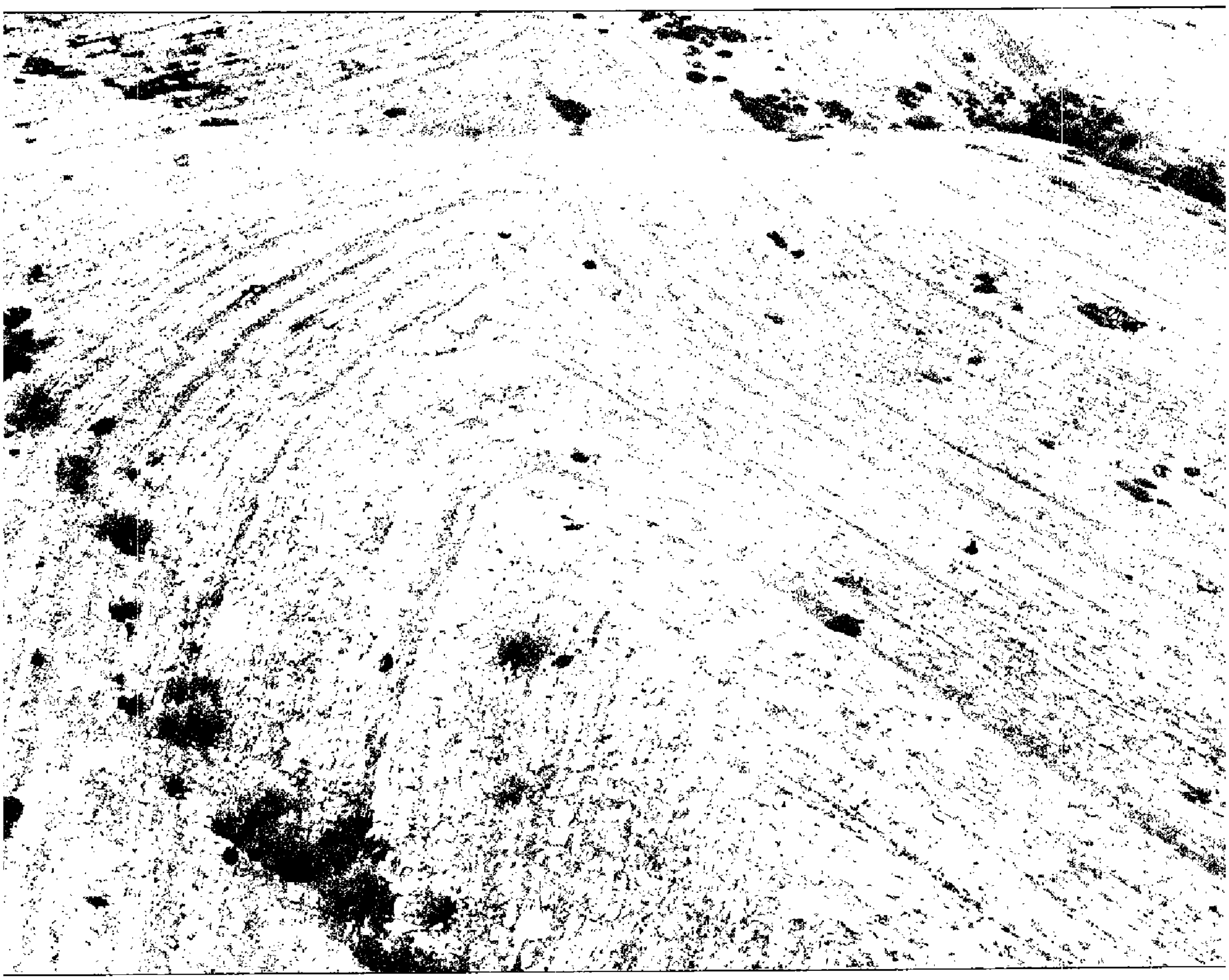
OKLAHOMA GEOLOGY

Oklahoma Geological Survey Vol. 50, No. 1 February 1990



On the cover—

Fold Bifurcation in the Slick Hills, Southwestern Oklahoma

In the Slick Hills of southwestern Oklahoma the Cambrian–Ordovician Arbuckle Group is ~5,500 ft thick. This immense thickness is built of carbonates which were deposited on a vast and little-changing shallow-water platform. As a result, the group has an overall homogeneity of character, consisting of thin beds of brittle, comprehensively cemented limestone and dolostone. Individual beds thicker than 5 ft are rarely seen. The Slick Hills were comprehensively deformed during the Pennsylvanian, when the area formed part of the frontal fault zone between the Wichita uplift and the Anadarko basin.

The principal response to tectonic stress shown by the group is controlled by bedding-related anisotropy; other controls are the brittle character of the rock and the ease with which carbonates will dissolve when stressed. Fold styles developed in the Slick Hills reflect these controls. Thus, folds show a parallel form, and profile adjustments are achieved by frequent horizons of bed-parallel faulting, which can only be detected where they become discordant (in hinge areas). Most fold hinges are sharply defined, and limbs are planar; i.e., the folds have semi-chevron profiles approximating to Class E of Huddlestone (1973).

The folds depicted here are located on the west side of Blue Creek Canyon (Fig. 1). The Canyon follows the line of the Blue Creek Canyon fault, a major dislocation in the frontal fault zone. The fault is an oblique reverse structure with a stratigraphic throw of ~2,000 ft down to the west. The trend of the fault is variable; in the Canyon it trends roughly N–S, but to the north it bends to the northwest. This bend may reflect an existing Cambrian fracture system in the area.

(continued on p. 34)

OKLAHOMA GEOLOGICAL SURVEY

CHARLES J. MANKIN
Director

KENNETH S. JOHNSON
Associate Director

OKLAHOMA GEOLOGY NOTES

Editor
Christie Cooper

Geologist/Editor
Larry N. Stout

Publications Clerk
Diana Gilstrap

Cartography
T. Wayne Furr, *Manager*
James H. Anderson
Adam P. Radzinski
Charlotte Lloyd

Oklahoma Geology Notes, ISSN 0030-1736, is published bimonthly by the Oklahoma Geological Survey. It contains short technical articles, mineral-industry and petroleum news and statistics, abstracts, notices of new publications, and announcements of general pertinence to Oklahoma geology. Single copies, $1.50; yearly subscription, $6. Send subscription orders to the Survey at 100 E. Boyd, Room N-131, Norman, OK 73019. Short articles on aspects of Oklahoma geology are welcome from contributors; general guidelines will be sent on request.

This publication, printed by the Transcript Press, Norman, Oklahoma, is issued by the Oklahoma Geological Survey as authorized by Title 70, Oklahoma Statutes 1981, Section 3310, and Title 74, Oklahoma Statutes 1981, Sections 231–238. 1,800 copies have been prepared for distribution at a cost of $1,106.03 to the taxpayers of the State of Oklahoma. Copies have been deposited with the Publications Clearinghouse of the Oklahoma Department of Libraries.

OKLAHOMA GEOLOGY

C O N T E N T S

INOLA LIMESTONE MEMBER OF THE BOGGY FORMATION (PENNSYLVANIAN) IN ITS TYPE AREA

LeRoy A. Hemish[1]

Abstract

The type area of the Inola Limestone Member of the Boggy Formation spans a distance of ~12 mi along the Rogers and Mayes County line in east-central Oklahoma. Because the formally designated type section of the Inola Limestone is near the northern limits of the type area and the type locality is at the southern limits, there are substantial differences between the sequence of rocks at the two locations. Therefore, a principal reference section is here established within the type locality, Inola Hill (the nomenclator did not measure a section in the area). Also, a subsurface reference section is here designated in the vicinity of the type section (Osage Hills).

The type section of the Inola Limestone Member is redefined to include all the beds from the base of the first limestone above the Bluejacket coal bed to the top of the first limestone below an unnamed black shale in the upper part of the Boggy Formation.

Introduction

The purposes of this article are (1) to clarify the definition of the Inola Limestone Member of the Boggy Formation, (2) to establish a principal reference section in the type locality of the Inola Limestone, (3) to designate a test well drilled by the Oklahoma Geological Survey (OGS) as a reference well to enhance subsurface knowledge of strata associated with the Inola, and (4) to provide a log of continuous core cut from the reference well.

The type area of the Inola Limestone extends for a distance of ~12 mi along the Rogers and Mayes County line, from Inola Hill on the south to the Osage Hills on the north (Fig. 1). Because of the distance between the originally designated type locality and the type section, there are substantial differences between the sequence of rocks at the two locations. In this article the writer attempts to alleviate some of the resultant stratigraphic problems encountered by workers investigating the Inola Limestone.

Stratigraphic Discussion

The Inola Limestone is an excellent marker bed, both at the surface and in the subsurface. It is important in aiding geologists to differentiate between the Bluejacket and the Taft Sandstones (Branson, 1954, p. 192).

---

[1]Oklahoma Geological Survey.

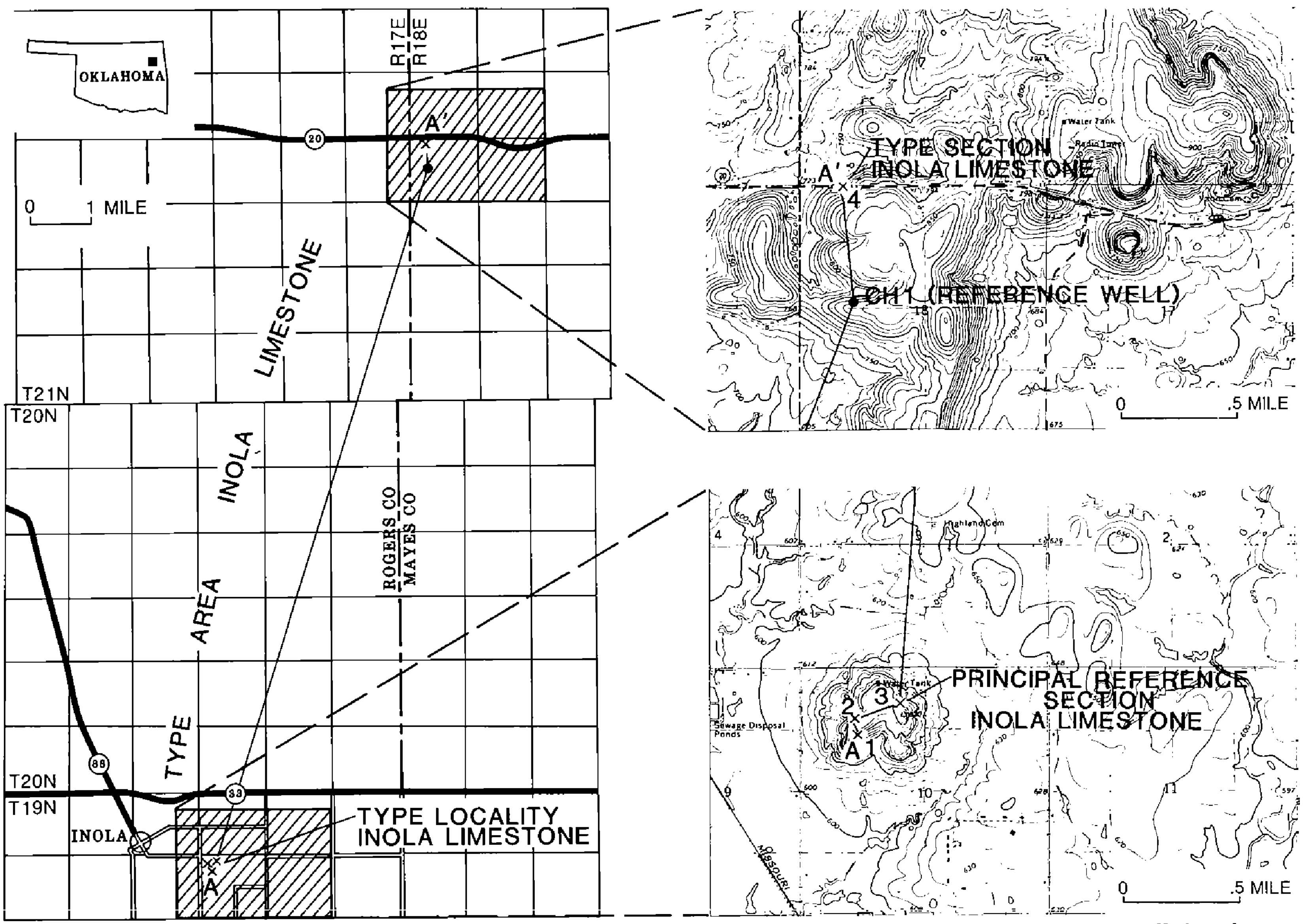


Figure 1. Map locating type area, type locality, type section, principal reference section, and reference well for the Inola Limestone Member of the Boggy Formation in southeastern Rogers County and southwestern Mayes County, Oklahoma.

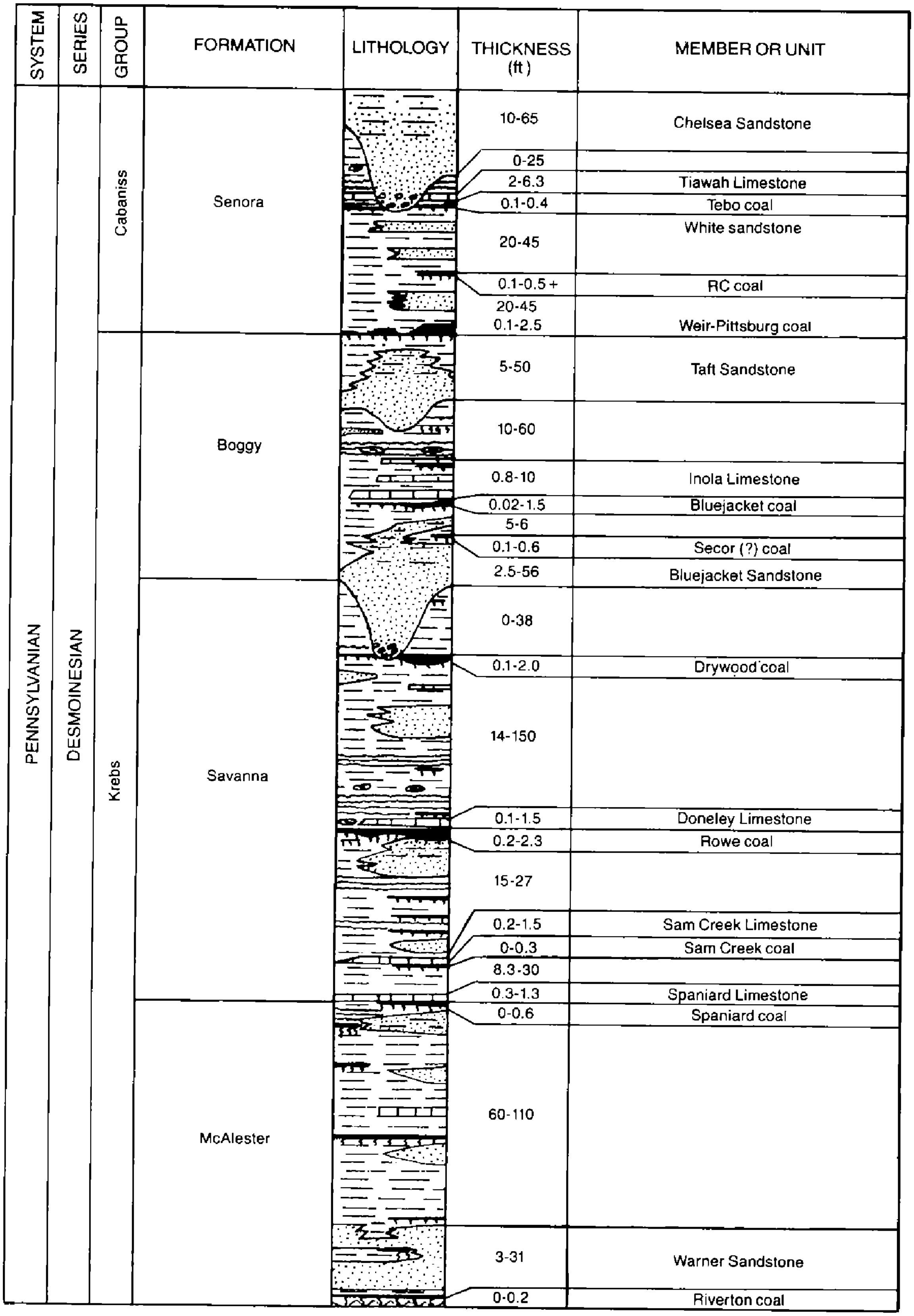


Figure 2. Generalized columnar section, showing rocks from the base of the McAlester Formation to the top of the Chelsea Sandstone Member of the Senora Formation in Rogers and Mayes Counties, Oklahoma (modified from Hemish, 1989b).

Figure 2 is a generalized columnar section showing the position of the Inola Limestone relative to other named units in the Boggy and Senora Formations in Rogers and Mayes Counties, Oklahoma. Key units for stratigraphic recognition of the Inola Limestone Member include the Bluejacket Sandstone, at the base of the Boggy Formation; the Bluejacket coal bed, closely underlying the Inola; a black, fissile shale containing ironstone concretions and small black, phosphatic nodules, overlying the Inola; and the stratigraphically higher Taft Sandstone.

Figure 3 shows excerpts from geophysical logs, illustrating the relationship of the Inola Limestone to underlying and overlying strata. Figure 3A shows the position of the Inola Limestone relative to the underlying Bluejacket Sandstone ("Bartlesville sand") and the overlying strata up to the Tiawah Limestone ("Pink lime"). Figure 3B, representing a different location, shows the position of the Inola Limestone relative to the overlying Taft Sandstone ("Red Fork sand") and the Tiawah Limestone.

Because of the usefulness of the Inola Limestone to stratigraphers, and because a type section was never formally established within its type locality (Inola Hill), the writer measured a section on Inola Hill. This section is herein designated as the principal reference section for the Inola Limestone (Measured Section 3, Appendix 1).

Tillman (1952, p. 32) measured a section in a road cut ~12 mi north from the type locality (Fig. 1), and proposed that it should be the type section for the Inola Limestone. At this exposure four separate limestone beds are present, which Tillman called "Upper Inola," "Second Inola," "Third Inola," and "Lower Inola" Limestone. Branson (1954, p. 192) formally designated Tillman's measured section as the type section for the Inola Limestone. Tillman's measured section is reproduced in Appendix 1 (Measured Section 4). In his formal definition, Branson (1954, p. 192) restricted the term Inola to the lower limestone of the four, and left the other three unnamed. However, Branson's restriction was not adopted by workers in succeeding years, and where more than one limestone bed is present, the term Inola was applied to all of them (Jordan, 1957, p. 103; Govett, 1959, p. 168–171; Gregg, 1976, p. 71; Hemish, 1989b; in preparation a). This practice was probably followed because of correlation uncertainties where only one, two, or three limestone beds are present in the Inola interval.

At the type locality, two limestone beds are present. In places, the lower limestone is either weathered and covered or discontinuous (Fig. 4); the upper limestone of the two is better developed and forms a resistant bench around Inola Hill. This bed apparently is the one Lowman (1932) originally intended to name the Inola Limestone; it probably does not correlate with the lower bed at the type section. Branson's restriction seems untenable and should be abandoned. Therefore, the writer here redefines the Inola Limestone Member of the Boggy Formation to include all beds from the base of the first limestone above the Bluejacket coal bed to the top of the first limestone below an unnamed, black, fissile shale containing abundant ironstone concretions. The Inola Limestone, as redefined, may consist of only a single limestone bed, or it may consist of as many as four limestone beds separated mostly by shale, thin coal stringers, and underclays, as at its type section.

Branson's (1954, p. 192) argument for confining the term Inola to the lower limestone bed was that each limestone occurred "in a separate cyclothem with coal seams under the first, third, and fourth." However, the North American Commis-

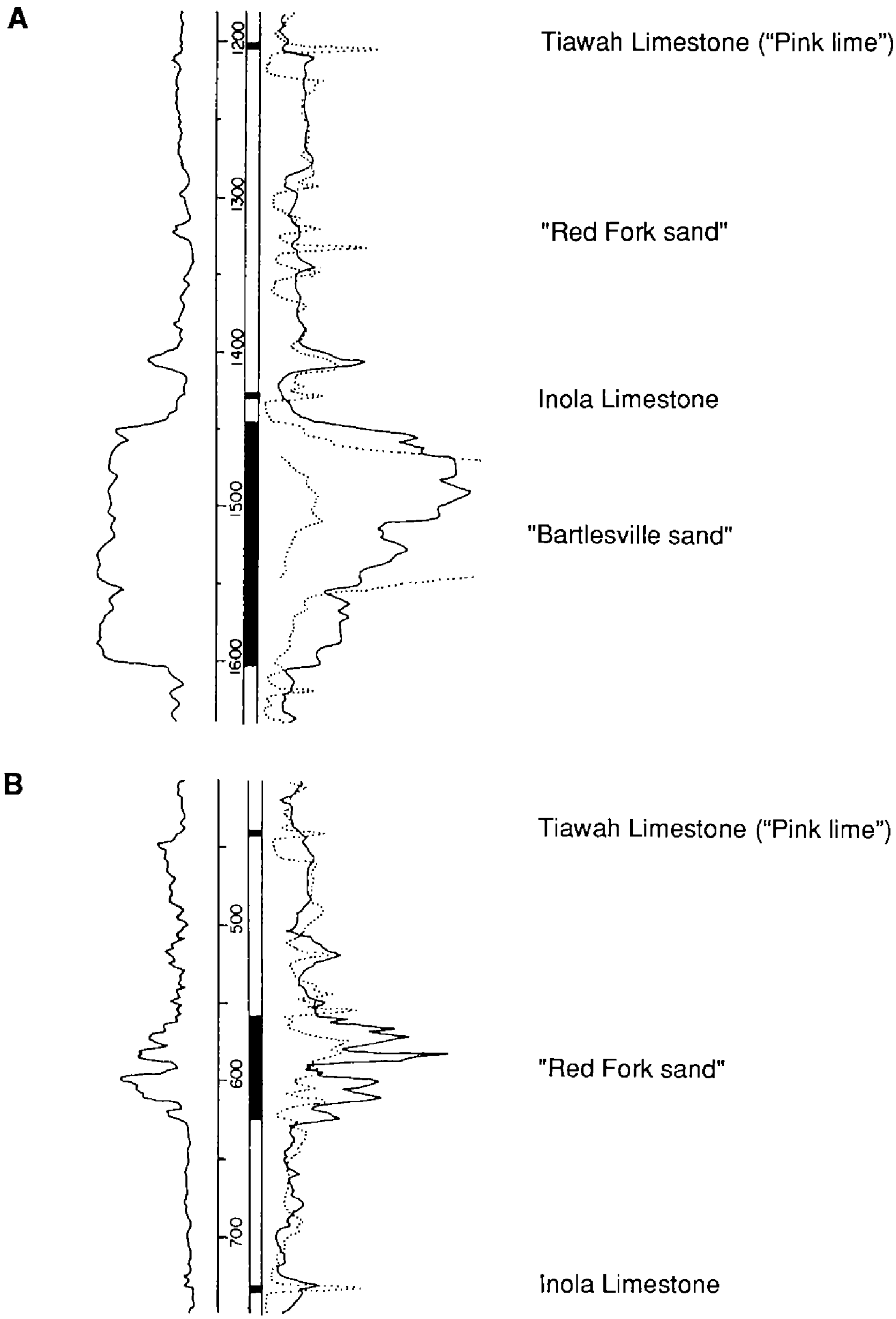


Figure 3. Excerpts from geophysical logs. *A*—Position of the Inola Limestone relative to the Bartlesville sand and to overlying strata; Gulf Oil Corp. No. 1-S Berryhill, NE¼ sec. 17, T. 17 N., R. 12 E. *B*—Position of the Inola Limestone relative to the overlying "Red Fork sand" and Tiawah Limestone; Pedco No. 1 Taft, SE¼SW¼SE¼ sec. 3, T. 14 N., R. 14 E. Modified from Jordan (1957, p. 76,153).

Figure 4. The lower of two limestone beds present on the west slope of Inola Hill in the type locality of the Inola Limestone. The bed is 0.2 ft thick, gray, thin-bedded, fossiliferous, and weathered.

sion on Stratigraphic Nomenclature (1983, Article 22d) states that "Inferred geologic history, depositional environment, and biological sequence have no place in the definition of a lithostratigraphic unit, which must be based on composition and other lithic characteristics." In compliance with definitions of the North American Commission on Stratigraphic Nomenclature (1983, Article 24) the Inola Limestone Member, as redefined, contains between its upper and lower limits repetitions of distinctive lithic units (limestones), and the upper and lower boundaries are marked by surfaces of definite lithic change.

Figure 5 is an abbreviated cross section showing the relationships among the strata at the type locality on Inola Hill, the type section, and a subsurface reference section (CH 1, Appendix 2) in the Osage Hills. Note that in the type locality on Inola Hill the Inola Limestone Member contains only two rather thin (0.2- to 0.8-ft-thick) dark-gray, fossiliferous, thin-bedded limestones with coal seams under each. The limestones are separated mostly by gray shales and underclays. In the principal reference section (north side of Inola Hill) only one 0.8-ft-thick bed of limestone (Fig. 6) is present between the Bluejacket Sandstone and the overlying black shale marker. A 3.6-ft-thick, fine-grained, thin-bedded sandstone appears to be the lateral equivalent of the lowermost Inola limestone bed that crops out on the west side of Inola Hill.

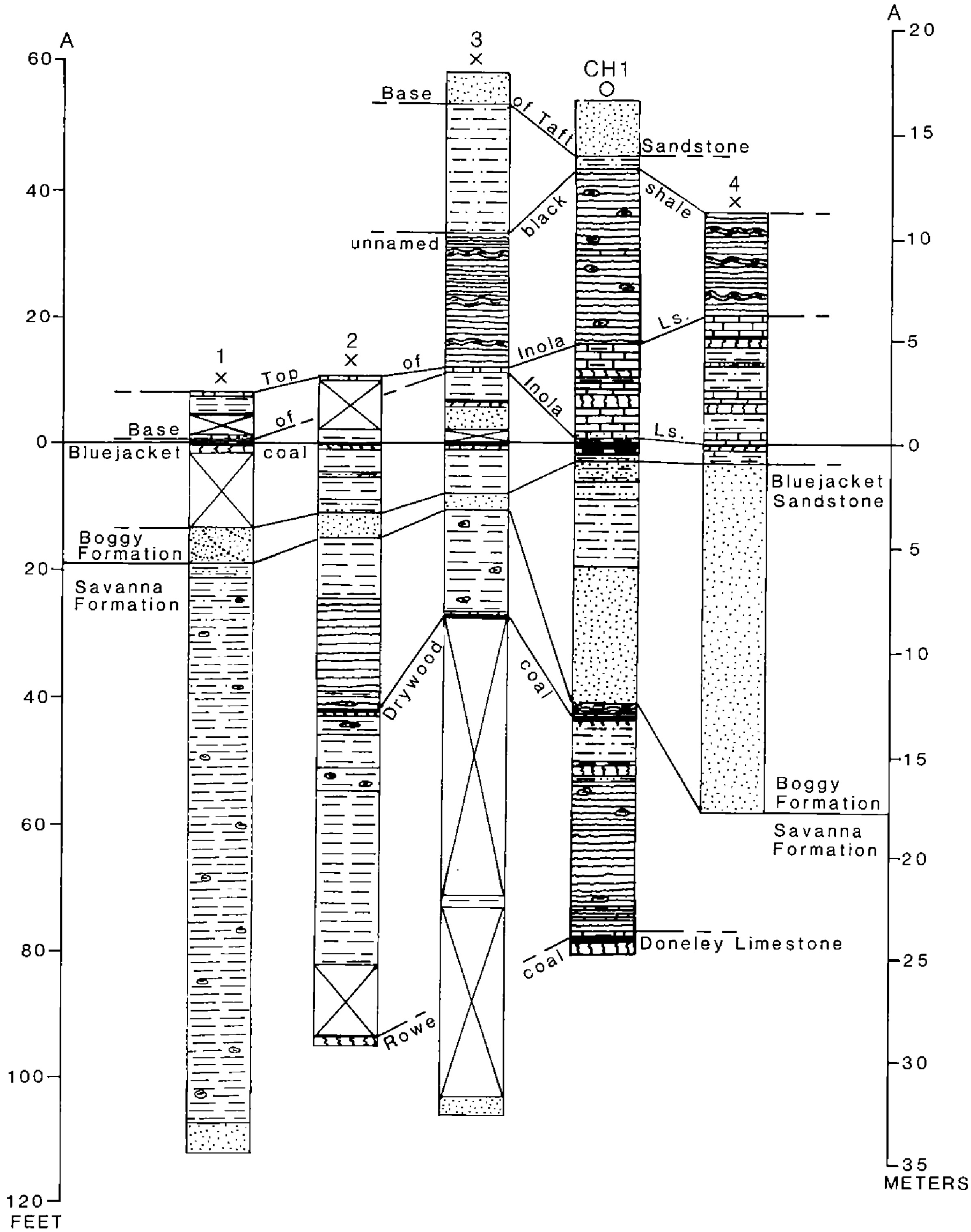


Figure 5. Cross section showing correlations of key units in the type area of the Inola Limestone. Line of cross section (A–A') shown in Figure 1; descriptions of lithologic units in Appendixes 1 and 2. No horizontal scale.

Figure 6. The single bed of Inola Limestone that crops out on the north slope of Inola Hill, as described in Measured Section 3, Appendix 1.

At the type section of the Inola Limestone, the lowermost bed is 1.9 ft thick, compact, and fossiliferous. Less than 0.5 mi away, in the reference well, the lower limestone is 5.4 ft thick, calcarenitic, and cross-bedded, and fossils are rare. The next higher limestone bed is underlain by ~2 ft of underclay in both the reference well and the type section, but no associated coal bed was observed. The limestone is similarly gray, hard, fossiliferous, and about the same thickness at both sites (1.5 and 2.1 ft).

Tillman's second Inola Limestone (from the top) is 0.5 ft thick, fossiliferous and silty. This bed is absent in the reference well.

The uppermost limestone is similar in most respects in the type section and the reference well. At both places the thickness is ~3.5 ft, and the bed is medium- to light-gray and fossiliferous. A thin coal seam with 1.5 ft of underclay immediately underlies the limestone at both sites.

Correlating the beds within the Inola Limestone Member between the type locality and the type section is problematical. However, the bounding markers are well-defined and present at both sites. The Bluejacket coal ranges from 0.2 to 0.6 ft thick on Inola Hill, and in the Osage Hills it ranges from 0.04 ft thick (type section) to 1.8 ft thick in the reference well. The coal is closely underlain by the Bluejacket Sandstone.

The upper contact of the Inola Limestone is sharp. Wherever observed, the upper limestone bed is overlain by a distinctive, black, fissile shale containing abundant ironstone concretions and, in places, black, phosphatic nodules. A gray, silty shale separates the black-shale unit from the overlying base of the Taft Sandstone (Fig. 5).

The Inola Limestone is not known to occur outside of Oklahoma. Hemish, in the type area of the Bluejacket Sandstone (1989a, p. 79,82), identified as the Inola Limestone a 0.1-ft-thick, bioclastic, shaly limestone overlain by a grayish-black shale and ironstone bed and closely underlain by a 0.1-ft-thick coal bed. This occurrence was observed in core cut from strata in sec. 25, T. 27 N., R. 20 E., northern Craig County, and is the northernmost known occurrence of the Inola.

The Inola Limestone is present southward into central McIntosh County, where it is a single bed, generally about 0.5–1.0 ft thick (Hemish, 1988, core-hole logs 17, 20, 23). The southernmost known exposure where the Inola can be identified with confidence is in the bed of Elk Creek, NW¼NE¼NW¼SE¼ sec. 8, T. 11 N., R. 17 E. (Hemish, in preparation b).

Establishment of Reference Well

In accordance with procedures recommended by the North American Commission on Stratigraphic Nomenclature (1983, p. 853–854) for establishing reference wells, a reference well for the Inola Limestone Member of the Boggy Formation is here described and defined. The reference well (CH 1, Appendix 2; Figs. 1,4) is located in the SE¼SE¼SW¼NW¼ sec. 18, T. 21 N., R. 18 E., Mayes County, Oklahoma, on the George Moore farm. Continuous 2-in. core was cut from below an 8.5-ft surface casing to a total depth of 441 ft. Samples of cuttings were collected and bagged from the upper 8.5 ft. Core-drilling was completed on 16 August 1988. Surface elevation was estimated from a topographic map at 815 ft above sea level.

All the core-drilling was done by the Oklahoma Geological Survey. Cores and cuttings from the reference well have been boxed and labeled, and are available for study by the public at the Oklahoma Geological Survey Core and Sample Library.

References

Branson, C. C., 1954, Marker beds in the lower Desmoinesian of northeastern Oklahoma: Oklahoma Academy of Science Proceedings, v. 33, p. 190–194.

Govett, R. W., 1959, Geology of Wagoner County, Oklahoma: University of Oklahoma unpublished Ph.D. dissertation, 182 p.

Gregg, J. M., 1976, Coal geology of parts of the Inola, Chouteau N.W., Catoosa S.E., and Neodesha Quadrangles, southeastern Rogers and northern Wagoner Counties, Oklahoma: Oklahoma State University unpublished M.S. thesis, 77 p.

Hemish, L. A., 1988, Report of core-drilling by the Oklahoma Geological Survey in Pennsylvanian rocks of the northeastern Oklahoma coal belt, 1983–86: Oklahoma Geological Survey Special Publication 88-2, 174 p.

——— 1989a, Bluejacket (Bartlesville) Sandstone Member of the Boggy Formation (Pennsylvanian) in its type area: Oklahoma Geology Notes, v. 49, p. 72–89.

——— 1989b, Coal geology of Rogers County and western Mayes County, Oklahoma: Oklahoma Geological Survey Bulletin 144, 118 p.
——— [in preparation a] Lithostratigraphy and core-drilling, upper Atoka Formation through lower Senora Formation (Pennsylvanian), northeastern Oklahoma shelf area: Oklahoma Geological Survey.
——— [in preparation b] Coal geology of McIntosh and Muskogee Counties, Oklahoma: Oklahoma Geological Survey.
Jordan, Louise, 1957, Subsurface stratigraphic names of Oklahoma: Oklahoma Geological Survey Guidebook 6, 220 p.
Lowman, S. W., 1932, Lower and Middle Pennsylvanian Stratigraphy of Oklahoma east of the meridian and north of the Arbuckle Mountains: Tulsa Geological Society Digest, v. 1, 4 p.
North American Commission on Stratigraphic Nomenclature, 1983, North American Stratigraphic Code: American Association of Petroleum Geologists Bulletin, v. 67, p. 841–875.
Stringer, R. S., 1959, Geology of the Krebs Group, Inola area, Rogers and Mayes Counties, Oklahoma: University of Oklahoma unpublished M.S. thesis, 63 p.
Tillman, J. L., 1952, Geology of the Tiawah area, Rogers and Mayes Counties, Oklahoma: University of Oklahoma unpublished M.S. thesis, 65 p.

Appendix 1

Measured Sections

MS 1

NE¼SW¼NW¼ sec. 10, T. 19 N., R. 17 E., Rogers County. Measured in western slope of Inola Hill, by Gregg (1976, Measured Section 2, App.).

	Thickness (ft)
Krebs Group	
Boggy Formation	
Inola Limestone Member, upper bed, light-brown where weathered, gray where fresh, fossiliferous; forms brow of hill; fragments are platy and form rubble on slope below outcrop	0.2
Shale, dark, carbonaceous, mostly covered; weathers to dark, clayey soil	3.5
Coal, banded bituminous, quite weathered; stained red and yellow; covered at most places	0.2
Covered, probably silty, gray shale or siltstone, as indicated by float	3.0
Inola Limestone Member, lower bed, gray, carbonaceous, thin-bedded, fossiliferous; quite weathered	0.2
Shale, black, very carbonaceous, fissile	0.1
Bluejacket coal, banded bituminous, quite weathered, stained red	0.2
Underclay, weathered to light-gray mud; contains coalified rootlets	2.0
Covered, probably siltstone, silty shale, and thin-bedded sandstone, as indicated by float	12.0
Bluejacket Sandstone Member, light-tan where fresh, black-varnish stained and reddish-brown where weathered; supports green and blue-green lichens; composed of fine quartz grains, roundness 0.8, sphericity 0.9, well-sorted; rather porous; micaceous; weathering cracks indicate low-angle small-scale to medium-scale cross-bedding; forms ridge about halfway up Inola Hill	5.5
Savanna Formation	
Sandy shale, weathers light-brown; very fine-grained, stained red; fissile; interbedded with lenses of sandstone as much as 1 in. thick	2.5
Shale, mostly covered, dark-gray where fresh, weathers light-brown; fissile; contains ironstone concretions; ratio of silt to clay seems to increase upward; grades into overlying sandy shale	85.0
Sandstone, light-tan where fresh, yellow-brown with dark varnish stain where weathered; composed of fine quartz grains, roundness 0.8, sphericity 0.9, well-sorted, micaceous; exposure poor, therefore bedding characteristics not observed; base of unit not exposed	5.0
Total	119.4

MS 2

SE¼NW¼NW¼ sec. 10, T. 19 N., R. 17 E., Rogers County. Measured up gully on west side of Inola Hill, by Stringer (1959, Measured Section 3, App.).

	Thickness (ft)
Boggy Formation	
Inola limestone, blue to gray, weathers buff, fossiliferous	0.2

Covered	8.3
Shale, gray	2.2
Bluejacket coal	0.2
Underclay, light-gray, soft	0.1
Shale, tan	4.1
Siltstone, gray, calcareous	0.1
Shale, buff, platy	4.5
Siltstone, buff	2.1
Bluejacket Sandstone, tan, weathers dark-brown, very fine-grained, ferruginous	3.6
Savanna Formation	
Shale, buff, platy	9.7
Shale, black	15.5
Shale, dark-gray	0.4
Clay ironstone, orange to maroon, nodular, hard	0.1
Shale, black	1.1
Coal	0.3
Underclay, light-gray, soft	0.2
Shale, light-gray, weathers buff, brittle, contains clay-ironstone nodules	3.4
Shale, gray	5.6
Shale, tan, weathers buff, contains calcareous clay-ironstone nodules	3.5
Shale, dark-gray, contains clay-ironstone nodules	15.9
Shale, gray to tan	11.4
Covered	11.3
Rowe coal	0.2
Underclay, light-gray, soft	1.0
Total	105.0

MS 3
(Principal Reference Section for the Inola Limestone)

NE¼NW¼ sec. 10, T. 19 N., R. 17 E., Rogers County. Measured from top of Inola Hill down north side, by LeRoy A. Hemish. (Estimated elevation at top of section, 830 ft.)

	Thickness (ft)
Krebs Group	
Boggy Formation	
Sandstone, reddish-brown, ferruginous, micaceous, non-calcareous, fine-grained, well-indurated	5.0
Shale, brown, highly sandy and silty, poorly exposed	20.0
Shale, very dark-gray to black, carbonaceous, platy; includes several layers of dark-purple-brown ironstone concretions that rarely contain marine fossils and occasionally grade into limestone; also includes small, spheriodal phosphatic nodules in lower part of unit	21.0
Limestone, dark-gray, impure, abundantly fossiliferous; bedding thin and irregular; includes a very thin ferruginous coaly zone at base unit (Inola Limestone)	0.8
Shale, dark-gray	4.7
Coal, black; grades downward into coaly shale (unnamed coal)	0.3
Underclay, light-gray and black; contains abundant thin, compressed, carbonized layers of plant fragments	0.6

Sandstone, buff to brown, ferruginous, fine-grained, noncalcareous, thin-bedded	3.6
Covered interval	2.0
Coal, black with reddish-brown staining on cleat surfaces (Bluejacket coal)	0.6
Underclay, orange and black; includes carbonized layers of plant material	0.4
Shale, gray and reddish-orange, banded, oxidized in part	7.0
Sandstone, olive-tan, very fine-grained, non-calcareous, micaceous, thin-bedded; includes scattered ferruginous concretions; weathers to flakes in lower part (Bluejacket Sandstone)	2.5
Savanna Formation	
Shale, gray, weathers tan-brown; includes scattered ironstone concretions	16.0
Limestone, light-gray, impure, fossiliferous	0.4
Shale, black, highly carbonaceous	0.1
Coal, black, weathered (Drywood coal)	0.3
Covered interval	44.0
Shale, dark-gray, weathers gray-brown	1.7
Covered interval	30.0
Sandstone, tannish-brown, micaceous, fine-grained, thin-bedded, poorly exposed	2.5
Total	163.5

MS 4
(Type Section for the Inola Limestone)

NE¼NW¼NW¼ sec. 18, T. 21 N., R. 18 E., Mayes County. Measured in fresh road cut on Oklahoma Highway 20 a few yards east of the northwest corner of the section, by Tillman (1952, p. 32).

	Thickness (ft)
Krebs Group	
Boggy Formation	
Shale, black, soft, fissile, with interbeds of clay-ironstone	16.0
Upper Inola limestone, irregularly massive bedded, fine-crystalline, light-gray, and fossiliferous; weathers into gray to reddish-brown layers	3.5
Coal	0.2
Underclay, soft, gray	1.5
Shale, soft, light-gray	2.5
Second Inola limestone, gray to red, rich in iron, silty, fossiliferous	0.5
Shale, gray to tan, silty	4.0
Third Inola limestone, gray, compact, fossiliferous, weathers quickly to an iron-stained clay	2.1
Underclay, gray	1.5
Shale, soft and fissile, becomes more silty towards top	3.0
Lower Inola limestone, light-gray with dark-gray spots, compact, fossiliferous—contains fusulinids, weathers rapidly	1.9
Coal	0.04
Underclay, gray	1.0
Shale, light-gray, calcareous	2.0
Bluejacket sandstone	55.0
Total	94.74

Appendix 2

Core-Hole Log

CH 1
(OGS Core and Sample Library No. C RM 1)
(Reference Well for the Inola Limestone)

SE¼SE¼SW¼NW¼ sec. 18, T. 21 N., R. 18 E., Mayes County, Oklahoma. Well cored by Oklahoma Geological Survey; lithologic descriptions by LeRoy A. Hemish. Drilled in pasture on hill south of pond. (Surface elevation, estimated from topographic map, 815 ft.)

	Depth to unit top (ft)	Thickness of unit (ft)
PENNSYLVANIAN SYSTEM		
Desmoinesian Series		
Krebs Group		
Boggy Formation		
Sandstone, moderate-reddish-brown, very fine-grained, noncalcareous, weathered	0.0	4.0
Sandstone, grayish-orange with dusky-brown flecks, very fine-grained, micaceous, noncalcareous, thin-bedded, weathered	4.0	4.5
Shale, dark-yellowish-orange to light-brown to pale-yellowish-brown, interlaminated with siltstone and very fine-grained sandstone, noncalcareous, weathered	8.5	2.0
Shale, grayish-black with dark-yellowish-orange bands, non-calcareous; contains some thin stringers of light-gray siltstone; fractured	10.5	2.5
Shale, grayish-black with medium-light-gray sideritic bands, noncalcareous	13.0	7.8
Shale, grayish-black to black, noncalcareous; contains light-brownish-gray sideritic concretions up to 2 in. thick	20.8	2.8
Limestone, light-brownish-gray, fine-grained, micritic, nonfossiliferous	23.6	0.5
Shale, grayish-black, noncalcareous; contains rare pyrite-filled burrows and light-brownish-gray sideritic concretions up to 1.5 in. thick	24.1	14.4
Limestone, medium-dark-gray to light-gray, impure, shaly, fossiliferous; contains abundant broken shells and other fossil fragments; becomes darker gray in lower 1 ft, with better preserved fossil shells; includes a 1⁄16-in.-thick coal stringer at contact with underlying unit (upper unit of Inola Limestone Member)	38.5	3.7
Underclay, medium-dark-gray to medium-light-gray, blocky fracture, carbonaceous in upper part	42.2	1.5
Shale, greenish-gray, clayey, noncalcareous; contains some bioturbation features in lower 8 in.	43.7	1.1
Limestone, light-gray with very light-gray mottling, fine-grained, hard; contains fossil shells and fossil fragments	44.8	1.5
Underclay, light-gray with minor grayish-black streaks, blocky fracture, silty; grades into underlying unit	46.3	2.2

Limestone, very light-gray, fine-grained, calcarenitic; contains rare fossil shells and minor disseminated pyrite; cross-bedded (basal unit of Inola Limestone Member)	48.5	5.4
Shale, medium-gray, noncalcareous, carbonaceous, pyritic; includes two coal layers totaling 0.75 in. in thickness at contact with overlying unit	53.9	0.1
Coal, black, bright, moderately friable, pyrite and calcite on cleats; includes a 4-in.-thick carbonaceous shale parting from 55.0 to 55.3 ft; 6 in. of coal below parting contains some thin shale laminae (Bluejacket coal)	54.0	1.8
Shale, medium-dark-gray, silty, sandy, coaly in upper part; contains abundant, well-preserved, black, carbonized plant compressions	55.8	0.4
Sandstone, light-gray with medium-dark-gray shale streaks, micaceous, very fine-grained, noncalcareous, rippled; contains abundant black, carbonized and pyritized plant fragments (upper unit of Bluejacket Sandstone)	56.2	3.9
Siltstone, medium-light-gray, interbedded with medium-dark-gray shale, noncalcareous, wavy-bedded and cross-laminated in part, burrowed; contains black, carbonized plant fragments	60.1	2.9
Shale, dark-gray with medium-light-gray siltstone bands and streaks, noncalcareous; contains black, carbonized plant fragments and rare light-brownish-gray sideritic concretions; contact with underlying unit sharp	63.0	10.7
Sandstone, medium-light-gray, fine-grained, noncalcareous, micaceous; contains scattered dark-gray shale streaks and pebbles, as well as numerous streaks of black coalified plant material; shows flame structure and flaser bedding in places; includes some coal spars up to 1.5 in. thick in lower 8 in. of unit; contact with underlying unit sharp (basal unit of Bluejacket Sandstone)	73.7	21.4
Savanna Formation		
Ironstone, brownish-gray; contains a thin, diagonal streak of white gypsum	95.1	0.2
Shale, black, noncalcareous	95.3	0.7
Limestone, dark-gray, impure, silty, contains abundant fossil shells and fossil fragments	96.0	0.4
Shale, black, coaly, calcareous	96.4	0.1
Coal, black, moderately friable; contains pyrite in thin lenses and streaks (Drywood coal)	96.5	0.1
Shale, medium-gray, noncalcareous; silty, wavy-laminated; contains black, carbonized plant fragments; includes 2 in. of poorly developed underclay at top of unit; contains scattered pyrite-filled burrows and light-brownish-gray sideritic concretions up to 1.25 in. thick	96.6	7.5
Shale, medium-dark-gray with grayish-black and black streaks, weakly calcareous; contains carbonaceous and pyritic layers as well as streaks of coal	104.1	0.1
Underclay, medium-gray, blocky fracture, slickensided, burrowed, silty	104.2	2.1
Siltstone, medium-light-gray, noncalcareous, shaly	106.3	0.6

Shale, grayish-black with light-brownish-gray bands in upper 6 ft, noncalcareous, burrowed; contains pyrite masses and sideritic concretions up to 1.25 in. thick	106.9	8.1
Shale, grayish-black, noncalcareous; contains rare pyrite-filled burrows, small, calcareous fossil shells, and white calcite in veinlets and on bedding planes; contains some light-brownish-gray sideritic concretions up to 1 in. thick in lower 3.5 ft of unit	115.0	11.8
Limestone, grayish-black, impure, silty, fine-grained, fossiliferous; contains shell fragments and small crinoid ossicles	126.8	0.1
Shale, grayish-black, noncalcareous; includes thin, very light-gray streaks of calcareous siltstone and sandstone	126.9	1.6
Limestone, grayish-black, impure, silty, fossiliferous; contains fossil hash; grades into underlying unit	128.5	0.1
Shale, black, very calcareous; contains abundant white fossil shells and crinoid ossicles; grades into underlying unit	128.6	2.4
Limestone, grayish-black, very impure, silty, shaly, carbonaceous; fossiliferous; contains fossil hash (Doneley Limestone)	131.0	0.8
Coal, black, bright, moderately friable, white calcite and pyrite on cleat surfaces (Rowe coal)	131.8	0.7
Underclay, brownish-gray, silty; contains black, carbonized plant fragments	132.5	1.8
Shale, medium-light-gray, silty, noncalcareous	134.3	1.5
Mudstone, medium-light-gray, noncalcareous	135.8	2.2
Sandstone and siltstone, medium-gray, shaly, very fine-grained, noncalcareous, laminated, burrowed	138.0	2.0
Shale, medium-dark-gray with light-gray streaks of siltstone and very fine-grained sandstone, noncalcareous, extensively burrowed; includes rare, light-brownish-gray sideritic concretions	140.0	9.3
Shale, medium-dark-gray, noncalcareous; contains rare, thin streaks of light-gray siltstone	149.3	13.0
Limestone, brownish-gray, impure, shaly, fine-grained; contains abundant fossil hash; includes a 0.5-in.-thick band of black, carbonaceous shale at base of unit (Sam Creek Limestone)	162.3	0.2
Underclay, medium-dark-gray, churned, slickensided	162.5	1.9
Shale, dark-gray, silty, sandy, noncalcareous; contains large bioturbation features filled with brownish-gray, very fine-grained sandstone	164.4	2.3
Shale, dark-gray with light-gray siltstone streaks and lenses, noncalcareous; contains rare light-brownish-gray sideritic concretions	166.7	4.1
Coal, black, interbedded with dark-gray, noncalcareous, slickensided shale and layers of pyrite up to 1/16 in. thick	170.8	0.7
Coal, black, bright, moderately friable, pyrite and calcite on cleat surfaces (unnamed coal)	171.5	0.3
Underclay, medium-gray, soft	171.8	0.4
Shale, medium-light-gray, burrowed, noncalcareous; includes a 0.5-in.-thick layer of fossiliferous limestone 4 in. above base of unit	172.2	4.8

Limestone, medium-dark-gray with light-brownish-gray sideritic bands ~1 in. thick, impure, shaly, fossiliferous; contains abundant brachiopod shells and fossil hash (Spaniard Limestone)	177.0	1.0
McAlester Formation		
Underclay, medium-gray, churned; contains a 2-in.-thick, calcarenitic limestone layer at 178.8 ft	178.0	1.7
Shale, medium-dark-gray to dark-gray, noncalcareous, brittle; includes rare, light-brownish-gray, sideritic concretions; extensively bioturbated in upper 15 in. of unit; contains rare burrows and streaks of pyrite in remainder of unit, with minor streaks of light-gray siltstone	179.7	24.1
Coal, black, slightly friable, white calcite on cleat surfaces (unnamed coal)	203.8	0.2
Underclay, medium-light-gray, blocky fracture; contains black, carbonized plant fragments; soft, crumbly	204.0	1.5
Shale, medium-gray, noncalcareous, blocky fracture	205.5	1.3
Siltstone, medium-gray, shaly, noncalcareous, hard	206.8	1.0
Shale, medium-gray, noncalcareous, blocky; contains light-gray siltstone streaks and lenses	207.8	2.2
Shale, dark-gray to grayish-black, noncalcareous; contains light-gray siltstone streaks and light-brownish-gray sideritic concretions up to 1.5 in. thick	210.0	5.8
Coal, black, slightly friable; calcite and minor pyrite on cleats (Keota[?] coal)	215.8	0.3
Underclay, medium-gray, churned; contains black, carbonaceous streaks	216.1	1.5
Siltstone, medium-light-gray to medium-dark-gray, very shaly, noncalcareous, extensively burrowed, grades into underlying unit	217.6	2.4
Sandstone, medium-light-gray with dark-gray shale streaks, very fine-grained, noncalcareous, rippled, burrowed	220.0	1.6
Shale, grayish-black, noncalcareous	221.6	1.2
Coal, black, moderately friable, white calcite on cleat surfaces (unnamed coal)	222.8	0.2
Underclay, medium-dark-gray, blocky fracture, slickensided	223.0	0.8
Shale, medium-dark-gray, noncalcareous, silty; grades into shaly sandstone	223.8	0.6
Sandstone, medium-gray, very fine-grained, very silty and shaly, noncalcareous	224.4	3.6
Shale, medium-dark-gray, silty and sandy, noncalcareous, burrowed	228.0	3.7
Shale, dark-gray with light-gray, very fine-grained sandstone streaks, rippled, burrowed, noncalcareous	231.7	2.5
Shale, grayish-black, noncalcareous; contains rare streaks of light-gray siltstone and pyrite-filled burrows; includes abundant black, macerated plant fragments on some bedding planes	234.2	32.4
Coal, black, slightly friable; contains pyrite masses and white calcite on cleat surfaces (Tamaha[?] coal)	266.6	0.1
Underclay, medium-gray, rooted, blocky fracture, slickensided; contains black, carbonized plant fragments	266.7	1.3

Shale, medium-light-gray, noncalcareous; interbedded with light-gray, very fine-grained, calcareous sandstone; extensively bioturbated; includes abundant sandstone-filled burrows	268.0	2.5
Shale, medium-dark-gray, noncalcareous; includes some ⅛-in.-thick, light-brownish-gray sideritic layers in bottom 1 ft of unit	270.5	4.8
Limestone, yellowish-gray, fine-grained, hard; contains abundant fossil shells, small crinoid ossicles, and other fossil debris; shaly in bottom 2 in. of unit	275.3	0.6
Shale, medium-dark-gray, noncalcareous	275.9	2.1
Shale, medium-gray, sandy, silty, noncalcareous, burrowed	278.0	1.3
Shale, dark-gray, noncalcareous; contains rare, thin streaks of light-gray siltstone in upper 3 in.	279.3	3.6
Shale, grayish-black, noncalcareous; contains rare, pyrite-filled burrows; includes light-brownish-gray, sideritic concretions up to 1.5 in. thick	282.9	7.4
Limestone, light-brownish-gray, fine-grained, impure, silty; shaly in upper 4 in., with pyritic masses up to 0.25 in. thick filling burrows; contains abundant fossil hash, including broken shells and small crinoid ossicles	290.3	1.6
Mudstone, dark-gray, churned; sand- and pyrite-filled burrows abundant, noncalcareous	291.9	2.1
Shale, medium-gray to dark-gray with abundant light-gray siltstone and very fine sandstone layers up to 0.75 in. thick, noncalcareous, wavy-bedded, burrowed	294.0	4.3
Shale, dark-gray with minor light-gray siltstone streaks, noncalcareous; contains rare pyrite-filled lenses and burrows, and small sideritic nodules; includes some black, carbonized plant fragments on bedding planes	298.3	18.5
Limestone, dark-gray to light-brownish-gray, fine-grained, hard; contains abundant broken fossil shells and small crinoid ossicles	316.8	0.7
Coal, black, slightly friable, white calcite on cleat surfaces (Stigler[?] coal)	317.5	0.1
Siltstone, medium-dark-gray, hard; grades into underlying unit	317.6	0.8
Shale, medium-dark-gray, silty, noncalcareous	318.4	0.6
Shale, black, noncalcareous	319.0	1.0
Siltstone, dark-gray, noncalcareous; very hard; contains scattered fossil shells and crinoid ossicles	320.0	0.4
Shale, medium-gray, blocky fracture, noncalcareous, burrowed	320.4	0.5
Shale, grayish-black with thin, scattered streaks of light-gray, very fine-grained sandstone and siltstone, noncalcareous; contains rare, small burrows and minor black plant compressions on bedding planes; includes some pyrite in burrows and lenses	320.9	22.4
Coal, black, slightly friable; veinlets of white calcite and pyrite occur on bedding surfaces and in cleats (unnamed coal)	343.3	0.2
Underclay, medium-gray; contains black, carbonized plant fragments; blocky fracture, slickensided, pyritic	343.5	2.5

Shale, medium-dark-gray, silty, noncalcareous; contains abundant sandstone-filled burrows, pyritic	346.0	1.3
Shale, dark-gray to grayish-black, noncalcareous, slickensided; contains rare light-gray siltstone streaks, and pyrite-filled burrows	347.3	6.4
Shale, black, calcareous; contains abundant fossil shell fragments as well as an irregular-shaped, fossiliferous, light-brownish-gray limestone mass 1 in. thick	353.7	0.3
Coal, black, moderately friable; contains white calcite on cleats as well as pyrite occurring as lenses and crusts on bedding planes (unnamed coal)	354.0	0.2
Sandstone, medium-light-gray with minor dark-gray shale streaks, noncalcareous, micaceous, very fine-grained, irregular-bedded to wavy-bedded; contains scattered shale pebbles in places (upper unit of Warner Sandstone)	354.2	3.9
Sandstone, light-gray with dark-gray shale streaks, calcareous, rippled; scour features and burrows abundant; micaceous	358.1	1.6
Siltstone, dark-gray, shaly, noncalcareous; includes abundant light-gray, very fine-grained sandstone burrows; pyritic and coaly in lower 1 in. of unit	359.7	0.8
Coal, black, bright, moderately friable; contains pyrite in cleats (Keefton coal)	360.5	0.4
Siltstone, dark-gray, noncalcareous; contains carbonaceous particles and coal streaks; bioturbated	360.9	0.3
Sandstone, light-gray to medium-gray, very fine-grained, noncalcareous; churned in upper part; contains some black, carbonized, fibrous plant material; cross-bedded in middle part; flat-bedded in lower part, with some convolute bedding near base of unit (basal unit of Warner Sandstone)	361.2	4.0
Siltstone, medium-dark-gray with light-gray streaks, noncalcareous, sandy, micro-faulted and burrowed; contains siderite-filled burrows just above contact with underlying unit (upper unit of McCurtain Shale Member)	365.2	0.4
Shale, grayish-black, noncalcareous; brittle; contains scattered calcareous and pyritized marine fossils and pyrite-filled burrows; slickensided; includes a 3-in.-thick layer of brownish-gray, mottled ironstone occurring as burrow fillings	365.6	15.9
Ironstone, brownish-gray with white, calcite-filled fractures, pyritic	381.5	0.3
Limestone, medium-dark-gray, impure, shaly; contains broken fossil fragments (basal unit of McCurtain Shale Member)	381.8	0.1
Hartshorne(?) Formation		
Sandstone, medium-gray, very fine-grained, calcareous; includes beds of noncalcareous, medium-gray shale; wavy-bedded; grades into underlying unit	381.9	0.9
Atoka(?) Formation		
Shale, dark-gray with very light-gray streaks of very fine-grained, calcareous sandstone; contains some burrows	382.8	1.7

Shale, grayish-black, noncalcareous; contains light-brownish-gray sideritic concretions up to 2 in. thick; includes rare streaks of light-gray siltstone, small fossil shells, and pyrite lenses; becomes calcareous and contains some irregular beds and lenses of calcarenitic limestone . .	384.5	15.7
Sandstone, light-gray, silty, very fine-grained; contains dark-gray shale clasts and pyritic coal streaks; very calcareous .	400.2	0.3
Underclay, medium-light-gray, sandy, blocky fracture; contains rare disseminated pyrite and black, carbonized plant fragments	400.5	0.8
Shale, medium-gray, noncalcareous, interbedded with light-gray, very fine-grained, calcareous sandstone	401.3	0.7
Limestone, light-brownish-gray, fine-grained, hard; contains scattered, broken shell fragments	402.0	0.3
Shale, medium-gray to dark-gray, noncalcareous; contains thin streaks of light-gray siltstone and rare burrows	402.3	4.0
Shale, grayish-black, silty, noncalcareous; contains abundant streaks of white, very fine-grained, calcareous sandstone; burrowed, slickensided; streaks of sandstone occur rarely .	406.3	17.2
Shale, light-brownish-gray, blocky fracture, noncalcareous . .	423.5	1.3
Sandstone, light-gray, very fine-grained, interbedded with medium-light-gray siltstone and shale, noncalcareous, wavy-bedded in part; brownish-gray, fine-grained, and massive, with some indistinctly defined fossil shells; medium-gray, very fine-grained, silty and shaly in lower 5 in. of unit	424.8	2.1
Shale, dark-gray to grayish-black, noncalcareous; contains rare pyrite-filled burrows; includes light-brownish-gray sideritic concretions up to 3.5 in. thick; slickensided	426.9	5.9
Siltstone, light-bluish-gray to medium-light-gray, very shaly, noncalcareous, flat-bedded to cross-bedded in part; grades into underlying unit	432.8	2.2
Shale, medium-gray with light-gray streaks of siltstone, noncalcareous, slickensided	435.0	1.5
Shale, dark-gray with light-gray streaks of siltstone and very fine-grained sandstone, noncalcareous, cross-bedded, burrowed	436.5	2.5
Sandstone, light-gray with medium-dark-gray shale streaks, very fine-grained, rippled, burrowed; contains a pyritic coal spar in upper 1 in.; noncalcareous, except for lower 2 in., which contain calcarenite-filled burrows	439.0	0.7
Fayetteville Formation(?) (Mississippian)		
Limestone, medium-gray in upper part to light-gray in lower part, calcarenitic; shaly and burrowed in upper part; contains thin, wavy shale streaks in lower part	439.7	1.3
Total depth		441.0

NEW OGS PUBLICATION

BULLETIN 144. *Coal Geology of Rogers County and Western Mayes County, Oklahoma,* by LeRoy A. Hemish. 118 pages. Clothbound, $30; paperbound, $24.

The Oklahoma Geological Survey has published the second in a series of studies that evaluates the coal reserves and resources of Oklahoma on a county basis. Issued as Bulletin 144, the new report covers Rogers County and western Mayes County in Oklahoma.

Author LeRoy A. Hemish, a coal geologist at the OGS, conducted this study to determine the location, amounts, and quality of the coal beds, and the stratigraphy of the coal beds and associated strata. While some 38,691,000 tons of coal have been mined or lost in mining in the area, Hemish has estimated the remaining resources at 392,918,000 tons, with estimated reserves of 62,910,000 tons. "Remaining resources" is the term used for all the coal still in the ground that has the potential for economic extraction. Current price levels, however, may not be sufficient to make mining of all resources economical. The term "reserves" is used for that portion of the resources that can be mined currently at a profit.

The Iron Post coal leads with 16,456,000 tons of reserves, while the Croweburg coal has the greatest remaining resources, 113,713,000 tons.

Summary information on reserves and resources is contained in tables and is listed according to township, coal thickness, county, and coal bed. Detailed data on estimated original, mined, and remaining coal resources and reserves are tabulated by township for each county according to coal thickness, overburden thickness, and reliability category. The text covers coal quality, coal rank, geology, and economics. The book is illustrated with photographs of active and abandoned coal mines and includes histograms showing reported coal production.

Included with Bulletin 144 are eight plates that show the outcrop boundaries of commercially important coal beds. The maps show the thickness of both the beds and the overburden. One plate shows structure contours, and three plates contain stratigraphic cross sections that form a crisscrossing network throughout the study area.

Appendixes provide details on resources and reserves, measured sections, and coal analyses.

Bulletin 144 can be obtained over the counter or postpaid from the Survey at 100 E. Boyd, Room N-131, Norman, OK 73019; phone (405) 325-3031.

AAPG SOUTHWEST SECTION CONVENTION
Wichita Falls, Texas, March 11–13, 1990

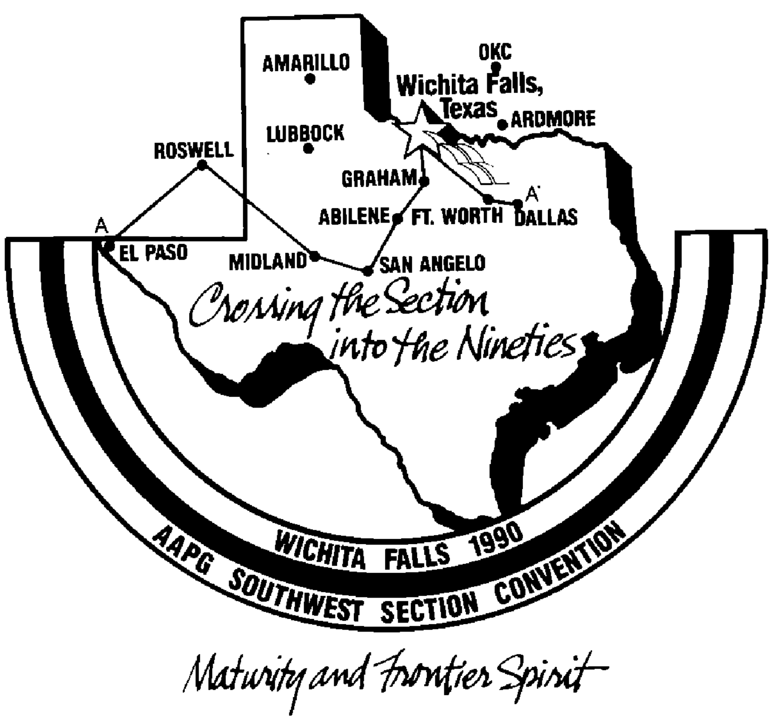
Hosted by the North Texas Geological Society, the theme of this year's AAPG Southwest Section Convention is "Crossing the Section into the '90s: Maturity and Frontier Spirit," stressing the need for frontier-style creativity to maintain successful exploration strategies across the mature areas in the Southwest.

The program calls for papers to be presented in technical sessions dealing with (1) Seismic and Geochemical Exploration Techniques; (2) Depositional Environments, Characteristics, and Field Studies of Producing Reservoirs; and (3) Applied Stratigraphy and Diagenesis in Exploration.

R. Nowell Donovan, Moncrief Chair of Geology at Texas Christian University, will lead a one-day, pre-convention field trip through the Slick Hills of southwestern Oklahoma. The principal theme to be addressed is stratigraphy and sedimentology of the Arbuckle Group, with attention to dolomitization, structural style, and hydrocarbon migration.

A pre-convention short course entitled "Current Seismic Technologies for Finding and Defining Hydrocarbon Reservoirs" will be taught by Norman S. Neidell.

For further information about the meeting, contact Will Tucker, Technical Program Co-Chairman, 825 MBank Building, Wichita Falls, TX 76301.



Clifford A. Merritt
(1899–1989)

In Memoriam

CLIFFORD A. MERRITT

Former University of Oklahoma Professor Emeritus of Geology

Dr. Clifford Addison Merritt, University of Oklahoma professor emeritus of geology, died November 2, 1989, in St. Petersburg, Florida. He and his wife, Dr. Iva Merritt, had moved from Norman to St. Petersburg in late September.

Dr. Merritt was born August 18, 1899, in Copetown, Ontario, Canada. He was the eldest of twelve children. He graduated from high school in Winnepeg, Manitoba, Canada, in 1916. In 1917–18, he served in the Canadian Navy and was stationed in Halifax, Nova Scotia. He completed his B.S. degree at the University of Manitoba in 1922 and his M.S. degree in geology and chemistry in 1924. In 1929, he completed requirements for the Ph.D. degree in geology from the University of Chicago. During the 1920s, he spent two summers in the Yukon and six summers in the Hudson Bay area of Canada, working with the Canadian Geological Survey.

Cliff joined the faculty of the Department of Geology, University of Oklahoma, in 1926. He became an associate professor in 1935 and full professor in 1939. He taught courses in mineralogy, petrology, and economic geology. He retired from the faculty in 1970 at the age of 70, having completed 44 continuous years of teaching. He did extensive field and laboratory work on the rocks of the Arbuckle and

Wichita Mountains of Oklahoma and published numerous articles on the geology of those areas. He directed numerous theses in petrology and led several field trips through the Arbuckles and Wichitas. He worked with Dr. C. E. Decker, Dr. William E. Ham, Gerald Chase, and other members of the Oklahoma Geological Survey. In 1958, he received a research grant from the University Alumni Fund to complete his work on the geology of the Lake Altus area.

Cliff was a fellow of the American Mineralogical Society, a member of the American Association of Petroleum Geologists, Sigma Xi, Geochemical Society, and the Oklahoma Academy of Science. He enjoyed a reputation of being an excellent teacher and a good friend of faculty and students alike. His hobbies included the cutting and mounting of gem stones, and golf. He continued playing golf until his 90th birthday.

His contributions to geological literature include *Physical Characteristics of the Arbuckle Limestone*, Oklahoma Geological Survey Circular 15, 1928 (with C. E. Decker); *Stratigraphy and Physical Characteristics of the Simpson Group*, Oklahoma Geological Survey Bulletin 55, 1931 (with C. E. Decker); *Iron Ores*, Oklahoma Geological Survey Mineral Report 4, 1940; *Iron Ores of the Wichita Mountains, Oklahoma*, Economic Geology, vol. 34, 1939; *Copper in the Red Beds of Oklahoma*, Oklahoma Geological Survey Mineral Report 8, 1940; *Barite in Oklahoma*, Oklahoma Geological Survey Circular 23, 1944 (with W. E. Ham); *Meers Quartzite*, Oklahoma Academy of Science Proceedings, vol. 33, 1954; *Igneous Geology of the Lake Altus Area, Oklahoma*, Oklahoma Geological Survey Bulletin 76, 1958; *Mineralogy of the Miarolitic Cavities of the Granites, Wichita Mountains, Oklahoma*, Oklahoma Academy of Science Proceedings, vol. 33, 1954; *Basement Rocks of Southern Oklahoma*, Oklahoma Geological Survey Bulletin 95, 1964 (with W. E. Ham and Rodger E. Denison); *Mount Scott Granite, Wichita Mountains, Oklahoma*, Oklahoma Geology Notes, vol. 25, 1965; *Rim Albite in Coarse-Grained Quanah Granite, Wichita Mountains, Oklahoma*, Oklahoma Geology Notes, vol. 26, 1966; *Names and Relative Ages of Granites and Rhyolites in the Wichita Mountains, Oklahoma*, Oklahoma Geology Notes, vol. 27, 1967. He also wrote a laboratory manual entitled *Mineralogy, An Introduction to the Study of Minerals and Crystals*, published by the University of Oklahoma Book Exchange (1949).

Dr. Clifford Merritt will be long remembered by his colleagues and friends for his honesty and integrity, his sense of fair play, and his thoughtful approach to our mutual problems. The Clifford Merritt Petrology Fund has been established in his honor in the School of Geology and Geophysics. Donations may be made to the OU Foundation, 100 Timberdell Road, Norman, OK 73019, and designated to the Clifford Merritt Petrology Fund.

George G. Huffman

INDUSTRY SUPPORTS OU PROGRAMS

• **Conoco/Du Pont** has given $216,500 to benefit several University of Oklahoma programs. The gift provides $100,000 to the College of Geosciences for the Energy Center tower project, representing the fourth year of a five-year $500,000 commitment to fund a floor in the tower.

Chemical engineering will receive $50,000, the second installment of a five-year, $250,000 pledge to fund the Conoco/Du Pont Professorship in Chemical Engineering, and an additional $10,000 general grant. The University Libraries also was granted $10,000. Geology and geophysics received $7,500; general engineering, $6,000; and chemistry, civil engineering, mechanical engineering, petroleum engineering, and the College of Business Administration each received $5,000. Engineering also received an $8,000 minority education grant.

• **Seismograph Services of Tulsa** presented to the University of Oklahoma computer software capable of processing three-dimensional seismic data. Part of a research cooperative agreement, the software is valued at more than $120,000. Geology and geophysics faculty and students will use the Phoenix proprietary geophysical software to conduct research in rock elastic properties and develop software for Seismograph.

The new software will be used on the Geosciences Computing Network, forming a necessary complement to OU's existing Seismograph Phoenix two-dimensional seismic software that is now used for research and teaching in seismic stratigraphy, the imaging of rocks and fluids, and their age determination in the subsurface. Presently used by the petroleum industry worldwide to determine the oil and gas potential in the subsurface by direct 3-D imaging of land and marine seismic data, the software is also currently receiving considerable attention for reservoir development.

• **Don O. Chapell**, University of Oklahoma alumnus, has given his alma mater $100,000 to establish the Geology and Geophysics Computer Enhancement Fund. The contribution will be used in conjunction with grants from the Digital Equipment Corp. to upgrade the Geosciences Computing Network. The network is used by College of Geosciences faculty and students for a variety purposes, including providing software used in exploring for minerals and energy, mapping forests, managing land use, predicting agricultural crop yields, and numerically forecasting the weather. The gift will enable the network to double the capacity of a new Digital Equipment Corp. mainframe as well as provide funds to enhance computer-based seismic processing. Chapell, a 1933 OU geology graduate, is an independent geologist and oil producer in Dallas.

• **Phillips Petroleum Foundation**, marking its 23rd year of educational funding assistance to OU, has made a gift of $76,300, $50,000 of which is part of a new $250,000, five-year commitment to fellowships and scholarships. A portion of the gift will support professional development funds in various disciplines.

Five $5,000 graduate research fellowships will be established in chemical engineering and mechanical engineering in the College of Engineering; accounting and management information systems in the College of Business Administration; and geophysics in the College of Geosciences. The gift will make possible new or expanded scholarships in several academic areas including law, engineering, and management information systems.

Of the total, $14,300 will support the professional development funds in the colleges of arts and sciences, law, engineering, and business administration and the office of Career Planning and Placement Services.

- **Mobil Foundation** and Mobil operating units have contributed $42,400 to the colleges of business administration, engineering, and geosciences. Sharing in the gift are the minority engineering program, which received $10,000; chemical engineering, $3,400; geology and geophysics, $3,000; mechanical engineering, $3,000; petroleum engineering, $5,000 for general support and $3,000 for scholarships; and petroleum land management, $5,000. In addition, two professors in the School of Geology and Geophysics each received $5,000 for their research programs.

- **Sun Exploration and Production Co.** has made a $22,000 gift to OU's School of Petroleum and Geological Engineering under its new name, Oryx Energy Co. Of the total, $20,000 will be used to fund salary supplements, awards to professors or financial assistance to petroleum engineering graduate students pursuing careers in U.S. education. The company will provide two $1,000 grants to petroleum engineering students who exhibit outstanding scholastic ability.

- **Chevron U.S.A.** presented a $3,000 gift to the University of Oklahoma as part of the company's aid to education program, contributing to a broad range of educational, cultural, and human services programs.

NOTES ON NEW PUBLICATIONS

A Computerized Data-Base System for Land-Use and Land-Cover Data Collected at Ground-Water Sampling Sites in the Pilot National Water-Quality Assessment Program

Data-base software has been developed for the management of land-use and land-cover data collected by the USGS as part of a pilot program to test and refine concepts for a National Water-Quality Assessment Program. Jonathon C. Scott describes the purpose, use, and design of the land-use and land-cover data-base software in this 139-page water-resources investigation report.

Order WRI 89-4172 from: U.S. Geological Survey, Water Resources Division, 215 Dean A. McGee Ave., Room 621, Oklahoma City, OK 73102; phone (405) 231-4256. A limited number of copies are available free of charge.

OKLAHOMA ABSTRACTS

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

Oil and Gas Developments in Oklahoma and Panhandle of Texas in 1988

ROBERT E. FRYKLUND, Amerada-Hess Corp., 1201 Louisiana, Houston, TX 77002

Exploitation of existing fields and discoveries remained the focus with development wells outnumbering exploratory wells 13 to 1 in 1988. The total number of development wells, however, remained flat from 1987 to 1988, but exploratory wells increased 3.9%. The success rate for exploratory wells remained the same; the success rate for development wells decreased 5.1%. The Sedgwick shelf was the most actively explored trend with 44 wells completed in 1988.

Two significant 1987 discoveries led to increased wildcatting in the Arkoma and Ardmore–Marietta basins. Elsewhere in Oklahoma, the dominant plays were the Misener and Wilcox in Grant County; the pre-Pennsylvanian on the Sedgwick shelf in Alfalfa County; the Viola, Hunton, and Wilcox along the Pauls Valley uplift in Pottawatomie County; and the Morrow–Springer in the Anadarko basin.

Ultra-deep drilling resumed with the spudding of 28,500-ft Arbuckle tests by both Exxon and Unocal in Beckham County, Oklahoma.

Consolidation and sales of assets continued with more than 15 companies buying or selling out in 1988.

Reprinted as published in the American Association of Petroleum Geologists *Bulletin*, v. 73, p. 130.

Preservation of Sandstone Reservoir Quality and Methane Reserves in Overmature Strata of Arkoma Basin

DAVID W. HOUSEKNECHT and LORI A. HATHON, Dept. of Geology, University of Missouri, Columbia, MO 65211

Since the pioneering work of David White in the Appalachians (1915), it has been widely assumed that there are thermal maturity limits on the occurrence of oil and gas. Recent literature indicates that no commerical gas accumulations exist above a vitrinite reflectance (R_0) of about 3%—not because methane is thermally degraded, but because it is thought that reservoir quality is destroyed by high temperatures. However, in the Arkoma basin prolific methane reserves are found in strata

that range from less than 1% to about 5% R_o, with no apparent relationship between thermal maturity and reservoir quality.

Petrography of reservoir sandstones in the Atoka Formation (Pennsylvanian) indicates that facies-selective diagenetic processes that occurred during shallow burial preserved porosity in some sandstones and destroyed porosity in others. During deeper burial, accumulation of hydrocarbons (including oil in some reservoirs) in porous sandstones located in favorable structural positions effectively terminated inorganic diagenesis and prevented further deterioration of reservoir quality. However, inorganic diagenesis proceeded below hydrocarbon-water contacts, resulting in nearly total destruction of porosity. This postaccumulation diagenesis occurred during or following metagenesis as evidenced by quartz cement that fills bubbles and cracks in pyrobitumen.

Good reservoir quality was thus preserved in Atokan sandstones from which water had been displaced by hydrocarbon accumulation, whereas reservoir quality was totally destroyed by high-temperature diagenesis in wet sandstones. This indicates that methane exploration is viable in overmature strata if trap formation and hydrocarbon accumulation predated metagenesis.

Reprinted as published in the American Association of Petroleum Geologists *Bulletin*, v. 73, p. 1160.

Seismic Stratigraphy of Upper Pennsylvanian Swope Limestone of Kansas and Oklahoma: Quantification of Thin-Bed Porosity through Attribute Analysis

M. N. AUSTIN, Conoco Inc., Lafayette, LA, and University of Oklahoma, Norman, OK; and J. D. PIGOTT and J. M. FORGOTSON, JR., School of Geology and Geophysics, University of Oklahoma, Norman, OK 73019

The Upper Pennsylvanian Swope Limestone is a prolific oil- and gas-producing reservoir in central and western Kansas and northwestern Oklahoma. However, rapid lateral variations in the oolitic lithofacies impede the prediction of reservoir quality from available well control.

A detailed attribute modeling and interpretative analysis using MIRA (Oklahoma Seismic Corp.) software of Vibroseis-acquired and conventional zero-phase processed seismic were conducted on the Swope interval in Comanche County, Kansas, and Woods County, Oklahoma. Three discrete ranges of fluid-filled porosity thickness can be delineated: less than 1.5 m, 1.5–3.0 m, and greater than 3.0 m. Thin-bed detection below the classic 1/30 wavelength threshold is possible in this setting owing to constructive wavelet tuning from multiple acoustic interfaces.

Optimal application of this attribute modeling/interpretation method to oil and gas exploration and exploitation is controlled by the accuracy of the geologic model and the quality of the acquired and processed data.

Reprinted as published in the American Association of Petroleum Geologists *Bulletin*, v. 73, p. 329.

Misener Sand Development over Basement Features Defined by High-Density Ground-Based Geomagnetic Surveys in Grant County, OK

MICHAEL W. SMITH and DAVID G. SMITH, Petro Magnetics, Inc., 4334 N.W. Expressway, Oklahoma City, OK 73116

The highly prolific Misener sand production being developed in Grant County, Oklahoma, has been the focus of recent exploration efforts. These storm-surge deposits of sand have aligned themselves on trend and immediately adjacent to a series of paleostructural highs. The delineation of paleostructural highs at this unconformity is the key to successfully mapping this elusive sand.

The basement rock configuration below these producing trends displays very definite anomalies. We anticipate this basement configuration has influenced resulting depositional sequences, particularly the Misener sand. Detailed high-density, ground-based geomagnetic surveys over the Misener-producing Hawley fields do illustrate the coincidence and possible relationship of Misener sand deposition with respect to underlying basement faults and structures.

Basement highs correlate with resulting pre-Chattanoogan paleostructural highs at the Sylvan Shale, up against which the Misener Sand is deposited. Subsurface data, seismic records, and current drilling activity continue to enforce the evidence of preexisting structures below this Misener sand trend.

Reprinted as published in the American Association of Petroleum Geologists *Bulletin*, v. 73, p. 1174.

Structures Associated with Southern Extension of Mid-Continent Rift System in Kansas

PIETER BERENDSEN, KEVIN P. BLAIR, W. LYNN WATNEY, K. DAVID NEWELL, and DON STEEPLES, Kansas Geological Survey, University of Kansas, Lawrence, KS 66044

Distinct geophysical anomalies and attendant rock types of the Mid-Continent rift system (MRS) can be traced southwestward from the Great Lakes region into southern Kansas. Rocks and structural deformation linked to rifting in Kansas occur in a north–northeast-trending 150-km-wide zone. A 50-km-long separation in southeastern Nebraska devoid of rift-derived rocks is related to a crosscutting transform fault or tectonic zone that extends several hundred miles northwest–southeast. Precambrian sedimentary rocks of the MRS occur in fault-bounded basins on either side of a central horst and are derived from the horst and from nearby granitic highlands.

North–northeast-trending faults dominate the structure within the MRS in Kansas, but possibly older northwest-trending structures are also important in determining the size, shape, and stratigraphy of individual horst blocks and basins. Both sets of faults were intermittently reactivated, with latest movements recorded within the Phanerozoic sedimentary sequence. Domal culminations and rhomboidal grabens also are recognized along the trend of the MRS, some serving as traps for petroleum accumulation. North–northeast-trending faults show Phanerozoic vertical displacement up to 600 m along the Humboldt fault system. Left-lateral motion (up to 15 km) during the Late Mississippian–Early Pennsylvanian along northwest-trending faults is also suggested.

Oil fields producing from several Phanerozoic reservoirs are located along north–northeast-trending structures subparallel to the MRS. Several structures are arranged in left-stepping en echelon patterns.

Reprinted as published in the American Association of Petroleum Geologists *Bulletin*, v. 73, p. 333.

Geologic Mapping—A Critical National Need

CHARLES J. MANKIN, Oklahoma Geological Survey, University of Oklahoma, Norman, OK 73019; DONALD C. HANEY, Kentucky Geological Survey, University of Kentucky, Lexington, KY 40506; and FRANK E. KOTTLOWSKI, New Mexico Bureau of Mines and Mineral Resources, Campus Station, Socorro, NM 87801

The strength of any nation is based, in large part, on its mineral wealth and water resources. These valuable assets are dependent upon geologic mapping for their discovery, evaluation, and adequate development. In addition, the prudent use of these resources involves the proper disposal of waste products that may be harmful to man's continued existence on our planet. All segments of society, including Federal agencies, state and local governments, private industry, academia, and the general public benefit from the use of geologic maps.

Currently, the combined capabilities of state, Federal, and academic groups to provide geologic mapping are not sufficient to meet the present needs of our country, not to mention future needs, which will be greatly increased. Geologic maps are vital to the National security, identification and mitigation of natural hazards, environmental protection, and providing the necessary energy and raw materials for our industries.

A focused Nationwide effort with dedicated dollars in the Federal budget is required if our country's geologic-mapping needs are to be met as we enter the 21st century. The Association of American State Geologists, in cooperation with the U.S. Geological Survey, is proposing to establish a National Geologic Mapping Program. Congressional authorization will be sought for this program whose objective is to complete large-scale maps of the surficial and bedrock geology of the U.S. in a timely fashion. The program will involve a Federal component, a state component, funding for support of research in map preparation, and support for geologic-mapping programs at colleges and universities.

Reprinted as published in the Geological Society of America *Abstracts with Programs, 1989*, v. 21, no. 6, p. A178.

Folds in the Slick Hills—*continued from p. 2*

Folds to the west of the fault show a similar variation in trend. At the southern end of the Canyon area only two folds (the Blue Creek Canyon syncline and Paradox anticline) are present; both these folds trend a few degrees west of north. The northern end of the Canyon displays four folds, the Kimbell anticline and syncline developing from the western flank of the Paradox anticline. The Kimbell folds trend ~40° west of north. All the folds plunge to the north and west at angles of up to 30°, as a result of which the relationships between the folds can be examined through a stratigraphic thickness of ~3,000 ft. This plunge is a response to the convergence of the Blue Creek and Meers faults (which have opposed senses of compression) to the south of the area. The cover photograph shows the principal bifurcation point from which the Kimbell folds form (Fig. 2); to the northwest of this point, in the upper part of the profile, a planar limb (trending ENE) separates the diverging axes of the Paradox and Kimbell anticlines. Further to the northwest, off the photograph and at a structurally higher level, the Kimbell anticline tightens, and the Kimbell

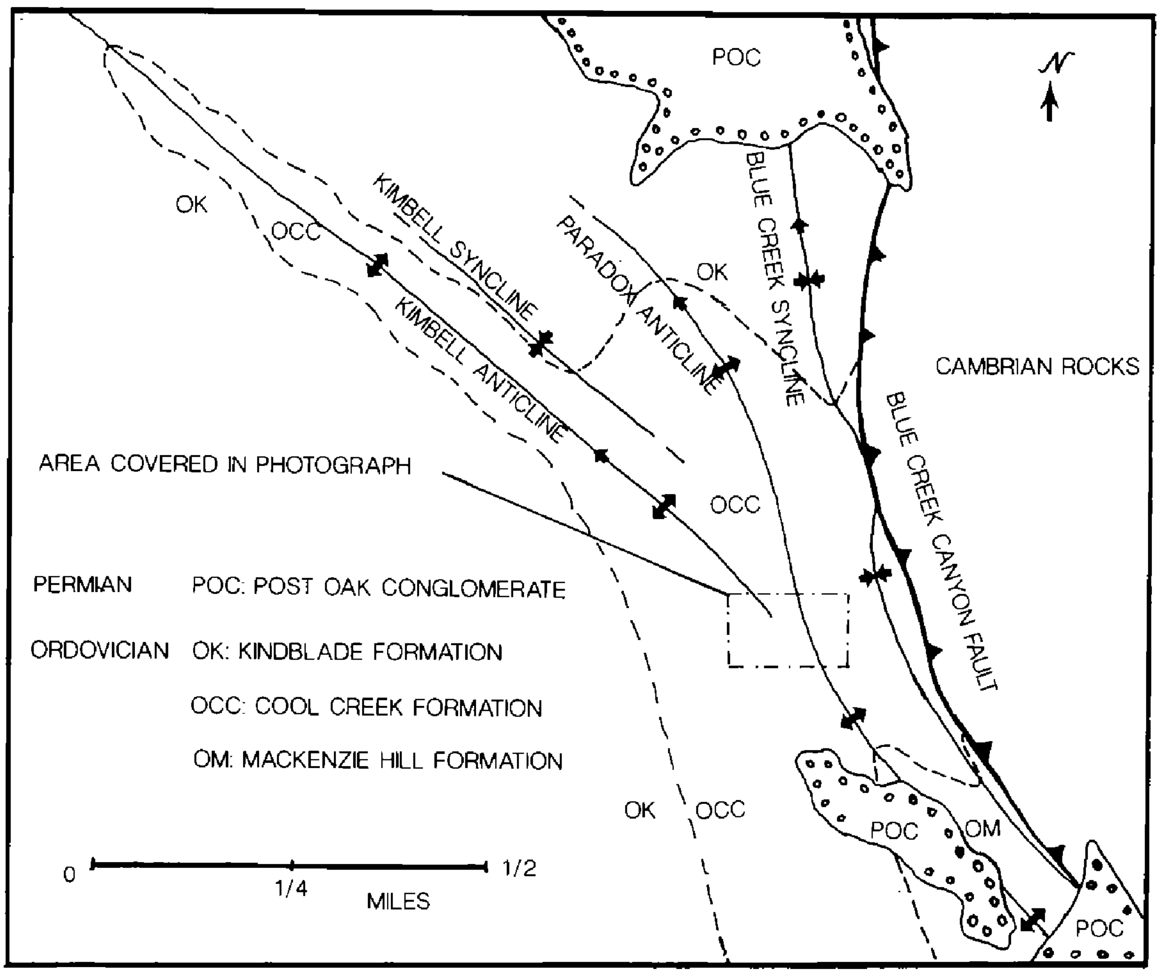


Figure 1. A simplified map of the Blue Creek Canyon area.

syncline develops between the two anticlines. A few yards north of (and above) the bifurcation point, a "snake's head" thrust is located in the hinge of the Upper Paradox anticline. This thrust is not a simple two-dimensional profile adjustment, but is a response to the bending of the fold axis in this area.

Reference

Huddleston, P. J., 1973, Fold morphology and some geometrical implications of theories of fold development: Tectonophysics, v. 16, p. 1–46.

R. Nowell Donovan
Texas Christian University

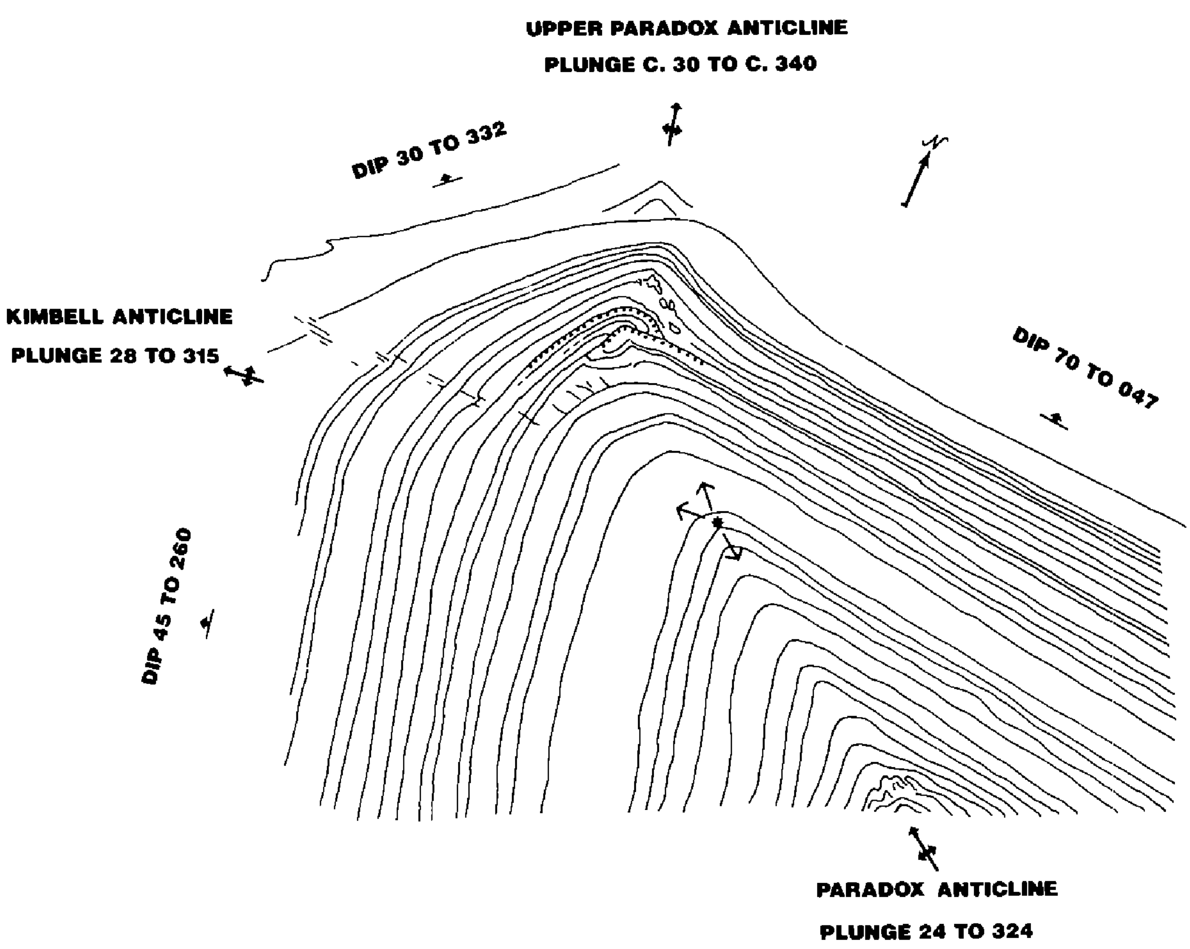


Figure 2. An outline sketch of the geometric relationships seen in the cover photograph.