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MISCELLANEOUS FIELD STUDIES MAP MF-2412
Version 1.0
GEOLOGIC MAP OF THE PONCA QUADRANGLE, NEWTON, BOONE, AND CARROLL
COUNTIES, ARKANSAS
By
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2003

Base from U.S. Geological Survey, 1967
Universal Transverse Mercator, Zone 15

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INTRODUCTION

This map summarizes the geology of the Ponca 7.5-minute quadrangle in the Ozark Plateaus region of northern Arkansas (fig. 1). The quadrangle is near the transition between two physiographic provinces, the Boston Mountains and the Springfield Plateau, and it contains a deep valley cut by the Buffalo River. The exposed bedrock of this region comprises an approximately 1,600-ft- (490-m-) thick sequence of Ordovician, Mississippian, and Pennsylvanian carbonate and clastic sedimentary rocks (fig. 2) that have been mildly deformed by a series of faults and folds.

The geology of the Ponca quadrangle was first mapped by Purdue and Miser (1916) at 1:125,000 scale and later by Morrison (1971) at 1:24,000 scale. The current map confirms many features of these previous studies but it also identifies new structures and employs a revised stratigraphy.

DESCRIPTION OF MAP UNITS

Description of map units Qty Younger terrace and active-channel alluvial deposits (Quaternary)—Unconsolidated sand and gravel of the Buffalo River. Terrace deposits are principally composed of light-brown fine sand and have smooth upper surfaces that are as much as 20 ft (6 m) above the base-flow level of the river. Active-channel gravel deposits are composed of subangular to rounded Paleozoic rock clasts of mixed lithology along drainages and they are interspersed with bedrock exposures (not mapped). Deposits are as thick as 20 ft (6 m)

Qtm Medial terrace and alluvial deposits (Quaternary)—Unconsolidated gravel and sand deposits adjacent to the Buffalo River. Deposits are poorly exposed and are principally a lag of brown-weathered, subrounded to rounded Paleozoic rock clasts of mixed lithology that are as high as 40–60 ft (12–18 m) above the base-flow level of the river. Thickness uncertain but probably as much as 20 ft (6 m)

Qto Older terrace and alluvial deposits (Quaternary)—Unconsolidated gravel and sand deposits adjacent to the Buffalo River. Deposits are poorly exposed and are principally a lag of brown-weathered, subrounded to rounded Paleozoic rock clasts of mixed lithology that are 100–120 ft (30–37 m) above the base-flow level of the river. Thickness uncertain but probably no more than 5 ft (1.5 m)

Qc Colluvial deposits (Quaternary)—Unconsolidated deposits of angular blocks as large as 20 ft (6 m) in diameter that are mostly derived from the basal sandstone of the upper Bloyd Formation. Colluvium in southeast corner of map is a continuation of a thick deposit centered on Boulder Creek in adjacent Jasper quadrangle (Hudson and others, 2001). Colluvium deposit in east-central part of map (sec. 13, T. 16 N., R. 22 W.) conceals probable erosional truncation of Pitkin Limestone and Wedington Sandstone Member of the Fayetteville Shale beneath Cane Hill Member of the Hale Formation. Colluvial deposits present elsewhere are not mapped. Thickness uncertain but probably more than 10 ft (3 m)

Pennsylvanian a

Atoka Formation (Middle Pennsylvanian, Atokan)—Interbedded shale, siltstone, and sandstone. Unit forms highest hills of map area and is poorly exposed. Sandstone is tan, thin to medium bedded, fine to very fine grained, and holds up topographic ledges. Beds are typically ripple-trough laminated, and locally bioturbated. Less commonly, sandstone is medium to coarse grained and contains white quartz granules. Siltstone is thin bedded with ripple cross-lamination. Shale is dark gray to black. Thickness of unit is as much as 100 ft (33 m)

Bloyd Formation (Lower Pennsylvanian, Morrowan)—Interbedded sequence of sandstone, siltstone, shale, and thin limestone beds separated into lower and upper parts. As much as 380 ft (116 m) thick

Pennsylvanian bu Upper part—Dominantly sandstone with interbedded siltstone and shale. Upper part of sequence is poorly exposed and contains dark-gray to black shale beds that form topographic flats and sandstone and siltstone beds that hold up ledges 3–6 ft (1–2 m) high. At least one bed of coal from 4 to 19 in (0.1 to 0.48 m) thick is interbedded with black shale and siltstone at the top of the sequence in the northwestern part of the area (J.D. McFarland, oral commun., 2000). Upper sandstone beds are tan, mostly fine to very fine grained, ripple-cross laminated to planar bedded, and locally bioturbated. Base of unit is crossbedded sandstone as thick as 100–150 ft (33–50 m) that forms prominent cliffs in most of the area. Basal sandstone is white to light-brown, fine- to medium-grained quartz arenite that has a sharp erosional base and is commonly a composite of several 1–3-ft- (0.3–1-m-) thick tabular and trough-crossbed sets. Sandstone contains concentrations of white quartz pebbles and casts of wood fragments. In the west-central part of the map area, the basal sandstone is interbedded with shale and does not form a prominent cliff. Thickness of unit is about 275 ft (84 m)

Pennsylvanian bl

Lower part—Dominantly dark-gray to black shale and siltstone interbedded with thin beds of sandstone and limestone. Sandstone beds locally exposed as ledges as much as 10 ft (3 m) high. Sandstone varies from tan, very fine to fine grained, thin bedded with ripple marks to orange brown, medium grained, thin to medium bedded with local basal conglomerate lenses containing clasts of sandstone and shale and rounded white quartz pebbles. The Brentwood Limestone Member at the base of the formation (not mapped) is a 5–20-ft- (1.5–6-m-) thick, reddish-gray, coarse bioclastic limestone. Unit is conformable with the underlying Hale Formation. Forms moderate to steep slopes and is poorly exposed. Unit is 40–100 ft (12–30 m) thick Hale Formation (Lower Pennsylvanian, Morrowan)—Interbedded sequence of sandstone, siltstone, shale, and thin limestone that consists of Prairie Grove Member and Cane Hill Member. Formation is 110–150 ft (35–46 m) thick

Pennsylvanian hg Prairie Grove Member—Brown to reddish-brown, fine- to medium-grained, thick-bedded, calcite-cemented sandstone. May contain bioclastic limestone interbeds and, at its base, quartz pebbles. Beds are planar or crossbedded and crossbeds may have bi-directional dips. Weathered sandstone forms massive, rounded surfaces with elliptical cavities as large as 8 in. (20 cm) long. The sandstone forms steep slopes that may be covered by slope debris from overlying units. Unit is 20–60 ft (6–18 m) thick

Pennsylvanian hc Cane Hill Member—Interbedded sequence of shale, siltstone, and sandstone. The upper part of the Cane Hill Member is poorly exposed and composed mostly of dark-gray shale and thin-bedded siltstone that form gentle to moderately steep slopes. The lower part is a 10–40-ft- (3–12-m-) thick sandstone interval with siltstone and shale interbeds. Sandstone varies from reddish brown, poorly sorted, fine to medium grained in medium to thick beds that may contain trough crossbeds, to tan to olive brown, very fine to fine grained, thin bedded with ripple cross-lamination or parallel lamination. Lower sandstone beds may contain wood as carbonized fragments or as casts and angular mudstone intraclasts, and also contain local conglomerate lenses with clasts of sandstone, shale, and crinoid-bearing limestone. Sandstone beds locally display soft-sediment slump folds. Unit unconformably overlies the Pitkin Limestone, the Wedington Member of the Fayetteville Shale, and the main body of the Fayetteville Shale. Unit is 80–140 ft (24–43 m) thick

Mp

Pitkin Limestone (Upper Mississippian, Chesterian)—Generally medium- to dark-gray, fetid limestone. Limestone varies from micritic to coarse grained and is locally oolitic. Limestone beds may contain abundant crinoids, brachiopods, corals, and Archimedes. The unit commonly forms a prominent ledge. Distribution of Pitkin is restricted to the northeastern part of the map area. The basal contact with the Fayetteville Shale is conformable, although rarely exposed. Upper contact with Cane Hill Member is unconformable and Pitkin was eroded beneath the unconformity in the western part of the area. Its thickness varies from 0 to 60 ft (0 to 18 m)

Fayetteville Shale (Upper Mississippian, Chesterian)—Consists of fine-grained sandstone and siltstone of Wedington Sandstone Member that grade downward into black, slope-forming shale of the main body of the unit. Thickness varies from 10 to 360 ft (3 to 110 m)

Mfw Wedington Sandstone Member—Brown, well-indurated, calcite-cemented sandstone and siltstone that form a distinctive unit in the upper part of the Fayetteville Shale. The Wedington Sandstone Member caps a steep slope and is separated from overlying Pitkin Limestone by a rarely exposed, thin, black shale that commonly forms a bench. Sandstone is fine- to very fine grained and is present in thin to thick planar beds with internal parallel laminations and locally developed low-angle crossbeds in highest beds. Sandstone grades downward into siltstone beds that are ripple cross-laminated and bioturbated. Distribution of the sandstone is restricted to the northeastern part of the map area and is thickest in the northeast corner of the map. Contains limestone interbeds south of the Buffalo River. The unit was probably eroded from the western part of the map area before deposition of the Cane Hill Member of the Hale Formation. The Wedington grades downward into main body, and its basal contact is placed at the first outcrop of dominantly siltstone or sandstone beds. Thickness is 0–20 ft (0–6 m)

Mf Main body—Below the Wedington Sandstone Member, the main body of the Fayetteville Shale is black shale that is poorly exposed. The lower part of the Fayetteville Shale outcrops along stream gullies where it consists of black fissile shale that may contain medium- to light-gray, fetid septarian concretions as large as 2 ft (0.6 m) in diameter. Unit is susceptible to landslides. Formation thickness varies from 10 to 340 ft (3 to 110 m). Large variation in thickness of unit partly results from Late Mississippian-Early Pennsylvanian erosion beneath unconformity at base of the Cane Hill Member of the Hale Formation

Mbv

Batesville Sandstone (Upper Mississippian, Chesterian)—Fine- to very fine grained, light- to medium-brown, calcite-cemented sandstone with interbedded limestone. Thin to medium beds are typically parallel laminated with low-angle crossbeds common in upper part of unit. Sandstone commonly contains burrows on bedding plane surfaces and breaks into tabular blocks. One or more discontinuous, 1–3-ft- (0.3–1-m-) thick, medium- to dark-gray, fetid, fossiliferous limestone beds are locally interbedded with sandstone. The Hindsville Limestone Member (Purdue and Miser, 1916) is present in the northeast map area at the base of the formation and is as much as 5 ft (1.5 m) thick in the Cecil Creek drainage. Hindsville Limestone

Member is distinguished by the presence of subangular clasts of white chert that range in size to as much as 2 in. (5 cm). Limestone beds of the Batesville contain crinoids and brachiopods. Sandstone and limestone beds contain 2–10-mm-diameter oxidized pyrite framboids that weather to reddish-brown spheres. The Batesville commonly forms a topographic ledge that forms small waterfalls along streams. Where stripped of overlying Fayetteville Shale, the top of the Batesville is typically a topographic flat that hosts sinkholes formed by collapse into dissolution cavities in underlying Boone Formation. Thickness is 3–30 ft (1–9 m) and is greatest in the northeastern part of the area

Boone Formation (Upper to Lower Mississippian)—Formation consists of limestone and cherty limestone of main body that grade into the basal St. Joe Limestone Member. The Boone Formation is a common host of caves and sinkholes. The total thickness of the formation is 380–405 ft (116–122 m)

Mb Main body (Upper to Lower Mississippian, Meramecian-Osagean)—Medium- to thick-bedded, chert-bearing bioclastic limestone. Limestone is light to medium gray on fresh surfaces and generally coarsely crystalline with interspersed crinoid ossicles. A 1–3-ft- (0.3–1-m-) thick bed of oolitic limestone is common at the top of the Boone Formation. Dense beds of limestone are present in the upper third of the unit. Beds are typically medium to thick and parallel planar to wavy. The chert content varies within the Boone Formation and is greatest in the northwestern part of the map. Chert forms lenticular to anastomosing lenses. Chert-rich horizons are generally poorly exposed and form slopes littered with float of white weathered chert that in uppermost part of unit contains large brachiopods casts. Thickness is 310–375 ft (95–114 m)

Mbs St. Joe Limestone Member (Lower Mississippian, Osagean to Kinderhookian)—Thin-bedded, coarse-crystalline bioclastic limestone with ubiquitous 3–6-mm-diameter crinoid fragments. Limestone is commonly pink to red due to hematite staining, but its color and hematite concentrations vary with location. Beds are thin and wavy in form. Chert nodules are uncommon but, where present, are tabular and reddish. The contact with the overlying main body of Boone Formation is gradational. The middle part of the St. Joe Limestone Member forms a local topographic flat on a slightly shaley limestone interval that commonly overlies a low limestone ledge above the basal unconformity. Base of unit is a 1.5–3-ft- (0.5–1-m-) thick sequence of phosphate-pebble-bearing tan sandstone and overlying greenish-gray shale that, although thin, is laterally persistent throughout much of northwestern Arkansas (McKnight, 1935). The member is approximately 30–50 (9–15 m) ft thick

Of

Fernvale Limestone (Upper Ordovician)—Thin- to medium-bedded, coarse-crystalline bioclastic limestone. Limestone is light to medium gray on fresh surfaces and it contains abundant cylindrical to barrel-shaped crinoid ossicles 3–10 mm in diameter. Continuous outcrop of this unit is restricted to the southwest part of the quadrangle but local lenses are recognized farther east in quadrangle. Thickness reaches 20 ft (6 m) in southwestern corner of map (McFarland, 1982)

Everton Formation (Middle Ordovician)—Interbedded sandstone, dolomite, and limestone sequence divided into upper part, Newton Sandstone Member, and lower part. Unit is 310–350 ft (95–107 m) thick

Oeu Upper part—The upper part of Everton Formation contains 3–20-ft- (1–6-m-) thick light- to dark-gray dolomite and limestone beds interbedded with sandstone. Fine crystalline, light-gray, limestone as thick as 10 ft (3 m) is present near top of unit in southwestern part of map. Sandstone is light tan to white quartz arenite containing well-sorted, well-rounded, and fine- to medium-grained quartz grains. Sandstone is variably cemented by dolomite or calcite and is transitional from carbonate sandstone to sandy carbonate; carbonate crystals locally envelop sand grains. Sandstone generally has medium to thick planar beds. Dolomite is light to dark gray, fine to medium crystalline, and thin to medium bedded with common sandstone stringers and beds. Dolomite is typically laminated and forms intervals 1–10 ft (0.3–3 m) thick. Includes Jasper Member and the informal “Member C” of Everton Formation of Suhm (1974). Unit is 80–100 ft (24–30 m) thick

Oen Newton Sandstone Member—Thick sandstone interval within the Everton Formation that forms prominent bluffs along the Buffalo River. The unit is quartz arenite containing well-sorted, well-rounded, and fine- to medium-grained quartz grains. Sandstone is light tan to white and variably cemented by dolomite or calcite; carbonate crystals locally envelop sand grains. Sandstone breaks with sugary texture. The sandstone generally has medium to thick planar beds. Newton Sandstone Member of the Everton was defined by McKnight (1935). Unit is 90–100 ft (24–30 m) thick

Oel Lower part—Interbedded sandstone, limestone, and dolomite. Upper part of unit is mostly limestone interbedded with sandstone. Limestone is light gray, finely crystalline, thin to medium bedded, commonly laminated, and locally stromatolitic. Limestone is 1–10 ft (0.3–3 m) thick. Limestone-rich part of the lower Everton is a common host of paleokarst features that consist of vertical columns of highly fractured or brecciated sandstone collapsed from overlying horizons. Sandstone is quartz arenite containing well-sorted, well-rounded, and fine- to medium-grained quartz grains. Sandstone is light tan to white and variably cemented by dolomite or calcite. Poorly cemented sandstone breaks with sugary texture. The sandstone has medium to thick planar beds. The lower part of unit is light- to dark-brownish-gray dolomite grading to sandy dolomite interbedded with sandstone. Dolomite is fine to medium crystalline, thin to thick bedded, commonly laminated, and may be stromatolitic. Dolomite beds present as intervals 1–10 ft (0.3–3 m) thick. Contact with underlying Powell Dolomite is placed at lowest bed of sandstone or sandy dolomite. Lower part of Everton equivalent to informal “Member B,” Kings River Sandstone Member, and the Sneeds Dolomite Member of the Everton Formation of Suhm (1974). Unit is 100–140 ft (30–43 m) thick

Op Powell Dolomite (Lower Ordovician)—Fine-grained, argillaceous to silty, gray dolomite with dark-gray shale interbeds. Dolomite beds are thin to medium, wavy, commonly laminated and stromatolitic. Contact with overlying Everton Formation is unconformable and beneath it Powell beds may be truncated with slight local angular unconformity. Unit is about 200 ft (60 m) thick in the only complete section exposed in Hemmed-In Hollow

Oc Cotter Dolomite (Lower Ordovician)—Brownish-gray dolomite with sparse chert nodules. Chert composed of concentric, alternating dark-gray and white bands within elongate nodules that are concentrated in dolomite beds in the upper part of the formation. Only the upper 20–30 ft (6–9 m) of unit are exposed along Hemmed-In Hollow

Contact

Fault—Dashed where inferred; dotted where concealed; ball and bar on downthrown side; showing fault dip (arrow) and rake (diamond-headed arrow); paired arrows indicate relative right-lateral strike-slip movement

Reverse fault—Dashed where inferred; dotted where concealed. Rectangles on upper plate

Thrust fault—Teeth on upper plate

Structure contours drawn on base of Boone Formation—Dashed where approximately located. Contour interval 50 ft

Strike and dip of inclined bedding

Horizontal bedding

Anticline

Syncline

Monocline

Axis of minor anticline showing direction and amount of plunge

Control point showing elevation in feet on lower or upper contact of Boone Formation

STRATIGRAPHY

The study area preserves a 1,600-ft- (490-m-) thick record of early and late Paleozoic deposition on what is now the southern margin of the North American continent. Stages for Pennsylvanian and Mississippian units are from McFarland (1988).

Pennsylvanian sandstone and shale of the upper part of the Bloyd Formation and the Atoka Formation were originally called Winslow Formation by Purdue and Miser (1916), with the basal Greenland Sandstone Member of the Atoka (Henbest, 1953) representing the prominent cliff-forming crossbedded sandstone. Morrison (1971) followed this convention. Zachry (1977), however, concluded that the cliff-forming sandstone was a time-equivalent unit with the Woolsey Member of the Bloyd Formation farther west and designated it with the informal term “middle Bloyd sandstone.” This sandstone interval comprises the basal interval of the upper part of the Bloyd Formation as used here. The contact between the Atoka and Bloyd Formations on the map is located within alternating shale and sandstone intervals and is indistinct. Atoka Formation is interpreted to be preserved within the map area because the aggregate thickness of strata above the Hale Formation is as great as 500 ft (152 m), much greater than the typical 100–150 ft (30–46 m) thickness of the Bloyd Formation 60 km to the west in Washington County where the presence of the Kessler Limestone Member at the top of the Bloyd Formation allows separation of the Bloyd and Atoka

Formations (Zachry, 1977; Zachry and Sutherland, 1984). Where it has been studied in Washington County, lower Atoka Formation is a marine sequence (Zachry and Sutherland, 1984). Within the map area, the presence of a thin coal bed approximately 250 ft (76 m) above the base of the upper part of the Bloyd Formation indicates deposition of these beds in a non-marine setting. Thus, the Bloyd-Atoka contact was placed above this horizon.

The base of the Morrowan Cane Hill Member of the Hale Formation represents a major erosional unconformity within the map area. Late Mississippian-Early Pennsylvanian erosion removed the Pitkin Limestone, the Wedington Sandstone Member, and much of the main body of the Fayetteville Shale in the western part of the map (fig. 2). This truncation is most abrupt across the Kyles Landing fault south of the Buffalo River (cross section B-B'), indicating that movement on this fault was pre-Pennsylvanian and that it caused differential erosion across the fault. North of the river, truncation of the Pitkin Limestone at the Web monocline suggests that this structure was also active before Pennsylvanian time. In addition to structural uplift, a sea-level drop at the end of the Mississippian Period (Sutherland, 1988) also was probably a key factor in development of the unconformity. Above the unconformity, the heterogeneous nature of the basal sandstone interval of the Cane Hill Member of the Hale Formation, as well as its content of conglomerate and wood fragments, suggests that this interval includes non-marine fluvial deposits that were deposited ahead of a Morrowan sea-level rise. Limestone clasts within conglomerates of the basal Cane Hill Member were probably derived from Pitkin Limestone.

The main part of the Boone Formation within most of the study area does not contain as much chert as described elsewhere in northern Arkansas. As a consequence, its contact with underlying St. Joe Limestone Member, which elsewhere is based on a marked increase in chert, is indistinct. This study did not confirm major thinning of the Boone Formation in the area of the Sneeds Creek dome, as proposed by Morrison (1971). Instead, apparent thinning can be attributed to offset between the base and top of the Boone Formation across a newly recognized northeast-striking normal fault. Although thin, the phosphate-nodule-bearing sandstone and overlying thin shale at the base of the St. Joe is persistent throughout much of northern Arkansas (McKnight, 1935). Based on petrography, Horner and Craig (1984) supported a correlation of the basal sandstone with the Sylamore Sandstone that was deposited as a transgressive lag during sea level rise in Late Devonian time. Strata of uppermost Ordovician through Devonian age are missing beneath the unconformity at the base of the St. Joe Limestone Member, although strata of these ages are preserved both to the east and west of the map area.

Suhm (1974) divided the Everton Formation into several formal and informal members that within the map area include, from top to bottom, the Jasper Member, B member, Newton Sandstone Member, C member, King River Sandstone Member, and Sneeds Dolomite Members. Only the Newton Sandstone Member, that forms a prominent cliff in much of the area, is mapped separately here. Suhm (1974) interpreted the mixed sandstone and carbonate interval of the Ordovician Everton Formation as barrier islands and adjacent tidal-flat environments.

STRUCTURAL GEOLOGY

Rocks within the map area were mildly deformed by a system of faults and folds. Structure contours on the base of the Boone Formation illustrate the location of structures and their vertical offset. The structure contours conform to elevations at 345 control points on the lower or upper contacts of the Boone Formation that were located on the topographic base map using one or a combination of a global position system receiver, a barometric altimeter, or a distinctive topographic contour pattern. A 390 ft (119 m) thickness for the Boone Formation was used to project the elevation of the basal contact from points on the upper contact, based on the average of several traverses across stratigraphic sections near the Buffalo River (Hudson, 1998).

The vertical offset across structures can be estimated from the elevation difference of formation contacts across the structures. Lateral offset is difficult to measure due to the lack of piercing points, but kinematic data suggest that strike-slip offset was important on small faults associated with the Adds Creek and Hanner Point monoclines. Fault striations that are sparsely preserved on planes of some mapped faults, or on adjacent, parallel, small-scale faults were used to infer the slip direction in some locations. Small cataclastic faults, or deformation bands (Aydin and Johnson, 1978), were commonly developed in porous Everton Formation sandstone in and adjacent to structures. Slip sense for mapped faults was inferred either from offset of bedding, from asymmetric minor fault-plane features, or from the geometry of conjugate sets of deformation bands in adjacent rock. Faults of normal, reverse, and strike-slip sense are all present within the map area.

The Kyles Landing fault is a reverse fault that dies out in the Bee Bluff monocline north of the Buffalo River. Beds of Everton and Boone Formations and Batesville Sandstone dip moderately to steeply adjacent

to the fault, defining a nearly horizontal model fold axis that trends south-southeast (fig. 3A). The orientation of this fold axis and the geometry of sparse small-scale reverse faults (fig. 3B) and conjugate deformation bands (fig. 3C) in hanging wall Everton Formation indicate that the fault has reverse motion. The plane of the Kyles Landing fault is not exposed but, assuming a south-southeast strike, its trace over topography suggests that it dips steeply west-southwest (cross section B–B ϕ). Traced southward, the Kyles Landing fault and adjacent folded strata are unconformably overlain by Cane Hill Member, indicating that this structure formed in Late Mississippian–Early Pennsylvanian time. To the north, the Bee Bluff monocline is interpreted to abut against a west-northwest continuation of the coeval Web monocline, although this interpretation is conjectural because the inferred connection is concealed beneath Pennsylvanian rock. Small strike-slip and normal faults were observed locally within the north-facing Web monocline in the adjacent Jasper quadrangle (Hudson and others, 2001), suggesting that it probably formed over a transtensional fault.

Normal faults are the predominant structures within the map area. In surface exposures the normal faults dip from 50° to 85°, averaging 71° dip for 15 measurements. Seven west-northwest-striking, en echelon normal faults form a 2-km-wide, N. 60° W.-trending zone that crosses the center of the area and intersects the east-northeast-striking Compton fault and the northeast-trending Hanner Point monocline. This en echelon pattern of normal faults is like that produced in analog models of low-angle oblique rifts (Withjack and Jamison, 1986), suggesting that the zone may have developed over a basement weakness. Striations on the individual mapped faults within this zone have high rakes (fig. 3D), indicating extension was essentially normal to their strike. Likewise, conjugate sets of deformation bands measured in Everton Formation sandstone at a footwall site (36° 3.99' N, 93° 18.77' W) adjacent to the California Point fault (fig. 3E) also indicate south-southwest extension. Within the zone, maximum down drop lies within the Jim Bluff graben, whose strata are about 600 and 450 ft lower than correlative strata on adjacent northern and southern zone flanks, respectively. The Compton fault dips steeply southeast and has normal throw of over 300 feet in its central part (cross-section A–A ϕ), but this offset decreases abruptly at its eastern end. Conjugate sets of deformation bands (fig. 3F) observed at a hanging wall site (36° 4.57' N, 93° 19.89' W) adjacent to the eastern part of the Compton fault are consistent with north-northwest extension on this fault, but the deformation bands at this site are crosscut by small-scale strike-slip faults (fig. 3G) that suggest that the fault was probably reactivated under north-northwest shortening. Mapped normal faults within the quadrangle affect all Paleozoic strata and thus they were active after Middle Pennsylvanian time. The normal faults accommodated north-directed extension that was probably caused by flexure of the foreland of the developing Ouachita orogeny to the south (Hudson, 2001).

The northeast-trending Adds Creek and Hanner Point monoclines in the western part of the map area are associated with a zone of short mapped faults and small-scale faults having strike-slip as well as dip-slip offset. Together with a northeast alignment of lead-zinc mines near Ponca (McKnight, 1935) and topographic features on and beyond the quadrangle, these structures lie within a N. 30° E.-trending zone that has been called the Ponca lineament (McFarland, 1988). It is likely that this lineament formed over a preexisting fault zone in Precambrian basement that was partly reactivated with strike-slip and down-to-the-southeast motion to form the overlying monoclines and associated small faults. The left step between the Adds Creek and Hanner Point monoclines is similar to what might form above an echelon Riedel faults within a buried northeast-trending dextral fault zone (Tchalenko, 1970). The Adds Creek and Hanner Point monoclines and associated faults affect all Paleozoic strata and thus they were active after Middle Pennsylvanian time.

The Sneeds Creek dome (Purdue and Miser, 1916) is an east-northeast-elongated, doubly plunging anticline in the footwall of the Compton fault within which rocks of the quadrangle achieve their highest elevation. Although this fold probably initiated as an extensional forced fold (Withjack and others, 1990) above the Compton normal fault, the presence of a small, south-southeast-vergent thrust fault in the fold core (Sec. 6, T. 16 N., R. 22 W.) suggests that this fold also accommodated some north-northwest shortening. We interpret that the Sneeds Creek dome probably was tightened during later reactivation of the Compton fault in response to north-northwest-directed compression at the end of the Ouachita orogeny.

Dips of bedding within folds in the map area are generally greater than 5° and have consistent directions. Away from structures, where structure contours indicate little dip of the base of the Boone Formation, dips of bedding at the surface are mostly low and variable in direction. These dispersed attitudes can be attributed to local subsidence caused by karst dissolution within the abundant limestone and dolomite rock units and to unrecognized rock creep.

Joints within the map area (406 joints measured) are distributed in two dominant strike sets (fig. 3H), northeast and north. A less prominent joint set strikes east. Joint planes within limestone and dolomite formations, such as the Boone Formation, are commonly enlarged due to dissolution.

