Oklahoma

GEOLOGY

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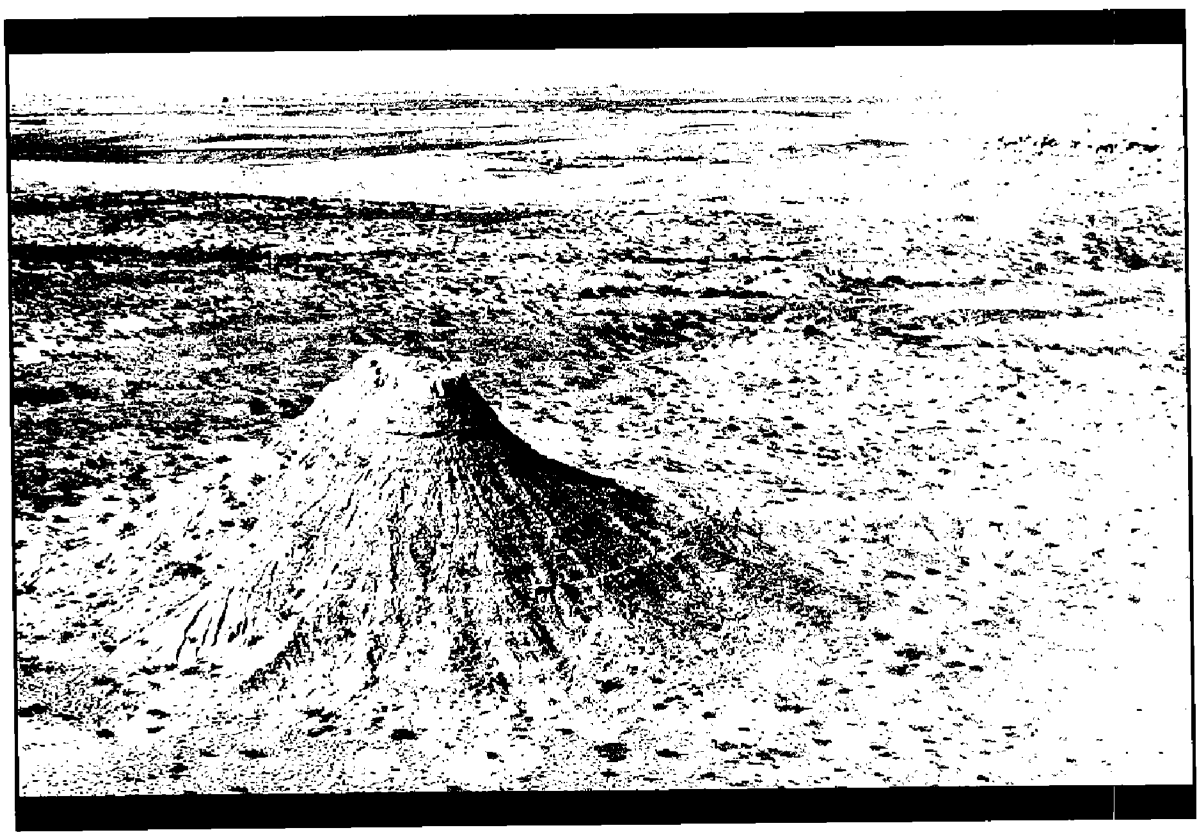

OKLAHOMA GEOLOGICAL SURVEY VOL. 47, NO. 4 AUGUST 1987

On the cover—

Haystack Butte, Greer County, Oklahoma

A conspicuous landmark in southwestern Oklahoma, Haystack Butte stands ~185 ft above the surrounding red-bed plains. The butte is located near the center N½N½ sec. 23, T7N, R23W, in north-central Greer County. It is ~14 mi north–northwest of Mangum, and ~5 mi west of Willow. This aerial photo shows the view to the southwest.

Capping Haystack Butte is the Haystack Gypsum Bed, the basal unit of the Permian Blaine Formation. Here, at its type locality, the Haystack Bed consists of 15 ft of massive, white gypsum directly overlying the Flowerpot Shale. Outcrops of the Flowerpot consist of 170 ft of red-brown shales with few thin interbeds of light-gray shale and white gypsum. At the base of Haystack Butte, the Oklahoma Geological Survey drilled through an additional 130 ft of Flowerpot strata and reached the base of the formation, thus establishing a total thickness of the Flowerpot Shale of ~300 ft at Haystack Butte.

Kenneth S. Johnson

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Oklahoma GEOLOGY Notes

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OKLAHOMA GEOLOGICAL SURVEY VOL. 47, NO. 4 AUGUST 1987

MISCORRELATION OF THE CHECKERBOARD LIMESTONE IN OKFUSKEE COUNTY PROVED BY OGS CORE-DRILLING

LeRoy A. Hemish[1]

Abstract

New data from core-drilling by the Oklahoma Geological Survey show conclusively that the Checkerboard Limestone has been incorrectly mapped in Okfuskee County, Oklahoma. A north–south cross section extending from the type locality of the Checkerboard Limestone in northwestern Okmulgee County into north-central Okfuskee County shows that a limestone incorrectly identified as the Checkerboard in earlier mapping is actually 200–240 ft higher in the section.

Discovery of the error necessitates corrections in thickness data for three named formations in Okfuskee County. The Coffeyville Formation is shown to be >200 ft thicker than previously believed. Lithologic work done for this report, as well as palynological and paleontological work by other geologists during the past decade, has shown the need for redefinition of the contact between the Holdenville and Seminole Formations. The new mapping reported here shows that the Holdenville Formation is 350–450 ft thick (150–200 ft thicker than previously believed) and that the thickness of the Seminole Formation decreases from ~150 ft in its type area (to the south) to only ~2 ft in central Okfuskee County; the Seminole thickens to the north in Okmulgee County. A geologic map shows the true outcrop trace of the Checkerboard Limestone, as well as the revised outcrop belts of the Holdenville, Seminole, and Coffeyville Formations in north-central Okfuskee County.

Introduction

Core-drilling by the Oklahoma Geological Survey (OGS) in northwestern Okmulgee County and north-central Okfuskee County has shown conclusively that a limestone here tentatively correlated with the DeNay Limestone Member of the Coffeyville Formation was incorrectly identified and mapped as the Checkerboard Limestone by Ries (1954) in Okfuskee County. The correlation error occurred at the Deep Fork crossing, where bedrock is masked for a distance of about five miles by alluvial deposits. Ries (1954, pl. 1) inadvertently correlated a 2-ft-thick, fossiliferous, sandy limestone that is well exposed in Okfuskee County with the Checkerboard Limestone. The miscorrelated limestone occurs in the middle part of the Coffeyville Formation ~224 ft above the true Checkerboard Limestone (Appendix 1, core-hole log 1; Appendix 2, measured section 5; Fig. 1).

[1]Oklahoma Geological Survey.

Krumme (1981, p. 16,26), through interpretations based on a study of electric logs, first noted that the surface trace of the Checkerboard Limestone had been misplaced in Okfuskee County. Bennison (1981, p. 10) and Dott and Bennison (1981, p. 26–29) also believed that a miscorrelation of the Checkerboard Limestone had been made by Ries and perpetuated by other stratigraphers. Bennison's interpretations were based on sporadic outcrops of a brown, thin-bedded, fossiliferous limestone north of Okemah which he believed to be ~150 ft stratigraphically lower than the sandy limestone misidentified by Ries as the Checkerboard.

This report uses new subsurface and surface data to trace the Checkerboard Limestone from its type locality (near the east–west quarter line of sec. 22, T15N, R11E, Okmulgee County) southwest into Okfuskee County. The new data require revision of previously mapped thicknesses for the Holdenville, Seminole, and Coffeyville Formations. The trace of the true Checkerboard Limestone is shown in north-central Okfuskee County (Oakes, 1963, pl. 1, showed the outcrop boundary of the Checkerboard Limestone in Okmulgee County). The Holdenville Formation and the Coffeyville Formation are shown here to outcrop in Okfuskee County over a much wider area than that mapped by Ries (1954, pl. 1).

The remapped area is restricted to north-central Okfuskee County (Fig. 2); boundaries have been redrawn in the stratigraphic interval from the Holdenville Formation to the Coffeyville Formation. The area of investigation (Fig. 1) includes northwestern Okmulgee County and central Okfuskee County.

Topographically, the area includes NE-trending cuestas capped by resistant sandstones and limestones, low shale plains, and alluvium-filled stream valleys. The indurated surface rocks are of Pennsylvanian age, and consist almost entirely of shales and sandstones. Limestones generally are thin.

Calculations made for this study, using outcrop and subsurface data, show that the beds in north-central Okfuskee County generally dip N. 30° W. at an angle of not quite 1°.

Procedures

Field work consisted in part of drilling three core holes (CH1, CH2, CH3) with the OGS drilling rig and describing the cores; the holes were drilled to depths of 390, 325, and 157 ft (see logs in Appendix 1). Additional field work consisted in traversing on foot selected parts of the study area where good exposures of bedrock were to be found, measuring nine stratigraphic sections (Appendix 2), and photographing various outcrops.

Reports of previous investigations were reviewed, mapped outcrops were checked in the field, relevant electric logs were examined, and a cross section was prepared to establish correlations.

Stratigraphy

Figure 3 shows the stratigraphic interval of interest in this investigation in Okmulgee and Okfuskee Counties and its relationship to the same interval in Seminole and Hughes Counties, just to the south. The rocks are Pennsylvanian and belong to the Desmoinesian and Missourian Series.

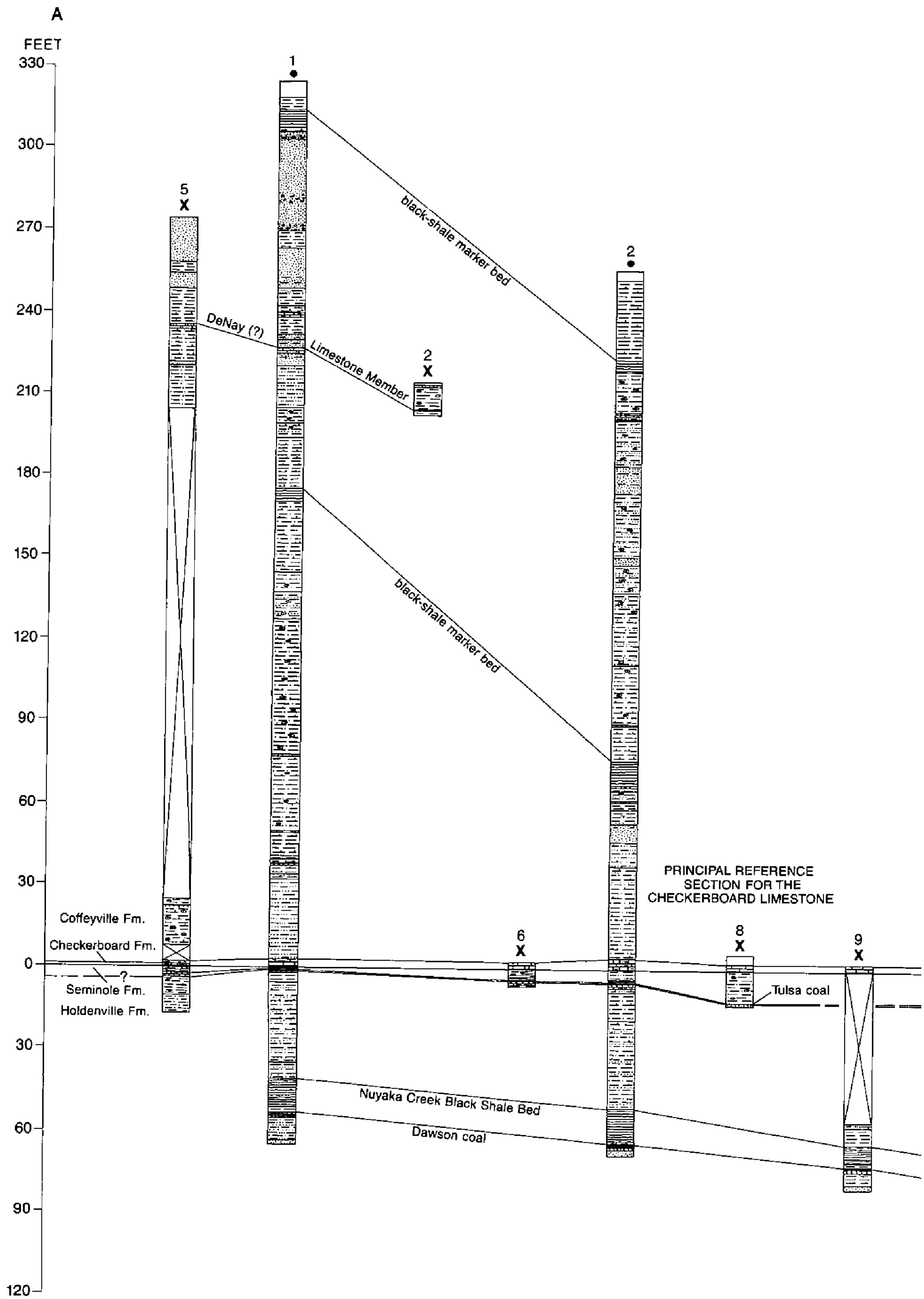
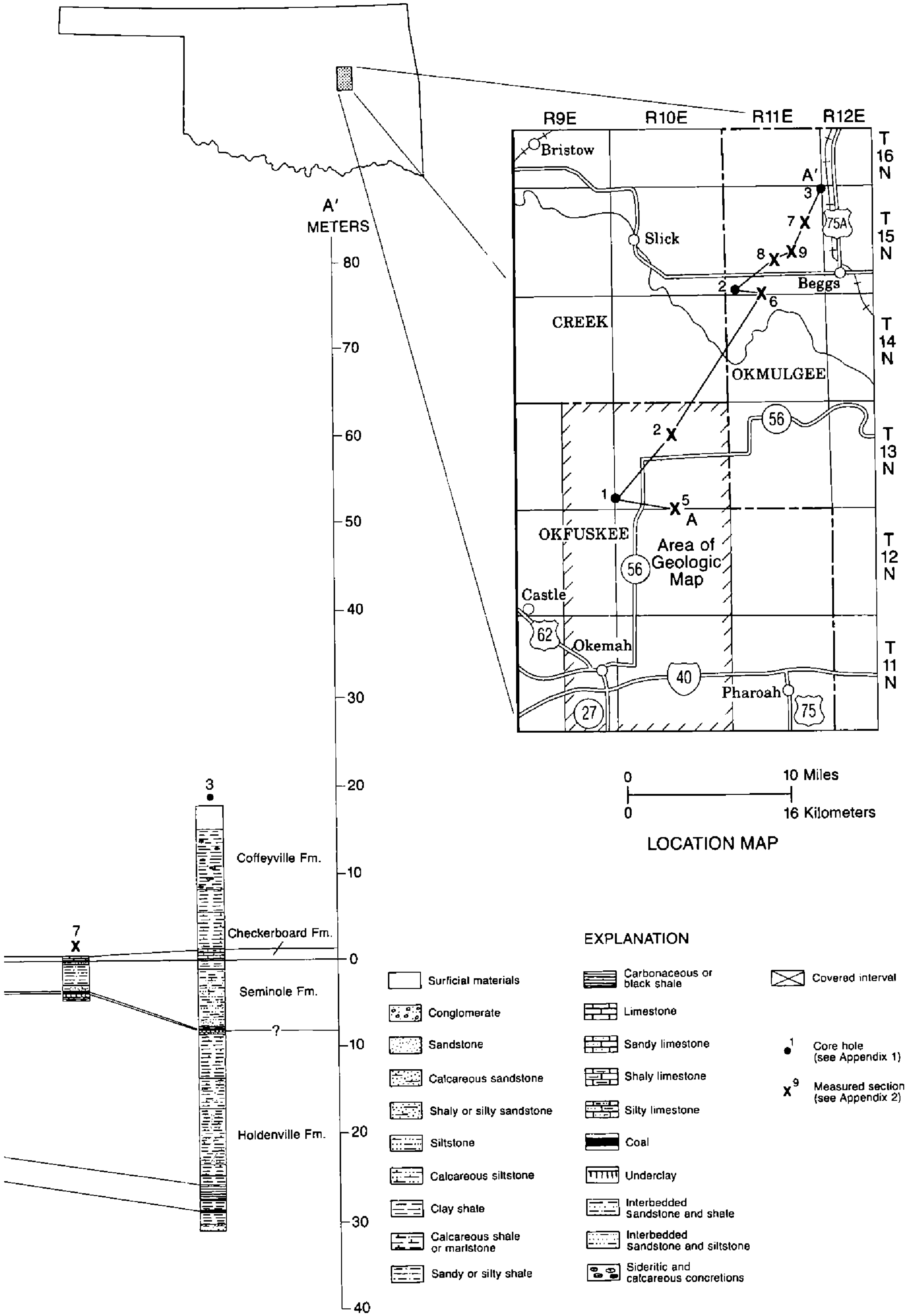


Figure 1. Cross section showing correlation of the Checkerboard Limestone and associated strata, from the type area in northwestern Okmulgee County southwestward into Okfuskee County.



R9E
R10E
R11E
R12E
T 16 N
T 15 N
T 14 N
T 13 N
T 12 N
T 11 N
Bristow
Slick
Beggs
CREEK
OKMULGEE
OKFUSKEE
Area of Geologic Map
Castle
Okemah
Pharoah
75A
56
62
40
27
75
A'
A
0
10 Miles
16 Kilometers
LOCATION MAP
A'
METERS
Coffeyville Fm.
Checkerboard Fm.
Seminole Fm.
Holdenville Fm.
EXPLANATION
Surficial materials
Conglomerate
Sandstone
Calcareous sandstone
Shaly or silty sandstone
Siltstone
Calcareous siltstone
Clay shale
Calcareous shale or marlstone
Sandy or silty shale
Carbonaceous or black shale
Limestone
Sandy limestone
Shaly limestone
Silty limestone
Coal
Underclay
Interbedded sandstone and shale
Interbedded sandstone and siltstone
Sideritic and calcareous concretions
Covered interval
Core hole (see Appendix 1)
Measured section (see Appendix 2)

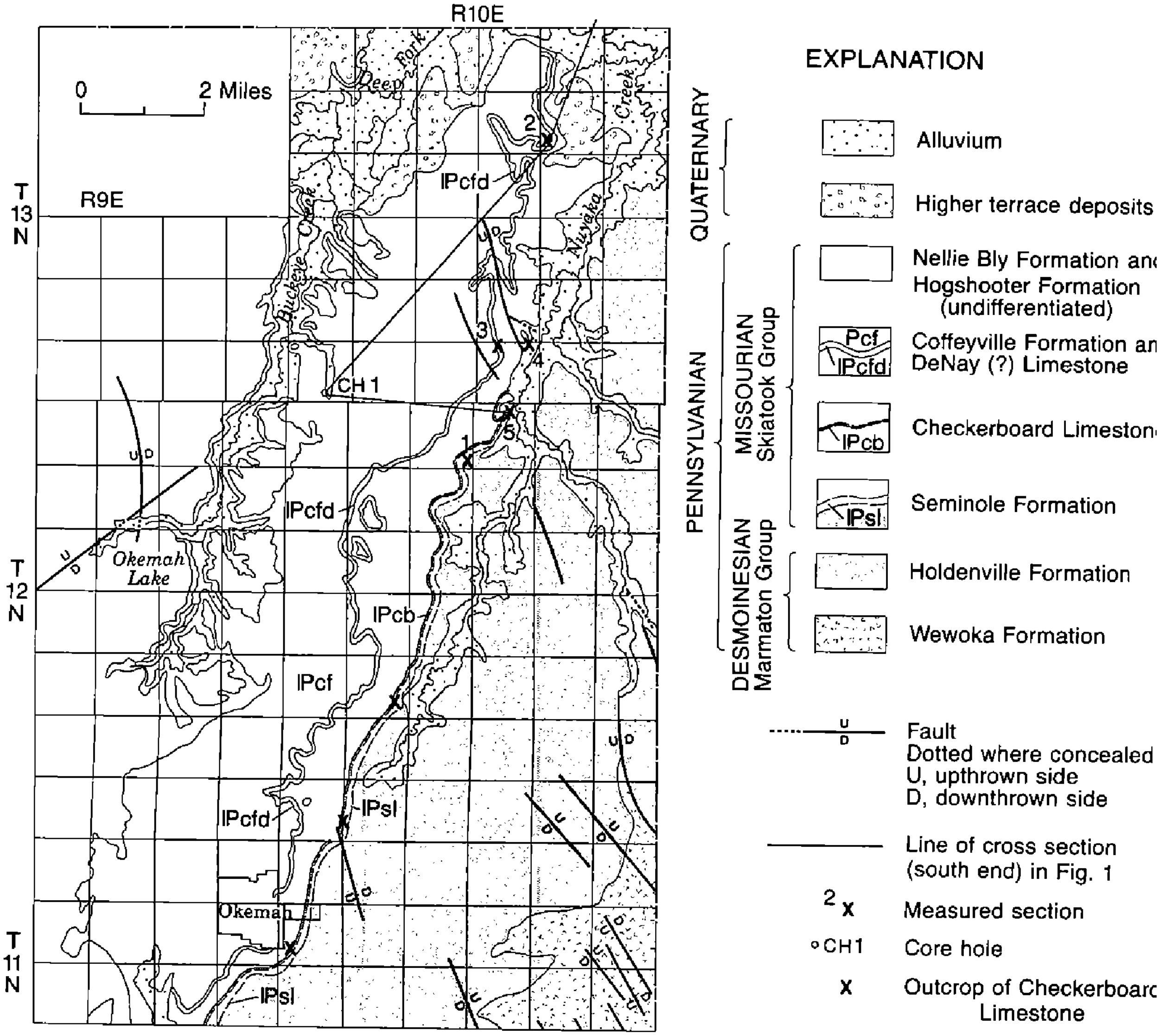


Figure 2. Generalized geologic map of north-central Okfuskee County, showing outcrop boundaries of the Holdenville, Seminole, Checkerboard, and Coffeyville Formations as determined by the present study. Modified in part from Ries (1954) and Bennison (1981, pl. 9).

Chronostratigraphic Units

Although the position of the Desmoinesian–Missourian boundary is not the focus of this paper, some points merit discussion. Using paleontological evidence, Ries (1954, p. 23) concluded that the Desmoinesian–Missourian boundary should be at the top of the Holdenville Formation, the uppermost formation of the Marmaton Group. However, several shale and sandstone units mapped by Ries in the overlying Seminole Formation of Missourian age have since been shown to be of Desmoinesian age and in the upper part of the Holdenville Formation (Boardman and Mapes, 1984, p. 55–56).

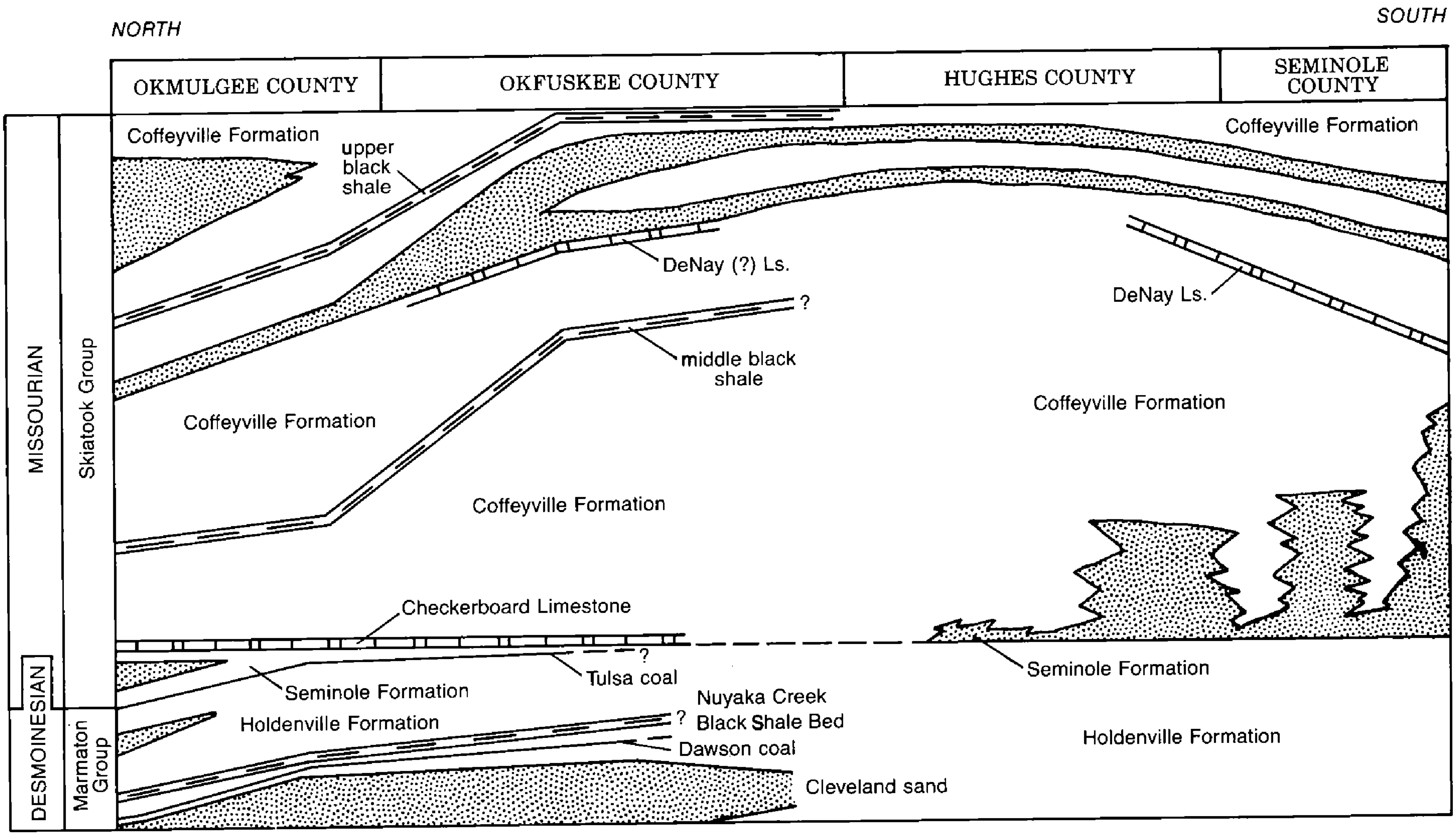


Figure 3. Diagrammatic north–south section for parts of Okmulgee, Okfuskee, Hughes, and Seminole Counties, showing stratigraphic positions of the DeNay(?) Limestone Member, Checkerboard Limestone, Tulsa coal, Dawson coal, and three black-shale marker beds. Portion for Hughes and Seminole Counties modified in part from Krumme (1981, figs. 18,22).

Oakes (1963, p. 53) stated that the Missourian Series is set off from the underlying Desmoinesian Series in Okmulgee County by an unconformity and a faunal change. He included the Dawson coal and a stratigraphically younger, then-unnamed coal in the Seminole Formation, the lowermost formation of Missourian age (Oakes, 1963, fig. 8); these two coal beds are key beds for correlation purposes in the cross section prepared for the present study.

Bennison (1972, p. 46) brought into question the position of the Desmoinesian–Missourian boundary when he stated that the Seminole Formation is "basal Missourian and possibly latest Desmoinesian" in nearby Tulsa County. Subsequent work in Tulsa County by Naff (1972), Wilson (1972,1984), and Pearson (1975) provided conclusive palynological and paleontological evidence that the Dawson coal is upper Desmoinesian and should be included in the Holdenville Formation. Wilson (1972,1984) and Pearson (1975) concluded that a local, thin coal bed below the Checkerboard Formation (named the Checkerboard coal by Bennison and others, 1979, p. 4) is lower Missourian. Another coal, the unnamed coal of Oakes (1963, fig. 8), which occurs in the interval between the Dawson coal and the base of the Checkerboard Formation, was named the Tulsa coal by Bennison and others (1979, p. 4–5). Wilson (1984, fig. 1, p. 253–258) assigned the Tulsa coal a Desmoinesian age, and included it in the Holdenville Formation. However, Pearson (1975), on the basis of palynological data, suggested that the Tulsa coal is Missourian. Krumme (1981, p. 15) stated that there is no unconformity at the base of the Missourian Series in Oklahoma, and that any horizon chosen as the base will be somewhat artificial.

The Desmoinesian–Missourian boundary has not been definitely established in Oklahoma, but palynological, paleontological, and lithologic work on the problem is in progress (P. H. Heckel, personal communication, 1986). For purposes of this report, using existing palynological and paleontological evidence and newly observed lithologic evidence (i.e., a weathered zone and a distinct, traceable color change from gray to green in the strata immediately underlying the Tulsa coal), the writer has tentatively selected the base of the Tulsa coal as the boundary between Desmoinesian and Missourian strata in the study area. The Holdenville Formation includes the uppermost Desmoinesian rocks mapped in the study area.

Lithostratigraphic Units

Holdenville Formation

The Holdenville Formation was named by Taff (1901, p. 4) in the vicinity of Holdenville, Hughes County, Oklahoma. In the type locality, the Holdenville is predominantly shale and is underlain by the Wewoka Formation and overlain by the Seminole Formation. In Okfuskee County, the Holdenville as mapped by Ries (1954) consists of a succession of shales, sandstones, and a few local limestones. The thickness according to Ries's mapping ranges from 280 ft on the south to 200 ft on the north; the outcrop belt averages ~2 mi in width (Ries, 1954, p. 42).

On the basis of this study and previously cited work by others, the Holdenville Formation is extended upward to the base of the Tulsa coal bed. The Dawson coal and overlying Nuyaka Creek Black Shale Bed (named by Dott and Bennison, 1981, p. 27) are herein included in the Holdenville Formation (Fig. 3). The redefined Holdenville thus includes part of the rocks mapped by Ries (1954, pl. 1) in the Seminole Formation (his units 1, 1a, 1b, 1c, 2, 2a, 2b). These rocks are predominantly sandstone, with a northward-intertonguing unit of shale, and are equivalent to the Cleveland sand. Their thickness is about 150–190 ft. The expanded thickness of the Holdenville Formation as shown in Figure 3 ranges from ~350 ft to ~450 ft, and the width of the outcrop belt averages ~4 mi.

Seminole Formation

The Seminole Formation was first described by Taff (1901) in the Seminole Nation (now Seminole County), Oklahoma, as 50 ft of conglomerate overlain by ~100 ft of brown sandstone. In its type area, the Seminole Formation is underlain by the Holdenville Formation and overlain by the Francis Formation. In north-central Okfuskee County and Okmulgee County, the Seminole Formation is underlain by the Holdenville Formation and overlain by the Checkerboard Formation. The interval is represented by only ~2 ft of dark-gray shale and a thin coal bed in central Okfuskee County (Appendix 1, core-hole log 1). The Seminole Formation thickens northward and is ~28 ft thick in northwestern Okmulgee County (Appendix 1, core-hole log 3).

Checkerboard Limestone

The name Checkerboard Limestone came into use in 1911 without formal definition (Hutchison, 1911, p. 157). Gould (1925, p. 72) designated as the type locality the old Checkerboard Crossing of Flat Rock Creek (now Checkerboard Creek) in sec. 22, T15N, R11E, Okmulgee County. Moore and others (1937, p. 40) raised the Checkerboard to formation rank.

In Okmulgee County, the Checkerboard is a single massive bed of bluish-white to dark-blue, fossiliferous limestone ~2 ft thick (Figs. 4,5). It is cut into large blocks by solution channels along two sets of perpendicular joints, creating a striking checkerboard pattern (Oakes, 1963, p. 60).

Because a type *section* per se has never been specified for the Checkerboard Formation (a type *locality* was designated by Gould in 1925), a principal reference section is herein designated in accordance with the North American Stratigraphic Code (1983, p. 853), at a location where associated underlying beds are exposed. The reference section is located in the type area of the Checkerboard Limestone in the NW¼NW¼NE¼SE¼SE¼ sec. 22, T15N, R11E, Okmulgee County, Oklahoma (Appendix 2, measured section 8). The beds immediately overlying the Checkerboard have been removed by erosion at the reference section, but ~13 ft of underlying strata are well exposed in a cutbank of Checkerboard Creek. These strata include the Tulsa coal, a marker bed critical for correlation purposes in this study (Fig. 1).

The outcrop of the Checkerboard Limestone extends southwestward from its type locality to the alluvium associated with Deep Fork in sec. 8, T14N, R11E, Okmulgee County. Oakes (1963, p. 61) seemed reluctant to endorse Ries's correlation of the Checkerboard Limestone south of Deep Fork in Okfuskee County. He said, "Limestone at the stratigraphic position of the Checkerboard appears in

Figure 4. Photograph of the 26-in.-thick Checkerboard Limestone in its type area ~0.35 mi south of Checkerboard Crossing, NW¼NW¼NW¼NW¼NE¼ sec. 27, T15N, R11E, Okmulgee County, Oklahoma.

the northern part of sec. 2, T13N, R10E, in Okfuskee County . . . Ries (1954) mapped this limestone southwestward as the Checkerboard . . ."

While doing field work south of Deep Fork, Bennison (personal communication, 1986) located an outcrop of fossiliferous limestone underlain by smutty coal in a bluff on the west side of Nuyaka Creek, in the NE¼ sec. 3, T12N, R10E, which he believed was the true Checkerboard Limestone. The writer measured a section at this location (Appendix 2, measured section 5). Correlation of stratigraphic units in Figure 1 shows that the outcropping limestone is indeed the Checkerboard, as suggested by Bennison.

The approximate outcrop belt of the true Checkerboard Limestone is shown in Figure 2, which is based in part on previous mapping by Bennison (1981, pl. 9). Outcrops of the Checkerboard are rare in Okfuskee County, because the limestone is shaly and not resistant to weathering. Furthermore, outcrops are totally obscured by alluvium associated with Deep Fork and Nuyaka Creek for several miles in northwestern Okmulgee County and northern Okfuskee County (Fig. 2). The approximate outcrop boundary of the Checkerboard Limestone occasionally can be mapped by locating outcrops of the underlying Tulsa coal (Appendix 2, measured section 1; Fig. 3), even though the limestone may be eroded away. The thin coal stringers exposed at measured section 1 represent the southernmost known outcrop of the Tulsa coal.

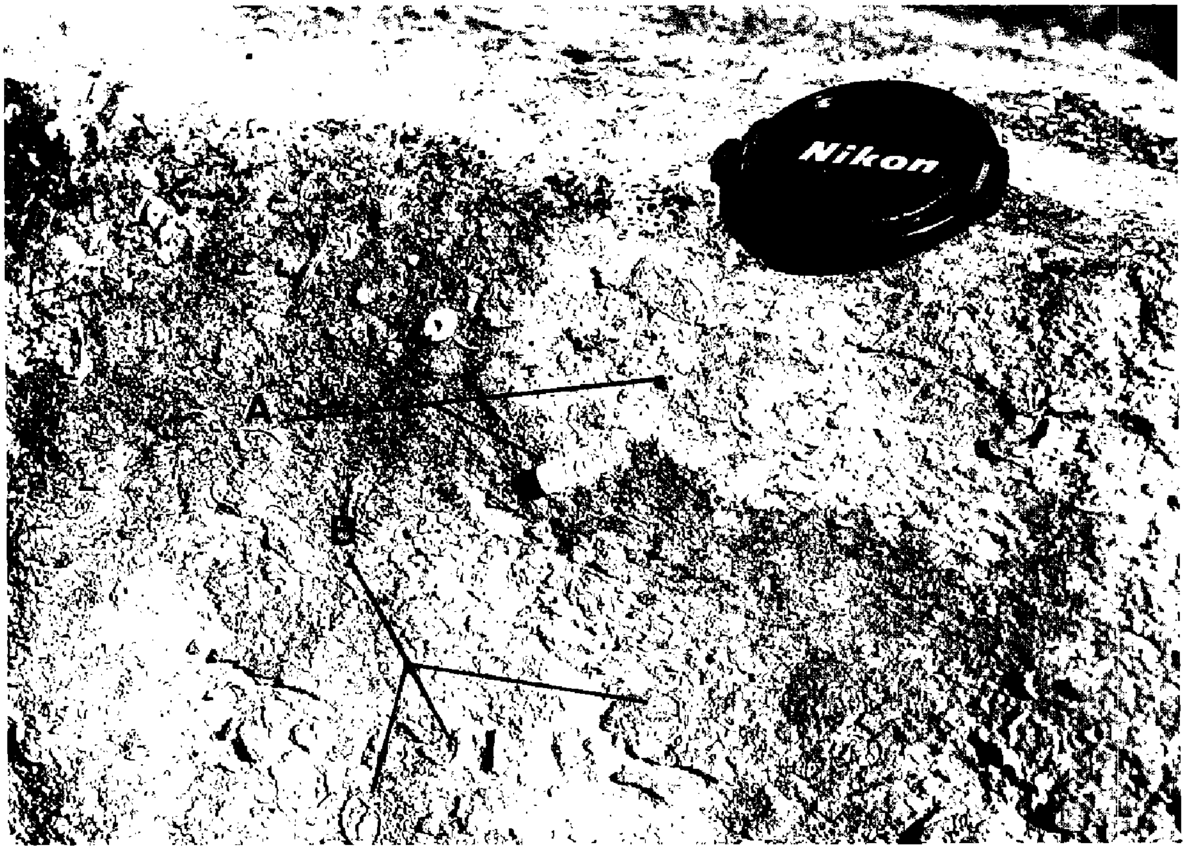


Figure 5. Close-up photograph of the outcrop of Checkerboard Limestone shown in Figure 4, showing its fossiliferous character. "A" points to crinoid columnals weathered out in relief on a joint surface, and "B" points to brachiopod valves.

Several outcrops of the limestone previously miscorrelated with the Checkerboard were examined and described by the writer to ensure that further miscorrelations would not be made (Appendix 2, measured sections 2–5; Figs. 1,2). Ries (1954, p. 55, pl. 1) discussed and mapped a limestone of particular interest that crops out in the SE¼ sec. 27, T13N, R10E, Okfuskee County (Appendix 2, measured section 4). He noted that this limestone "crops out in an open field and not in the same escarpment as the lower sand of the Coffeyville," and that it may be "brought to this position as the result of a large fault." This limestone crops out at about the same elevation as the true Checkerboard Limestone just a mile to the south (Appendix 2, measured section 5). However, because of differences in the lithologic character and thicknesses of the limestones at the two outcrops, and because the underlying strata at the outcrop in the SE¼ sec. 27 do not include the Tulsa coal, the writer agrees with Ries's interpretation that the limestone at this locality is downthrown along a fault (although an additional fault not shown on Ries's map is required). In lithologic character and thickness, this limestone is almost identical with the limestone that crops out in the escarpment ~0.75 mi to the west, on the upthrown side of the fault in the SW¼ sec. 27, T13N, R10E (Appendix 2, measured section 3; Fig. 2), which herein is tentatively correlated with the DeNay Limestone Member of the Coffeyville Formation. Figure 6 is a photograph of the limestone on the upthrown side of the fault, in the SW¼ sec. 27, T13N, R10E.

Coffeyville Formation

The Coffeyville Formation was named by Schrader and Haworth (1906, p. 14) in the vicinity of Coffeyville, Kansas. The history of the formation name has been reviewed by Oakes (1940,1959), who excluded some portions of the geologic section that had been included in the Coffeyville Formation in Kansas. The name as now used in Oklahoma applies only to the strata above the Checkerboard Limestone and below the Hogshooter Formation.

The Coffeyville Formation consists predominantly of sandy shale, with sandstone and minor amounts of clay shale and sandy limestone, and thin coal beds. Ries (1954, p. 58) believed that the Coffeyville Formation in Okfuskee County is ~245 ft thick. The addition of ~220 ft of shale and other minor beds (Appendix 1, core-hole log 1) which lie between the true Checkerboard Limestone and the limestone miscorrelated by Ries with the Checkerboard brings the total thickness of the Coffeyville Formation in Okfuskee County to ~465 ft, and increases the width of the outcrop belt by a maximum of ~2 mi.

This correction explains what formerly seemed to be an anomaly in the thickness of the Coffeyville Formation in Okmulgee and Okfuskee Counties. Oakes (1963,

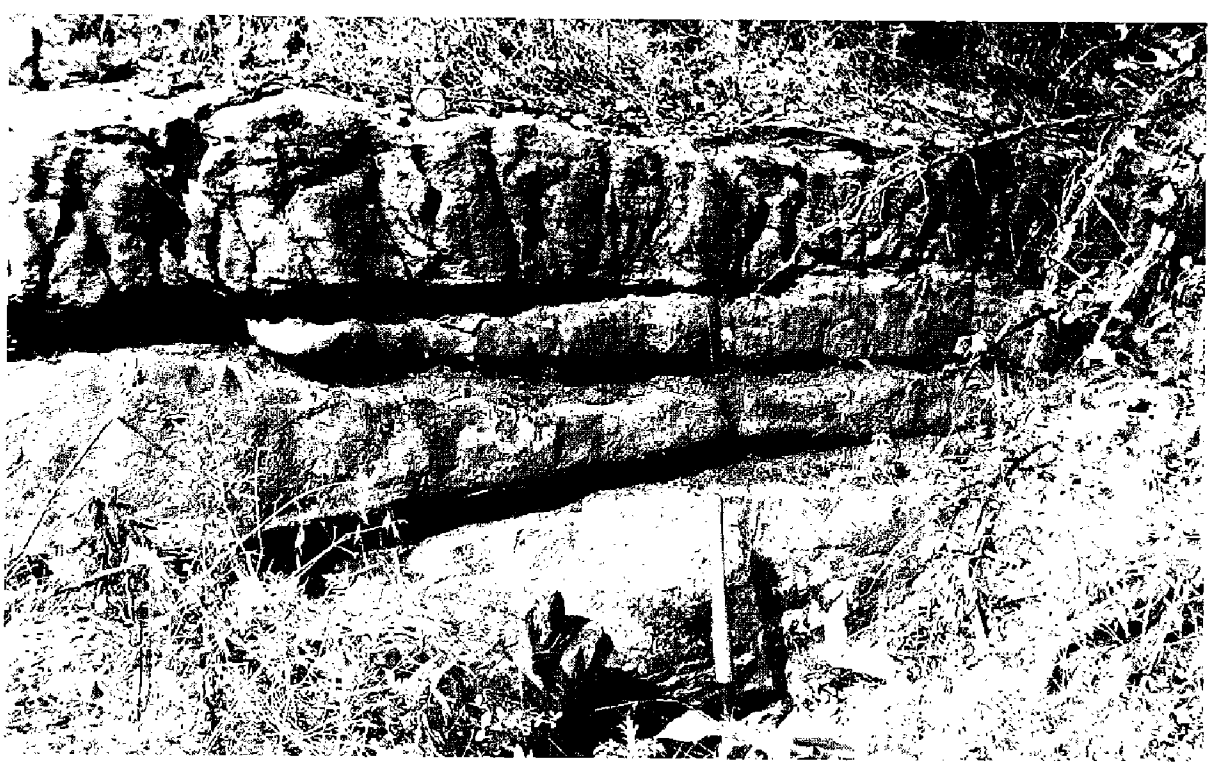


Figure 6. Photograph of the DeNay(?) Limestone Member in the SW¼ sec. 27, T13N, R10E, Okfuskee County, Oklahoma.

p. 62) stated, "It [Coffeyville Formation] ranges from 175 to 235 feet across Washington and Nowata Counties; increases southward across Tulsa County from 240 feet to 440 feet; ranges across eastern Creek County from 375 to 500 feet; decreases southward across northwestern Okmulgee County from 470 to 450 feet; and is 250 feet thick in Okfuskee County."

Although the entire thickness of the Coffeyville Formation was not penetrated in either core hole 2 (drilled in northwestern Okmulgee County) or core hole 1 (drilled in central Okfuskee County), the interval between black-shale marker bed 2 (see Fig. 1) and the top of the Checkerboard Limestone is shown to increase southward by 91 ft (Appendix 1; Figs. 1,3). This discovery is significant, as Ries's interpretation implied that the Coffeyville Formation thins by more than 200 ft between Okmulgee and Okfuskee Counties, whereas it obviously thickens, even without the addition of the mismapped beds.

The limestone bed in Okfuskee County that Ries miscorrelated with the Checkerboard Limestone occurs some 200–240 ft above the base of the Coffeyville Formation in the study area. It thins to the north in Okfuskee County, and has a measured thickness of only 0.1 ft in the SW¼ sec. 11, T13N, R10E (Appendix 2, measured section 2). No evidence was found in Okmulgee County to indicate that this limestone bed is present north of Deep Fork. Ries (1954, p. 55) traced it south in Okfuskee County to the NW¼ sec. 23, T11N, R9E. He observed (p. 56) that "it is approximately the same age as DeNay Limestone of central Oklahoma . . . "

The DeNay Limestone was named by Morgan (1924, p. 110) after DeNay School, in sec. 5, T4N, R7E, Pontotoc County. In the southern part of Seminole County (immediately southwest of Okfuskee County), the DeNay Limestone was interpreted by Morgan (1924) and Tanner (1956) as the basal member of the Coffeyville Formation. Bennison (1981, p. 4) proposed that the DeNay be included in the upper Coffeyville Formation. It is a dense, yellow to brown, fossiliferous limestone a few inches to a few feet thick (Tanner, 1956, p. 64), not unlike the limestone in the upper Coffeyville in Okfuskee County. Tanner (1956, p. 59) observed that "the DeNay, when considered in relation to the lowest Coffeyville Sandstone, climbs steadily in section to the north . . ." He further stated (p. 61) that "in Seminole and Hughes Counties, the DeNay vanishes northward in the middle of a shale sequence, with no indication of truncation." Ries (1954, p. 54) described the limestone that he miscorrelated with the Checkerboard as passing southward into a thick shale sequence in southern Okfuskee County. Tanner (1956, p. 64) stated that "near the Hughes-Okfuskee-Seminole County corner the Checkerboard Limestone Formation [not the true Checkerboard Limestone, rather the limestone here tentatively correlated with the DeNay] appears, much in the same manner as the DeNay disappeared." There is a gap of ~30 mi between outcrops of the two limestones, but they apparently lie at approximately the same horizon. The writer feels that the evidence permits tentative correlation between the DeNay Limestone Member in Hughes, Pontotoc, and Seminole Counties and the limestone in the upper Coffeyville Formation in Okfuskee County. The alternative is to introduce a new name for the Okfuskee County limestone (the name "Okemah Limestone" was proposed by Bennison, 1981, pl. 9), which seems unnecessary.

Conclusions

1. A cross section incorporating core-hole logs and measured sections shows that a limestone in the upper Coffeyville Formation in Okfuskee County was misidentified by Ries (1954) as the Checkerboard Limestone.

2. A principal reference section is herein designated for the Checkerboard Limestone in the SE¼ sec. 22, T15N, R11E, Okmulgee County.

3. The true Checkerboard Limestone is identified by its position relative to two underlying key beds in the Holdenville and Seminole Formations, the Dawson coal bed and the Tulsa coal bed.

4. The limestone bed mistaken for the Checkerboard Limestone in Okfuskee County occurs 220–240 ft higher in the section, near the middle of the Coffeyville Formation.

5. The previously miscorrelated limestone in the upper Coffeyville Formation in Okfuskee County is herein tentatively correlated with the DeNay Limestone Member.

6. The DeNay(?) Limestone Member of Okfuskee County is not known to extend north of Deep Fork.

7. The Seminole Formation is herein tentatively defined as the interval between the base of the Tulsa coal and the base of the Checkerboard Limestone in that part of Okfuskee County north of the North Canadian River where the two units are mappable.

8. The rocks below the Tulsa coal in Okfuskee County, mapped by Ries (1954) as the Seminole Formation, are included in the upper Holdenville Formation.

9. The rocks between the DeNay(?) Limestone Member and the Checkerboard Limestone in Okfuskee County, mapped by Ries (1954) as shales in the Seminole Formation, are here included in the lower Coffeyville Formation.

10. The position of the Desmoinesian–Missourian boundary has not been definitely established in Oklahoma, but it is in the interval between the Dawson coal bed and the Checkerboard Limestone, probably below the horizon of the Tulsa coal bed.

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Appendix 1

Core-Hole Logs

CH 1

SE¼SW¼NW¼SW¼SE¼ sec. 31, T13N, R10E, Okfuskee County. Drill hole cored by Oklahoma Geological Survey; lithologic descriptions by LeRoy A. Hemish. Drilled in pasture at SW corner of farm pond, 2,420 ft FEL and 700 ft FSL. Surface elevation, estimated from topographic map, 738 ft.

	Depth to top of unit (ft)	Thickness of unit (ft)
Silt, brownish-gray; contains organic material	0.0	3.5
Sand, grayish-orange, clayey, fine- to coarse-grained, poorly sorted	3.5	2.5
Sand and gravel, moderate-yellowish-brown, clayey; gravel clasts composed predominantly of subangular, moderate-reddish-brown sandstone	6.0	2.5
Skiatook Group		
Coffeyville Formation		
Shale, pale-yellowish-brown to moderate-brown, soft, clayey, noncalcareous, weathered	8.5	1.7
Shale, brownish-gray, with moderate-yellowish-brown bands, soft, clayey, noncalcareous, weathered	10.2	0.6
Shale, black, with moderate yellowish-brown bands, soft, flaky; iron-oxide deposits on stratification surfaces	10.8	1.2
Shale, black, hard, brittle, fractured; iron-oxide deposits on fracture and stratification surfaces; contains small phosphatic nodules; noncalcareous	12.0	5.1
Marlstone, medium-gray, soft, silty; contains abundant crinoid columnals, increasing in numbers downward	17.1	1.7
Sandstone and mudstone, medium-gray, marly, fine-grained; contains abundant crinoid ossicles	18.8	1.6
Shale, medium-gray, sandy, silty, noncalcareous; interfingers with underlying unit	20.4	1.1
Sandstone, light-gray, with medium-dark-gray laminations, fine- to very fine-grained, noncalcareous, cross-stratified; thick-bedded from about 33.0 to 41.0 ft and uniform in appearance, grain size increasing to fine- to medium-grained; conglomeratic from 41.0 to 45.0 ft, with abundant greenish-gray shale pebbles; also conglomeratic from about 52.0 to 54.7 ft; includes abundant black macerated plant fragments in lower 5 ft of unit; lower contact sharp	21.5	33.2
Shale, medium-dark-gray, silty, noncalcareous; bioturbated in lower part; includes some interbedded, light-gray, very fine-grained sandstone below 60 ft	54.7	6.5
Sandstone, light-gray, with medium-dark-gray streaks and layers, fine- to very fine-grained; contains black, macerated plant fragments; noncalcareous, cross-stratified, extensively bioturbated in part, shaly below 71 ft	61.2	14.2

Shale, medium-dark-gray, silty, fossiliferous noncalcareous, bioturbated in part; interbedded with lenses and layers of very fine-grained, fossiliferous, weakly calcareous sandstone as much as 1.5 in. thick	75.4	6.6
Shale, medium-dark-gray, silty, calcareous, fossiliferous	82.0	2.5
Limestone, medium-dark-gray, very shaly, fossiliferous; contains abundant bryozoans, brachiopods, and crinoid columnals; grades into underlying unit	84.5	1.8
Shale, medium-dark-gray, silty, calcareous, fossiliferous; contains abundant crinoid columnals and brachiopod valves, generally concentrated in layers as much as 0.5 in. thick	86.3	6.5
Sandstone, medium-dark-gray and medium-light-gray, hard, shaly, very calcareous, fossiliferous, bioturbated in part, intricately convoluted and laminated; high-energy depositional features common	92.8	1.7
Sandstone, medium-dark-gray to medium-light-gray and dark-gray, very fine-grained, shaly, noncalcareous, bioturbated; bedding contorted; contains fossil fragments	94.5	1.5
Sandstone, dark-gray, with medium-light-gray contorted bands, very fine-grained, shaly, silty, noncalcareous, bioturbated, fossiliferous	96.0	1.5
Limestone, very light-gray, with brownish-gray mottling, hard, sandy, fossiliferous; includes abundant brachiopods and pelecypods (DeNay[?] Limestone Member)	97.5	2.0
Sandstone, light-greenish-gray, very fine-grained, calcareous, conglomeratic in upper 3 in.; bedding obscure; bioturbated in part; includes some fossil fragments; becomes noncalcareous below 101 ft	99.5	4.5
Siltstone, medium-dark-gray, sandy, muddy, calcareous, fossiliferous; contains scattered brachiopod shells and crinoid columnals; laminated; bioturbated in places	104.0	15.5
Shale, medium-dark-gray to olive-black, silty, weakly calcareous; contains lens-shaped, brownish-gray, sideritic concretions about 0.5–1 in. thick	119.5	5.8
Shale, medium-dark-gray to olive-black, silty, calcareous, interstratified with occasional layers of very fine-grained, medium-light-gray, calcareous sandstone 0.25–3 in. thick; contains lens-shaped, brownish-gray, sideritic concretions generally <0.75 in. thick	125.3	4.9
Shale, medium-dark-gray to olive-black, calcareous; contains scattered marine-fossil fragments and brownish-gray, sideritic burrow fillings; includes minor pyrite associated with trace fossils on stratification surfaces	130.2	19.1
Shale, grayish-black to black, brittle, noncalcareous; contains pyritized and calcareous marine fossils; upper contact sharp	149.3	4.7
Shale, dark-gray, very calcareous; includes abundant fossil shells	154.0	0.1
Shale, dark-gray, silty, calcareous, fractured; includes pyritized burrow fillings and fossil shells and shell frag-		

ments; contains rare brownish-gray, sideritic concretions about 1–2 in. thick; burrows and fossils rare below 170 ft; grades into underlying unit	154.1	25.9
Shale, dark-gray, silty, noncalcareous; contains rare light-brownish-gray, sideritic concretions 0.25–2 in. thick; includes some sparsely distributed brachiopod shells and pyritized trace fossils; minor calcite veins along fracture surfaces	180.0	7.4
Shale, medium-gray to medium-dark-gray, silty, hard, noncalcareous; contains rare light-brownish-gray sideritic concretions ~0.5 in. thick; sparse marine fossils	187.7	3.4
Shale, medium-dark-gray, silty, noncalcareous, interlaminated with light-gray, very fine-grained sandstone; contains numerous small, elongated, lens-shaped, light-brownish-gray, sideritic concretions	190.8	4.2
Shale, medium-dark-gray to dark-gray, silty, noncalcareous; includes lens-shaped, light-brownish-gray, sideritic concretions as much as 1 in. thick (probably burrows); calcareous from 203 to 239 ft; contains scattered light-brownish-gray, fossil-cored concretions ~0.25 in. in diameter; small pyritized trace fossils; grades into underlying unit	195.0	51.7
Limestone, very light-gray and dark-gray, interstratified with calcareous shale, fossiliferous; composed predominantly of small crinoid ossicles; grades into underlying unit	246.7	0.5
Shale, dark-gray to medium-dark-gray, silty, calcareous; fossiliferous, with abundant small crinoid ossicles in upper 1 ft; includes a 1.5-in.-thick, medium-light-gray limestone concretion at 249.5 ft; bioturbated; contains numerous light-brownish-gray, sideritic bands and concretions (probably burrows)	247.2	27.7
Limestone, dark-gray, impure, shaly, fossiliferous; brachiopod shells and shell fragments abundant	274.9	0.3
Shale, dark-gray, very calcareous, fossiliferous; contains scattered marine shells and shell fragments; includes some minor pyrite on stratification surfaces, and pyrite-filled burrows	275.2	9.0
Shale, medium-dark-gray, noncalcareous; includes abundant closely spaced laminae of siltstone; bioturbated	284.2	1.4
Shale, dark-gray to grayish-black, carbonaceous, weakly calcareous; contains gastropods, brachiopod shells and shell fragments; includes coalified plant fossils and stringers of coal as much as 0.5 in. thick	285.6	0.2
Shale, medium-dark-gray, calcareous, fossiliferous; contains pelecypods and other marine fossils, and scattered, black, carbonized plant fragments; abundance of marine fossils increases markedly in lower 1 in. of unit	285.8	1.0
Coal, black, moderately friable; includes calcite on cleat surfaces (unnamed coal)	286.8	0.1
Underclay, dark-gray to medium-light-gray, carbonaceous in upper part; grades into underlying unit	286.9	0.2

Shale, medium-bluish-gray, clayey, noncalcareous, slickensided; includes some brownish-black, carbonaceous shale layers as much as 0.75 in. thick in bottom 2 ft of unit	287.1	3.7
Shale, medium-gray, calcareous, bioturbated; includes laminae of very fine-grained, light-brownish-gray sandstone in lower 1 ft of unit	290.8	1.9
Siltstone, medium-gray, calcareous, hard, bioturbated; shaly in part; includes some lens-shaped laminae of very fine-grained, light-gray sandstone; contains sparsely distributed marine fossils such as crinoid columnals and brachiopod shells; fossil content increases markedly in bottom 6 in. of unit; grades into underlying unit	292.7	29.3
Checkerboard Limestone		
Limestone, medium-light-gray, extemely fossiliferous; brachiopods and crinoid columnals most abundant; very silty in upper 1 ft of unit; impure throughout	322.0	2.3
Seminole Formation		
Shale, brownish-black, silty, very calcareous, carbonaceous; contains scattered small marine fossils	324.3	0.5
Shale, brownish-black to black, carbonaceous; contains abundant thin stringers of coal; noncalcareous	324.8	0.4
Shale, medium-dark-gray, clayey, noncalcareous, slickensided; becomes dark-gray and carbonaceous in lower 1 in. of unit	325.2	0.8
Coal, black, bright, slightly friable; includes white calcite on cleat surfaces (Tulsa coal)	326.0	0.1
Marmaton Group		
Holdenville Formation		
Underclay, medium-dark-gray, slickensided; grades into underlying unit	326.1	0.4
Shale, greenish-gray; fracture blocky; crumbly, noncalcareous, slickensided	326.5	3.9
Shale, medium-dark-gray, with medium-gray bands, very silty, hard, interstratified with abundant layers of very fine-grained sandstone, extensively bioturbated; calcareous to ~350 ft, then weakly calcareous, and becoming noncalcareous below 353 ft	330.4	29.6
Shale, dark-gray, silty, noncalcareous; contains thin stringers and small lenses of light-gray, very fine-grained sandstone; bioturbated, hard, fractured; white gypsum fills fractures; grades into underlying unit	360.0	6.0
Shale, dark-gray to grayish-black, noncalcareous, hard, brittle, fossiliferous; contains scattered brachiopod shells and shell fragments; includes small, pyritized trace fossils on stratification surfaces; grades into underlying unit	366.0	4.2
Shale, grayish-black to black, hard, brittle, noncalcareous; includes some minor pyrite and rare marine fossils; contains phosphatic nodules ~0.5 in. in diameter (Nuyaka Creek Black Shale Bed)	370.2	6.1
Shale, medium-dark-gray, noncalcareous, bioturbated, fossiliferous; contains pyrite-filled burrows and brachiopod valves; slickensided	376.3	2.0

Coal, black, bright, pyritic; contains closely spaced veinlets of white gypsum (Dawson coal)	378.3	0.1
Underclay, greenish-gray, slickensided; thickness of unit irregular	378.4	0.2
Coal, black, bright, pyritic; contains closely spaced veinlets of white gypsum, thickness of unit irregular (Dawson coal)	378.6	0.1
Underclay, greenish-gray, slickensided; thickness of unit irregular	378.7	0.2
Coal, black, bright, pyritic; contains closely spaced veinlets of white gypsum; thickness of unit irregular (Dawson coal)	378.9	0.1
Underclay, greenish-gray, slickensided; includes some brownish-black layers of carbonaceous clay as much as 1 in. thick; grades into underlying unit	379.0	1.0
Mudstone, greenish-gray, noncalcareous; interbedded with brownish-black, carbonaceous sandstone and very fine-grained, silty, greenish-gray sandstone	380.0	8.5
Sandstone, light-gray, with medium-light-gray bands, well-indurated, very fine-grained, noncalcareous, cross-bedded	388.5	1.5
Total depth		390.0

CH 2

NW¼NW¼NE¼SW¼NW¼ sec. 31, T15N, R11E, Okmulgee County. Drill hole cored by Oklahoma Geological Survey; lithologic descriptions by LeRoy A. Hemish. Drilled at NW edge of pond 550 ft FWL and 1,450 ft FNL. Surface elevation, estimated from topographic map, 748 ft.

	Depth to top of unit (ft)	Thickness of unit (ft)
Silt, brownish-gray; includes some moderate-reddish-orange mottling, unbedded; contains organic material . .	0.0	3.5
Skiatook Group		
Coffeyville Formation		
Shale, grayish-orange, clayey, weakly calcareous; includes some dark-yellowish-orange, limonitic concretions; weathered	3.5	5.5
Shale, light-olive-gray to olive-gray, with dark-yellowish-orange mottling, clayey, calcareous, partly weathered; becomes olive-gray and dark-yellowish-brown at ~12 ft; fractured; gypsum and calcite occur as crusts along fractures; medium-light-gray in unweathered parts of lower part of unit	9.0	13.5
Shale, dark-gray and dark-yellowish-brown, with dark-yellowish-orange bands, calcareous	22.5	1.5
Shale, dark-gray to brownish-black, with dark-yellowish-orange, limonitic crusts on parting surfaces; calcareous, fractured; contains some bioturbation traces and rare marine-shell fragments	24.0	9.1

Shale, grayish-black to black, hard, brittle, noncalcareous; includes some disseminated pyrite and pyrite crusts on parting surfaces; contains phosphatic nodules as much as 1 in. long and 0.5 in. thick	33.1	3.8
Limestone, dark-gray to medium-dark-gray, very shaly, fossiliferous; grades into underlying unit	36.9	0.2
Shale, medium-gray, silty, bioturbated, weakly calcareous in upper 3 in., noncalcareous in lower part; contains some pyritic trace fossils; includes numerous light-brownish-gray, sideritic, concretionary bands, ranging from about 0.1 to 0.5 in. thick	37.1	15.0
Sandstone, medium-dark-gray, very fine-grained, shaly, calcareous; contains small fossil particles	52.1	0.4
Limestone, medium-gray, impure, silty, hard, nonfossiliferous, micritic	52.5	0.2
Mudstone, medium-dark-gray, noncalcareous	52.7	1.3
Limestone, light-brownish-gray, hard, unfossiliferous, micritic	54.0	0.1
Shale and siltstone, medium-gray; interstratified with light-gray, very fine-grained sandstone; extensively bioturbated in part; noncalcareous, but some sandstone layers highly calcareous; sandstone units contorted and cross-laminated in part, with abundant scour-and-fill features; interstratified units range from thin laminae to beds 12 in. thick; includes some light-brownish-gray, sideritic concretions about 0.5 to 1 in. thick	54.1	17.9
Sandstone, medium-gray, very silty, noncalcareous, wavy-laminated and cross-laminated in part, microfaulted in places, with abundant soft-sediment deformation and scour features; fines upward	72.0	10.0
Shale and siltstone, medium-gray; interstratified with light-gray, very fine-grained sandstone; noncalcareous, bioturbated, laminated; interstratified sandstone units cross-laminated and contorted in places; scour-and-fill features abundant; includes light-brownish-gray, sideritic concretions as much as 1.5 in. thick; becomes medium-dark-gray and finer-grained below 96 ft	82.0	23.5
Sandstone, medium-light-gray to medium-gray, very fine-grained, noncalcareous, bioturbated, unbedded to cross-bedded; slump features common; shaly below 105.8 ft	105.5	2.7
Shale and siltstone, medium-dark-gray; with few beds of interstratified light-gray, very fine-grained sandstone; noncalcareous, bioturbated; includes some interbedded units of medium-light-gray, very fine-grained, highly contorted sandstone as much as 1 ft thick; contains light-brownish-gray, sideritic concretions about 0.25–0.5 in. thick	108.2	10.5
Shale, medium-dark-gray, very silty, noncalcareous; contains light-brownish-gray concretions as much as 1 in. thick; includes several contorted beds of light-gray to medium-light-gray, very fine-grained sandstone 0.5–10 in. thick	118.7	8.3

Shale, medium-dark-gray to medium-gray, silty; includes abundant light-brownish-gray, sideritic layers and burrow fillings; noncalcareous, but contains some widely spaced, thin layers of very fine-grained, calcareous sandstone; includes a layer of black coal 0.25 in. thick at ~137.5 ft; contains sparse calcareous fossil shells; includes a fossiliferous, 1.5-in.-thick, sideritic concretion at 144.7 ft	127.0	18.4
Shale, medium-dark-gray to dark-gray, silty, calcareous; contains fossil marine shells, as well as light-brownish-gray, sideritic concretions and burrow fillings as much as 1.25 in. thick; noncalcareous from 150 to 154 ft; includes rare carbonized and pyritic plant fossils; proportion of brachiopods increases markedly at 165 ft; grades into underlying unit	145.4	21.2
Limestone, dark-gray, impure, shaly, fossiliferous; fossil hash abundant; brachiopod and crinoid fragments common; bioturbated in lower part	166.6	0.4
Shale, dark-gray, calcareous; contains small, pyritic trace fossils and sparse calcitic and pyritic brachiopods	167.0	13.2
Shale, grayish-black to black, calcareous; contains disseminated pyrite, pyrite-filled burrows, and pyritic brachiopod shells; fossils sparse	180.2	9.1
Limestone, dark-gray, impure, shaly, fossiliferous; fossil hash abundant; light-gray and unfossiliferous in lower 1 in.	189.3	0.5
Shale, dark-gray, silty, calcareous; includes a 1.5-in.-thick limestone concretion 3 in. above base of unit	189.8	1.2
Shale, dark-gray, silty, calcareous; interstratified with thin layers of siltstone and very fine-grained sandstone; bioturbated in lower part; contains several light-gray limestone concretions as much as 2 in. thick	191.0	3.8
Limestone, medium-light-gray, impure, silty, shaly, fossiliferous; fossil hash abundant; includes a 1.5-in.-thick, medium-dark-gray shale parting near the middle of the unit	194.8	0.5
Shale, dark-gray, calcareous, fossiliferous; well-preserved brachiopods abundant; contains pyritized burrow fillings .	195.3	2.8
Shale, medium-dark-gray, silty, noncalcareous, bioturbated; contains pyrite and pyritized burrow fillings; includes abundant medium-light-gray laminae of siltstone and very fine-grained sandstone; scour-and-fill features common; proportion of sandstone increases markedly below 201 ft; unit grades downward into shaly sandstone; bedding greatly contorted from 203 to 203.5 ft; sequence fines upward	198.1	5.4
Sandstone, medium-light-gray, very fine-grained, calcareous from 203.5 to 206.6 ft; upper 4 ft of unit extensively bioturbated; bedding disturbed and contorted; cross-laminated in part; pyritic in places; contains rare pelecypod shells; color darkens downward	203.5	6.5

Siltstone, medium-gray, sandy, calcareous; contains abundant fossil pelecypod shells from 211.8 to 214.4 ft; bioturbated in part; laminated; grades into underlying unit	210.0	9.0
Shale, medium-gray, silty, bluish-gray in lower part, calcareous; contains sparse marine shells and shell fragments; includes some thin wisps of light-gray, very fine-grained sandstone in upper part of unit; contains rare pyritic trace fossils; grades into underlying unit	219.0	33.8
Checkerboard Limestone		
Limestone, medium-gray to light-gray, silty, hard, fossiliferous; marine shells and crinoid columnals abundant; shaly in bottom 4 in.	252.8	3.6
Seminole Formation		
Shale, medium-dark-gray, with medium-light-gray, very fine-grained, silty sandstone laminae; noncalcareous; contains rare brachiopod valves and plant fragments, as well as small, pyritized trace fossils	256.4	3.9
Shale, dark-gray, carbonaceous, noncalcareous; contains disseminated pyrite and carbonized plant fragments on stratification surfaces	260.3	0.6
Coal, black, bright, very friable, shaly in part; pyrite on cleat surfaces (Tulsa coal)	260.9	0.4
Marmaton Group		
Holdenville Formation		
Underclay, greenish-gray, noncalcareous, silty, bioturbated; contains carbonized plant fragments	261.3	1.3
Limestone, light-olive-gray to light-brownish-gray, impure, sandy, fossiliferous; contains brachiopod shell fragments and fossil hash, particularly in upper 2 in.	262.6	0.8
Siltstone and sandstone, greenish-gray, hard, extensively bioturbated, very calcareous, shaly in part	263.4	1.7
Shale, medium-dark-gray, silty, calcareous; contains rare, small limestone concretions, sparse marine fossils, and minor pyrite	265.1	10.4
Shale, dark-gray, very silty, hard, weakly calcareous, extensively bioturbated; contains abundant thin laminae and lenses of light-gray, very fine-grained sandstone; includes minor pyrite on stratification surfaces; grades into underlying unit	275.5	32.5
Shale, dark-gray to grayish-black, silty, calcareous; contains sparse marine fossils including nautiloids and ammonoids, as well as trace fossils; grades into underlying unit	308.0	9.0
Shale, grayish-black to black, brittle, noncalcareous; contains lens-shaped phosphatic nodules; includes sparse, partially pyritized cephalopods and rare brachiopod shells and shell fragments (Nuyaka Creek Black Shale Bed)	317.0	3.9
Shale, dark-gray to grayish-black, calcareous, slickensided, pyritic and carbonaceous in lower 1 in. of unit	320.9	0.5
Coal, black, slightly friable; includes white veinlets of gypsum; contains minor pyrite (Dawson coal)	321.4	0.5

	Depth to top of unit (ft)	Thickness of unit (ft)
Shale, brownish-black, very carbonaceous; includes thin stringers of coal	321.9	0.2
Underclay, medium-gray, soft; kaolinitic; contains carbonized plant fragments	322.1	0.9
Sandstone, light-gray, with medium-dark-gray and brownish-black streaks; bedding disturbed and indistinct; noncalcareous, fractured, fine- to very fine-grained; contains some oil stains	323.0	2.0
Total depth		325.0

CH 3

SW¼NE¼NE¼NE¼SE¼ sec. 1, T15N, R11E, Okmulgee County. Drill hole cored by Oklahoma Geological Survey; lithologic descriptions by LeRoy A. Hemish. Surface elevation, estimated from topographic map, 781 ft.

	Depth to top of unit (ft)	Thickness of unit (ft)
Silt, grayish-brown to dark-yellowish-brown, coarse; contains some very fine sand grains and organic material (soil)	0.0	4.0
Silt, pale-yellowish-brown, clayey	4.0	2.0
Clay, yellowish-gray, silty	6.0	2.5
Skiatook Group		
Coffeyville Formation		
Shale, yellowish-gray, with dark-yellowish-orange mottling, weathered, soft	8.5	1.5
Shale, olive-gray, with dark-yellowish-orange mottling and streaks, partly weathered, soft; includes several layers of moderate-reddish-brown clay-ironstone 0.5–1 in. thick; jointed, with limonite deposits along fracture surfaces	10.0	21.0
Shale, medium-bluish-gray, jointed; moderate-yellowish-brown limonite deposits on fracture surfaces	31.0	8.6
Shale, medium-bluish-gray to medium-gray, highly calcareous	39.6	13.4
Checkerboard Limestone		
Limestone, medium-dark-gray and brownish-gray, hard, vuggy, fractured, shaly in upper 4 in., highly fossiliferous (brachiopods predominant)	53.0	3.5
Seminole Formation		
Shale, dark-gray, highly silty, noncalcareous	56.5	3.7
Siltstone, dark-gray, with light-gray banding, shaly; interstratified with shale and very fine-grained sandstone, cross-bedded and cross-laminated in part, contains several 0.25- to 1-in.-thick layers of brownish-gray, calcareous siltstone, spaced at irregular intervals; includes black, macerated plant debris on stratification surfaces of sandstone layers	60.2	21.6

Shale, medium-gray	81.8	0.4
Shale, brownish-black, very carbonaceous; contains abundant thin stringers of bright, hard coal from as much as 0.1 in. thick (Tulsa coal)	82.2	0.7
Coal, black, bright, hard (Tulsa coal)	82.9	0.2
Marmaton Group		
Holdenville Formation		
Underclay, grayish-black, carbonaceous, slickensided	83.1	0.1
Underclay, greenish-gray, noncalcareous	83.2	0.6
Limestone, light-olive-gray to greenish-gray, sandy, fossiliferous; brachiopods abundant in lower part; bioturbated in upper part	83.8	0.5
Shale, greenish-gray in upper 6 in.; medium-gray in lower part, calcareous	84.3	2.7
Shale, dark-gray, calcareous	87.0	14.0
Shale, dark-gray, with light-gray streaks and spots, silty, calcareous; contains abundant very thin streaks and lenses of very fine-grained sandstone; contains numerous round sandstone-filled burrows about 1/16 in. in diameter, and lens-shaped burrows ~0.75 in. long and 0.25 in. thick; grades unto underlying unit	101.0	11.0
Shale, dark-gray, with light-gray laminae and spots, silty, sandy; as above, but with thin sandstone layers and streaks more closely spaced (4 to 8 per inch)	112.0	21.0
Shale, dark-gray, with light-gray streaks and spots, weakly calcareous; includes minor bioturbation traces and thin streaks of very fine-grained sandstone which become less common downward; cut by vertical veinlets of white calcite	133.0	4.0
Shale, dark-gray, weakly calcareous; cut by vertical veinlets of white calcite	137.0	3.0
Shale, grayish-black, hard; cut by vertical veins of white calcite; contains sparse fossil shells in bottom 1 ft of unit; noncalcareous (Nuyaka Creek Black Shale Bed)	140.0	5.8
Shale, dark-gray, noncalcareous, carbonaceous in bottom 0.5 in.	145.8	3.7
Coal, black, hard; white calcite on cleat surfaces (Dawson coal)	149.5	0.7
Shale, medium-gray, soft, flaky; contains abundant compressed, carbonized plant fragments	150.2	3.0
Shale, light-greenish-gray, noncalcareous	153.2	1.6
Sandstone, light-gray, with some medium-gray streaks in upper part; very fine-grained and silty in upper part, becoming very fine- to fine-grained in lower 18 in.; wavy-bedded and cross-bedded in upper part, massive in lower part	154.8	2.2
Total depth		157.0

Appendix 2

Measured Sections

MS 1

SE¼NE¼SE¼SE¼ sec. 4, T12N, R10E, Okfuskee County, Oklahoma. Measured in cutbank of tributary of Nuyaka Creek, by LeRoy A. Hemish. Elevation at top of section, estimated from topographic map, 730 ft.

	Thickness (ft)
Silt, brownish-gray, sandy; contains abundant organic material	0.8
Clay, pale-yellowish-brown with dark-yellowish-orange mottling, silty; includes scattered gravel clasts in lower 1 ft	4.8
Gravel, grayish-orange, clayey; clasts range up to pebble size and are predominantly very fine-grained sandstone; indistinctly imbricated	0.4
Skiatook Group	
Seminole Formation	
Clay, light-gray and dark-yellowish-orange, plastic	0.1
Coal, black, soft, smutty, weathered; about 0.5 in. thick (Tulsa coal)	0.1
Underclay, medium-light-gray and dark-yellowish-orange, sticky, gypsiferous; includes a 1/16-in.-thick stringer of coal smut at base of unit (Tulsa coal)	0.6
Underclay, medium-light-gray to light-olive-gray, with dark-yellowish orange mottling; sticky, carbonaceous in part	0.5
Coal, black, soft, smutty, weathered, ~0.75 in. thick (Tulsa coal)	0.1
Marmaton Group	
Holdenville Formation	
Underclay, medium-light-gray to light-olive-gray, with dark-yellowish-orange mottling; contains black carbonaceous material; gypsiferous	1.0
Shale, light-olive-gray, noncalcareous	2.0
Siltstone, light-olive-gray to light-greenish-gray, highly calcareous; crops out ~30 ft downstream	1.6
Total	12.0

MS 2

NW¼SW¼SW¼SW¼ sec. 11, T13N, R10E, Okfuskee County, Oklahoma. Measured in road cut on east side of gravel road, by LeRoy A. Hemish. Elevation at top of section, estimated from topographic map, 762 ft.

	Thickness (ft)
Silt, grayish-orange, sandy, clayey; contains organic material	1.0
Skiatook Group	
Coffeyville Formation	
Sandstone, moderate-reddish-brown, very fine-grained, noncalcareous, well-indurated, extremely fossiliferous; well-preserved brachiopods abundant; weathers to a pitted, irregular surface	0.3
Shale, moderate-yellowish-brown; fracture blocky; contains numerous stringers and nodules of moderate-reddish-brown and dark-yellowish-orange ironstone; noncalcareous; olive-gray where unweathered	8.7

Limestone, light-brownish-gray, impure, sandy, hard; includes abundant trace fossils, which occur primarily as sole markings; upper and lower contacts sharp (DeNay[?] Limestone Member)	0.1
Shale, olive-gray with dark-yellowish-orange staining, noncalcareous, blocky fracture	1.9
Total	12.0

MS 3

W½SW¼SE¼SW¼ sec. 27, T13N, R10E, Okfuskee County, Oklahoma. Measured in ditch adjacent to trail running north from section-line road, by LeRoy A. Hemish. Elevation at top of section, estimated from topographic map, 870 ft.

	Thickness (ft)
Skiatook Group	
Coffeyville Formation	
Sandstone, moderate-reddish-brown to grayish-orange, very fine-grained, noncalcareous, cross-laminated, medium-bedded, bioturbated, well-indurated	5.0
Shale, dark-yellowish-brown to olive-gray, with dark-yellowish-orange mottling, poorly exposed	22.0
Sandstone, dark-reddish-brown, dark-yellowish-orange on fresh surface, very fine-grained, cross-bedded, noncalcareous, fossiliferous; brachiopods abundant; trace fossils common on bed sole	0.8
Shale, olive-gray to medium-gray, with dark-yellowish-orange mottling, weathered; includes dark-yellowish-orange ironstone concretions	9.2
Limestone, pale-yellowish-brown, impure, sandy, hard, medium-bedded; extremely fossiliferous in upper 10 in.; brachiopods and shell fragments abundant; becomes extremely sandy downward and changes to pale-yellowish-orange; large brachiopod casts and burrows common in lower lower part of this interval; lower contact sharp (DeNay[?] Limestone Member)	3.5
Shale, pale-yellowish-brown to moderate-yellowish-brown, noncalcareous, silty; base covered	6.5
Total	47.0

MS 4

SW¼SE¼SE¼SE¼ sec. 27, T13N, R10E, Okfuskee County, Oklahoma. Measured in low bluff on west side of Nuyaka Creek flood plain, by LeRoy A. Hemish. Elevation at top of section, estimated from topographic map, 713 ft.

	Thickness (ft)
Skiatook Group	
Coffeyville Formation	
Limestone, brownish-gray to moderate-yellowish-brown, hard, impure, sandy, fine-grained, very fossiliferous; shell fragments abundant; feels hackly on weathered surface; weathers into large rectangular blocks that slump down face of bluff (DeNay[?] Limestone Member)	3.2

Shale, light-olive-gray with dusky-yellow mottling, very calcareous, clayey; base of unit covered (shale exposed in road along section line)	6.8
Total	10.0

MS 5

S½SE¼ sec. 33, T13N, R10E, and N½NW¼ and N½NW¼NE¼ sec. 3, T12N, R10E, Okfuskee County, Oklahoma. Measured in road ditch from top of hill east to water level in Nuyaka Creek, by LeRoy A. Hemish. Elevation at top of section, estimated from topographic map, 890 ft.

	Thickness (ft)
Skiatook Group	
Coffeyville Formation	
Sandstone, moderate-reddish-brown to grayish-orange, very fine-grained to fine-grained, noncalcareous, bioturbated, medium-bedded	16.0
Shale, olive-gray, with dark-yellowish-orange mottling, noncalcareous, poorly exposed	4.0
Sandstone, pale-yellowish-orange, very fine-grained, noncalcareous, cross-bedded, thin-bedded in part, ripple-marked, bioturbated; contains abundant well-preserved brachiopod molds and casts	5.5
Shale, greenish-gray, with light-brown staining, clayey, noncalcareous in upper part, calcareous and fossiliferous in lower part; brachiopod shells and crinoid ossicles abundant	13.5
Limestone, moderate-yellowish-brown to grayish-red, fine-grained, dense, hard, sandy, fossiliferous; brachiopod shells abundant; cross-bedded in part, bioturbated in lower part; feels hackly on weathered surfaces; fossils concentrated in upper 1 ft (DeNay[?] Limestone Member)	1.7
Shale, light-olive-gray with dark-yellowish-orange mottling, silty, calcareous	12.0
Sandstone, moderate-brown to moderate-reddish-brown, very fine-grained, noncalcareous, cross-bedded, bioturbated, well-indurated	1.2
Shale, greenish-gray, with dark-yellowish-orange streaks, noncalcareous, silty, poorly exposed (base covered)	16.1
Covered (approximate interval)	180.0
Shale, olive-gray to dark-yellowish-gray, with light-brown mottling, calcareous, fossiliferous; includes conulariids, bryozoans, pelecypods, and brachiopods; contains abundant moderate-red to dark-yellowish-orange ironstone concretions that weather to pebble-sized fragments on the outcrop; also contains fossiliferous, discoidal, medium-gray limestone concretions and a thin (0.3-ft), soft, smutty-coal stringer	17.0
Covered (approximate interval)	6.0
Shale, light-olive-gray, extremely calcareous; grades into underlying unit; weathers grayish-orange	0.4
Checkerboard Limestone	
Limestone, grayish-orange, impure; extremely shaly in upper 6 in., fossiliferous; brachiopods abundant; feels hackly on weathered surface	1.6
Seminole Formation	
Shale, grayish-orange, with light-brown mottling, extremely calcareous	0.6
Shale, medium-gray; weathers dark-yellowish-orange; clayey, noncalcareous; contains some black, carbonized plant fragments	1.4

Coal, black, soft, smutty; includes shale partings laterally along the outcrop; coal thicknesses vary from 1 to 2 in. (Tulsa coal)	0.1
Underclay, yellowish-gray, with dark-yellowish-orange bands; locally includes lenses of coal as much as 1 in. thick and 1 ft long	0.5
Coal, black, soft, smutty, weathered; thickness ~0.75 in. (Tulsa coal)	0.1
Marmaton Group	
Holdenville Formation	
Underclay, yellowish-gray, with dark-yellowish-orange streaks; includes abundant limonitic stains	0.7
Shale, medium-gray and light-olive-gray, partly weathered, noncalcareous, fossiliferous; fracture blocky; includes stringers of grayish-orange clay-ironstone concretions as much as 1 in. thick	7.0
Shale, medium-dark-gray, silty, calcareous; weathers olive-gray (to water in creek)	6.6
Total	292.0

MS 6

NW¼NE¼NW¼NW¼ sec. 4, T14N, R11E, Okmulgee County. Measured in cutbank of small tributary stream of Tiger Creek, ~100 ft southwest from bridge, by LeRoy A. Hemish. Elevation at top of section, estimated from topographic map, 700 ft.

	Thickness (ft)
Skiatook Group	
Checkerboard Limestone	
Limestone, yellowish-brown, very highly fossiliferous; fragments of crinoids, horn corals, bryozoans, and brachiopods abundant; limestone weathered, broken, and mixed with dark-brown, silty topsoil	2.0
Seminole Formation	
Shale, light-gray, with orange-brown oxidized bands, clayey; includes numerous thin stringers of light-brown clay-ironstone	2.5
Shale, dark-grayish-brown, silty, carbonaceous	2.0
Coal, black, soft, weathered; locally includes partially coalified and silicified pieces of fossil wood more than 1 ft long and 8 in. in diameter (Tulsa coal)	0.1
Marmaton Group	
Holdenville Formation	
Underclay, light-greenish-gray, weakly calcareous	0.9
Limestone, orange; calcareous clay in part; highly weathered and fragmented; surface of outcrop has a hackly appearance; fossils rare	0.8
Limestone, brown, highly fossiliferous, hard, well-jointed, silty, massive	0.3
Shale, bluish-gray, clayey, highly calcareous; includes 0.5-in.-thick lenses of brown, impure limestone (to water level in stream)	0.4
Total	9.0

MS 7

SW¼SW¼SW¼SW¼ sec. 12, T15N, R11E, Okmulgee County. Measured from the southwest corner of the section northeast to exposure in cutbank of stream directly west of oil well, by LeRoy A. Hemish. Elevation at top of section, estimated from topographic map, 733 ft.

	Thickness (ft)
Skiatook Group	
Checkerboard Limestone	
Limestone, bluish-gray, weathers light-brown; includes abundant marine fossils	1.8
Seminole Formation	
Shale, tan, weathered	0.5
Sandstone, brown, very fine-grained, highly calcareous	0.5
Shale, orange-brown, weathered, silty; olive-brown where less weathered	8.0
Sandstone, light-grayish-brown, highly silty, noncalcareous; weathers tannish-brown; ripple-drift cross-laminated; siltstone in part	3.0
Coal, black, with reddish-brown staining, impure and shaly in upper 3 in. (Tulsa coal)	0.8
Marmaton Group	
Holdenville Formation	
Underclay, very dark-gray; grades downward to light-grayish-green; contains coal streaks and coalified wood fragments	1.0
Marlstone, light-grayish-white; includes scattered brachiopods	0.1
Limestone, reddish-purple, fossiliferous	0.2
Shale, grayish-green (to water level in creek)	0.6
Total	16.5

MS 8

(Principal Reference Section for the Checkerboard Limestone)

NW¼NW¼NE¼SE¼SE¼ sec. 22, T15N, R11E, Okmulgee County. Measured in low bluff on south side of Checkerboard Creek, where stream bends to the east, by LeRoy A. Hemish. Elevation at top of section, estimated from topographic map, 705 ft.

	Thickness (ft)
Sand, silt, and gravel, grayish-brown, with moderate-yellowish-brown mottling, poorly sorted, contains organic material; unit consists of an admixture of alluvial materials directly overlying the weathered surface of the Checkerboard Limestone	3.5
Skiatook Group	
Checkerboard Limestone	
Limestone, grayish-orange to moderate-yellowish-brown, hard, dense, fine-grained, massive, well-jointed, very fossiliferous; contains abundant crinoid columnals, brachiopods, and lesser numbers of echinoid spines, as well as other marine fauna	2.2
Seminole Formation	
Shale, yellowish-gray, silty, micaceous, noncalcareous, soft, flaky; contains discontinuous layers of dark-yellowish-orange clay-ironstone concretions as much as 1.5 in. thick; grades downward into light-olive-gray to medium-gray shale	12.0

Coal, black, soft, weathered; includes a light-medium-gray, 0.5-in. shale parting in middle of unit (Tulsa coal)	0.2
Marmaton Group	
Holdenville Formation	
Underclay, medium-light-gray to dark-greenish-gray, with dark-yellowish-orange mottling; contains black, carbonized plant material	0.6
Shale, greenish-gray, with moderate-reddish-brown mottling, clayey, noncalcareous; contains small flecks and streaks of black, carbonized plant material; fracture blocky (to water level in Checkerboard Creek)	0.5
Total	19.0

MS 9

W½NE¼NE¼ and NW¼SE¼NE¼ sec. 23, T15N, R11E, Okmulgee County. Measured from road cut southeast to base of bluff on west side of south-flowing tributary of Salt Creek, by LeRoy A. Hemish. Elevation at top of section, estimated from topographic map, 725 ft.

	Thickness (ft)
Skiatook Group	
Checkerboard Limestone	
Limestone, medium-gray; weathers moderate-brown; extremely fossiliferous; brachiopod shells and crinoid columnals abundant; fine-grained, dense, massive	2.0
Seminole Formation	
Covered (approximate interval)	10.0
Marmaton Group	
Holdenville Formation	
Covered (approximate interval)	46.0
Siltstone, light-gray, sandy; weathers light-yellowish-gray; extremely calcareous, fossiliferous; occurs as thin, weathered flakes in weathered, soft, light-brown shale	2.0
Shale, grayish-brown, clayey, weathered; includes bands of dark-yellowish-orange, limonitic clay	6.0
Shale, grayish-black, fissile; contains phosphatic nodules; weathers grayish-brown (Nuyaka Creek Black Shale Bed)	6.0
Limestone, light-brownish-gray; weathers light-yellowish-gray; occurs as discontinuous layer of roughly spheroidal septaria as much as 1 ft in diameter	0.3
Shale, brownish-gray, noncalcareous	1.7
Shale, dark-gray, with dark-yellowish-orange streaks, noncalcareous	0.3
Coal, black, with moderate-reddish-brown iron-oxide staining on cleat surfaces, soft, very friable (Dawson coal)	0.8
Underclay, light-gray with dark-yellowish-orange streaks	1.0
Shale, light-brownish-gray, noncalcareous	5.0
Sandstone, moderate-reddish-brown, very fine-grained, noncalcareous; total thickness not known; well-exposed downstream along creek	1.9
Total	83.0

OGS HOSTS OUACHITA MOUNTAINS COGEOMAP WORKSHOP

Neil H. Suneson[1]

From April 1 to 4, 1987, the Oklahoma Geological Survey hosted a Ouachita Mountains COGEOMAP Workshop and conducted a related field trip. OGS Associate Director Kenneth S. Johnson organized the workshop that included geologists from the OGS, the Arkansas Geological Commission, and the U.S. Geological Survey. Discussions focused on the accomplishments of the agencies over the past two years and plans for the future. Following the workshop, Neil Suneson and Charles Ferguson of the Oklahoma Survey led a field trip to examine some of the geology of the Ouachita Mountains near Hartshorne and Wilburton, Oklahoma.

The Ouachita Mountains in Oklahoma and Arkansas are the target of the COGEOMAP effort because they are one of the least understood of the major tectonic provinces in the central part of the United States. The geologic and tectonic history of the Ouachitas is not well understood, the stratigraphic and biostratigraphic relationships of the sparsely fossiliferous rock units are not well established, and the amount of compiled and released geophysical data on the region is inadequate for proper geologic interpretations. Since initiating the COGEOMAP program, the state survey geologists have established a data base for the mapping portion of the project, mapped large parts of the Arkansas Ouachitas, and started detailed geologic mapping in the frontal belt of the Oklahoma Ouachita Mountains. Plans call for continuing several aspects of the project and accelerating the mapping phase of the work.

The purposes and social benefits of the Ouachita COGEOMAP program are multiple. The Ouachita Mountains produce moderate amounts of oil and gas and are an active exploration target, albeit at levels reduced from those of several years ago. Some industry geologists consider parts of the Ouachitas to be the largest untested anticlinal structure in the continental United States. Many metallic and nonmetallic minerals are known to be present in the region. Certain thick shale beds are prone to landslides that are a significant hazard to highway maintenance and other development. The quality and quantity of ground-water supplies are largely dependent on the subsurface geology and are highly variable throughout the region. The academic contributions are also great. Understanding the geologic and tectonic history of the Ouachitas would help greatly in unraveling the evolution of basins and the history of plate tectonics along the southern edge of the North American craton.

[1]Oklahoma Geological Survey.

At the meeting, Neil Suneson, stratigrapher with the OGS, summarized the results of the first year of detailed mapping in the frontal belt. The Higgins and Damon 7.5′ Quadrangles and the southern part of the Wilburton 7.5′ Quadrangle are nearing completion at a scale of 1:24,000. This part of the frontal belt is being mapped first because of industry interest along the northern part of the mountains, and because the area has not been mapped in detail since 1926. Charles Ferguson, field geologist with the OGS, described the significance of two geographically distinct populations of over 270 measured paleocurrent azimuths in the Atoka Formation.

Robert O. Fay, OGS geologist, has compiled a comprehensive bibliography on Arkansas and Oklahoma Ouachita geology. To date, about 800 papers have been indexed and cross-indexed into 41 major subjects. Fay estimates that another 2,000 papers have to be read and entered into the files. Fay is working with Michelle Summers, OGS geological data coordinator, who is computerizing the bibliography. Summers stated that the Ouachita bibliography file currently contains 244 Arkansas records and 733 Oklahoma records (record being the annotated citation for one published article or book that can be searched using keywords). Ken Luza, OGS engineering geologist, summarized his compilation of existing geologic maps of the Oklahoma Ouachita Mountains.

Margaret Burchfield, petroleum geologist with the OGS, reported that the computerized oil-and-gas well file currently contains 3,654 records on individual wells; the "fringe area" (Arkoma basin) is complete, and one-half to two-thirds of the "core area" is complete. Major sources of information for the well file are Oklahoma Corporation Commission 1002A completion records; scout tickets; electric logs; various libraries containing sample logs, cores, or cuttings; and official descriptions of oil and gas fields. Michelle Summers described some of the information contained in the well file: API well number, drill stem and initial production test, formation depths and tops, perforations, samples, cores, well-log identifiers, and API gravity.

Jim Chaplin, OGS geologist, described his work in reviewing biostratigraphic and chronostratigraphic studies in the Oklahoma Ouachita Mountains. He critically reviewed 450 references for age assignments of rock units and biostratigraphically defined chronostratigraphic units. Chaplin compiled about 60 pages of tabulated biostratigraphic data, including worker(s), reference date, locality, stratigraphic position, age-assignment criteria, worker responsible for identifications, and proposed age of the unit. He also compiled a table of chronostratigraphic data including worker(s), reference date, unit rank, type area or locality, type section, condition of main reference section, original definition, redefinition, lithology, thickness, stratigraphic position, correlation/age, and special problems. This work will be published shortly.

Brian Cardott, OGS organic petrologist, has collected 43 shale samples throughout the Oklahoma Ouachita Mountains for evaluation of hydrocarbon source-rock potential and vitrinite-reflectance studies. To date, he has R_0 values for 12 samples, 23 samples are crushed and being digested in acid, and the remainder are awaiting crushing. Jane Weber, organic chemist with the OGS, has collected 54 shale samples to determine amount, type, and maturity level of contained organic matter. She has determined total organic carbon and bitumen for 15 of these samples, and gas chromatograms of the saturate fraction of the bitumen have provided information indicating the type and maturity level of the organic matter. Jock Campbell and Dorothy Smith, OGS petroleum geologists, reported on their subsurface studies of the buried Ouachita Mountains south of the Cretaceous overlap. Cretaceous isochore, base of Cretaceous structure, and a pre-Cretaceous subcrop and major-structural-features maps are complete for Bryan County and half of Choctaw County. A map of photo-geomorphic anomalies is complete for the west half of Bryan County. Radar imagery (SLAR) has been acquired for the northern half of the area, and efforts are being made to acquire Landsat imagery. Nearly 3,000 mi^2 of southeastern Oklahoma will be mapped using a variety of remote-sensing techniques.

Assistant State Geologist Bill Bush, of the Arkansas Geological Commission, and Charles Stone and Boyd Haley, AGC geologists, presented the results of their work in the Arkansas Ouachitas. The first phase of their work was to develop a data base of existing information, which included establishing an annotated bibliography, an index to geologic mapping and field studies, a catalog of oil and gas wells, and a preliminary report on chronostratigraphy. This information is being maintained as open-file material and is available for public inspection.

The second phase of the Arkansas program consists of office compilation of existing geologic maps and aerial photographic work, field checking and amending the maps and photo-interpretations, and preparing the resulting geologic maps for open-file reports and reduction to 1:250,000. To date, 17 7.5′ quadrangles are ready for final drafting, and 67 quadrangles are ready for field checking. In addition to the mapping, rock samples from six core holes (two drilled by the AGC) have been analyzed for 31 elements by the USGS and published by the AGC. Additional rock samples from AGC core holes or those donated by industry will be submitted for analysis.

Following the Arkansas presentation, John Nichols, minerals manager for the Ouachita National Forest, U.S. Forest Service, Hot Springs, described how the Forest Service might be able to help in field investigations on lands administered by the federal government.

Dave Miller, COGEOMAP coordinator for the U.S. Geological Survey, described the history of USGS funding for the Oklahoma–Arkansas COGEOMAP effort. Cash awards plus in-kind services totaled $125,000 in fiscal year 1985, $190,000 in 1986, and $118,000 in 1987. He said that initiatives have been submitted to the Department of the Interior for additional funding in support of mapping and directly related programs. Jonathan Matti, who may succeed Miller as USGS COGEOMAP coordinator, spoke about future funding possibilities and projects associated with geologic mapping. He said that a National Geologic Mapping Program, new in October 1987, will incorporate federal mapping, COGEOMAP, map modernization, and external grants to universities and industry. Following discussions covering past, present, and future directions of federal involvement in COGEOMAP, USGS contributions to the project were discussed; these include compilation of existing aeromagnetic data at 1-mi spacing in Arkansas and 60-mi spacing in Oklahoma, reprocessing COCORP seismic data, and Anadarko basin source-rocks studies. Other USGS investigators present at the workshop also described their work.

John Repetski, USGS paleontologist at the National Museum in Washington, reported on his conodont color-alteration-index work in the Arbuckle and Ouachita Mountains and Anadarko basin. With Chaplin, he has been searching for internal USGS service reports and re-evaluating old USGS collections. Bill Perry, with the USGS Branch of Petroleum Geology in Denver, has worked extensively on the structural geology of the Arbuckle Mountains, particularly within the Turner Falls 7.5′ Quadrangle. He is attempting to tie the sequential deformation of the Arbuckle foreland to events within the Ouachita thrust belt. Bob Kosanke, palynologist with the USGS in Denver, has analyzed nine samples from the Higgins 7.5′ Quadrangle for palynomorphs; four samples were productive and two of those were very productive. Kosanke collected additional shale samples during a three-day field trip after the meeting, with the goal of providing correlation lines that may prove useful in the field mapping.

Following the meeting, Neil Suneson and Charles Ferguson of the OGS led a three-day field trip to examine in detail the frontal-belt geology in the Higgins and Damon 7.5′ Quadrangles and to obtain a larger-scale picture of the Ouachitas in the Talihina and Wilburton areas. Three stops provided an overview of the leading edge of the Choctaw fault, closer examination of the oldest units that are present along the base of the Choctaw thrust sheet (Springer, Wapanucka, Spiro), and some unusual WSW to ENE paleocurrent indicators in the basal part of the Atoka Formation in the Choctaw sheet. Later field-trip stops included a "Johns Valley-looking" olistostrome within the Atoka north of the Ti Valley fault, some classic turbidite structures in the lower Atoka Formation immediately south of the Ti Valley fault, the Exxon Retherford No. 1 well site and Spiro-equivalent(?) sandstone, and some cephalopod-bearing limestone and calcareous shale within the Atoka. A large chert block within the Atoka was visited, and discussion focused on whether this represented an olistostrome or a thrust slice. Features representing soft-sediment and tectonic deformation were observed in an outcrop of mesoscopic, N-verging folds on the south limb of a major anticline in the Atoka Formation. The contact between the Atoka and Johns Valley Formations was examined at two places along Highway 2 south of Wilburton.

Later observations provided some of the participants who had never been to the Oklahoma Ouachitas a glimpse of some of the larger-scale geology: quarried slabs of Wildhorse Mountain Formation (Jackfork Group) with excellent sole marks and trace fossils at the Buffalo Valley school; outcrops of Arkansas Novaculite and Bigfork Chert in the Potato Hills; an excellent outcrop of Stanley Formation at the spillway of Lake Carl Albert near Talihina; and severely deformed Atoka Formation along Highway 82 south of Red Oak.

OGS COAL GROUP PARTICIPATES IN ANNUAL FORUM OF WESTERN INTERIOR COAL BASIN GEOLOGISTS

Samuel A. Friedman[1]

Eighteen staff members of five state geological surveys and the U.S. Geological Survey participated in the 11th Annual Forum of Western Interior Coal Basin Geologists held at Columbia, Missouri, May 5–6, 1987.

Joy L. Bostic, geologist in charge of coal-resources studies at the Missouri Division of Geology and Land Survey (MDGLS), coordinated the meeting and presided.

James H. Williams, the new director and state geologist of the MDGLS, opened the meeting by welcoming the forum participants from Oklahoma, Iowa, Kansas, Arkansas, Missouri, and (Reston) Virginia.

Speakers at the first session addressed coal mining and production in each state for 1986. Bostic said that 13 surface coal mines produced 4.5 million tons of coal averaging 4.3% sulfur in nine counties in southwestern and north-central Missouri. The majority of the 24 million tons of coal consumed in the state was shipped from Illinois for use in electric-power generation. Some coal from northeastern Oklahoma was shipped to the City of Springfield (Missouri) Public Utilities.

Lawrence L. Brady, chief of geologic investigations at the Kansas Geological Survey, reported that five strip mines in four counties in southeastern Kansas produced 1.5 million tons of high-sulfur coal in 1986, 50% more than in 1985. About 66% of this production was from the Mulberry coal. Of the 14 million tons of coal consumed in the state in 1986, 85% was shipped by unit train from Wyoming.

Mary Howes, coal geologist at the Iowa Geological Survey, reported that 499,566 tons of coal was produced at six surface mines and one drift mine in Iowa in 1986. The Whitebreast coal, which is believed to be correlative with the (Desmoinesian) Croweburg coal of Kansas, Missouri, and Oklahoma, was the only coal mined that contains <2% sulfur, although most of the coal mined contained 2.2–9.5% sulfur. Approximately two-thirds of Iowa's total coal consumption of 12 million tons was shipped from Wyoming.

William V. Bush, geologist at the Arkansas Geological Commission, reported that small quantities of low-volatile bituminous coal was produced at six surface mines, mostly for activated-charcoal and chemical uses. Also, Arkansas became the second state to require the use of some local coal by its electric-power generating plants.

Samuel A. Friedman, OGS senior coal geologist, citing data from the Oklahoma Department of Mines, said that in 1986 25 strip mines and one drift mine produced 3 million tons of bituminous coal in eight counties in eastern Oklahoma. This was the smallest coal production in 11 years. Although most of this production

[1]Oklahoma Geological Survey.

was shipped to out-of-state electric-power plants and cement and lime kilns, about 600,000 tons was consumed in Oklahoma's cement, lime, other industrial, and electric-power plants. Of the total coal production, 31.9% was from the high-sulfur Iron Post coal, 25.5% from the low-sulfur Croweburg coal, 21.7% from low- to high-sulfur Hartshorne coals, 15.5% from the low- to high-sulfur McAlester and Stigler coals, and 5.5% from the medium-sulfur Secor coal.

Research projects were briefly summarized in the second session of the coal forum. Bob Clark presented a summary of the activities of the Mined Land Reclamation Commission of Missouri, which he directs. This agency also supervises reclamation of abandoned mined land. A project to record and map mined-land subsidence, coal-mine drainage, and open shafts was explained by Mimi Garstang of the Missouri Geological Survey.

A mined-lands inventory in Iowa was described by Mary Howes, who directed the project that located and plotted 850 sites on 1,500 maps and completed a revised map showing abandoned underground mines in the area of Des Moines, Iowa. Howes also noted that coal resources were determined in two Iowa counties on 12 7.5′ quadrangle maps by use of a digitizer.

Brady reported that subsurface research in Kansas resulted in a discovery of thin coals overlying the Cherokee sequence in the eastern part of the Sedgwick basin. Geologist Mike Staton's research based on geophysical logs and a computer entry system showed lithofacies variations in the Cherokee basin. He concluded that stratigraphic sequences above the Mineral coal extend westward across the Cherokee basin, but lower beds lap onto the Nemaha ridge. Staton also digitized maps to recalculate coal resources in the Kansas coalfield.

Bush reported that a 10-year, $1 million study of Arkansas lignite deposits resulted in a series of publications showing driller's and geophysical logs, some of which were encoded in the National Coal Resource Data System (NCRDS) of the U.S. Geological Survey. The lignite resources are in the Claiborne and Wilcox Groups of Tertiary age.

Bostic and Larry Nuelle reported that coal-resource studies were progressing in Howard, Randolph, and Boone Counties, Missouri, and in the Joplin 1 × 2° topographic quadrangle map area, from which coal data were encoded in the federal NCRDS.

Friedman noted that trace-element and coal-resource data from two of his research projects were provided to a major Virginia-based industrial corporation that plans to construct a 300-MW fluidized-bed-combustion, cogeneration electric-power plant in economically depressed Le Flore County, Oklahoma. In undifferentiated Oklahoma coal resources, whole-coal analyses show fluorine at 80.3 ppm, beryllium at 1.4 ppm, lead at 19.1 ppm, and mercury at 0.2 ppm.

LeRoy A. Hemish, coal geologist at the Oklahoma Geological Survey, distributed his first in a planned series of publications of Oklahoma's coal resources, *Coal Geology of Craig County and Eastern Nowata County, Oklahoma* (Oklahoma Geological Survey Bulletin 140), complete with colored maps, stratigraphic sections, tables, and chemical analyses. Hemish also presented an illustrated talk on Upper Pennsylvanian lithostratigraphy, stressing the Checkerboard Limestone.

Brian J. Cardott, organic petrologist at the Oklahoma Geological Survey, presented his latest petrographic data on the Checkerboard, Tulsa, and Cedar Bluff coals of northeastern Oklahoma, and he distributed L. R. Wilson's palynological bibliography for use in Pennsylvanian correlation studies.

Michelle Summers, OGS data coordinator, summarized the Oklahoma input into the NCRDS. The analytical and stratigraphic files consisting of 1,200 records have been encoded.

M. D. (Debbie) Carter, geologist with the USGS Coal Branch, reported that the NCRDS program will contain more funds for cooperative state programs. The Coal Branch has been reorganized to stress and tie in with coal chemistry, characterization, and geochemistry of coal resources.

On the second day of the meeting Bostic, assisted by Nuelle and David Smith of the Missouri Geological Survey, led the 18 participants to examine the geology and coal mining at two active strip mines about 30 mi northwest of Columbia, Missouri. Along the route, a stop was made at a large roadcut to permit us to examine an excellent exposure of the Burlington–Keokuk Limestone, overlain by the Cheltenham Clay, in turn overlain by a clastic sequence that includes the Croweburg coal; thus, the Mississippian–Pennsylvanian boundary was well exposed.

The participants welcomed the invitation from Mary Howes to convene in Iowa next May.

Samuel A. Friedman examining siderite nodules in a medium-gray mudstone overlying Bevier–Wheeler coal at strip mine near Moberly, Missouri.

EARTHQUAKE FAULT IN SW OKLAHOMA DESCRIBED

Investigation of the Meers Fault, Southwestern Oklahoma is the title of Special Publication 87-1, recently published by the Oklahoma Geological Survey.

Recent mapping in southwestern Oklahoma has shown that the Meers fault offsets Quaternary alluvium. The scarp in youthful deposits indicates that movement on the fault may have produced large earthquakes in the geologically recent past, and it may be capable of producing earthquakes in the future.

According to the authors, Kenneth V. Luza of the OGS and Richard F. Madole and Anthony J. Crone of the USGS, the presence of a possible major seismogenic fault in southwestern Oklahoma raises serious questions about the presumed tectonic stability and the potential for damaging earthquakes in the entire southern Midcontinent. Assessing the earthquake threat posed by the Meers fault requires an understanding of the characteristics and history of recent displacements that have created the scarp. Toward that end, a general study of Quaternary deposits in the vicinity of the fault was made, trenches were excavated across the scarp to reveal stratigraphic and structural relationships, and detailed seismic monitoring of possible microearthquakes along the fault was undertaken.

No microearthquakes definitely associated with the fault have been detected over a span of two years, and more-general data from a preexisting statewide seismic network indicate that the Meers fault has been essentially aseismic for at least the last 25 years. Furthermore, judging from general historical records, it is likely that no earthquakes exceeding magnitude 4 on the Richter scale have occurred since Fort Sill was established 116 years ago.

Authors' abstract:

The Meers fault is part of a major system of NW-trending faults that form the boundary between the Wichita Mountains and the Anadarko basin in southwestern Oklahoma. A portion of the Meers fault is exposed at the surface in northern Comanche County and strikes approximately N. 60° W. where it offsets Permian conglomerate and shale for at least 26 km. The scarp on the fault is consistently down to the south, with a maximum relief of 5 m near the center of the fault trace.

Quaternary stratigraphic relationships and 10 ^{14}C age dates constrain the age of the last movement of the Meers fault. The last movement postdates the Browns Creek Alluvium, late Pleistocene to early Holocene, and predates the East Cache Alluvium, 100–800 yr B.P. Fan alluvium, produced by the last fault movement, buried a soil that dates between 1,400 and 1,100 yr B.P.

Two trenches excavated across the scarp near Canyon Creek document the near-surface deformation and provide some general information on recurrence. Trench 1 was excavated in the lower Holocene part of the Browns Creek Alluvium, and trench 2 was excavated in unnamed gravels thought to be upper Pleistocene. Flexing and warping was the dominant mode of deformation that produced the scarp. The stratigraphy in both trenches indicates one surface-faulting event, which implies a lengthy recurrence interval for surface faulting on this part of the fault. Organic-rich material from two samples that postdate the last fault movement yielded ^{14}C ages between 1,600 and 1,300 yr B.P. These dates are in excellent agreement with the dates obtained from soils buried by the fault-related fan alluvium.

SP 87-1 can be purchased over the counter or postpaid from the Oklahoma Geological Survey at the address given inside the front cover of this issue. The price is $4.

PHOENIX

GSA ANNUAL MEETING • PHOENIX, ARIZONA • OCTOBER 26–29, 1987

GSA's first visit to Phoenix will be well remembered. Arizona has an abundance of popular geologic destinations, so when the location is put together with an offering of 34 field trips, which will explore the southern Colorado Plateau and Basin and Range, this is shaping up as one of GSA's largest and most unusual meetings.

Twenty-seven symposia will address topics from the geology of human origins and cultural evolution to the geology in China. Eight new short courses sponsored by the Society include contaminant hydrogeology, paleoseismology and active tectonics, planetary geology and remote sensing, and site characterization for high-level nuclear waste disposal.

The 200-booth technical geosciences exhibit will include the newest and finest in computer hardware and software, spectroscopes, microanalysis equipment, X-ray diffraction, cameras, maps, publications, and field supplies. The Society will offer its popular employment service, which is open to both employers and job seekers.

Using Phoenix as a gateway, visitors can reach impressive natural wonders and unusual cultures that excel in their beauty, scale, and emotional impact. Arizona's boundaries encompass the Grand Canyon, Lake Powell, San Francisco Peaks, Indian reservations, the southwestern art community of Sedona, Oak Creek Canyon, Monument Valley, Canyon de Chelly, the Petrified Forest and Painted Desert, mining towns such as Prescott, the Mogollon Rim, Saguaro National Monument, and Arizona–Sonora Desert Museum. If at all possible, plan to extend your visit through a weekend. This really is a grand opportunity at an exquisite time of year.

—GSA

GSA Annual Meeting Agenda

Symposia

Geology of Human Origins and Cultural Evolution
Predicting Coal Quality by Means of Basin Analysis, Geophysical Data, and Geochemical Techniques
Neotectonics in Earthquake Evaluation
California–Arizona Crustal Transect: Detachment Terrane to Colorado Plateau
History of Studies of Arid Lands: Ancient and Modern
Geochemical Reactions and Related Physical Processes Associated with Organic Compounds in Ground Water
Global Change: A Geological Perspective on Earth-System Science
Tectonic versus Eustatic Effects on Cretaceous Sedimentation of the Western Interior of North America

Structure and Tectonics of Accretionary Prisms
Paleoceanography and Paleontology of the Gulf of California
Cenozoic Potassium-Rich Igneous Rocks of the Colorado Plateau and Surrounding Regions
Collections for the Future: Archivists, Curators, Historians, Bibliographers Speak
Synchrotron Radiation Research in Geological Sciences
Time, Life, and the Rock Record: New Implications for Teaching
Rates of Evolution in Fossil Lineages
Proterozoic Ores of the Southern Cordillera
Phanerozoic Ore-Bearing Granite Systems: Petrogenesis and Mineralization Processes
Geology and Tectonics of Mexico
The Cordilleran–Caribbean Connection: Mesozoic Geology from the Mojave Desert to the Gulf of Mexico
Sedimentary Facies, Biostratigraphy, and Paleoecology of the Southwestern Margin of the Cretaceous Western Interior Seaway
Tertiary Extensional Tectonics of the Lower Colorado River Region
Early Proterozoic Continental Assembly of Southwestern North America
"Anorogenic" Silicic Magmatism
Inception and Timing of Deformation in the Late Mesozoic and Early Cenozoic Cordilleran Fold-Thrust Belt
Geology in China
Origins of Methane in the Earth
Structure and Evolution of the Rio Grande Rift

Field Trips

Premeeting Trips

Mesozoic Thrust Faults, Tertiary Detachment Faults, and Associated Rocks, Fabrics, and Mineralization, Whipple–Buckskin–Harcuvar Area, Western Arizona and Southeastern California
Terraces of the Lower Salt River Valley in Relation to the Late Cenozoic History of the Phoenix Basin, Arizona
Lower Cretaceous Coral-Algal-Rudist Patch Reefs in Southeastern Arizona
Archaeological Geology of Paleo-Indian Sites in Southeastern Arizona
Paleoecology and Taphonomy of Recent to Pleistocene Intertidal Deposits, Gulf of California
Late Paleozoic Depositional Systems, Sedona–Jerome Area, Central Arizona
Geomorphology and Structure of Colorado Plateau/Basin and Range Transition Zone, Arizona
Tectonic and Magmatic Contrasts Across a Two-Province Proterozoic Boundary in Central Arizona
Colorado River Float Trip to Examine the Geology of Eastern Grand Canyon, Arizona
Late Cenozoic Volcanism in the San Francisco and Mormon Volcanic Fields, Southern Colorado Plateau, Arizona

Geology of the Grand Canyon (backpack)
Miocene Extension, Volcanism, and Sedimentation in the Eastern Basin and Range Province, Southern Nevada
Late Pleistocene Alluvium and Megafauna Dung Deposits of the Central Colorado Plateau
Large-Scale Silicic Volcanism of the Jemez Mountains and Geology of the Adjacent Rio Grande Rift, New Mexico
Cretaceous of Black Mesa and Kaiparowits Basins, Northeastern Arizona and Southeastern Utah
Crustal Transect: Colorado Plateau-Detachment Terrane-Salton Trough
Coal Deposits and Facies Changes Along the Southwestern Margin of the Late Cretaceous Seaway
Selected Hydrogeologic Problems in Central Arizona

Postmeeting Trips

Geology of the Lower Grand Canyon and Upper Lake Mead by Boat—An Overview
A Geologic Reconnaissance into the Western Grand Canyon, Arizona
Metamorphic Core Complexes, Mesozoic Thrusts, and Cenozoic Detachments: Old Woman Mountains–Chemehuevi Mountains Transect, California–Arizona
Alkaline Rocks and Volcanic Structures of the Pinacate Volcanic Field, Sonora
Land Subsidence and Earth Fissure Formation in Eastern Maricopa and Northern Pinal Counties, Arizona
Late Cenozoic Mammal Faunas and Magnetostratigraphy, Southeastern Arizona
Geology of Porphyry Copper Ores in the Globe–Miami District
Ductile to Brittle Evolution of the South Mountains Metamorphic Core Complex
Structural Geology of the Rincon and Pinaleño Metamorphic Core Complexes, Southeastern Arizona
Tectonic Setting and Sedimentological Features of Upper Mesozoic Strata in Southeastern Arizona
Massive Sulfide Ores at Jerome, Arizona
Upper Holocene Alluvium of the Southern Colorado Plateau
Mesquite Mine
Big Maria–McCoy–Mule–Chocolate Mountains Transect
Cross-Bedding and Other Eolian Structures in the Navajo and Entrada Sandstones
Superstition Volcanic Field

Short Courses

Thermodynamic Modeling and Geological Materials: Minerals, Fluids, and Melts, *October 23–25*
Planetary Geology and Remote Sensing: Short Courses and Field Trips, *October 23–25*
Quantitative Sedimentary Basin Modeling, *October 24*
Contaminant Hydrogeology, *October 24–25*
Site Characterization for High-Level Nuclear Waste Disposal, *October 24–25*

Fossil Prokaryotes and Protists, *October 25*
Current Aspects of Basin Analysis and Sedimentary Geology, *October 25*
How to Do History of Geology, *October 25*
Spreadsheets on Microcomputers: Versatile Geological Tools, *October 25*
Paleoseismology and Active Tectonics, *October 29*

For further information about the annual meeting, contact GSA, Meetings Dept., P.O. Box 9140, Boulder, CO 80301; (303) 447-2020. The preregistration deadline is September 25.

UPCOMING MEETINGS

North American Conference on Tectonic Control of Ore Deposits, October 6–9, 1987, Rolla, Missouri. Information: Geza Kisvarsanyi, Dept. of Geology and Geophysics, University of Missouri, Rolla, MO 65401; (314) 341-4663.

AAPG, Eastern Section, Annual Meeting, October 7–10, 1987, Columbus, Ohio. Information: William Rike, P.O. Box 763, Worthington, OH 43085; (614) 888-6745.

32nd Annual Midwest Groundwater Conference, October 28–30, 1987, Madison, Wisconsin. Information: Jim Krohelski, U.S. Geological Survey, 6417 Normandy Lane, Madison, WI 53719-1133; (608) 276-3850.

AAPG, Gulf Coast Section, Annual Meeting, October 28–31, 1987, San Antonio, Texas. Information: Don F. Tobin, 1530 Milam Building, San Antonio, TX 78205; (512) 227-9540.

Petroleum Hydrocarbons and Organic Chemicals in Ground Water: Prevention, Detection, and Restoration—Conference and Exposition, November 4–6, 1987, Houston, Texas. Information: National Water Well Association, 6375 Riverside Dr., Dublin, OH 43017; (614) 761-1711.

Biodegradation Processes: Their Utility in Cleanup of Organic Contaminants in Aquifers and Soils, November 5–6, 1987, San Antonio, Texas. Information: National Water Well Association, 6375 Riverside Dr., Dublin, OH 43017; (614) 761-1711.

SEPM, Gulf Coast Section, 8th Annual Research Conference, "Paleontological Applications in Petroleum Exploration," December 6–9, 1987, Houston, Texas. Information: Charles L. McNulty, Geology Dept., University of Texas at Arlington, UTA Box 19049, Arlington, TX 76019; (817) 273-2979.

American Geophysical Union Fall Meeting, December 7–11, 1987, San Francisco, California. Information: Ann E. Singer, American Geophysical Union, 2000 Florida Ave., N.W., Washington, DC 20009; (202) 462-6903.

AAPG MID-CONTINENT SECTION MEETING
Tulsa, Oklahoma, September 27–29, 1987

On behalf of members and spouses of the Tulsa Geological Society and the Mid-Continent Section of the American Association of Petroleum Geologists, I welcome you to Tulsa, the "Oil Capitol of the World."

From its beginning as a town on the bank of the Arkansas River, in the late 1800's, "Tulsy Town" has grown to become the second largest city in Oklahoma, nineteenth in the nation.

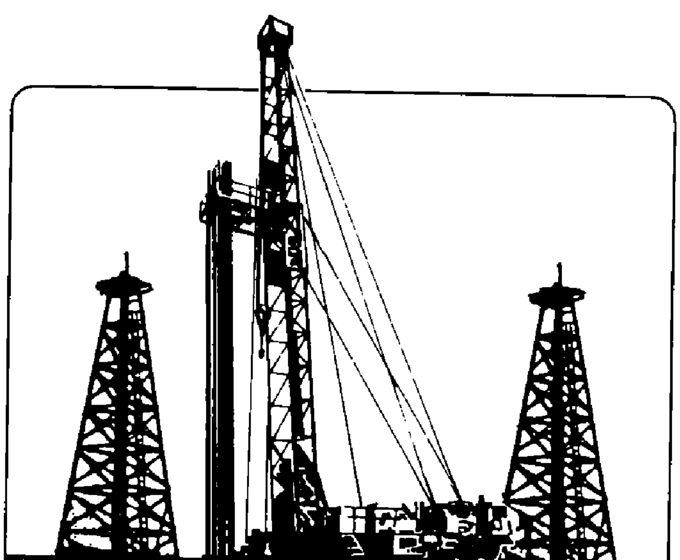
Visitors often comment about the green country atmosphere of enthusiasm prevalent here. Its entrepreneurial spirit is recognized and it is a place where one can come to start a business, or "work a deal."

Our 1987 convention theme is "New Frontiers in Old Areas: Part II." The technical program emphasizes techniques and knowledge to enable us to work smarter, not harder. A variety of papers on Pennsylvanian sandstone reservoirs and a keynote theme dealing with new techniques in enhanced oil recovery focus on two of the objectives in the region. A field trip, poster sessions, two short courses dealing with carbonate reservoirs and prospect generation, and special presentations offer a broad range of learning opportunities.

Our convention hotel is the Excelsior, perhaps the most beautiful in downtown Tulsa. It is located near 7th Street and Houston, just across from the Convention Center, and several blocks from the Williams Center Shopping Forum.

We look forward to seeing you in Tulsa, and in sharing an exciting and rewarding time with you.

—George A. Bole
General Chairman



New Frontiers in Old Areas: Part II
Mid-Continent Section Meeting
September 27-29, 1987 Tulsa, Oklahoma

AAPG Mid-Continent Section Meeting Agenda

Technical Sessions

September 28

New Frontiers in Old Areas: Rediscovering the Resource Base
Future Petroleum Potential of the Mid-Continent
A Personal Computer (PC) as the Heart of a Geological Workstation
Unconformities: The Key to Hydrocarbon Migration and Entrapment
The Idiosyncrasies of the Cherokee Genetic Sequence of Strata, North-Central Oklahoma
Stratigraphy and Depositional Environments of the Cherokee Group (Desmoinesian, Middle Pennsylvanian), Central Cherokee Basin, Southeast Kansas
Depositional Setting and Thin-Section Petrology of the Misener Formation (Devonian) in the NE Nash and Nearby Fields, North-Central Oklahoma
Source Rock Potential of Upper Devonian–Lower Mississippian Formations in Oklahoma and Western Arkansas
Petrographic Constraints on Provenance and Sediment Dispersal Patterns, Atokan Sandstones of the Arkoma Basin, Oklahoma and Arkansas
Hydrocarbons in an Overmature Basin, I. Thermal Maturity of Atoka and Hartshorne Formations, Arkoma Basin, Oklahoma and Arkansas
Hydrocarbons in an Overmature Basin, II. Is There a Thermal Maturity Limit to Methane Production in the Arkoma Basin, Oklahoma and Arkansas?

September 29

Improved Reservoir Productivity Through the Use of Horizontal Drilling
Dispersivity as an Oil Reservoir Rock Characteristic
Prediction of Pressure Depletion from Wire Line and Mud Logs, Golden Trend Field, Garvin County, Oklahoma
Diagenetic Evolution and Petrophysical Characteristics of Oomoldic Facies in U.S. and Middle East Reservoirs
The Red Fork and Lower Skinner Sandstones in the NW Tecumseh Field, Pottawatomie County, Oklahoma
Hunton and Sycamore Reservoirs in the Golden Trend Field, Garvin County, Oklahoma
Enhancement of Prospect Presentations in Difficult Times
Relationship Between Structural Development, Carbonate Reservoir Development, and Basement Faulting in Southern Scott and Northwestern Finney Counties, Kansas
High Resolution Aeromagnetics: A Cost-Effective Reconnaissance Tool for Mature Provinces
Seismic Stratigraphy of a Fracture Reservoir: Case Study of the Albion–Scipio Trend, South-Central Michigan
Seismic Expression of Red Fork Channels in Major and Kay Counties, Oklahoma
Seismic Expression of Upper Morrow Channel Sands, Western Anadarko Basin, Oklahoma

Depositional Model, Dolomitization, and Porosity of the Henryhouse Formation (Silurian), Anadarko Basin, Oklahoma

Depositional Model and Diagenetic History of the Frisco Formation (Lower Devonian) in Central Oklahoma

Correlation and Facies Analysis in Exploration for the Subtle Traps within the Hunton Group, Oklahoma

Short Courses

Defining a Prospect, *September 26*

Exploration Concepts in Carbonate Rocks, *September 27*

Field Trip

Pennsylvanian Sandstone Reservoirs of Northeastern Oklahoma Outcrops, Cores and Well Logs, *September 27*

For further information about the Mid-Continent Section Meeting, contact AAPG, Convention Dept., P.O. Box 979, Tulsa, OK 74101; (918) 584-2555. The preregistration deadline is September 4.

OKLAHOMA CITY GEOLOGICAL SOCIETY ANNOUNCES NEW OFFICERS

Officers in the Oklahoma City Geological Society for the 1987–88 term are:

President, Robert Young, Anadarko Petroleum Corp.
President-Elect, M. Stuart Kirk, Consultant
Vice-President, Robert A. Northcutt, Independent
Secretary, William S. Boyd, Regency Exploration, Inc.
Treasurer, George W. Troutman, Troutman Geological, Inc.
Editor, Jan M. Dodson, Newville Engineering, Inc.
Library Director, G. Phil Spurlin, Consultant
Social Chairman, Kathy Gentry, Consultant
Publicity Chairman, Marcus P. Weinmeister, Independent
Chmn. Delegates to AAPG, Leonard Dionisio, Capitol Exploration
Rep.-at-Large, Mid-Continent AAPG, John Hogan, Celtic Exploration

In Memoriam

ROY D. DAVIS

Retired OGS Cartographer

Roy D. Davis (1924–1987)

Roy Derrell Davis, 62, a cartographer with the Oklahoma Geological Survey from 1954 until his retirement in 1981, died following a long illness on April 26 at his home in Norman. A graveside service was held on April 28 at Chapel Hill Memorial Gardens in Oklahoma City.

Roy is remembered at the OGS not only for the excellence of his pen-and-ink work in the cartographic section, but also for his friendship, his wit, and his wisdom, which were dispensed in daily doses to his fellow employees. After he retired, his visits to the Survey always drew a crowd of friends and well-wishers when his laugh was heard in the hallways.

During Roy's 27 years of continuous service in the cartographic department of the OGS, he was known for the quality of his pen-and-ink work. A true artist with a Leroy lettering set, his speed and accuracy were legendary.

Roy also provided many beautifully detailed pen-and-ink renderings for use in OGS publications. Roy's sense of humor is evident in one illustration that, upon close inspection, reveals many minute faces in the rocks. Like a true master, Roy only did this once, although his name is carefully worked into the bottom of some of his other drawings.

Rather than being a draftsman who began to view his work as art, it was art that led Roy into drafting. Born near Ft. Towson in Choctaw County, his family moved to Valliant, in McCurtain County, when Roy was six. While he was in the seventh grade at Valliant, he promoted establishment of an art class and was later art editor of the high school paper.

After World War II, when Roy served with the U.S. Navy for two years, he worked at Tinker Air Force Base and attended night classes at Oklahoma City University. There he focused his artistic skills on graphics and engineering drawing.

Roy's love of art, geology, and nature came together in a very unique hobby. He was widely known for his reproductions of ancient cave paintings, including samples of Aztec, Toltec, Mixtec, and Egyptian paintings. These were carefully researched and painted on stone, using colors that he prepared from natural pigments that he and many of the OU geologists gathered. These paintings are treasured by friends and private collectors who bought them at the shows and exhibits Roy frequently attended. A large "Library" sign Roy painted on stone hangs at the entrance to the OU School of Geology and Geophysics library in Gould Hall.

For his work, his art, and most of all his friendship, Roy will be missed by many.

Connie Smith

OKLAHOMA ABSTRACTS

The Oklahoma Geological Survey thanks the Geological Society of America and the authors for permission to reprint the following abstracts of interest to Oklahoma geologists.

Washita Valley Fault, Murray County, Oklahoma: Style and Timing of Movement

RANDY COX and ROY VANARSDALE, Department of Geology, University of Arkansas, Fayetteville, AR 72701

Detailed mapping in the vicinity of the westernmost surface exposure of the Washita Valley Fault (WVF) suggests that the structure of the area developed in several stages. Middle Cambrian rifting established a W–NW structural grain in the region. Late Pennsylvanian crustal shortening along a bearing of approximately N 34 E produced folding and thrusting. Through cross-cutting relationships, this folding (parallel to the WVF trend) has been shown to have preceded the development of a strike-slip zone (the present WVF). This early compressional event occurred before the Middle Virgilian age Collings Ranch Conglomerate was deposited in depressions along the later strike-slip fault. The Middle to Late Virgilian convergent left-lateral faulting (transpression) resulted from an eastward shift of the bearing of the greatest principal stress. Subsidiary faulting suggests a greatest principal stress bearing of approximately N 43 E in the early stages of this strike-slip event and a bearing of approximately N 75 E in a later stage.

Modern valley constrictions, alluvium ponding, buried scarps, displaced terraces, and apparent left-stepping deflections in stream courses along the WVF suggest Quaternary down-to-the-south and left-lateral fault motion. In light of similar faulting style of Quaternary age on the en echelon Meers Fault 80 km to the west, the WVF may have potential for strong seismicity.

Reprinted as published in the Geological Society of America South-Central Section *Abstracts with Programs, 1987*, v. 19, no. 3, p. 149.

Tufa/Marl Deposits as Indicators of Neotectonic Activity

CHARLES P. THORNTON, DAVID P. GOLD, Department of Geosciences, The Pennsylvania State University, University Park, PA 16802; and JANET S. HERMAN, Department of Environmental Sciences, University of Virginia, Charlottesville, VA 22903

Holocene deposits of calcium carbonate (tufa and/or marl) occur along many streams in the Shenandoah Valley of Virginia and in the southern Cumberland Valley of Pennsylvania, in many (and perhaps in all) cases just downstream from points where these streams cross faults or where they cross lineaments that intersect faults at depth. Many of the deposits are forming at the present time, but others are inactive and are being eroded by the streams. Along Holman Creek between Forestville and Quicksburg, Virginia, deposition of tufa

was followed by alluviation, and the deposits are overlain marginally by up to 3 m of sands and silts, yet the travertine is still younger than the establishment of the present valley of Holman Creek. Localization of the deposits downstream from fault or lineament traces seems to indicate the source of the $CaCO_3$-saturated waters to be the fault zones, along which crushing of the limestones resulted in their higher-than-normal solubility. However, it seems unlikely that this crushing dates from the time of origin of these faults some 250 m.y. ago: the supply of crushed limestone produced at that time should long since have been exhausted. The more probable alternative is that recent movement along these faults has produced a new supply of crushed limestone for the circulating ground water to act on; the age of a deposit then reflects the time of most recent movement along the fault. In one case, the Saumsville fault in the Shenandoah Valley, this hypothesis is supported by the systematic right-lateral offset of $CaCO_3$-depositing streams crossing the fault, evidence that movement has occurred along this fault since the time of establishment of the present drainage pattern.

Reprinted as published in the Geological Society of America Southeastern Section *Abstracts with Programs, 1987,* v. 19, no. 2, p. 133.

Geology of the Turner Falls Area, Arbuckle Mountains, Oklahoma: Evidence for Left-Lateral Strike-Slip Movement Along The Washita Valley Fault Zone During the Deformation Stage of the Southern Oklahoma Aulacogen

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It has been widely recognized that Pennsylvanian conglomerate units of southern Oklahoma record the deformation stage of the southern Oklahoma aulacogen. One of these conglomerates, the Late Pennsylvanian (Middle Virgilian) Collings Ranch Conglomerate, is the main rock unit exposed at the Turner Falls area of the Arbuckle Mountains, Oklahoma. The conglomerate is deposited as an alluvial fan in a divergent strike-slip (pull-apart) basin which formed in response to left-stepping along the Washita Valley fault zone (WVFZ), a major fault zone of the Arbuckle Mountains. It is about 300 ft (100 m) thick in a measured section along I-35 but is probably thicker elsewhere in the basin which is 3½ miles in length and ½ mile in width. When present, imbricate structures of the conglomerate show paleoslope directions compatible with the strike-slip origin.

In the Turner Falls area, the WVFZ consists of two main branches. One of these bounds the Collings Ranch Conglomerate to the south and the other one cuts through the conglomerate. The two strands are almost vertical and join together about ⅕ of a mile east of I-35. Southeastward, the WVFZ is composed of a single vertical fault until it branches again into two strands about ⅕ of a mile south of the Falls Creek Assembly. There the northern branch trends southeasterly and dips southward with a well pronounced reverse separation along the northern edge of a small (1 by ½ mile) convergent (transpressional) zone which it forms together with the left-lateral movement along the southern strand.

The presence of both divergent and convergent zones along the WVFZ suggests to us that the fault zone had substantial left-lateral strike-slip movement during and probably after the deposition of the Collings Ranch Conglomerate which was, in turn, during the deformation stage of the Southern Oklahoma Aulacogen.

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Paleostress Analysis Along the Reagan and Sulphur Fault Zones, Arbuckle Mountains, Oklahoma

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Detailed mapping along the Reagan and Sulphur fault zones and orientation of the principal stress axes based on the calcite twin lamellae suggest a complex deformational history for the Arbuckle Mountains. In the Wapanucka area the relationship between the southerly dipping Sulphur fault and the east–west trending Wilson syncline suggests right-lateral strike-slip motion on the fault. Paleostress data indicate a change in the stress pattern. An early east–west trending compression argues for left-lateral strike-slip motion on the Sulphur fault. In the Arbuckle dam area, the southwesterly dipping Reagan fault and associated structures indicate a left-lateral strike-slip motion on the Reagan fault. The north–south compression, attributed to the later deformational events, implies right-lateral strike-slip motion on the Reagan fault. In general, both compression and extension axes are sub-horizontal to horizontal. The magnitude of strain is relatively low, but is distinctly higher within the fault zone, which also indicates that the large folds (Dougherty anticline) have been developed by flexural-slip mechanism, with very little internal strain. This could be related to initial thrust or gravity slide mechanisms. These folds, however, have been modified by later strike-slip offset, apparently first by left-lateral and then by right-lateral, which also twinned the calcite grains. As a whole, the Arbuckle Mountains have experienced a complex deformational history with several fault movement directions. This scheme is more complex than usually presented, but similar to that proposed by Ham (1950).

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Subsurface Structural Analysis of the Southeast Hoover Field, Arbuckle Region, Southern Oklahoma

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The Southeast Hoover field, located on the northern side of the Arbuckle Mountains, typifies the structural style common to the foreland of southern Oklahoma. This oil field, which produces primarily from the upper Arbuckle Group carbonates, was created in response to the Late Pennsylvanian Arbuckle Orogeny. Various interpretations of the mode of deformation have been proposed such as wrench faulting, gravity sliding, and overthrusting. This research

supports the idea of moderately dipping thrust faults created by northeast–southwest compression. Paleozoic rocks, originally deposited on the northern edge of the Southern Oklahoma Aulacogen, have been transported to the northeast on southwest-dipping thrust faults, and now comprise the leading edge of the Arbuckle Mountains.

In a detailed study, the Southeast Hoover field was reinterpreted in light of the compressional thrust-fault theory. Large-scale structural closure controls the location of hydrocarbon accumulation in the Arbuckle Group. Structures in the shallower horizons are characterized by detached anticlines that were created as a response to volume adjustments in adjacent upward-tightening synclines. Fault cutoff lengths and hanging-wall cutoff angles provide clues to pre-deformation fault-plane geometry.

Comparison of the Southeast Hoover field with other structures in the Arbuckle region indicates a close similarity of style, which suggests this study can be used as a geologic model for interpreting foreland oil fields throughout southern Oklahoma.

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Toward an Evolutionary Basis for Conodont Zonation of Mid-Carboniferous (Mississippian–Pennsylvanian) Strata

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A synthesis of new and existing data suggests that an evolutionary basis for a more globally applicable Mid-Carboniferous conodont zonation is within reach. However, attainment of this goal may involve modification of the conventional understanding of conodont species, lineages, and phylogenetic relationships versus first appearances of distinctive biofacies.

Mid-Carboniferous conodont index species seemingly consist of a broad range of intergradational morphotypes. Although gradual evolutionary trends are evident, punctuated shifts in the range of morphotypic variation and appearance of new morphs provides a less subjective basis for defining species limits. In addition, once the relative timing of speciation events is firmly established they could serve as the basis for an integrated system of lineage-species zones.

The following is a preliminary outline of evolutionary events, whose timing is critical to biologic evaluation of Mid-Carboniferous chronostratigraphic relationships. *Adetognathus* and *Rhachistognathus* are comparatively simple lineages which each consist of two species. The significant evolutionary event within the two lineages (*A. unicornis–A. lautus* and *R. muricatus–R. primus*) is nearly coincident with the lower of two levels that have been regarded as positions to locate the M/P boundary. *Gnathodus girtyi* is the oldest species of a lineage that probably includes *G. higginsi* and "*Neognathodus*" *symmetricus*. The speciation events producing the latter two taxa cannot be precisely fixed but appear to coincide with the lower and upper M/P boundary positions, re-

spectively. *Declinognathodus noduliferus* appears at or near the lower M/P boundary horizon; its origin is not clear but *G. bilineatus* is the likely ancestor. At the higher M/P boundary level, *Declinognathodus* gives rise to *D.* n. sp. A. and *Idiognathoides sinuatus.*

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Environmental Factors Associated with an Upper Cambrian Conodont and Trilobite Zonal Boundary

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The base of the uppermost Croixan *Cordylodus proavus* Zone is marked by major faunal turnover. In North American shallow marine facies, the most common euconodont species disappear abruptly at the top of the underlying zone, along with most trilobites. New species of both groups appear in overlying strata; this faunal extinction produces probably the most distinctive zone boundary in the upper Cambrian. This zonal contact in the rock is often sharp and may show evidence of subaerial erosion; it marks the start of an interval of sea level fluctuations named the Lange Ranch Eustatic Event. The horizon has a distinctive geochemical signature. The base of the *C. proavus* Zone has a concentration of trace elements (As, Co, Cr, Ni, Sb, Sc, and Zn) in Utah, Oklahoma, and Texas, and a similar concentrate zone is known in SE and NE China. This horizon in the U.S.A. has changes in Rare Earth Elements (Cerium Anomaly) that suggest an increase in sea water anoxia, followed by increasing oxygenation in the lower *C. proavus* Zone. Preliminary magnetostratigraphic studies in Kazakhstan, China, and Texas indicate a polarity reversal coincident with this geochemical, eustatic, and faunal event. *C. proavus* has an undescribed ancestor known from underlying strata in noncratonic areas. The evolution, extinction, and migration of conodonts and trilobites at the base of the *C. proavus* Zone appear to have been influenced by environmental factors that are not yet fully understood but seem to have operated worldwide.

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Evolutionary Distinction Between Atokan and Desmoinesian (Pennsylvanian) *Neognathodus*

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Several occurrences of *Neognathodus* have been reported from rocks of Morrowan and Atokan age using the classification scheme developed by Merrill for the Desmoinesian. We interpret these older occurrences to represent several ancestral species whose diagnostic characters have not generally been recognized. We illustrate our interpretation by contrasting Atokan species of *Neognathodus* with those from the Desmoinesian and outlining their evolutionary development.

The distinction between Atokan and Desmoinesian species is difficult when only the outline of the platform is considered. In cross-section Atokan neognathodids exhibit parapets that extend above the carina, whereas in the Desmoinesian only the inner parapet is developed above the carina. In oral view, Atokan neognathodids closely resemble their Desmoinesian descendants with which they have been confused. Our collections suggest that the development of the outer parapet as seen in the Atokan is reversed during its subsequent decay in the Desmoinesian.

The evolution of Middle Pennsylvanian neognathodids takes place through both punctuated and gradualistic steps. The evolutionary change from Atokan to Desmoinesian neognathodids involves abrupt changes in cross-sectional appearance. However, evolution within the Late Atokan and Early Desmoinesian species is more gradual. Atokan specimens assigned to *N. atokaensis* Grayson evolve gradually by posterior extension of the outer parapet until bilateral symmetry is attained. Desmoinesian neognathodids show a reversal of this trend although decay of the outer parapet follows a different path.

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Conodonts from the Missouri Mountain Shale (Silurian–Devonian?) and Lower Arkansas Novaculite (Devonian), Black Knob Ridge, Oklahoma

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Conodont faunas ranging in age from Early Silurian to questionably Early Devonian have been obtained from the green-grey clay shales of the Missouri Mountain Shale at the Grants Gap section of Hendricks and others (1937). The lower three-quarters of the unit is Late Llandoverian in age (*celloni* and *amorphognathoides* zones). Faunas are dominated by elements of *Dapsilodus* with lesser numbers of *Distomodus* elements. The most prolific samples are associated with sandy layers; most conodonts from these layers appear to have been transported into the depositional area with the coarse clastics. No diagnostic Wenlockian conodonts were recovered. Ludlovian conodonts (*siluricus* Zone) are poorly represented in the upper part of the unit. Fragments of *Icriodus* occur in the uppermost beds.

Cherts and black shales of the middle chert and shale member of the Arkansas Novaculite unconformably overlie the Missouri Mountain Shale at Grants Gap. Questionable Middle Devonian forms of *Polygnathus* occur in the lowermost beds. Missing are approximately 35 meters of green-grey cherts and shales that comprise the lower member of the Arkansas Novaculite a few miles to the south. Thus far, this lower chert and shale member of the Arkansas

Novaculite at Black Knob Ridge has yielded only undiagnostic elements of *Belodella, Dvorakia,* and a carminate species.

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Conodonts of the Welden Limestone (Osagean, Mississippian), South-Central Oklahoma

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Conodonts obtained from the Welden Limestone in Pontotoc County, Oklahoma, are Early Osagean in age (*isosticha*–Upper *crenulata* and *typicus* zones). Faunas are dominated by *Gnathodus,* which experienced a rapid radiation during the *isosticha*–Upper *crenulata* zone. All possible transitional forms of *Gnathodus* are represented along with species of *Staurognathus, Bactrognathus,* and *Pseudopolygnathus.* Because the elements are abundant and well preserved, multielement taxonomy is possible.

The Welden Limestone is a condensed unit, approximately 1.5 meters at its thickest. It pinches out laterally to the southeast and disappears to the west. A condensed green-gray shale of Late Kinderhookian age underlies the Welden (pre-Weldon Shale). Above the Welden lies a condensed unit of Late Osagean age. The controlling factors for the deposition of this deep water carbonate are yet unknown. The Welden Limestone correlates to the Chappel Limestone of the Llano uplift region, of central Texas.

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