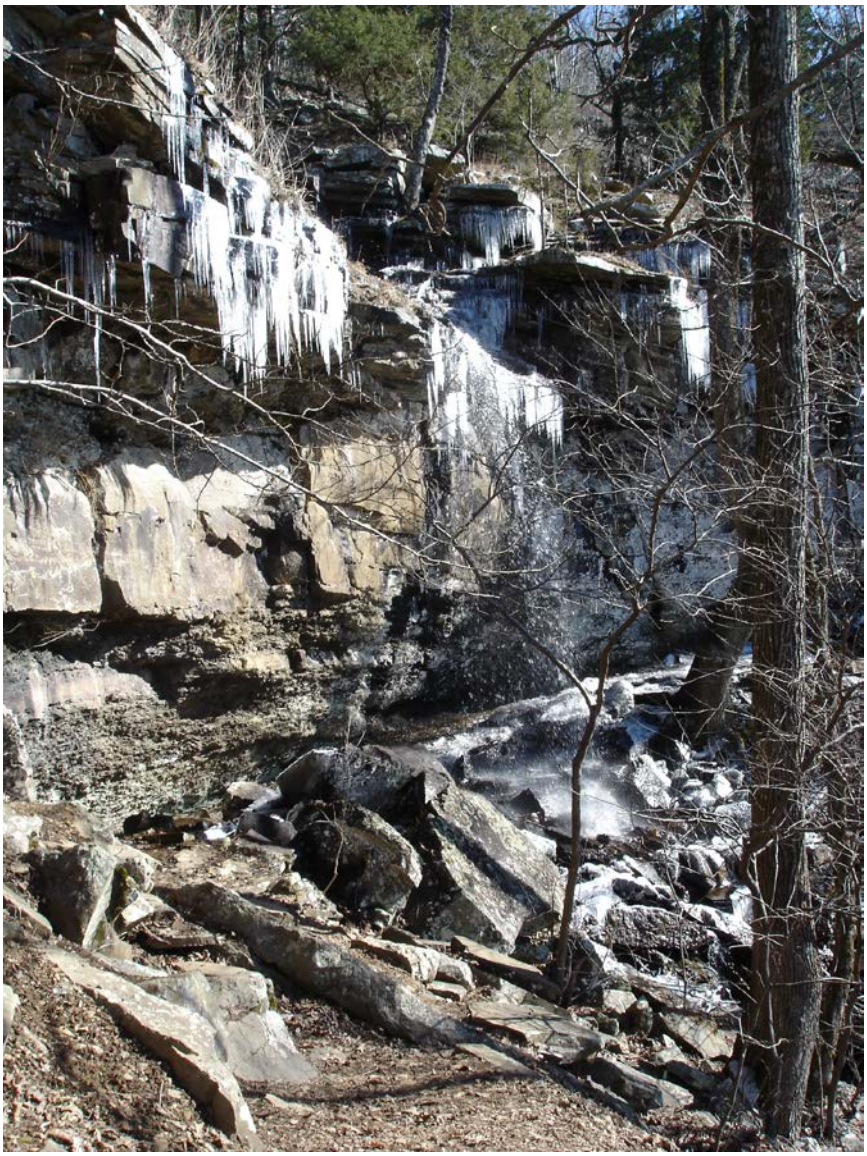

Figure 7. Mount Nebo Seasonal Waterfall in winter

Stop 5: Rim Trail: Liesegang Structures.
Return to the mountain summit and turn right following the Rim Trail southward through a wooded area along the mountain perimeter. After only a few yards, sandstone slabs with curious ridged swirl patterns occur in the middle of the trail (Fig. 8). These swirl patterns are due to iron oxide concentrations (known as "liesegang banding") that occur in the sandstones of the Hartshorne Formation. During the long periods after the sands were accumulated and compacted, groundwater percolating through the rocks deposited iron oxide along cross-bedded layers, ripples, and fractures. The iron concentrations may appear concentric, straight, or possess a "waffle iron" like pattern. In the case of the swirled bands at Stop 5, the iron oxides were probably concentrated along the curved surfaces of cross-beds.

Figure 8. Liesegang banding in Hartshorne Sandstone (car keys in the upper center of photo used for scale)

Stop 6. Rim Trail Hartshorne Bedding

The Rim Trail winds past three private homes on the southwest side of Mount Nebo. Wind and rain have exposed the surfaces of layers of the Hartshorne Sandstone along the mountainside here. The layers tilt back toward the center of the mountain, evidence that the mesa-like mountain is actually a very broad down-fold (syncline). The layers are covered by lichen, however, some ripple marks and cross-bedding are visible.

The sandstone layers also exhibit features that appear as hard "crusts" of minerals (Fig. 9). These "crusts", known as "case hardening" are the result of iron oxides and quartz minerals that have been precipitated along the surfaces of the layers. Evaporation of mineral-laden waters from the surfaces of layers through time concentrated minerals in near-surface waters, resulting in precipitation of hard durable minerals when the evaporation processes was completed.

Figure 9. Case Hardening on surface layers of the Hartshorne Sandstone along the Rim Trail

Stop 7. Cabin 60

The Rim Trail continues eastward at this point toward Sunrise Point passing additional exposures of the Hartshorne Sandstone that feature more ripple marks and cross-bedding. For those who wish to proceed quickly to stops 8-11, a short trail leading off to the left takes you to Cabin 60 and County Road 102. Head right (east) on the paved country road to Sunrise Point.

Stops 8-11: Sunrise Point Vicinity

Stop 8: Sunrise Point Overlook

Sunrise Point overlooks the Arkansas River Valley area to the east and southeast. Much of the panorama includes scenes viewed earlier at the Bench Overlook. To the distant south, the mountains and the valleys of the Ouachita Mountains stretch from east to west. Closer by to the southwest are Harkey Valley and Chickalah Mountain. Harkey Valley is composed of shales and sandstones of the Atoka Formation. The valley is a broad up-fold (anticline) in the earth's crust whose crest was fractured and breached by erosion. Erosion proceeded more quickly through the shales than the sandstones that form the flank of the up-fold creating a valley in the landscape. Chickalah Mountain is another broad synclinal mountain. Broad pastures slope toward the center of the mountain indicating the broad down-fold.

The rocks exposed at Sunrise Point preserve some excellent sedimentary features. Probably some of the best exposures of ripple marks and cross-beds are located just south of the overlook (Figs. 10 and 11).

Figure 10: Ripple Marks (car keys for scale) **Figure 11: Cross-bedded sandstone**

Stop 9: Plant Casts in Hartshorne Sandstone

A trail connects Sunrise Point to the Rim Trail just to the west of the overlook. Follow the rock stairs to the Rim Trail. Turn left and proceed beneath the Sunrise Point Overlook. The Rim Trail passes towering cliffs of cross-bedded sandstone. As the trail passes right under the overlook, look down onto the trail path. You are looking at casts of ancient trees commonly called “scale trees” (Fig. 12).

Stop 10: Cross Beds and Plant Casts

The trail makes an abrupt turn to the left at the base of Sunrise Point. Excellent cross-beds are readily visible at about waist level (Fig. 13). Look up to observe the bottoms of the sandstone layers and you will see superbly preserved plant tree-trunk casts (Fig. 14).

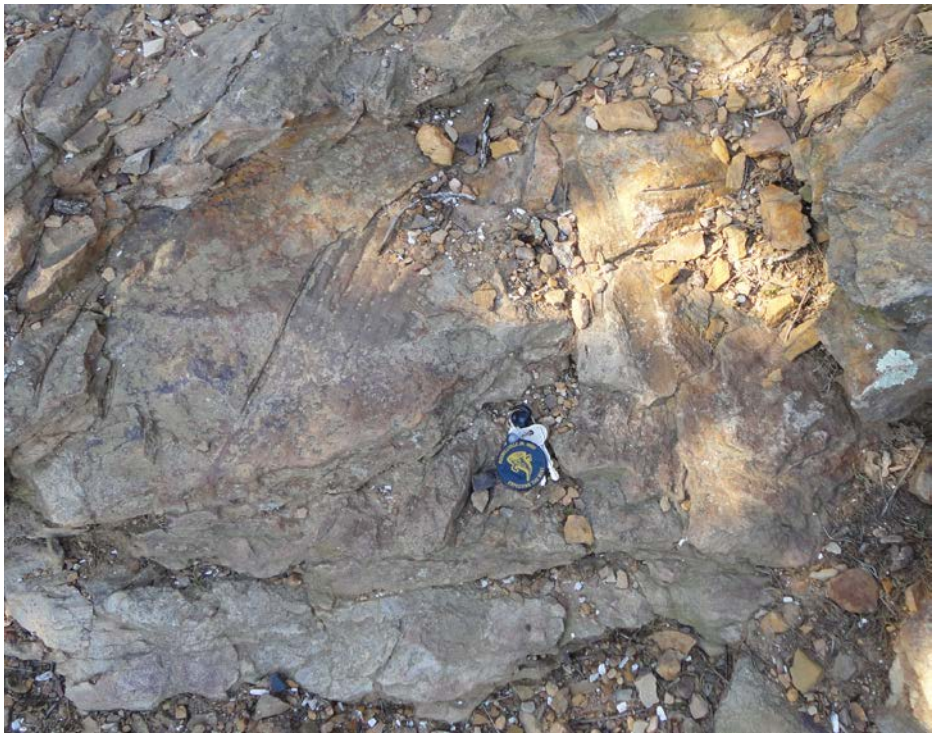

Figure 12: "Scale Tree" casts along the Rim Trail below Sunrise Point

Figure 13: Cross-bedded sandstone along the Rim Trail below Sunrise Point

Figure 14: "Scale Tree" cast in sandstone along the rim Trail below Sunrise Point (car keys for scale)

Stop 11: Hartshorne Column

The Rim Trail continues northward along the east face of Mount Nebo. Several hundred yards to the north towers an imposing column of heavily weathered sandstone with numerous fractures (Figs. 15 and 16). Large continuous fractures (joints) in this column are probably from stress related to mountain building responsible for the creation of the Ouachita Mountains. Additional irregular fractures and widened bedding surfaces are probably due to expansion of rocks in response to erosion and removal of overlying rock layers and by freeze-thaw.

Large "streams" of rock talus ring the summit of Mount Nebo and other mountains capped by sandstones in the Arkansas River Valley (Petit Jean Mountain, Mount Magazine). Examination of this column shows that it is not only weathered at the base but beginning to separate from the mountain. It is believed that collapse of large sandstone columns such as this one is responsible for the large talus slides on the flanks of Mount Nebo.

This column is in jeopardy of imminent failure. Triggers such as heavy rains, winter freeze-thaw or further erosion at the base could lead to collapse at any time.

Figure 15. Rock column of Hartshorne Sandstone near Sunrise Point

Figure 16. Separated base of column shown in Figure 15

The field trip ends at Stop 11. Hikers may retrace steps to Sunrise Point or may continue northward along the Rim Trail. The Rim Trail northward offers more excellent panoramas of the Arkansas River Valley and additional views of the sedimentary features representative of the Hartshorne Sandstone. The Rim Trail returns to the summit of Mount Nebo close to the pavilion and camp ground. The summit is reached by way of a very steep flight of rock stairs that should be negotiated carefully.

Acknowledgements

Thanks is extended to the Arkansas State Parks for permission to use Mount Nebo maps from the ***Mount Nebo Park Brochure***. Arkansas Tech University student, Amber Johnson provided the photograph of the Atoka Formation in Figure 2.