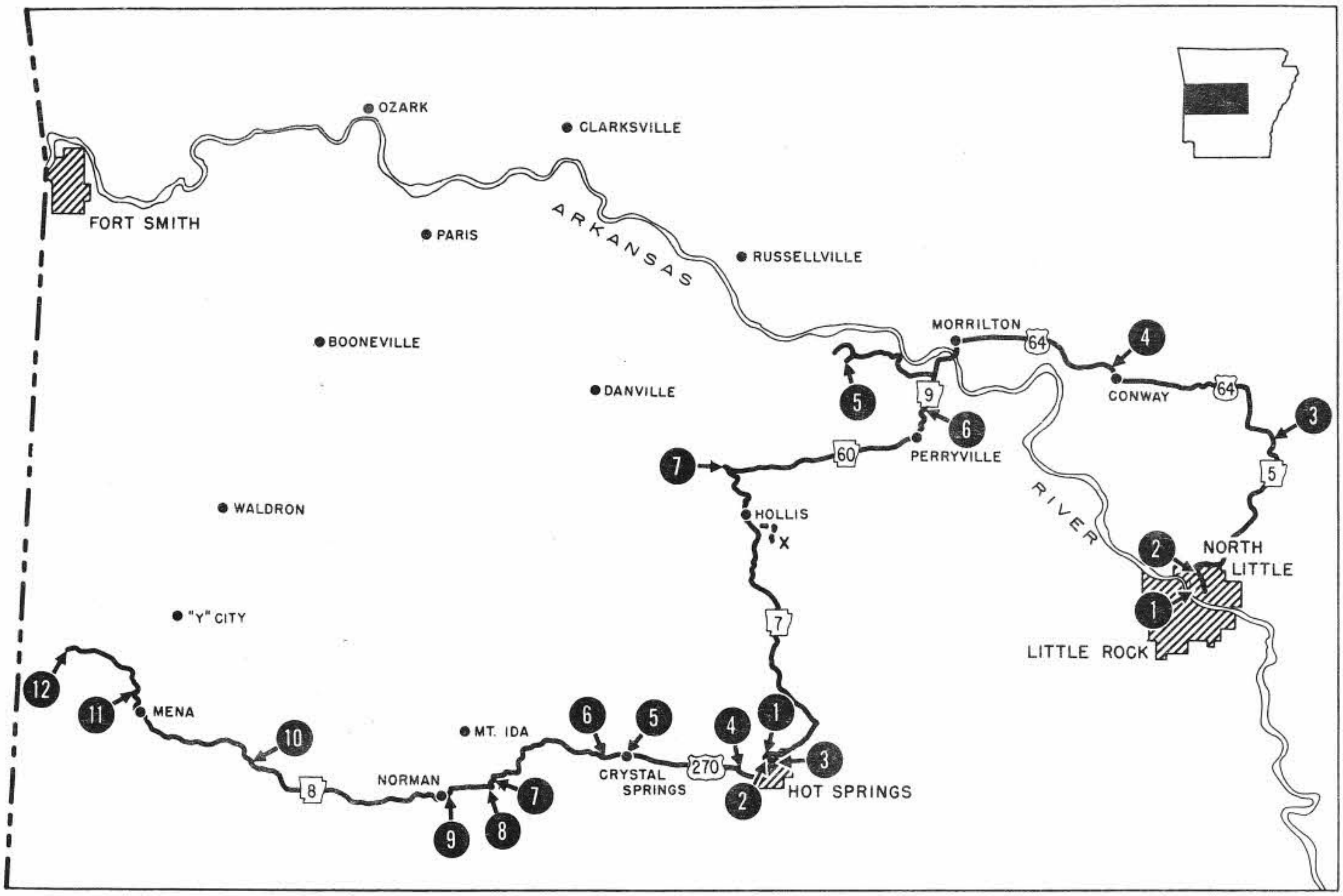
GUIDE BOOK

Second Regional

FIELD CONFERENCE

The Fort Smith Geological Society



Southeastern Arkansas Valley

and

The Ouachita and Frontal Ouachita Mountains, Arkansas

May 2-4

1963

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"SOME PHILOSOPHICAL NOTES ON THIS PROFESSION OF OURS"

George Dillon*

It has always been with a certain whimsical pride that geologists point out that the occasion seldom arises when geologists are in complete agreement in any particular phase of petroleum geology. What to one geologist may be considered a poor economic risk represents to another, with the addition of a few extenuating factors, an exceptionally good risk.

This difference of opinion sometimes results in new wildcat discoveries and sometimes, perhaps more often, in dry holes. Nevertheless, this is the basis on which geologists work. This rather peculiar professional outlook can be viewed two ways; either the operating companies are satisfied with the geological success ratio as it is, or else as some professional men in other phases of the industry have uncharitably put it, "They just ain't caught on to your little game yet".

During the past fifty years, however, and let us all be very honest, if any region ever fit the picture of a completely condemned area, the Ouachita Mountains would come as close as any to being completely condemned and for any number of excellent geological reasons. Not all of us, to be sure hold such a dim view of the Ouachitas, but most of us do tend to guffaw a bit when a non-professional mentions its possible potential.

Cases such as this lead to embarrassment and to one of the more interesting paradoxes of our profession. On the one hand our most chronic complaint is that management fails to give the consideration we think due our ideas and recommendations, while on the other, we find to our chagrin that an area almost universally condemned is suddenly discovered to be a new potential gas province because an oil company drills a wildcat well justified on no stronger grounds than that the acreage is expiring.

We can all assume that it is probable that sometime in the future we will find ourselves geologically involved with this southern Arkansas Valley-Ouachita Mountain relationship in some degree, and it was for this reason that the idea of this field trip was conceived. The primary purpose of this trip is to profit by the experience of those more familiar with the area than most of us can reasonably be expected to be, to meet and glean from one another every particle of information we can of the area, to trade ideas and to defend viewpoints against those who disagree.

The writer knows personally that it is a most humbling experience to work in the Ouachita Mountains. It is not without some wry humor that the writer remembers the first time that he ran into a field situation involving horizontal beds abutting against vertical beds, and of his frantic groping for a solution, of his discovering after three days of extensive field work that it represented a fault gouge zone of large areal extent, and to discover still further that he had been mapping the bottoms of overturned beds and that that nice little anticline he had been mapping was not really an anticline after all. This problem of what represents true bedding in the Ouachitas has been plaguing geologists for years and will probably continue to do so.

There is a tendency among younger geologists to criticize older geological work on the grounds that it is too sketchy, or because it may contain errors of varying significance. The writer thinks that it should be pointed out that, after all, basic geologic principles have not changed through the years and the fact that it was done "the hard way" (on foot) could give it more credence than if it were done with aerial photos and by jeep by virtue of the simple fact that it was painstakingly done. It has always been the writer's personal opinion that until a geologist has attempted to do extensive field work without the aid of aerial photographs automobiles, road maps or even roads, he should be very slow to criticize.

Now that the philosophy has been exhausted, those of us involved in assembling and conducting this field trip welcome all of you and trust you will find the trip interesting and informative.

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TENTATIVE CORRELATION OF PALEOZOIC ROCKS IN THE OZARK, ARKANSAS VALLEY, AND OUACHITA MOUNTAIN REGIONS, ARKANSAS

	GENERALIZED SECTION	OZARK–ARKANSAS VALLEY SECTION		OUACHITA MTN. SECTION	
PENNSYLVANIAN	DES MOINES	Boggy fm.		(Missing)	
		Savanna fm.			
		McAlester fm.			
		Hartshorne ss.			
	ATOKA	Atoka fm.		Atoka fm. ✱	
	MORROW	Bloyd sh.	Kessler ls. mbr.	Johns Valley sh.	
			Woolsey mbr.		
			Brentwood ls. mbr		
		Hale fm.	Prairie Grove mbr.		
			Cane Hill mbr.		
MISSISSIPPIAN	UPPER	Pitkin ls.			
		Fayetteville sh.		Jackfork ss.	
			Wedington ss. mbr.		
		Batesville ss.			
			Hindsville ls. mbr.		
		Ruddell sh.			
		Moorefield fm.			
		Boone fm.		Stanley sh.	
	LOWER		St. Joe ls. mbr.	Arkansas novaculite	Upper mbr.
		Chattanooga sh.			Middle mbr.
DEVONIAN	UPPER	Sylamore ss.			Lower mbr.
	MIDDLE	Clifty ls.			
	LOWER	Penters chert			
SILURIAN	UPPER	(Missing)		Missouri Mountain sh.	
	MIDDLE	Lafferty ls.		Blaylock ss.	
		St.Clair ls.			
	LOWER	Brassfield ls.			
ORDOVICIAN	UPPER	Cason sh.		Polk Creek sh.	
		Fernvale ls.		Bigfork chert	
	MIDDLE	Kimmswick ls.			
		Plattin ls.			
		Joachim dol.			
		St.Peter ss.		Womble sh.	
		Everton fm.	Jasper ls. mbr.		
			Newton ss. mbr.		
			Kings River ss. mbr.		
	LOWER	Powell dol.		Blakely ss.	
		Cotter dol.			
		Jefferson City dol.		Mazarn sh.	
		Roubidoux fm.		Crystal Mountain ss.	
		Gasconade–Von Buren fms.			
			Gunter mbr.		
CAMBRIAN	UPPER	Eminence dol.		Collier sh. (Cambro–Ord.?)	
		Potosi dol. (?)			
		Derby–Doerun–Davis fms (?)			
		Bonneterre dol.			
		Lamotte ss.			
Pre-C		Igneous Rocks		Older rocks not exposed.	

✱ Basal portions of Atoka in Ouachita Mountain area are possibly Morrowan.

Note: This chart, with slight modification, is the one that was originally prepared for the Sixteenth Field Trip Guidebook, Mississippi Geological Society, May 3–6, 1962.

NOTES ON THE GEOLOGY OF THE EASTERNMOST FRONTAL OUACHITAS—SOUTHEAST ARKANSAS VALLEY AREA, ARKANSAS

Charles G. Stone*

Introduction

This discussion is based on recent field mapping by the writer in the general area of the Frontal Ouachitas and the Arkansas Valley that will be traversed on the first day of the field trip. The route also crosses the Benton-Broken Bow Uplift, (the last 15 miles from Jessieville to Hot Springs). However, since time did not permit the inclusion of scheduled stops, the geologic description of this portion of the route has been limited to outcrop descriptions in the road log.

At their eastern end the Frontal Ouachitas are bordered by the Arkansas Valley on the north and the Benton-Broken Bow Uplift on the south. In this area the Frontal Ouachitas are not everywhere sharply defined but in general they comprise an east-west trending structural belt characterized by steep narrow folds locally overturned and accompanied by major thrust faults. Formations exposed are the Stanley Shale, Jackfork Sandstone and Atoka Formation.

In contrast to the Frontal Ouachitas the southeastern Arkansas Valley area is characterized by simpler structures; broader more gentle folds and less faulting. Sandstones and shales of the Atoka Formation are the surface rock over most of the area, but the Hartshorne Sandstone and McAlester Shale are preserved locally in synclines.

Formation Descriptions

Stanley Shale. The Stanley Shale is the dominant rock unit in the area between the Panther Creek and Ti Valley (?) faults. Outcrops have not been observed north of the Ti Valley (?) fault. South of the Panther Creek fault it occurs in synclinal remnants surrounded by Arkansas Novaculite and older rocks.

In this area the Stanley has been divided into an upper and lower lithic unit. The lower is composed essentially of gray silty shale, with numerous slump-slide sandstone, siltstone and a few chert masses. The extreme lower portions commonly has buff to gray shales and thin gray to white chert. The Stanley is apparently conformable with the underlying Arkansas Novaculite. This unit is probably about 4,000 feet thick in the area. This lower lithic unit is believed to be Mississippian and at least in part, Meramecian in age.

The upper lithic unit is primarily shale but contains more sandstone than the lower unit. It is characterized by slump-slide sandstone masses some of which occasionally contain a thin outer rim or coating of highly fossiliferous, reef like sandstone. Some large sandstone masses that occur as lenticular channels are also believed to have originated through submarine slumping and sliding. Worm trails are numerous on tops of many sandstone beds. Plant fossils are common in some sandstone masses. Certain thin sandstone beds indicate a high degree of sediment flow. Other thin sandstones laterally in the same zone may have delicate flute casts on the bottom with worm trails on top indicating turbidity currents. The unit is thought to be about 2,000 feet thick in the area. Fossils collected from one of these slump-slide sandstone masses in Burns Park in North Little Rock, have been preliminarily determined as probably Morrowan by MacKenzie Gordon (personal communication) of the U. S. Geological Survey. This zone is about 800 feet stratigraphically below the basal Jackfork, which occurs on Big Rock Mountain to the south.

At the Lake Winona spillway about 20 miles west of Little Rock, numerous slump and erratic masses of gray to white chert, siliceous shale, sandstone and siltstone some of which are fossiliferous, occur in the Upper Stanley. A collection of fossils from a small lense-shaped claystone mass at this locality has been determined by MacKenzie Gordon (personal communication) of the U. S. Geological Survey as being Late Mississippian. This material is probably not over 1,000 feet stratigraphically below the basal Jackfork which outcrops about one mile to the west.

Near Forked Mountain slump-slide or erratic masses of limestone are believed to occur in the Upper Stanley. They have been determined to be of Pitkin age by MacKenzie Gordon (personal communication) and Maxim K. Elias. (See side trip in first day road log.)

Eastward from the Forked Mountain-Lake Winona area siliceous shales or cherts seem to be generally absent in the Upper Stanley.

*Geologist, Arkansas Geological Commission, Little Rock.

The Stanley slump-slide masses indicate wild-flysch. Some beds indicate sediment flows. Still others indicate turbidity flow. Much of the sediment of the Stanley appears to have been derived from the east-southeast. However, some of the slump-slide masses were probably derived from the north.

Jackfork Sandstone. The Jackfork occurs in this region between the Panther Creek and Ti Valley (?) faults, primarily as synclinal, or as faulted remnants. It has not been found on the surface north of the Ti Valley (?) fault. South of the Panther Creek fault it does not outcrop, except in the southern Ouachitas.

Along the Marche syncline in the Sylvan Hills-Camp Robinson area north of North Little Rock, about 2,000 feet of the lower Jackfork is present. This represents the greatest thickness in this area. The Jackfork is composed of alternating massive sandstone and shale units. The sandstone is commonly fine-grained but contains some coarse sand grains indicating a possible bimodal origin. Worm trails are common on some of the shales. Plant fragments are found in some sandstones. Scant invertebrate remains have been found in conglomerates in the basal sandstone bed at a few localities. Large individual channels are common in the basal sandstone units. The basal Jackfork is transgressive to the north in this area.

There are a few bottom markings present on some of the sandstone beds, however, they are rare. The sandstones exhibit good lineations, sharp contacts with shale above and below, shale blebs and masses in siltstones, and some cross-stratification. There is a general lack of sorting in the siltstone and sandstone beds. Also there is generally the absence of noticeable grading of beds. These are characteristics of sediment flows so dense that little water was entrained and turbulence was not developed.

The Jackfork, however, throughout most of the Ouachita region is thought to be mainly turbidity current or flysch type of deposition. For instance, in the Arkadelphia area in the southern Ouachitas, the Jackfork displays turbidity deposition features. Prod casts, flute casts and graded bedding are common. The bottom markings indicate that in most places the turbidity currents moved westward down the axis of the paleoslope. Coarse fossiliferous grits are common at the base of the massive sandstone units.

The Frontal Ouachita zone near Little Rock represents a more nearshore environment than the Jackfork in the southern Ouachita-Arkadelphia area. The Jackfork sediments were primarily derived from the east-southeast.

MacKenzie Gordon (personal communication) has recently examined additional fossiliferous rocks from the basal Jackfork from near Pulaski Station in Little Rock. He states that it is still considered as Morrowan, as were the original samples collected by Miser and Girty in 1927.

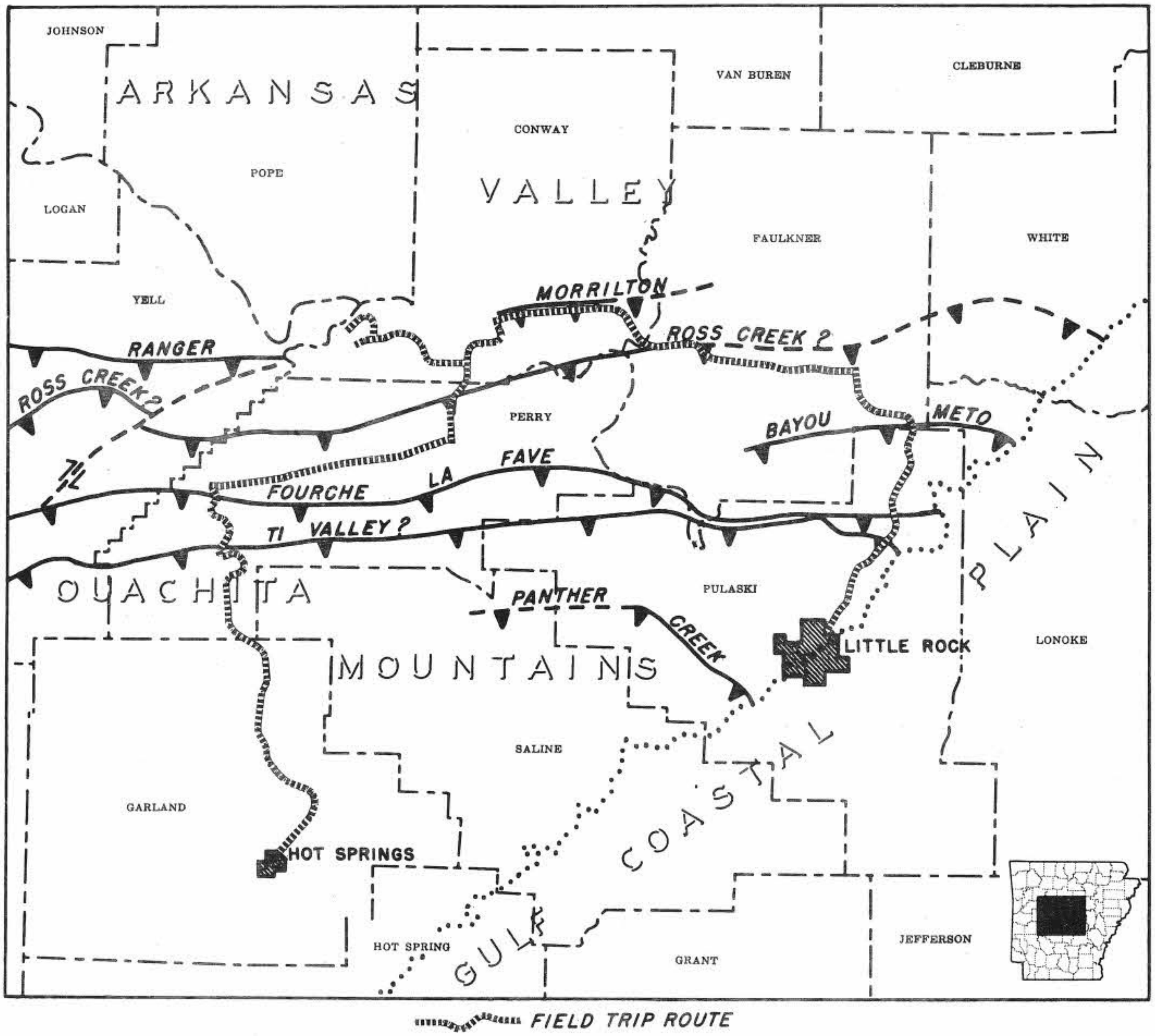
Johns Valley Shale. The Johns Valley Shale has not been noted in the northeastern Ouachitas of Arkansas, primarily because of the aforementioned Ti Valley (?) fault which thrusts Stanley over Atoka, and the fact that the synclines to the south of this fault are not deeply enough folded to retain Johns Valley remnants.

Atoka Formation. The Atoka comprises practically all the surface rock in the region north of the Ti Valley (?) fault. It has not been noted to the south of this fault in this area. Miser and Purdue describe two narrow east-west belts in the southern Ouachitas of Arkansas.

In this Frontal Ouachita-Arkansas Valley area the Atoka has been divided into three lithic units, lower, middle and upper.

The lower lithic unit in the Frontal Ouachita zone consists of approximately 12,000 feet of thin alternating sandstone, siltstone and shale beds of near equal proportions. A type of graded bedding, convolute bedding, several varieties of laminations and flute casts are characteristic of this unit. Ripple marks are found on top of some beds. Invertebrate animal remains are rare, although a few crinoidal columnals have been found in some sandstone beds. Coalified plant fragments and coarse mica are characteristic of some siltstones. Plant fragments occur locally in the sandstones. Sediments of the lower unit apparently were deposited in a fairly deep basinal environment. Bottom markings on the sandstone beds indicate turbidity current origin with a paleocurrent from the east-southeast.

Northward in the Arkansas Valley in the Conway-Morrilton area this unit thins very rapidly in a hinge line or series of hinge lines and passes into a narrow transition zone resembling sediment flow deposits. The sediments of this transition zone were probably being derived from both the north and the east. Farther north this unit passes into a shelf-littoral type environment. The Lower Atoka is thought to be a transgressive unit in the Frontal Ouachita-Arkansas Valley area and the middle or upper portions of the units are thought to be



REVERSE FAULTING IN THE EASTERN FRONTAL OUACHITAS—SOUTHEASTERN ARKANSAS VALLEY REGION, ARKANSAS.

equivalent to the Lower Atoka in the Boston Mountains. The basal portions of the Lower Atoka as mapped in the Frontal Ouachitas may well be equivalent in part to the Morrow.

The Middle Atoka lithic unit consists of approximately 2,500 to 4,000 feet of shale and sandstone in the Frontal Ouachita area. It has a thick shale section at the base overlain by three characteristic, flaggy, sandstone units (The Traceable Three) which are separated by shale intervals. The sandstone units have many of the characteristics of sediment flow deposition; cross-lamination, lack of sorting, and lack of graded bedding. Ripple marks are very common. Invertebrate fossil fragments indicating transportation are numerous in some areas. Plant fossils and traces of coal stringers occur at other localities. These characteristic units have been traced on the surface throughout most of the southern Arkansas Valley-northeast Frontal Ouachita region. The source of these sands is from the east, and occasionally from the north. To the north the Middle Atoka lithic unit apparently passes into a more shelfward or deltaic environment.

The Upper Atoka lithic unit consists of approximately 5,000 feet of section in the Frontal Ouachitas. Shale predominates in the unit, although there are numerous sandstone beds. Ripple marks, diastems, coal beds and small discontinuous fossil-bearing sandstone lenses or channels are characteristic of the unit and seem to indicate a cyclothemic period oscillating between continental swamp-deltaic and marine shelf-littoral conditions. Plant and invertebrate animal remains are fairly common at some localities. The Upper Atoka lithic unit undergoes a uniform rate of thinning to the north across the Arkansas Valley. The source of the sediments is from the north, east and south. The Atoka is apparently overlain with slight unconformity by the Hartshorne.

The pronounced thickening of the Atoka Formation was probably caused by the rate of generally continuous deposition keeping pace with the rate of subsidence in a basin.

Several fossil collections have been made from the Atoka, however their age has not yet been determined. The author believes that the lower portions of the lower lithic unit as mapped may well be Morrowan in age.

Hartshorne Sandstone. The formation occurs as comparatively small synclinal areas on Petit Jean and Round Mountains in the area. The Hartshorne is composed of medium to coarse-grained, usually massive sandstone with shaly partings. Some units are highly cross-bedded, ripple marks are common, and plant material is abundant in some places. The formation varies from 140 to 225 feet thick on Petit Jean Mountain. Its easternmost exposure, which includes only the basal 35 feet, occurs on Round Mountain south of Conway. The very unusual shapes and designs of the Hartshorne outcrops on Petit Jean Mountain are believed to be a result of zonal weathering.

The remains of invertebrate animals in the Hartshorne Sandstone of the Arkansas Valley comprise only a few poorly preserved brackish-water forms. Most of the plant remains were transported from nearby land areas, though some may have lived either in fresh water or in the sea.

The Hartshorne Sandstone may be an example of molasse-type sedimentation.

McAlester Shale. The only exposure of the McAlester Shale in this area occurs on the southern portions of Petit Jean Mountain where approximately the lower 400 feet is exposed. It is composed of gray shale, with at least one traceable flaggy sandstone bed having some characteristics of sediment flow deposition. One thin coal bed (the lower Hartshorne coal) occurs at the locality.

Invertebrate fossils are sparingly present in the Arkansas Valley at several horizons in the McAlester Shale. The fossils are mostly pelecypods, too poorly preserved to be accurately identified. Plant fossils are abundant and well preserved at several horizons, and have served as a useful check on their correlation. Several of the McAlester Shale units are non-marine other units may possibly represent nearshore accumulations.

ROAD LOG — FIRST DAY

Charles G. Stone

LITTLE ROCK TO HOT SPRINGS VIA VILONIA, CONWAY, MORRILTON PETIT JEAN MOUNTAIN, PERRY, PERRYVILLE, NIMROD DAM AND HOLLIS

SUMMARY

This trip starts in the Frontal Ouachitas (which is about 25 miles wide at Little Rock) and proceeds northward across this complex zone into the Arkansas Valley. The lunch stop will be on scenic Petit Jean Mountain, and from there the trip continues southward across the Frontal Ouachitas ending in the Zigzag Mountain section of the central Ouachitas at Hot Springs.

***NOTE**: AT 7:00 A.M. ALL CARS WILL BE AT KROGERS ASSEMBLY AREA ON U. S. HWY. 65 — 1.1 MILES NORTH OF ARKANSAS RIVER BRIDGE

MILEAGE	DESCRIPTION
0.0	Leave Sam Peck Hotel, Little Rock, Arkansas and proceed east on Capitol Avenue. In this general area a thin Tertiary section (Midway clay, marl and limestone and Wilcox sand and clay) lies unconformably on Stanley Shale (Mississippian-Pennsylvanian). This is the Fall Line separating the Mississippi Embayment from the Paleozoic Highlands.
0.2	Turn right on S. Spring Street.
0.25	Turn right on W. 6th Street.
0.3	Turn right on S. Broadway (Hwys. 5-65-67-70-167).
0.8	Arkansas River. About ten blocks downstream is the original Little Rock outcrop. It is a large sandstone slump-slide mass in the upper part of the Stanley Shale.
1.2	North Little Rock, Arkansas. Turn left, follow U. S. Hwy. 65.
* 2.3	**Kroger Store Assembly Point.** Proceed west on W. 13th Street.
2.75	Turn right on N. Crutcher Street. Boone Park Elementary School on left side of road.
2.95	Turn left on W. 16th Street.
3.3	Turn right on N. Julian.
3.35	Turn left on W. Long 17th Street.
3.55	Outcrop of shale and siltstone in upper portions of Stanley Shale. Jackfork on Big Rock Mountain to right.
3.7	Turn right at dirt road. Arkansas River on left.
4.55	**STOP 1. BIG ROCK JACKFORK QUARRY.** Excellent basal Jackfork exposures. Good example of sediment flow deposition. Numerous individual channel sandstone masses. Some minor bedding plane faults. Traces of plant and invertebrate fossils.
5.4	Retrace steps, turn left.
5.65	Continue down W. Long 17th Street.
5.95	Turn left on N. Crutcher.
6.1	Turn right on W. 18th Street.
6.6	Junction U. S. Hwy. 65, turn left, follow U. S. Hwy. 65.
7.25	Stanley-Jackfork contact along axis of Big Rock syncline. Small bedding-plane fault along contact indicates that Jackfork has moved up both flanks of syncline at this locality. Small quartz veins common.
8.6	**STOP 2. UPPER STANLEY SHALE.** This fine exposure occurs near the axis of the Maumelle anticline. Numerous slump-slide masses of sandstone occur in this and other similar outcrops in the region. The bedding is literally in all directions. Cleavage is toward the north. Small faults are common. Use caution; heavy, fast traffic. Several of these slump-slide masses exposed in the Burns Park area about one mile west of here contain an outer layer of highly-fossiliferous material suggesting two or more periods of slumping. These fossiliferous slump-slide sandstone masses are characteristic of the Upper Stanley unit.
9.25	Turn left on Military Road. To the northwest about 1½ miles is the Jeffrey Stone quarry which is in the lower Jackfork Sandstone. At the quarry many unusual minerals such as, rectorite and silica gel occur in small quartz veins. Messrs. Milton and Miser of the U. S. Geological Survey are preparing a paper on these minerals.
9.4	Turn left on Parkway Drive.
9.75	Faulted zone in upper portions of Stanley on left side of road.
10.7	Turn left on W. 41 Street.
11.0	Turn left on Camp Robinson Road.

11.95 Upper Stanley Shale outcrop on right.
12.4 Fork in road, continue right.
12.7 Basal Jackfork outcrops.
12.9 Railroad crossing -- Catholic Orphanage on left.
13.5 Camp Robinson (formerly Camp Pike) on left.
14.55 Continue right on west Maryland Avenue. In this general area we are along the axis of the Marche syncline. The rocks exposed in this synclinal area are believed to represent the greatest exposed sequence of Jackfork in the eastern Frontal Ouachitas of Arkansas (probably about the lower 2,000 feet of Jackfork). The Jackfork is only present in the region as synclinal or faulted remnants south of the Ti Valley (?) fault which has thrust Stanley over Atoka.
The upper portions of the Jackfork and the Johns Valley Shale are not present at the surface in the northeastern Ouachitas.
16.2 Sylvan Hills, Arkansas. Turn left on Hwy. 5. In this area flagstone is quarried from the upper Jackfork.
17.25 Junction of Kellogg Avenue, continue on Hwy. 5. The Kellogg mine is located one-half mile to the north. Quartz veins containing lead, zinc, and silver minerals occur in a highly fractured zone in the Upper Stanley Shale.
18.35 Stanley-Jackfork contact.
18.8 Sandstone in the Upper Stanley Shale. This clean sandstone resembles those in the Jackfork, however, it is very lenticular and variable in character.
19.2 Kellogg Creek.
19.45 Gravel Ridge Community.
20.25 Approximate trace of Ti Valley (?) fault. The Stanley Shale is thrust northward over the Lower Atoka lithic unit. West of here a few miles the Stanley rests on Middle Atoka.
The Ti Valley (?) fault is the major thrust fault in the Frontal Ouachitas in this region. Surface mapping indicates that this fault probably has a lateral displacement of about 15-20 miles.
20.95 Bayou Meto Creek. Lower Atoka rocks are exposed here.
22.45 Entrance Little Rock Air Force Base. Continue on Hwy. 5.
22.8 Bottom markings on Lower Atoka sandstones.
23.15 Fourche LaFave River thrust fault. The fault is well exposed at the Air Base to the east. This is one of the most prominent faults in the Frontal Ouachitas of Arkansas, possibly extending from the Waldron Quadrangle eastward into this area. The displacement is only a few thousand feet.
23.8 **OPTIONAL STOP.** Lower flaggy sandstone bed of "Traceable Three" of Middle Atoka. Illustrates excellent sediment flow features such as cross-lamination. Ripple marks present on top of beds. Scattered quartz veins. A few slickensided surfaces.
24.8 Middle bed of "Traceable Three". This unit is somewhat fossiliferous at this locality. One mile to the west it is highly-fossiliferous.
25.05 Upper bed of "Traceable Three".
25.6 Thin sandstone in lower portions of Upper Atoka lithic unit.
26.75 Approximate axis of Cato syncline in Upper Atoka shale.
27.15 To right rear is Prairie Peak which represents a channel sandstone developed in lower portions of Upper Atoka.
27.55 Another exposure of this channel sandstone.
28.45 Upper bed of "Traceable Three".
29.05 Middle bed of "Traceable Three".
29.65 Lower bed of "Traceable Three".
30.45 Broad shale valley at base of Middle Atoka lithic unit.
30.75 Upper part of Lower Atoka lithic unit.
31.45 **STOP 3. BEDS OF MIDDLE PORTIONS OF LOWER ATOKA LITHIC UNIT.** Alternating sandstone, shale, siltstone beds in Lower Atoka. Turbidity current deposition characterized by graded bedding, and bottom or sole markings (flute casts, etc.). Siltstones commonly contain coal fragments which characterize certain portions of the Lower Atoka.
32.45 Typical bottom markings in lower portions of Lower Atoka.
32.9 Enter Faulkner County.
33.25 Axis of Bayou Meto anticline.
33.75 Highly faulted zone on right. This extreme Lower Atoka (?) shale has been thrust over middle portions of Lower Atoka along the northern flank of the Bayou Meto anticline. This shale is about 18,000 feet stratigraphically below the Hartshorne Sand-

stone which outcrops on Round Mountain a few miles west of here.

35.2 Top bed of Lower Atoka.

35.25 Otto, Arkansas.

35.7 Thick shale section at base of Middle Atoka lithic unit.

36.1 Lower bed of "Traceable Three".

36.2 Middle bed of "Traceable Three".

36.3 Upper bed of "Traceable Three".

36.85 Numerous "pimple mounds" on right side of road developed in colluvial or second bottom alluvial-colluvial deposits.

37.25 Sandstone in lower portions of Upper Atoka. Several small channels or diastems are present.

37.3 Crossing south fork of Cypress Bayou.

37.9 Axis of Conway syncline.

39.0 City limits of Vilonia.

39.35 Junction of U. S. Hwy. 64. Turn left, follow U. S. Hwy. 64.

39.65 Ridge on right represents "Traceable Three" on south flank of Cadron anticline. We will follow this structure into Conway, Arkansas.

42.65 On left is quarry in channel sandstone in lower portions of Upper Atoka.

48.05 Thin sandstone in lower portions of Upper Atoka.

49.7 Excellent exposure of a small dip-slip fault. Slickensided surfaces are common. The clay mineral, dickite, is present in the zone and indicates faulting elsewhere in the Arkansas Valley region.

51.75 City limits of Conway, Arkansas. Follow U. S. Hwy. 64 through Conway.

54.9 **STOP 4. UPPER BED OF "TRACEABLE THREE" OF MIDDLE ATOKA.** This outcrop occurs on the south flank of the Cadron anticline. It illustrates distinctive bedding features of sediment flows. Ripple marks are present on top of the flaggy beds. Plant fragments are also common. The Shell Oil Company No. 1 C. Stewart, a dry and abandoned gas test recently drilled in 26-6N-14W, on the north flank of this structure, was spudded near the base of the Middle Atoka and reportedly encountered Fayetteville Formation at 6,618 feet. Total depth was 9,383 feet.

56.7 Prominent ridge to right (about ⅔ of a mile) represents upper portions of Lower Atoka, along faulted axis of Cadron anticline. The Lower Atoka exposed in this area might be considered as transitional both in character and type of deposition between the turbidity unit to the south and the more shelfward facies to the north.

59.0 Railroad bridge.

59.35 Enter Conway County.

59.95 Axis of westward plunging Cadron anticline. Ross Creek (?) fault which has a displacement of 10-15 thousand feet in the Casa-Perry area continues along this structure but has considerably less displacement. It is present as several faults of lesser magnitude. Some overturning of surface outcrops result from this faulting.

60.65 Bed of "Traceable Three".

61.5 Thin sandstone in lower portion of Upper Atoka. Axis of Menifee syncline.

62.3 Menifee, Arkansas. Slightly north of axis of westward plunging Menifee syncline.

62.75 Ridge to north represents "Traceable Three" along south flank of Morrilton anticline.

67.3 City limits of Plumerville.

67.5 Junction of Arkansas Hwy. 92. Axis of Morrilton anticline a few hundred yards to north exposes top of Lower Atoka unit. Several small reverse fault zones are also exposed locally causing some overturning. Croneis reports that a well drilled on this structure near here furnished gas that was used commercially in Plumerville in 1905 and 1906. An Atlas missile site to north about one mile.

68.35 We are now traveling through units developed at the base of the Upper Atoka. In this area they have many features related to the "Traceable Three".
The "Traceable Three" outcrops on the ridge to the north. In this region and farther north they appear to be somewhat transitional in character between sediment flow and littoral deposition.

71.05 Morrilton city limits. Morrilton anticline plunges to west in this area. The Atkins anticline on to west a few miles is probably a different structure.

72.2 Junction U. S. Hwy. 64 and Arkansas Hwy. 9. Turn left on Hwy. 9 and cross railroad tracks.

72.45 Intersection — turn left. Follow Hwy. 9.

72.95 Junction — Proceed right on Hwy. 9.

73.0 Sandstone bed in lower portions of Upper Atoka.

73.2 Sandstone bed overlying last unit in lower portions of Upper Atoka.

74.2 Lower terrace of Arkansas River.

75.0 Arkansas River. Good shale outcrop on right in Upper Atoka. Petit Jean Mountain to west.

75.5 Alluvial bottom of the Arkansas River.

77.7 Shale and siltstone in Upper Atoka.

77.85 Home of W. J. Sadler, who first showed samples of Oppello breccia to Dr. Croneis.

78.0 Oppello breccia is approximately 250 yards west of here on the west side of small pond.

78.35 Oppello, Arkansas.

78.45 Junction Hwy. 9 and 154. Turn right on Hwy. 154 to Petit Jean Mountain.

79.65 For next few miles we will be driving through lower terrace material of the Arkansas River. Arkansas River alluvium is on right. Some colluvial deposits are present at some places on left side of road.

80.2 Entering Ada Valley near axis of small Ada anticline. Petit Jean Mountain (Hartshorne) on right. Blue Point Mountain (Hartshorne) nearest ridge on left. Perryville Mountain (Lower Atoka) farthest ridge on left in distance.

82.1 The Sinclair Oil and Gas Company No. 1 W. Rockefeller a dry and abandoned gas test recently drilled in 8-5N-17W (a few hundred yards south of here), was spudded in Upper Atoka shale and reportedly was in sand and shale at total depth of 11,850 feet. A Pitkin (?) call was made at 9,110 feet.

84.45 Small high angle reverse fault in extreme Upper Atoka shale and siltstone. Upthrown block to south. Numerous small channels exhibited in subsequent outcrops of Upper Atoka. Petit Jean Rock (Hartshorne) directly above and beautiful view of Arkansas River below.

85.3 Atoka-Hartshorne contact. Locally coal bed near top of Atoka.

85.5 Petit Jean grave to right.

85.7 Junction — continue left.

88.15 In this general area a number of "pimple mounds" are developed in colluvial deposits which rest directly on Hartshorne Sandstone.

89.65 Petit Jean Park Headquarters.

89.75 Turn right on Boat House Drive.

89.9 **LUNCH STOP.** This is an unusually scenic locality and worth investigating during the lunch stop. After lunch we plan to visit Winrock Farm, the home of Winthrop Rockefeller, and the scenic and geologically interesting Cedar Falls.

90.1 Turn right.

90.3 Junction left to Indian Cave and Red Bluff Drive — turn right to Rockefeller's home and farm (Winrock).

90.8 Winrock farm on left.

91.4 Winrock grass farm. Turn left.

92.5 Scenic view to right, town of Atkins to north, Arkansas River in distance, Petit Jean River directly below.

92.8 Small building stone quarry in Hartshorne Sandstone.

92.95 Large house on right is home of Winthrop Rockefeller.

93.1 Winrock dairy barn. Return to Winrock grass farm and turn right to lunch area.

94.7 Turn right.

96.17 Turn right on Hwy. 154.

97.0 Turn right to Cedar Falls.

97.25 **STOP 5. CEDAR FALLS.** Cedar Falls plunges from Hartshorne Sandstone into shales and siltstones of extreme Upper Atoka. Rock prominences found at this locality are typical of many other areas on Petit Jean Mountain. There is a small unconformity at the base of the Hartshorne. The many unusual structures, features and designs present in outcrops of Hartshorne Sandstone near the parking area are believed to partly be the result of zonal weathering on bedding, cross-bedding and fracture surfaces. McAlester Shale occurs about two miles south of this area along the axis of the Poteau syncline. Return to Oppello along Hwy. 154.

109.75 Oppello, Arkansas. Junction Hwys. 154 and 9. Turn right on Hwy. 9. For next few miles you will see the lower terrace of the Arkansas River and colluvial material.

113.3 Cypress Creek.

113.7 Town of Perry, Arkansas, junction of Hwys. 9 and 10. You are now crossing Ross Creek (?) fault. Lower portions of Lower Atoka, to the south, have been thrust over Upper Atoka to the north. The displacement at this particular locality is about 13,000 feet.

Croneis measured over 9,000 feet of section between here and Perryville, practically all of which is in the Lower Atoka lithic unit. To the west a few miles a few thousand more feet of Lower Atoka are believed to be exposed at the base of Croneis' section.

114.85 **STOP 6. LOWER ATOKA SECTION (CRONEIS).** Alternating sandstone, siltstone, and shale near middle of the Lower Atoka lithic unit. Convolute bedding, graded bedding, bottom markings all indicate turbidity deposition. Shale generally increases as we proceed upward in the section.

115.1 Perryville sill (?) — covered.

115.85 Harris Creek.

116.65 Junction Hwy. 60 — continue on Hwys. 9 and 10. Perryville city limits.

117.0 Turn right on Hwy. 60. At town of Perryville we are on the north flank of Fourche La Fave syncline. At this spot we are at the shale break below the "Traceable Three" in the extreme lower portion of the Middle Atoka.

122.65 View to south; Lower Atoka and Jackfork hills in distance.

127.3 Aplin, Arkansas.

128.45 Fourche La Fave River terrace, mostly sandstone cobbles with some chert cobbles.

130.45 Sandstone in upper portions of Lower Atoka. Contains grit and fossil fragments near base.

132.85 Nimrod, Arkansas.

137.7 Fourche Junction, intersection of Hwys. 7 and 60, continue straight ahead.

137.75 Turn left to Nimrod Dam.

138.25 **STOP 7. NIMROD DAM.** Fourche La Fave River fault zone developed in upper portions of Lower Atoka. In the vicinity of this dam and along several roads in the area one can see the effects of the Fourche La Fave River fault. Dickite is present on some fault surfaces. Return to junctions of Hwys. 7 and 60. Proceed south on Hwy. 7.

139.3 Fourche La Fave River.

139.85 Highly fractured and jointed sandstone to south of Fourche La Fave River fault in upper portions of Lower Atoka lithic unit.

141.7 Highly-laminated zone at top of massive sandstone on right side of road.

142.2 Several small faults and folds in Lower Atoka.

143.1 Bottom markings on sandstone in Lower Atoka lithic unit on left side of road.

144.5 Small fault in Lower Atoka on right side of road.

145.1 Big Cove Creek.

145.75 Small fault in Lower Atoka.

146.9 View of Stanley-Jackfork terrain to south. Tall peak is Forked Mountain which is believed to be basal Jackfork.

148.25 Probably tear fault here.

148.55 Ti Valley (?) fault is believed to be in this immediate area.

148.7 Overturned drag fold on left side of road.

149.15 Massive sandstone on left possibly in Lower Atoka.

149.35 Hollis, Arkansas. The vertical dipping sandstones are believed to be in the upper portions of the Stanley Shale. The Hollis-Forked Mountain area must be mapped in more detail before many of the questions can be answered in this region.

149.55 South Fourche River.

149.65 Disturbed shale and sandstone. Probably in Stanley Shale.

150.1 Sam-Ann's Cafe. Excellent food.

150.7 **OPTIONAL SIDE TRIP.** Junction of North Fork Road to left.

Side Trip to Forked Mountain-Pitkin Limestone erratics. Follow North Fork Road past Lower Jackfork (?) Sandstone quarry on right.

Continue for three miles, turn right on Oak Mountain Road, continue for 2.8 miles. On left side of road are siliceous shale and thin cherts which are conodont-bearing. The sandstone to the north contains some invertebrate remains. Elias placed the Mississippian-Pennsylvanian break between these two units. Continue for 0.2 miles to bottom of hollow and park. Erratics are about ⅔ of a mile down old logging road to east. They occur at the bottom of the draw. The Pitkin Limestone erratics occur in shale and siliceous shale some of which contain conodonts. These 6 or 7 erratics occur as lense-shaped to rounded masses. They vary in size from cobbles to masses larger than a car. They are interpreted as being slump-slide masses from the north. One Pitkin cobble is within a sandstone boulder, indicating at least two cycles of slumping. This zone may truly be classified as wildflysch. It is my present opinion that the erratics are in the Upper Stanley.

151.4 Slump masses in Upper Stanley. This zone is along strike with Pitkin Limestone erratics which occur a few miles east of here and are described in the Side Trip.

151.5 Bear Creek.

152.2 Vertically-dipping sandstone and shale, possibly in Stanley Shale. For the next few miles we are passing through a highly complex interval of Stanley and Jackfork.

153.8 Sugar Creek.

157.7 Garland-Perry County line.

157.95 Several small folds and faults in Jackfork (?) Sandstone.

158.45 Middle Fork Saline River.

158.55 Large quartz vein. The clay mineral rectorite occurs in this vein.

158.75 Iron Springs Park.

159.25 Stanley Shale outcrops.

160.3 Lower Stanley exposures.

160.95 Upper members of Arkansas Novaculite.

161.1 Middle member Arkansas Novaculite. Notice high degree of cleavage. The Arkansas Novaculite in this Frontal Ouachita area is less massive and possibly thinner than in the Hot Springs region.
The basal portions of the Stanley to the north of this outcrop is marked by brownish-red to buff shale. This zone has been observed at several other localities in the Ouachitas.

161.2 Lower member of Arkansas Novaculite.

161.9 Middle Fork Saline River.

162.05 Banded slate in Womble Shale caused by cleavage at an angle to the bedding. Miser and Purdue describe several such occurrences in the Womble and Mazarn Formations in the Hot Springs district.

163.4 Jessieville, Arkansas.

164.15 Coleman Creek.

165.25 Blakely Sandstone. This is a very fine exposure showing both weathered and fresh rock. A coarse conglomerate occurs in some beds. Quartz veins are common.

165.5 **OPTIONAL STOP. Blue Springs.**
Charlie Coleman's quartz crystal stand. This is an excellent place to obtain many varieties of fine quartz crystals.

166.9 Anticlinal valley of Mazarn Shale.

167.5 Outcrop of Blakely Sandstone.

167.95 Blakely-Womble contact. A few rounded granitic fragments have been found at this locality.

169.25 Mountain Valley, Arkansas. Approximately one mile to the right is Mountain Valley spring and water-bottling plant.

170.95 Bigfork Chert.

171.65 Structural disturbance in Womble Shale.

172.8 South fork Saline River. Bigfork Chert.

173.45 Bigfork Chert exposure on right.

174.0 Bigfork Chert. Small drag folds and quartz veins are present in this thin-bedded chert.

175.1 Junction on Hwys. 5 and 7, continue right on Hwy. 5. Womble Shale valley with Bigfork Chert at the west end.

179.05 Hot Springs city limits.

179.25 **OPTIONAL SIDE TRIP.** Hwy. 70 junction left. 0.15 miles massive lower member of Arkansas Novaculite, 0.2 miles farther Polk Creek Shale outcrop, 0.3 farther outcrop of Missouri Mountain Shale overlain by massive lower member of Arkansas Novaculite.

181.2 The Vapors. Bigfork Chert exposed in rear.

181.3 Majestic Hotel. Directly across street is massive bed of Lower Novaculite.

END OF ROAD LOG FOR FIRST DAY

AN INTRODUCTION TO THE CENTRAL OUACHITA MOUNTAINS OF WESTERN ARKANSAS

O. A. Wise, Jr.*

The Ouachita Mountain anticlinorium of Arkansas is a well developed, strongly expressed east-west trending structural feature that extends from the state line in the west to the Mississippi embayment in the east where its surface expression becomes mantled and obscured by Tertiary sediments. The extent and trend of the feature have not been precisely determined beyond this point but it would appear that the axis swings to the southeast.

The rocks making up the Ouachita Mountains have undergone intense deformation resulting in the development of overturned and recumbent folds and locally, considerable shear cleavage is in evidence. This cleavage often obliterates the original bedding of the sediments and frequently is mistaken for it. Almost all faults identified in the area are parallel to the axis of folding and, therefore, easily obscured. The intense folding and crumpling of the strata coupled with the difficulty in delineating faults makes it exceedingly difficult to determine whether repetition has or has not taken place in any single outcrop. This in turn makes it extremely difficult to arrive at a reliable thickness of the stratigraphic section or a single formation.

The first major work of a regional nature that was published concerning the geology of the Ouachita Mountains of Arkansas was Volume III of the Annual Report of the Geological Survey of Arkansas for 1890, titled **Whetstones and the Novaculites of Arkansas** by L. S. Griswold. As the title implies the purpose of this study was the determination of suitable quarry sites in the Novaculite for whetstone raw material.

The preface of the report (written by John C. Branner, State Geologist, at that time) gives an interesting insight to the conditions under which the work was accomplished. Branner points out that the work was done in a sparsely populated area, on foot and almost entirely alone in heavily wooded country. Branner goes on to remark that there was a lack of maps that was "well-nigh appalling".

In spite of these formidable obstacles the structure, and outcrop patterns set forth in this report have remained essentially unchanged since that time. The stratigraphy has been refined and corrected in subsequent reports, the principle ones being:

The Slates of Arkansas, by A. H. Purdue

The Hot Springs Folio (Geologic Atlas) by A. H. Purdue and H. D. Miser

Geology of the DeQueen and Caddo Gap Quadrangles by H. D. Miser and A. H. Purdue

In the Novaculite report, Griswold was responsible for only a two part stratigraphic breakdown of the Paleozoic rocks into the Lower Carboniferous and Lower Silurian. The refinement of this two part breakdown into the classification as we know it today was accomplished by Purdue and Miser through their work on the "Slate", "Hot Springs", and "Caddo Gap" reports.

In all formations where a definite age has been established for rocks older than the Novaculite it has been done on the basis of graptolites. For the formations that have not as yet yielded any identifiable fossil remains an age assignment has been made based on their stratigraphic position and apparent relation to the adjacent formations.

There is a general thinning of the sedimentary section and individual formations to the north and locally a wedging out of the sandstones of the Blakely formation; a wedging out of the Blaylock formation and the novaculite in the northern mountains. However, it is quite possible in the case of the Novaculite formation that the thinning is at least partly due to erosion, but the lack of extensive developments of conglomerate throughout the remainder of the section would militate against truncation being responsible for any appreciable thinning.

There is considerable speculation and little factual information regarding the nature of the relationship between the Pre-Mississippian Ouachita Paleozoic section and correlative rocks of the Arkansas Valley-Ozark region. The area in which this phenomenon would be expected to take place is buried under a thick layer of steeply dipping, highly faulted post-Novaculite sediments that may postpone indefinitely the subsurface penetration of this section. As yet, no outcrop has been described showing an interrelation of the two facies. The general northward thinning of the older Paleozoic rocks suggests the possibility that an area of

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non-deposition exists between the two in this region.

The following observations and conclusions have been made during the progress of surface work in the S½ of the Mt. Ida-Oden quadrangles, and as the work is still in progress it is quite possible that they may be revised as a result of subsequent findings.

Locally there is a thin conglomerate in the Lower Stanley at or near the interval the Novaculite formation should occupy.

The Novaculite is thought to be missing throughout much of the area in the northern mountains and is thin (fifty feet or less) when identified. The reason or reasons for the thinning or absence of the Novaculite have not been completely determined but it is considered at least in part erosional.

The Blaylock is not developed or has not been identified in the Mt. Ida-Oden areas.

The Bigfork Chert replaces the Novaculite as the dominant ridge-former in the northern mountains. At several localities the Bigfork gives evidence of having had interbedded limestones of a very fossiliferous nature that were possibly biostromal. These interbeds have been resilicified to the point of destroying or obscuring most of this fossil evidence. There is locally, an unusual (for Arkansas Bigfork) development of finely crystalline thin to medium-bedded black limestone in sections 5 and 6, 2 S., 25 W., in the Upper Bigfork. This thickness may be in excess of fifty feet.

The Womble shale is considerably thinner than in the southern mountains. Part of this thinning is a result of faulting that may entirely eliminate the Womble in an area about a mile north of Rock Springs.

The sandstones in the Blakely become very lenticular in the Mt. Ida area. Locally lenses of sandstone up to 30 feet or more in thickness develop and wedge out in a distance of perhaps 1,000 feet. Where the sands are not developed the formation is represented by a shale that so closely resembles the Womble and Mazarn as to frequently make them indistinguishable. As a general rule, the sandstones of the Blakely seem to be more tightly-cemented and thinner-bedded than those of the Crystal Mountain. Frequently the shales of the Blakely are green or a mottled red, the latter probably being a result of weathering.

The Crystal Mountain Sandstone is a prominent ridge-former in the Mt. Ida and Oden quadrangles, however, the sandstone is not as well developed nor are the individual beds as massively developed as in the area around Collier Springs. In the area where older rocks have been mapped as underlying the Crystal Mountain an oolitic limestone conglomerate is frequently found at the contact. This conglomerate can be found just east and west of the junction of Gaston road, and Lybrand road, and on Little Cedar Creek in sec. 29, and 30, 2 S., 25 W. This rock is quite similar to the oolitic limestone found just southwest of Collier Springs.

The Collier of this area is predominantly limestone with the aforementioned conglomerate and minor amounts of shale, and chert. The limestone is thin-bedded, black, very fine to finely crystalline, with occasional quartz and calcite veins and rare stylolites. No fossils have been identified from the Collier as yet, however, some material that is thought to be an algal development has been collected recently.

The general stratigraphic and structural relationships developed by Miser and Purdue in their works provide an excellent foundation for beginning work in an unmapped portion of the Ouachitas.

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ROAD LOG — SECOND DAY

HOT SPRINGS — NORMAN — MENA — WILHELMINA STATE PARK

(This section conducted by O. A. Wise, Jr.)

SUMMARY

This portion of the trip begins on the south side of the Central Ouachita Mountains. It swings back and forth along the axis of the structure and terminates in the frontal zone near Mena.

NOTE: DEPARTURE WILL BE AT 7:30 A.M. FROM THE MAJESTIC HOTEL PROCEEDING NORTHWEST ON WHITTINGTON STREET.

MILEAGE **DESCRIPTION**

0.0 Majestic Hotel

0.2 Turn right on Walnut Street

0.6 Turn left on Myrtle

0.7 **STOP 1. BIGFORK CHERT FORMATION.** (Middle Ordovician) Thin even-bedded cherts with thin layers of inter-bedded shales. The chert is highly-fractured and jointed. This is responsible for the development of considerable scree on the outcrop and also makes it somewhat difficult to obtain a fresh surface in hand specimens. The fresh rock is usually dark but on weathering changes to a silvery gray color. The intense deformation that has taken place and the ability of this rather massive and competent unit to survive this deformation without faulting extensively is well illustrated in the face of the quarry. This illustrates the questionable value of small isolated outcrops in working out structural interpretations in the central Ouachita region.

0.9 Turn right on Whittington

1.1 Turn left on West Mountain Drive

1.5 Bigfork on right

1.6 **STOP 2. POLK CREEK SHALE (Upper Ordovician), MISSOURI MOUNTAIN SHALE (Silurian), ARKANSAS NOVACULITE (Dev.-Miss.)** Here the thin-bedded shales of the Missouri Mountain and Polk Creek have weathered to a reddish buff and buff color. The Missouri Mountain at the left of the exposure contains several beds of conglomerate about a foot thick. This is a local and unusual development. About midway in the exposure are several thin sandstone beds about 3 inches thick. These may possibly be the remnants of the Blaylock formation in this locality. Here the Arkansas Novaculite is a massive to thin-bedded white, sometimes speckled translucent to opaque chert. Zones of cavities resembling fossil molds are present. From place to place the rock is highly-joined and fractured, some of the joints giving a false appearance of bedding planes. Keep in mind that this entire section on West Mountain is overturned.

2.3 **STOP 3. HOT SPRINGS FORMATION (MISSISSIPPIAN).** Unevenly-bedded chert pebble conglomerate and medium to massive-bedded sandstone. The sandstone is composed of quartzose sand, rounded and frosted and well cemented. Thin shale beds are present in the outcrop on the left. Because of the overturned position of the beds the conglomerate appears to overlie the sandstone.

2.9 Scenic Mountain Drive

3.4 Junction with Prospect Terrace; turn right on Prospect Terrace.

3.8 Turn right on Grand Avenue.

4.1 Turn left on Lacey.

4.4 Turn right on Hobson.

4.7 Turn left on Gardner.

5.0 Turn right on Highway 270.

7.4 Turn right on Music Mountain Lodge Road.

7.5 Turn left, DO NOT CROSS RAILROAD.

7.6 Turn left (Arm of lake seen through trees on right)

7.8 **STOP 4. STANLEY SHALE. (MISSISSIPPIAN)** Relatively fresh exposures of Stanley are well exposed in the cuts behind the buildings to the right and left of this road and across the highway. The shales are black thin-bedded and brittle. When weathered, the shales take on a buff brown color. No microfossils have been reported from this area. We are located structurally near the axis of the southwest plunging nose of the overturned anticline that forms West Mountain.

7.8 Turn right onto Highway 270.

16.0 Brady Mountain Lodge Road

18.8 Passing through gap in Novaculite Ridge

19.1 House on left, old home of Col. Elias W. Rector, father of Arkansas Geological Survey. House is l ocated between ridges of Novaculite and Bigfork in the interval that would be occupied by the Polk Creek Shale, Blaylock Sandstone, and Missouri Mountain Shale if all are present.

21.0 **STOP 5. WOMBLE SHALE.** (Lower and Middle Ordovician). A black carbonaceous, thin-bedded shale, weathering brown, locally beds of black very finely crystalline limestones are present. The shales in this immediate vicinity have yielded more varieties of graptolites than any other locality in the Ouachita Mountains. We are here situated on the nose of northeast plunging anticline. The Blakely sandstone ridge, ½ mile to the northwest strikes about 20 degrees north of east, then makes an abrupt swing to the west for about 2 miles, and then again swings to the east striking almost east-west and passes about a mile and a half north of this locality. The ridge to the south is formed by the Bigfork Chert and roughly parallels the Blakely outcrop.

21.2 Lewis Brothers Crystal Stand at Crystal Springs

21.5 Crystal Springs Post Office

24.1 **STOP 6. BLAKELY SANDSTONE.** (Lower Ordovician). Well rounded, coarse to fine-grained sand, calcareous in part. Here the sandstone is rather dark where fresh, weathering to a rusty brown. A weathered monchiquite sill is exposed in this cut. Relatively unweathered igneous rock can be found in the shale on the south side of the road in the borrow ditch back towards Hot Springs. As the route continues to the northwest it will pass through gaps in ridges of Blakely and Crystal Mountain with the Mazarn shale forming the intervening valley. Then, across the northeast plunging nose of an anticline, the structure can be seen in the dips of the Crystal Mountain exposure on the left side of the road.

25.5 Crossing anticlinal nose indicated by dips in Crystal Mountain Sandstone in left road bank.

27.4 Limestone in right road bank.

27.9 Limestone in right road bank.

29.0 Joplin Landing Road

29.9 Shangri La Lodge Road

31.0 "Rolled" shale in left road cut.

33.9 Rod and Reel Motel and 270 Steak House (Excellent cuisine)

34.1 Turn left on Alamo-Logan Gap-Norman Road.

36.7 Turn right on Norman Road. This portion of the route runs through the Crystal Mountain Structural complex which is made up principally of sandstone ridges of the Crystal Mountain formation and shale valleys of the Mazarn formation.

36.8 Keep straight on Norman-Collier Springs Road.

39.8 Turn left on Scenic Route-Collier Springs-Norman Road.

40.5 Crystal Mountain Sandstone, very poorly cemented, conglomeratic in part.

41.3 Collier Springs and Comfort Station (up hill on left)

41.5 **STOP 7. CRYSTAL MOUNTAIN SANDSTONE.** (Lower Ordovician) Thin to massive bedded, highly fractured and jointed, medium grained, rounded and frosted, well cemented.

41.9 **STOP 8. COLLIER SHALE.** (Cambrian?) At this stop the formation is represented by a black oolitic, sometimes conglomeratic, limestone in addition to the interbedded black shales and thin-bedded finely-crystalline limestones and dense black chert normally described in the section. These older rocks are here exposed in a breached anticline with Crystal Mountain on either flank. This represents the axis of the Crystal Mountain uplift and Ouachita anticlinorum.

42.1 Interbedded cherts, shales and limestones at left of bridge.

42.9 High Peak Fire Tower Road, keep right.

44.5 Crystal Recreation Area (Lunch Stop)

47.7 **STOP 9. MAZARN SHALE.** (Lower Ordovician) Black shale, weathering to a buff brown, highly jointed and fractured resulting in rapid disintegration of outcrops. This Mazarn outcrop is on the south side of the uplift. The Blakely Sandstone can be seen on a hillside on the left of the road when entering Norman. The route will then turn left along the Blakely until reaching Black

Springs and from there it will cross Womble and Bigfork until reaching Stop 10.

47.7 Turn left on Highway 27.

48.2 Passing through Blakely ridge, sandstone can be seen up hillside to the left.

48.4 Junction with Highway 8 at Norman, proceed south and west on Highway 8.

48.5 Turn right.

50.3 Black Springs. Notice nobby Bigfork hills on skyline in front and smooth line of distant Novaculite ridge to left front. Nobby development is typical of Bigfork in most areas. For next 20 miles or so route will generally parallel Bigfork ridges with intervening valleys of Womble and Polk Creek.

52.0 Limestone in right road bank.

52.8 Carbonaceous zone in Bigfork.

71.5 **STOP 10. BIGFORK CHERT, WOMBLE SHALE CONTACT.** (Middle Ordovician) Note variations in dip that could be obtained for limited exposures along this series of outcrops. This stop shows an excellent relationship between the Bigfork and the Womble. The interbedded nature is quite evident in spite of some minor faulting that has taken place. Graptolites are exceptionally abundant in the Womble Shales at the eastern end of the outcrop. A few feet to the west the graptolites have been almost obliterated by bedding plane movement in the shales and now are recognizable only as silvery smears.

This Bigfork ridge marks the boundary in this area for the Central Ouachita province. After leaving this series of outcrops the remainder of the trip will be in the Frontal Province.

85.8 Intersection State Highway 8 and U. S. Highway 71.

(This section conducted by D. R. Seely)

85.8 From intersection of U. S. Highway 71 and State Highway 8 continue northwestward through Mena to Skyline Drive and proceed toward Ward Lake Dam.

86.5 Note terrace deposits on the east side of road.

87.4 Take left cutoff into Ward Lake Dam.

87.5 **STOP 11. WARD LAKE DAM.** Park just south of dam. Rocks exposed in the Lake spillway and near the east end of the dam are undifferentiated (probably upper) Stanley beds, the Chickasaw Creek Siliceous Shale, and basal beds of the Jackfork Group. They possess ripple marks, cross-bedding, bottom marks, plastic-flow structures and stylolites. The section is disrupted by the Windingstair fault which is here near its eastern terminus.

87.6 Intersection with Mena-Wilhelmina State Park gravel road. Turn left and continue up east end of Rich Mountain. Sandstones and shales of the Lower Jackfork are well exposed at several places along this road.

95.6 Continue straight ahead on Skyline Drive toward Wilhelmina Inn. The road on the left is to Rich Mountain Lookout Tower.

97.4 Merge with hard surface road and continue up the mountain.

98.1 Take sharp left turn into parking area at Wilhelmina State Park.

98.3 **STOP 12. WILHELMINA INN.** From this unusual vantage point one may see the eastern end of Lynn Mountain syncline, Blackfork Mountain, the traces of Honess and Windingstair faults, and the Broken Bow-Benton uplift.

End of Road Log for second day.

STRUCTURE AND VEIN QUARTZ OF THE OUACHITA MOUNTAINS OF OKLAHOMA AND ARKANSAS[1]

Hugh D. Miser[2]

Introduction

The structure and the vein quartz of the Ouachita Mountains are closely related in origin and they in turn are related to the other geologic features of the region. They thus constitute an important chapter on the geology of the Ouachita Mountains.

The exposed sedimentary rocks are 25,000 feet thick; they range in age from Cambrian to Pennsylvanian; and they were folded, faulted, and metamorphosed during the Pennsylvanian period. The deposits of vein quartz, asphaltite, and certain metaliferous minerals were formed during the same period. Igneous rocks — some of probable Cretaceous age and some of possible Ordovician age — are exposed in a few small areas.

Structure

The present discussion of the structure of the Ouachita Mountains is abstracted mainly from my paper of 1929 on this subject which was published as Bulletin 50 of the Oklahoma Geological Survey. This discussion is, however, brought up to date by including the subsequent studies of many geologists.

The paper of 1929 gave the first published description of the structure of the entire Ouachita Mountain region. It was based on information that I had obtained during all or parts of 14 field seasons beginning in 1907, and on the work of other geologists including Griswold (1892), Ashley (1897), Drake (1897), Taff (1902), Wallis (1915), Honess (1923, 1924), Purdue (1909), and Purdue and Miser (1923). From 1923 to 1925 I compiled, for the State geologic maps of Oklahoma (Miser, 1926) and Arkansas (Branner, 1929), all available maps including much unpublished mapping by Taff, Purdue, and me. Also, at this time I compiled a geologic map of the Ouachita Mountains which showed clearly the major structural features including the Oklahoma structural salient. The recognition of this salient led promptly to my interpretation of its forward thrusting. Next, there followed in 1927 my mapping and discovery of the window in the Potato Hills in Oklahoma. In December of that year a paper on the structure of the Ouachita Mountains was presented by me at the Cleveland, Ohio, meeting of the Geological Society of America. My conclusions stated there included discussion of the window in the Potato Hills and of a probable window near Broken Bow, McCurtain County, Oklahoma. The interpretation of a window in that county was based on Oklahoma Geological Survey Bulletin 32 by Honess. He was at the meeting and commented favorably about my conclusions.

The geologic map (Fig. 1) herewith includes not only the mapping that was compiled in 1923-1925 for the Arkansas part of the Ouachita Mountains but also the mapping of Reed and Wells (1936) and of Reinemund and Danilchik (1957). It also follows the second geologic map of Oklahoma (Miser, 1954) which contains the mapping of Hendricks, Gardner, Knechtel, and Averitt (1947) and the mapping of many oil companies.

The rock strata throughout the Ouachita Mountains have been deformed by folding and faulting. The faults are chiefly reverse and thrust faults. The individual folds range from open to closely compressed anticlines and synclines. Also, there are compound folds — anticlinoria and synclinoria — some of which are normal fan folds and some are inverted fan folds.

The principal anticlinal fold of the Ouachita Mountains extends from Benton, Arkansas, in a west-southwest direction to Broken Bow, Oklahoma, and is essentially a compound anticlinorium consisting of several anticlinoria. It is here named the Broken Bow — Benton uplift. Along its higher parts, strata of Devonian, Silurian, Ordovician, and Cambrian age are exposed and these are succeeded on the flanks of the fold by strata of Pennsylvanian and Mississippian age. A smaller anticlinorium is

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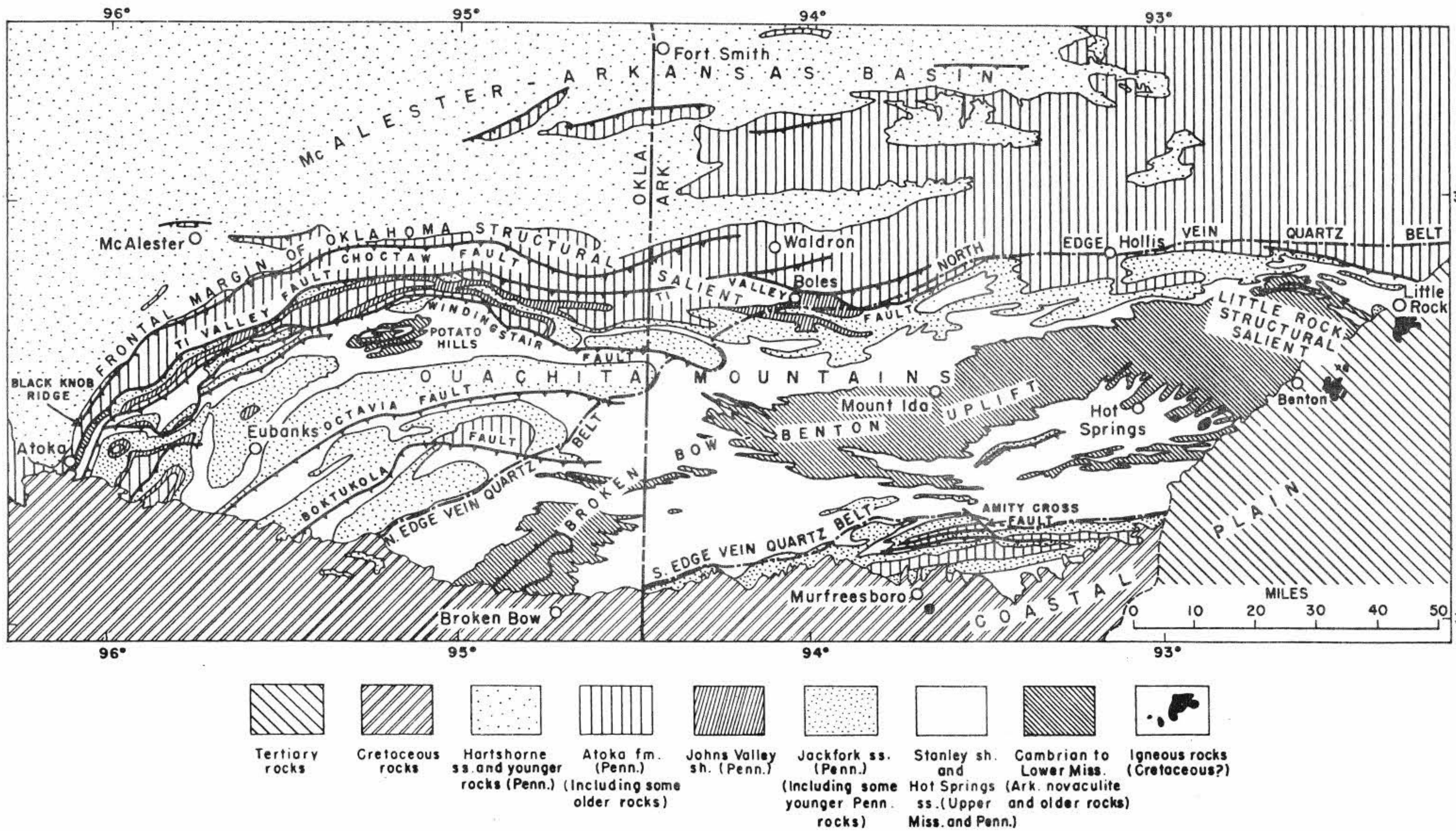

Fig. 1. Geologic map of Ouachita Mountains. Also shows progressive regional metamorphism of Jackfork sandstone and Arkansas novaculite.

in the Potato Hills where strata of Devonian, Silurian, and Ordovician age are exposed in a window and in the overthrust sheet. A belt of outcrop which may represent one limb of a smaller fold is at Black Knob Ridge in Oklahoma where the same rocks are exposed on the northwest edge of an overthrust sheet (Hendricks, Knechtel, and Bridge, 1937; Hendricks, Gardner, Knechtel, Averitt, 1947). Several small faulted exposures of strata of Devonian and Mississippian age overlain by Pennsylvanian strata lie in the frontal or northwestern part of the mountains in Oklahoma.

A dominant feature of the Ouachita Mountains is the Oklahoma structural salient which occupies all the Oklahoma part of the mountains and extends into western Arkansas. A second and smaller like feature is the Little Rock structural salient at the east end of the mountains.

The frontal marginal belt of the Oklahoma structural salient forms a great arc about 200 miles long. It trends northeasterly and then easterly along the northern edge of the mountains in Oklahoma and next passes southeasterly transverse to the mountains in western Arkansas from Boles to the Amity cross fault (see Figs. 1 and 2). The Choctaw fault lies at the north edge of the mountains in Oklahoma. Other long, generally concentric and parallel faults are farther south in that State; and several structural blocks, each separated by a major fault and each being more or less distinctive in the structure and stratigraphy of the rock formations, have been recognized and described by Hendricks (1947). Concerning these structural blocks Hendricks states, "Geologically, the area between the Choctaw and Ti Valley faults may be considered the frontal part of the Ouachita Mountains, for this area exhibits many features that indicate a transition from the geology of the McAlester coal basin and the Arbuckle Mountains to that of the central part of the Ouachita Mountains. Structurally, this frontal part of the Ouachita Mountains is similar to the central part of the mountains, and is unlike the McAlester coal basin and Arbuckle Mountain regions. Stratigraphically, it is similar to the coal basin and Arbuckle Mountain regions and is almost completely unlike the central part of the Ouachita Mountains."

The rock sequence that is south of the Ti Valley fault is commonly called the Ouachita Mountain facies. The rocks of this facies seem to have been thrust north-northwestward a distance of 20 miles or more. This estimate of the thrusting was obtained by measuring the distance from the Ti Valley fault to a projected line that represents a west-southwesterly continuation of the structural axes of the region immediately north of Mount Ida, Arkansas, (Fig. 2). Such a continuation of these axes would pass through or near Eubanks, Oklahoma. The distance from the Ti Valley fault to Eubanks is about 20 miles. The asphaltite deposits (Ham, 1956), the oil seeps, and the few known small oil pools of the Ouachita Mountains are found in Oklahoma as far as 20 to 25 miles southeast of the Ti Valley fault. They thus are restricted to the northwest part of the Oklahoma structural salient. My opinion is that these hydrocarbons did not come from the Ouachita Mountain facies but came from rocks like the Arbuckle Mountain facies over which the Ouachita rocks have been thrust a distance of about 20 miles (Miser, 1934a). If the hydrocarbons were indigenous in the Ouachita facies, some indications of them should have been preserved and noted farther south and east in the Ouachita Mountains of Oklahoma and Arkansas.

The discovery of the window in the Potato Hills in 1927 established the presence of a low-angle overthrust planes in the Oklahoma structural salient. Since then, Hendricks, Gardner, and Knechtel (1947, Prelim. Map 66, sheet 1) have mapped a klippe of the Ti Valley fault in Oklahoma, and Reinemund and Danilchik (1957) have mapped low-angle faults in the Waldron area, Arkansas. The window fault in the Potato Hills is interpreted by me to represent a southward and somewhat folded continuation of the plane of the Windingstair fault which follows the south base of Windingstair Mountain, 3 miles north of the Potato Hills. The northward thrust of the rocks above the window fault seems to be 3 miles or more. The rock formations exposed inside the window and in the thrust sheet are the Stanley shale, Arkansas novaculite, Missouri Mountain shale, Polk Creek shale, Bigfork chert, and Womble shale. A layer of conglomerate, generally less than 1 foot thick, occurs at or near the base of the Stanley shale in the window; it was not observed by me in the Stanley shale outside the window. Otherwise the rock strata in the window and those of the thrust sheet are the same. The anticlines inside the window are more closely compressed than those outside the window. During my mapping of the Potato Hills in 1927 I considered the possibility of a faulted inverted fanfold there, but the facts, as I saw them, indicated the existence of a window. Others who have worked in the Potato Hills and who follow the window interpretation include Miller (1956), Arbenz (1956), and company geologists, one of whom did the mapping in the Potato Hills as shown on the 1954 edition of the Oklahoma geologic map.

My interpretation of the window near Broken Bow, in northern McCurtain County, is that the window fault is a southward and slightly folded continuation of the plane of the Boktukola fault (Figs. 1 and 2). This interpretation, first presented publicly in a paper in 1927, was first published in 1929 (Oklahoma Geol. Survey Bull. 50). Later it was included on the second geologic map of Oklahoma (Miser, 1954), which represents my present opinion on the subject. It is based on the structural and stratigraphic data presented by Honess in his monumental contribution to the geology of the Ouachita Mountains (Honess, 1923). He points out that the deformed strata in the central part of the pre-Carboniferous area in McCurtain County do not partake of the folds of the rocks that surround the central area. To explain these differences in structure I interpret the central area to be a window through the overthrust sheet of the Boktukola fault. My estimate of the thrusting of this sheet is 5 miles and possibly 8 miles. These distances are the apparent amount of displacement of the Atoka formation, Jackfork sandstone, and Stanley shale, which are exposed along the trace of the Boktukola fault.

The low-angle thrusting just described supports the conclusion of Powers (1928), that the faulting in the Ouachitas included "notable overthrusting of the sheet (Decken) type". His outline map of the Ouachita Mountains in Oklahoma and one of his structure sections show the window in the Potato Hills (Powers, 1928, pp. 1038-1039).

The Little Rock structural salient at the east end of the Ouachita Mountains shows an arcuate arrangement of the structural trends in the region between Little Rock and Hot Springs (Figs. 1 and 2). Apparently, the great part of the salient lies beneath the Cretaceous, Tertiary, and Quarternary strata of the Coastal Plain.

Relation of structure to gravity

A gravity minimum of great regional significance coincides with the combined area of the Ouachita Mountains and the adjacent McAlester-Arkansas basin (Lyons, 1950; Cook, 1956). This gravity feature culminates, as stated by Cook, "in a tremendous gravity minimum over the Ouachita Mountains with a closure of about 70 milligals (Lyons, 1950). * * * This anomaly constitutes the strongest gravity minimum in the Midcontinent region." The area of greatest minimum within the minus 100-milligal contour (Lyons, 1950, map on pp. 34-35) includes the Potato Hills and the adjacent region. The minimum seems to be due to a combination of several factors including (a) the thick sequence of Pennsylvanian and Mississippian strata in the area of closure, (b) the relatively thick sections of shale in the pre-Mississippian rocks of the Ouachita facies, and (c) the thickening of the rock section by the piling up of overthrust sheets.

Relation of structure to exotic boulder beds

Exotic boulder beds are found in an arcuate belt 125 miles long and 17 miles wide along the northern part of the Oklahoma structural salient. These boulder beds are mainly in the Johns Valley shale (Ulrich, 1927; Powers, 1928; Harlton, 1934, 1938, 1947; Miser, 1934; Moore, 1934; Cooper, 1945; Hendricks and others, 1947; Rea, 1947; Reinemund and Danilchik, 1957) but other beds are in the Stanley shale (Harlton, 1938, 1947) and Jackfork sandstone (Harlton, 1938, 1947; Hendricks and others, 1947). The exotic boulders are chiefly masses of limestone of Ordovician to Mississippian age and masses of shale of Ordovician and Mississippian age. Some areas of shale of Mississippian age have been interpreted by Cline (1956a) as beds in their normal stratigraphic position between strata that have undergone marked changes in depositional facies. The exotic boulders have been interpreted by me as having a local source from fault scarps along the north side of the Johns Valley sea. Some of the source areas may now lie between the Choctaw and Ti Valley faults but some of the source areas seem to have been overridden by the thrust sheets of the Oklahoma structural salient. The boulders in the Johns Valley shale at and near Boles, Arkansas, resemble rocks that are exposed in the Ozark region and those in Oklahoma resemble rocks that are now exposed between the Choctaw and Ti Valley faults and in the Arbuckle Mountains. My present opinion is that the boulders were transported by submarine landslips from local fault scarps but that some of the largest masses of limestone (Mississippian and older and of Caney shale (Mississippian) on and near the Ti Valley fault may have been derived directly by overthrusting from parent beds.

A shale that contains a few blocks of limestone, some of Early Mississippian age and others of Late Mississippian age (Mackenzie Gordon, oral communications, 1956, 1958) is exposed in the Little Rock structural salient. The exposure is at the south base of Forked Mountain, 5 miles east of Hollis, Arkansas, and 45 miles west of Little Rock, Arkansas. These blocks may lie in a fault zone or in an exotic boulder bed in or below the Jackfork sandstone which forms Forked Mountain. Factors that are involved in offering these two suggestions include the Pennsylvanian age (White, 1934, 1937 and Girty in Miser, 1934) of the Jackfork sandstone and the Pennsylvanian and Mississippian age (White, 1934, 1937; Hass, 1950, 1956) of the underlying Stanley shale. A solution of the stratigraphy and structure of the Forked Mountain area awaits geologic mapping there.

Times of deformation

The boulder-forming orogeny to account for the faulting in Johns Valley time (of Morrow age) was the earliest of several mountain-making movements that took place in the Ouachita region in Pennsylvanian time. Deformation after Johns Valley time and before Atoka time (also Early Pennsylvanian) seems to be indicated by a basal conglomerate of the Atoka formation in the Ouachita Mountains and by chert conglomerates (Melton, 1930) in the Atoka formation. Further deformation including thrust faulting probably took place coincident with movements in the Arbuckle Mountains in Middle and Late Pennsylvanian time (Ham, 1954; Arbenz, 1956). The Tishomingo anticline of the Arbuckle Mountains is believed by Ham (1956) to have moved northwestward between the Washita Valley and Reagan faults, probably as a result of stress transmitted from the Ouachita Mountains. Melton (1930) and van der Gracht (1931) suggest overthrusting of the rocks of the Ouachita Mountains in the Permian period.

Relation of structure to metamorphism

The rock strata in the central belt of the Broken Bow-Benton uplift show the effects of low-grade metamorphism that was produced by dynamic movement and by heat from depth of burial. The arching to form this uplift took place after the major part of the deformation (the close folding and the overthrusting) and after most of the metamorphism of the rock strata of the Ouachita geosyncline (see Figs. 1 and 2).

In the Broken Bow-Benton uplift the basal part of the Stanley shale (Pennsylvanian and Mississippian) and the older shales (Devonian to Cambrian) have been changed in most areas to slates, some of which show differently colored ribbon-like bands on cleavage surfaces that cut across the bedding. In addition, the Crystal Mountain sandstone (Ordovician?), the Blakely sandstone (Ordovician), the Blaylock sandstone (Silurian), and the sandstones of the Stanley shale (Mississippian and Pennsylvanian) and the Jackfork sandstone (Pennsylvanian) have been metamorphosed. A noteworthy feature is that the most altered rocks of the Ouachita Mountains occur in an area north of Broken Bow, Oklahoma, and in a large area southwest of Little Rock, Arkansas. Here the slates are more schistose than elsewhere and the Arkansas novaculite resembles fine-grained quartzite. Furthermore, in the Little Rock area the Jackfork sandstone is quartzite and the Stanley shale as a whole is more slaty, is harder, and is blacker than it is in exposures elsewhere. Rocks of the same age and same original character as those of the Broken Bow-Benton uplift are exposed in Black Knob Ridge at the west end of the Ouachita Mountains and in the Potato Hills in the northwest part of the mountains. In these two areas the rocks have not been metamorphosed like those of the Broken Bow-Benton uplift; the shales have not been changed to slates nor have the sandstones been changed to quartzites.

To add to our knowledge of the observed field relations just described Robert P. Bryson of the United States Geological Survey made a petrographic study of specimens that were collected by me from the Jackfork sandstone and Arkansas novaculite at numerous localities in all parts of the Ouachita Mountains. The study disclosed (1) that a wide belt of metamorphosed rocks occupies the central part of the Broken Bow-Benton uplift, (2) that the metamorphism reaches a maximum near Broken Bow, Oklahoma, and Little Rock, Arkansas, and (3) that the metamorphism decreases both northward and southward from the Broken Bow-Benton uplift (see Fig. 1).

The progressive metamorphism of the Jackfork sandstone has resulted in marked changes, namely, (a) the formation of less regular boundaries, between the sand grains, (b) the formation of sutures along the contacts between the grains, and (c) the transformation of the interstitial material into coarser-grained material, with the development of new quartz grains, mica, and chlorite. These changes have thus transformed the texture of the Jackfork sandstone to the mosaic texture of quartzite in parts of the area. The specimens of sandstone from the different localities have been

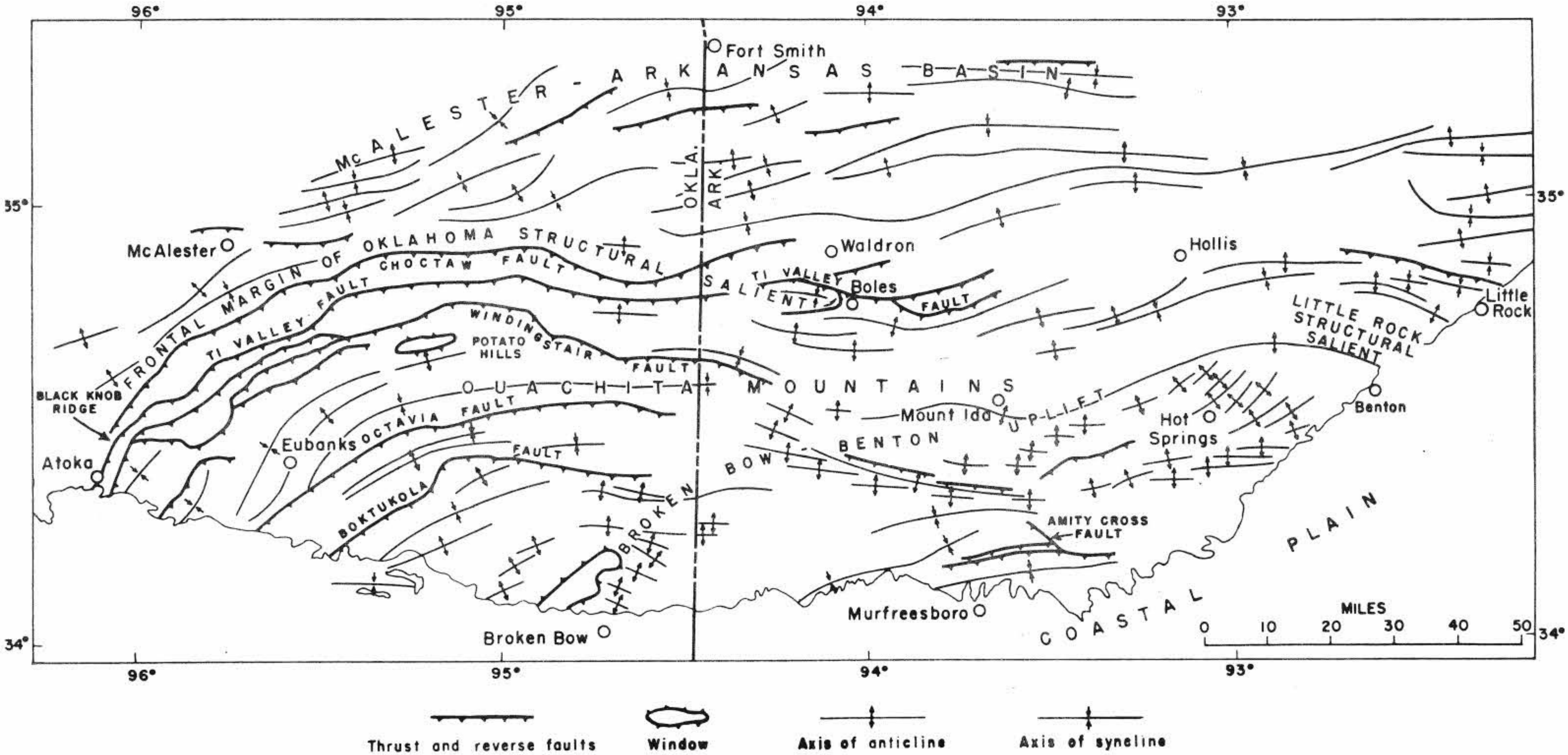

Fig. 2. Structure map of Ouachita Mountains.

classified by Bryson into four stages or groups (designated by Roman numerals) on the basis of the progressive changes recognized during the microscopic examination of thin sections of the specimens. A brief description of these four stages follows:

I. Rounded sand grains; grain boundaries showing no effect on individual grains of their impingement on adjacent grains.

II. Rounded to angular sand grains; some grain boundaries modified by impingement on adjacent sand grains; some small amount of recrystallization of interstitial material to make new quartz, chlorite, and mica.

III. Angular sand grains; many grain boundaries modified and sutures developed on contacts between (a) adjacent original sand grains, (b) new grains of quartz formed by the partial recrystallization of the interstitial material, and (c) original and new grains.

IV. Mosaic of angular grains with sutured boundaries, resulting from modification of the original sand grains and recrystallization of the interstitial material to make new quartz, chlorite, and mica.

Progressive metamorphism of the Arkansas novaculite has destroyed original sedimentary textures and increased the grain size. It has caused the disappearance of radiolaria, detrital quartz grains, and grains of rhombohedral calcite and chalcedony, present in the original novaculite. In addition, dynamic metamorphism has produced fracturing and shearing and preferred orientation of the grains in some of the specimens. The novaculite specimens have been classified by Bryson into four stages (designated by Roman numerals). A description of the four stages is here given:

I. Fine-grained (less than 0.01 mm.) novaculite; variable grain size; radiolaria, chalcedonic grains, detrital quartz sand grains, and rhombohedral grains of calcite are preserved in specimens from many localities; quartz veins may be present.

II. Fine-to medium-grained novaculite; radiolaria and chalcedonic grains not preserved; detrital quartz grains show boundary changes; rhombohedral grains or casts of calcite may remain; quartz veins common.

III. Medium-grained novaculite; detrital quartz and rhombohedral grains or casts not preserved; quartz veins common.

IV. Coarse-grained (more than 0.03 mm.) novaculite.

The oilstone quarries in the Arkansas novaculite near Hot Springs, Arkansas, are in an area where the stage of metamorphism falls in stage II (Fig. 1). Another area showing this stage of metamorphism of the novaculite is a few miles north of Broken Bow, Oklahoma.

Several notable contributions to the petrography and metamorphism of the rocks of the Ouachita Mountains have been made in recent years. These include papers by Goldstein and Reno (1952), Goldstein and Hendricks (1953), Goldstein (1955), Goldstein and Flawn (1958), and Weaver (1958).

Vein quartz

The pursuit of my hobby — the collecting of Arkansas quartz crystals since 1907 — aroused my interest in their geologic story, and I presented in 1943 some observations and conclusions on the quartz crystals and veins and on the relations of the quartz veins to the structure, metamorphism, and metalliferous deposits of the Ouachita Mountains (Miser, 1943).

Most of the veins and crystals are restricted to a belt, 30 to 40 miles wide, extending in a west-southwesterly direction from Little Rock, Arkansas, to Broken Bow, northern McCurtain County, Oklahoma, a distance of about 150 miles (see Fig. 3). I do not know how far the vein-bearing rocks extend eastward beyond Little Rock, owing to their concealment by Cretaceous and Tertiary strata, but the vein-bearing rocks extend southwestward beneath Cretaceous strata in southeastern Oklahoma and northeastern Texas, as shown by cuttings from wells.

The veins reach a width of 30 feet in Arkansas and 100 feet in Oklahoma and are most numerous in the central part of the vein quartz belt where they occur in shale, slate, sandstone, and other rocks. But along and near the borders of the vein quartz belt the veins are usually confined to sandstone beds that lie between thick beds of shale. The veins were formed by the filling of open fissures and do not show evidence of much replacement of wall rock.

Associated minerals include calcite (as veins and tabular and rhombohedral crystals), siderite, chlorite, adularia, orthoclase, and dickite. Outside the vein quartz belt dickite, paper-thin quartz veinlets, and small quartz crystals are widely distributed along and near reverse and thrust faults; some occurrences of these minerals along and near such faults are in the Oklahoma-Arkansas coal field.

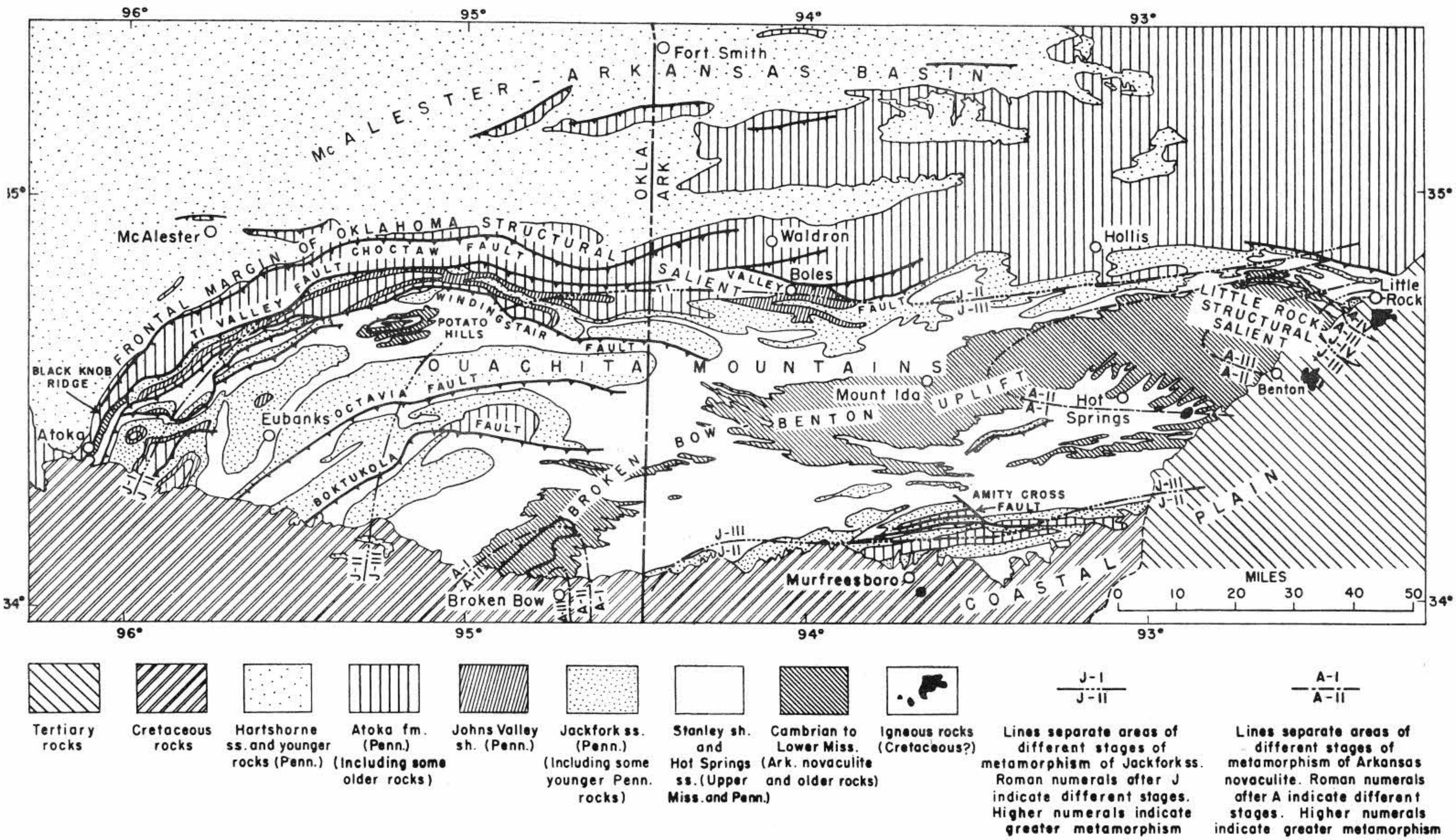

Fig. 3. Geologic map of Ouachita Mountains showing area of occurrence of vein quartz.

The vein quartz, the quartz crystals, and the associated minerals of the Ouachita Mountains are hydrothermal and they were formed during the closing stage of Pennsylvanian orogeny (Honess, 1932; Miser, 1943; Engel, 1946, 1952). The time of quartz deposition is inferred largely from the structural relations of the veins to the enclosing rocks and from the deformation of the veins themselves. The deformation of the rocks of the Ouachita Mountains began early in the Pennsylvanian period and continued to the late part of the period. Quartz veins follow faults, fractures, and bedding planes; and vein-filled fractures cut across folds and across slaty cleavage. The veins are not folded but have been faulted, fractured, and crushed at numerous places.

The emplacement of the quartz veins thus seems to have taken place after the more intense deformation of the rocks and after the formation of the slates in the central part of the Broken Bow-Benton uplift. But their emplacement seems to have preceded or accompanied moderate deformation. The suggestions are offered (1) that the regional arching to form the Broken Bow-Benton uplift was the final stage of the Pennsylvanian orogeny and (2) that the arching developed tensional fractures to serve as suitable sites for the quartz veins. Such upwarping during the period of quartz deposition would have produced brecciation and fractures in the quartz that would be healed partly or wholly by a later deposition of quartz.

The belt of vein quartz thus coincides with the Broken Bow-Benton uplift. Also, the belt coincides with the belt of metamorphosed rocks on that uplift. The widest quartz veins in Arkansas are west of Little Rock and the widest veins in Oklahoma are north of Broken Bow.

Deposits of antimony, lead, copper, zinc, and mercury, are found at places in the Ouachita Mountains, and are associated with a small amount of vein quartz. Some geologists have connected the origin of these deposits with the probable Cretaceous igneous rocks of Arkansas (Hess, 1908; Branner, 1932) but others, among whom I may be counted, believe that these metalliferous deposits and their associated minerals are related to the time of Pennsylvanian structural deformation (Honess, 1932; Stearn, 1935; Reed and Wells, 1938; Gallagher, 1942; Miser, 1943). This conclusion indicates that these metalliferous deposits were formed at the time of the extensive vein quartz deposition.

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GAS PURCHASE CONTRACTS
WITH PARTICULAR REFERENCE TO THE ARKOMA BASIN

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The demand for natural gas reserves has greatly accelerated over the past 20 years since World War II. This increase in demand is due primarily to the number of new pipeline companies being organized to transport gas from Southern and coastal sources of supply to the large Eastern markets. Consequently, the buying of gas in the field has become more and more competitive each year since each pipeline company must maintain a substantial reserve index in order to insure a firm supply to its customers and future expansion. Therefore, in a relatively short time, field prices have increased at a rapid rate from 3¢ in the early Forties to a maximum of 21½¢ plus 2¢ or 23½¢ in South Louisiana. This was the Catco price covering 3 trillion feet of gas. Such a sharp increase is, of course, partially due to inflation during that same period of time, which has affected all phases of the oil and gas business. However, inflation has been but a secondary factor in this sharp rise in gas costs. Increased demand has been the main factor affecting the increase.

Gas purchase contracts have, in the last 15 years, changed from a very simple one-page letter agreement to a present day complex instrument incorporating some 40 odd pages and covering every possible occurrence that can be imagined to take place in the buying and selling of gas. The producers have been responsible for complicating the contracts equally as much as the pipeline companies. Both producer and gas company employees detest these lengthy contracts but have found it necessary to cover all phases of the purchase.

The following discussion concerns the major points of a gas purchase contract:

PRICE:

Naturally, the meat of the contract is considered the price. The producers are, of course, looking for highest prices possible to afford them the fastest payout on their investment. The majority of the present day contracts provide for a price schedule setting out a starting price with periodic step-ups. These periodic step-ups, or price escalations, are built into the contract to cover an anticipated continuation of the present inflationary trend. I would estimate that the average price escalation in present day contracts would be in the range of 2/10¢ per year.

The producer felt that he also needed additional protection against inflation and, as a result, many pipeline companies were forced into use of Favored Nations Clauses in many of their contracts. This clause, in effect, provides that if the pipeline company purchasing the gas later contracts for gas at a higher price with another party in a particular area, then the pipeline company will be obligated to increase the price in the first contract. This particular clause, however, has had adverse effects in many cases on the producers. A pipeline company that has completely tied all of its gas reserves into contracts with Favored Nations Clauses finds itself in a position of not being able to increase the price due to the tremendous total increase in its total cost of gas that would occur under all its other contracts. It is my opinion that, in general, Favored Nations Clauses have actually been the direct cause of depressed prices in many areas. The producers nowadays apparently realize the adverse effect of these Favored Nations Clauses, and we very seldom have a request to include a Favored Nations Clause in current contracts.

QUANTITY:

Of course, another very important clause in a gas purchase contract is the quantity clause. I personally consider this even more important than the contract price since the Federal Power Commission has authority to regulate the price and the producer is seldom in a position to know exactly what price will be approved by the FPC when he makes a contract to sell his gas. On the other hand, the FPC never makes any ruling as to quantity clauses and a producer who has a contract for a low price but a good quantity clause is in a better position to show a short-term payout on his investment than the producer with a high price and a poor quantity clause.

There are several different types of quantity clauses:

a. Most pipeline companies desire a quantity clause based on a 20 to 27 year depletion of the reserves.
b. Other quantity clauses provide for a set minimum per sand well.
c. Of course, on the purchase of oil well gas,

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most companies attempt to take all gas produced with the oil in order that the oil allowables will not be penalized.

PRESSURE:

Pressure and compression provisions in a contract all are of prime importance to the producer since the producer is inevitably faced with the necessity of compressing his gas before his reserves are depleted. Generally speaking, requirements in gas purchase contracts range in the area of 1,000 to 1,200 pounds maximum delivery pressure. However, many of the more localized pipeline companies, such as ourselves, where the market is not too distant from the supply source, can in instances offer pressure provisions in the contract at maybe 500 pounds maximum or even less depending on the location of the gas reserves.

Field compression probably costs the producers 1¢ to 2¢ per MCF. However, the cost per MCF is not as great an obstacle as the necessity of facing a large initial investment. Most of the producers would rather invest their money in other oil and gas prospects than tie up a large amount of cash in a compression unit. Consequently, many times in a competitive negotiation gas is sold into a pipeline with lower pressures at a lower price than could have been obtained from another pipeline with high pressure lines in the vicinity of the gas.

POINT OF DELIVERY:

Another important provision in a gas purchase contract is the point of delivery which, of course, establishes how much pipeline the producer, or the purchaser, will be obligated to construct to deliver the gas to the pipe line.

Generally, the point of delivery provisions fall in three categories: wellhead, central point in the field, and central point at the purchaser's pipeline. Many pipeline buyers require delivery of the gas at their line, whereas ALG is usually willing to negotiate on the basis of wellhead delivery or field delivery. Our willingness to negotiate on any of the three delivery points has in many cases aided us in purchasing gas which might have gone to a competitive pipeline. We feel that our agreement to lay pipelines to each wellhead is worth an additional 1¢ to 3¢ per MCF in the price by the time you figure the cost of the pipeline, interest on the money, and operating costs.

TAXES:

The tax clause of a contract is generally a complicated clause since the wording must anticipate what may occur in the future through the action of a third party, such as a State Legislature. Producers are usually reluctant to commit their gas for a long term at a set price without some guard against increased taxes. Generally, the tax clause of all pipeline companies' contracts provide that each party will pay the tax levied upon that party as of the date of the contract, with the major portion of any increases being shared by the pipeline company.

EFFECTIVE DATE AND TERM:

The contract usually becomes effective with the date of first delivery of gas and, generally, the term will be for a period of 20 years with year-to-year extensions unless cancelled by either party at the end of 20 years. I realize that a 20-year contract may seem like an extensive period of time in which to project operating and other costs. However, due to the nature of a gas utility company operating under Federal Power Commission regulatory requirements, it is necessary that pipeline companies negotiate 20-year contracts to maintain reserve indices in the range of 15 years.

PROCESSING:

I am sorry to say that this clause does not apply to gas in the Arkansas Valley Area since this gas is extremely dry, and a processing plant in this area would be very uneconomical. However, many pipeline companies such as ours who own or control their own processing plants include processing supplements in the gas purchase contracts. These processing provisions, of course, provide for additional revenue to the producer on the sale of his share of the liquids extracted from the gas. The importance of this clause in a contract depends largely on the richness of the gas and I have seen, in a few instances, where the gas was so rich that the negotiation of the processing portion of the contract was more important than the negotiation for the purchase of the gas.

We are fortunate in having nine gas line plants so located on the Southern portion of our system in North Louisiana, East Texas, and South Arkansas which are operated by a wholly owned subsidiary. Thus we are usually in a position to offer processing clauses in our gas purchase contracts. We feel that these plants have been a great aid in our buying gas in that area.

DEDICATION:

This is a very important clause to the pipeline company. Several pipeline companies in certain areas require that the producer dedicate all acreage he owns at the time of the contract or any time in the future in an area as large as a township and range. Most companies, however, require the producer to dedicate all the acreage which he has in a particular field whether that acreage is actually developed or not. I feel this is especially fair to the pipeline company that is required to make an expensive pipeline extension into a field. The third type of dedication is a one-well dedication. However, this latter type is an exception to the rule and usually there are other reasons why additional acreage is not dedicated at that time.

DEHYDRATION:

Most of the pipeline companies which require delivery of gas at their pipeline also require that the gas be dehydrated to a maximum of seven pounds of water per million cubic feet. Our contracts vary on this provision depending on the location of the gas and whether it is so connected to our system to flow through one of the dehydrators on our system.

This is a costly operation to the producer and generally a major trading point in the negotiation of a contract.

STANDARD CLAUSES:

All contracts have clauses which are important but on which very little trading is done in the negotiation of a contract. These clauses are usually covered by a supplement to the main contract since they are generally standard in their nature. The general clauses I am referring to are method of measurement, quality, description of pay period, successors and assigns clauses, warranty clause, arbitration clause, and several others.

As I mentioned earlier, the contracts of 15 years ago essentially covered nothing but price and point of delivery.

I hope I have given you a clear enough description of present-day contracts where you can see for yourselves that our present-day contracts are a far cry in complexity from earlier contracts.

ARKANSAS RIVER VALLEY:

As most of you know, Arkansas Louisiana Gas Company has been vitally interested for many years in development of the Arkansas River valley, both as a producer and as a purchaser of gas. In this area, now known as the Arkoma basin, we have under lease on the Arkansas side some 100,000 acres, of which a portion has been developed for gas production. In addition, about 550,000 acres, of which portions have been developed, is dedicated to Arkla by purchase contracts. Here, too, we are pursuing an active exploration program.

In 1959 we built a $5\frac{1}{2}$ million, 16-inch transmission line from the area of the Cecil field to a point about 100 miles to the southeast where it connected to our main system near Hot Springs. Then, late in 1960 we constructed an 18-inch line from this point east to the Mississippi River at Helena, at a cost of about $8 million.

We're still very optimistic about the western Arkansas River Valley. In 1962 this area had a 72.7 per cent success ratio in field-well drilling, and a phenomenal 41.9 per cent success ratio in wildcat drilling.

ARKOMA BASIN:

Then beginning two or three years ago when the first deep gas discoveries were being drilled on the Oklahoma side of the Arkoma basin, we initiated a major effort to acquire new reserves through purchase contracts as they were developed by producers in the area. At the end of 1962 we had under contract approximately 720 billion cubic feet of gas in this new eastern Oklahoma area, and in the past three months this figure has been raised substantially.

To make this new gas available to the Arkla system we made application to the Federal Power Commission in 1962 for permission to build a major transmission line into eastern Oklahoma. In February, 1963, the FPC gave formal approval to this project. As now planned we will spend some $14 million to build about 160 miles of large diameter transmission lines, which will extend westward from our system lines near Paris, Ark., to a point near Centrahoma, Okla. Approval for this line, of course, is conditioned on subsequent approval by the FPC of the arrangements under which gas to supply the line will be purchased by us from the producers. At present we anticipate no delay in this project and are proceeding rapidly with plans for construction of the new transmission line.

We are extremely optimistic, also, about potential new gas development in eastern Oklahoma. This side of the Arkoma basin in 1962 had a 29.2 per cent success ratio in wildcat drilling and 84.5 per cent success ratio in field wells. Here also Arkla is active in exploration.

Actually, the developments in the Arkansas Valley and in eastern Oklahoma—the Arkoma basin—have postponed indefinitely the time when our Company will have to look to some more distant source, such as the Louisiana-Texas Gulf Coast, for additional gas supplies.

OIL AND GAS POSSIBILITIES IN THE OUACHITA MOUNTAIN REGION OF ARKANSAS

William M. Caplan*

The Ouachita Mountain region of Arkansas and the Arkansas Valley region (Arkansas portion of the Arkoma basin) are related tectonically, although the depositional environments and lithologies of the two regions are different. The pre-Stanley rocks in the Ouachitas have a greater resemblance to their correlatives in the Valley than the Stanley and younger rocks.

Dry gas has been produced in commercial quantities for more than 60 years in the Valley region, chiefly from the Pennsylvanian Atoka Formation. However, foreland or Ozark-Arbuckle facies rocks of Siluro-Devonian, Mississippian and Pennsylvanian (Morrow) ages also are productive of gas currently in this province. Unlike the Valley the Ouachita Mountain region in Arkansas has yet to produce hydrocarbons in commercial quantities and, further, remains essentially unevaluated from the petroliferous standpoint.

Few wells have explored Ouachita facies rocks in the state for oil or gas either in the structural belt exposed in west-central Arkansas or in the considerable areas where rocks of Ouachita facies are buried beneath younger strata. Where such wells have been drilled little comprehensive geological data has been obtained. The lack of information can be attributed mainly to the inadequate density of drilling. In the few instances where cuttings have been saved from wells penetrating Ouachita rocks, relatively little knowledge has been gained either because of the lack of penetration stratigraphically or the inability to delimit formations in the wells from the data at hand.

The projection of Ouachita facies rocks eastward and southward into the Gulf Coastal Plain is difficult to plot because of the Cretaceous, Tertiary, and Quaternary cover. Further complications are introduced by the possible presence of major faulting involving the Paleozoic beds and the inability to differentiate between Paleozoic structure and topography beneath the younger beds.

Regional Bouger gravity surveys and limited magnetometer and seismic surveys have been conducted for various purposes in the Ouachitas in Arkansas. The results, especially the large gravity minimum revealed by the Bouguer surveys, indicate that the general techniques should prove useful in exploring for oil or gas in the province. However, the lack of agreement over a variety of regional geological problems in the Ouachitas makes it difficult to reconcile some of the geophysical and geological data on a more localized basis. This is especially true along the extension of the Ouachitas into the Gulf Coastal Plain province where the geophysical interpretations become more elusive along with the geology.

Many geologists assume erroneously that rocks must necessarily be highly metamorphosed to be regarded as Ouachita facies rocks. Actually this facies classification does not require that the rocks be metamorphosed to any particular degree if at all. Goldstein and Hendricks (1962), for example, in their study of Late Mississippian and Pennsylvanian sediments of Ouachita facies in Oklahoma, Texas, and Arkansas, defined sedimentary rocks of Ouachita facies as "rocks lithologically similar and stratigraphically equivalent to sedimentary and low-grade meta-sedimentary rocks exposed in the Ouachita Mountains of Oklahoma and Arkansas."

Some sediments of the Ouachita geosynclinal facies deformed in Arkansas and Oklahoma during the Ouachita orogeny do exhibit varying degrees of metamorphism, up to weak or in some instances even low-grade, on the outcrop. However, there is no pronounced uniformity of metamorphism throughout the Ouachita facies rocks exposed, and counterparts of some of these strata show no apparent metamorphism either elsewhere on the outcrop or in the subsurface. Even in the areas north of Broken Bow, Oklahoma, and west-southwest of Little Rock, Arkansas, where the most metamorphosed rocks in the Ouachita Mountains are exposed, the highest degree of metamorphism in evidence is classified only as low grade. In addition the metamorphism apparently decreases away from the principal anticlinorial uplift occurring arcuately between those areas.

Numerous geological reasons have been offered by operators for their general reluctance to explore the Ouachita Mountain region for oil or gas. These include, among others, high fixed carbon ratios,

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suggesting the dissipation of hydrocarbons that may have been present; the detrimental effects of thrust faulting in the region; the inability to map closed structural traps at depth because of the complex surface geology; and the destruction of primary porosity and permeability by various means.

Fixed carbon ratio studies in Arkansas have concentrated on the northwestern portion of the state, where coals are abundant, in marked contrast with the Ouachita region. Even throughout the Arkansas Valley and Ozark sampling areas, using Hartshorne, Atoka, and Baldwin (Morrow) coals, the results have been highly anomalous. Consequently, little would be added to the knowledge of the Ouachitas at present by trying to extrapolate carbon ratios. One of the most interesting anomalies in the carbon ratio study presented by Croneis (1930) is demonstrated by coal (Hartshorne) in the Bates district just north of the Choctaw fault extension from Oklahoma into Scott County, Arkansas. This coal, among others in the Croneis report, shows lower carbon ratios than coals farther to the north in the Valley or in the Ozark regions, although it is nearer the areas of greater deformation. The general discussion of carbon ratios by Croneis suggests the considerable number of factors that may influence the interpretations of such studies.

In the Arkansas Valley province dry gas is produced from areas in or near which carbon ratios close to 90 have been recorded. Theoretically no oil or gas should be produced from such areas. In parts of eastern Oklahoma, Pennsylvania, and Virginia hydrocarbons also are produced commercially from areas that would be condemned on the basis of carbon ratios. Therefore, it appears that fixed carbon ratios cannot be used validly at this time to condemn the Ouachitas as a possible oil or gas producing province.

The presence of thrust faulting in the Ouachita region and the inability to map subsurface closures because of complex surface geology undoubtedly will make exploration more difficult. Neither, however, necessarily reduces the ability of the Ouachita facies rocks to trap oil or gas in commercial quantities. Hydrocarbons have been produced commercially from thrust faulted regions such as those in Virginia and Canada. Moreover, the gas production from the Bigfork Chert (Ouachita facies Ordovician) in the Potato Hills area of Latimer County, Oklahoma, is thought to be related either to thrust faulting or overturned folding.

As for the inability to map closed structural traps at depth in the Ouachitas, the lack of drilling is enough to question the value of this premise. Even if it could be shown that no such traps existed in the Ouachita region, it has not yet been demonstrated conclusively in the gas producing foreland area that structural trapping is required for production.

The destruction of primary porosity and permeability in Ouachita facies rocks is one of the main points of concern among prospective operators. Local examples of loss or reduction of these properties are in evidence, but so little of the Ouachita column is readily available for examination that condemnation of the Ouachita Mountain region from this standpoint is unjustified.

Portions of the Ouachita facies outcrops, such as sandstones of Jackfork age in the Little Rock area, are notably quartzites. However, in other parts of the Ouachitas equivalent strata contain sandstones consisting of angular to rounded sand grains with little if any recrystallization of interstitial material or interaction between the adjacent sand grains themselves. Even where intergranular porosity and permeability have been destroyed, either by orogenic or normal diagenetic processes, the possibility of fracture porosity exists. If a fracture system is extensive enough, whether in sandstones, shales, or carbonates, a reservoir of commercial significance might be established.

Branner (1937) presented an interesting study of sandstone porosities in the Ouachita Mountain, Arkansas Valley, and Ozark regions of the state. Determinations were based on a total of ninety-eight sandstone samples of various ages. Seventeen were from the Ouachitas, sixty-three from the Valley, and eighteen from the Ozarks. Most, if not all, of the porosities and densities were determined by the acetylene tetrachloride method (Russell, 1926).

The porosities obtained during the study were determined, wherever possible, from unweathered, relatively pure quartz sandstones. Branner indicated, however, that separate porosities obtained were not exactly comparable because some of the samples contained iron oxides, carbonates, or feldspathic minerals. Russell (1937) pointed out that even in the same locality unweathered, pure quartz sandstones were subject to large, abrupt porosity variations which might have been produced by deposition, compaction, cementation, and solution before weathering at the surface began.

According to the Branner report the regional average sandstone porosity in the Ouachita Mountains was found to be 5.7 percent; in the Arkansas Valley, 7.8 percent; and in the Ozark Plateaus, 10.9 percent. The average dip of folded beds in the Ouachita Mountains, from incomplete figures, was estimated to be 54.1°; in the Valley, 17°; and in the Ozarks, 5.1°. These results were taken to indicate, broadly, the relationship between the average regional porosity and density of the sandstones and the average surface deformation of the rocks in the Paleozoic outcrop region of the state.

Some of the results and various comparisons from the Branner report are shown here in tabular form. Tables I and II and Figure 1 of this present paper have been taken from Branner's report with slight modifications. It should be noted that both of the tables show data for sandstones in the Savanna and the Fort Smith Formations, among others. However, these formation divisions have been redefined since Branner's report (Hendricks and Parks, 1950).

In Figure 1 the physiographic boundaries shown are those used by Branner but presumably patterned after Croneis (1930). Generally, the eastern half of the boundary between the Arkansas Valley and the Ouachita Mountains is placed farther to the south, closer to the Little Rock area, on index maps (Hendricks and Parks, 1950; Goldstein and Hendricks, 1962), but it continues to be somewhat arbitrary.

The Choctaw, Ti Valley, and other faults have been traced into western Arkansas from Oklahoma, where they mark major structural and stratigraphic changes between the Arkoma basin and the Ouachitas. One or more of these faults or related fault systems may traverse Arkansas in a general easterly direction to the Coastal Plain margin or beyond. As in Oklahoma, the major stratigraphic change between the Ouachitas and the Arkoma basin (Arkansas Valley) across Arkansas probably does not coincide with the structural boundary between the provinces.

Few hydrocarbon occurrences have been reported from the Ouachita Mountain region of Arkansas. However, the presence of oil, gas, and solid hydrocarbons in some abundance in the Oklahoma Ouachitas appears to warrant an optimistic attitude toward oil and gas possibilities in the Ouachita region of Arkansas. In Oklahoma a number of shallow wells have produced oil or gas within the Ouachitas, notably from the McGee Valley in Atoka and Pittsburg Counties and from the Redden area of Atoka County. The oil is reported to range from about 36 to 42 gravity. Redden field produced oil from the Stanley at irregular intervals since 1914. Both the McGee Valley and Redden production are obtained from depths above 500 feet.

According to Chenoweth (1960) a well drilled in 1950, in the Kiamichi Valley, Pushmataha County, was reported to have produced as much as 10 barrels of 52 gravity oil per day. An offset well was dry and the first well abandoned. The oil was found in sandstone of Stanley age at 345 feet.

The discovery well of Southwest Moyers field, Pushmataha County, was completed from the Stanley late in 1960. The well flowed 500,000 cubic feet of gas and one barrel of oil per day from two zones between 3,062 and 5,640 feet.

One of the more significant tests in the Oklahoma Ouachita region was the previously mentioned Potato Hills well completed in Latimer County in 1960 as the Sinclair Oil and Gas No. 1 Reneau. The wildcat started in the Stanley Shale. Production was from 2,340-2,410 feet in the Bigfork Chert. A calculated open-flow potential of 1.85 million cubic feet of gas per day was reported.

Noncommercial gas shows and oil-stained sandstones have been reported from the Stanley-Jackfork section in various Oklahoma wells. In some of these the hydrocarbons were found in beds overlying thousands of feet of Ouachita facies rocks and were presumed to be indigenous. In other instances the presence of oil, gas, or solid hydrocarbons was attributed to migration from underlying foreland facies rocks.

Veins or irregular bodies of asphaltite, some classified as grahamite, have been noted in Bigfork, Arkansas Novaculite, Stanley, and Jackfork rocks in the Oklahoma Ouachitas. Ham (1956) reported that some of the asphaltite deposits in the Ouachita Mountains in Oklahoma appeared to be softer and more petroleum-like at depth.

In the Arkansas Ouachita region a solid bitumen deposit has been found in sandstone of Jackfork age in Scott County, about one mile east of Eagle Gap. The material, identified tentatively as impsonite, probably was formed by the devolatilization of petroleum which might have originated in older rocks and migrated into the Jackfork along faults.

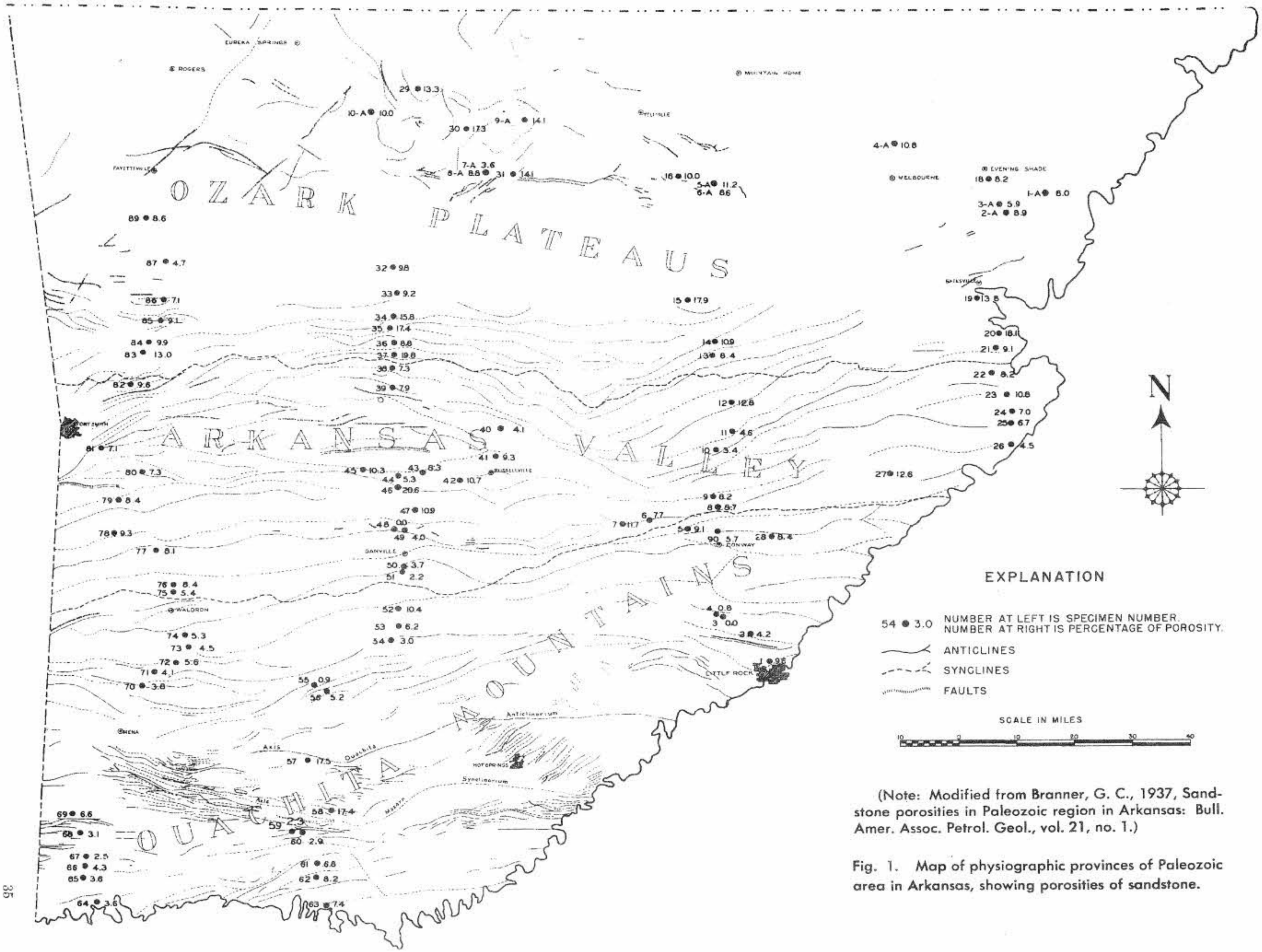
TABLE I
DENSITY AND POROSITY DETERMINATIONS

Specimen No.*	Type of Sandstone	Density	Porosity	Inclination	Location by Section, Township, Range, and County	Sec.	T.	R.	County
1	Jackfork	2.44	9.6	40°	SW. ¼ NE. ¼	27	2 N.	12 W.	Pulaski
2	Atoka	2.54	4.2	45° S.	NE. ¼	36	3 N.	13 W.	Pulaski
3	Atoka	2.60	0.0	Crest	NW. ¼ NW. ¼	18	3 N.	13 W.	Pulaski
4	Atoka	2.59	0.8	Crest	NE. ¼ NE. ¼	13	3 N.	14 W.	Pulaski
5	Atoka	2.40	9.1	Crest	SW. ¼ NE. ¼	30	6 N.	14 W.	Conway
6	Atoka	2.40	7.7	40° S.	NE. ¼ NE. ¼	24	6 N.	16 W.	Conway
7	Atoka	2.36	11.7	45° S.	SW. ¼	20	6 N.	16 W.	Conway
8	Atoka	2.41	8.7	Crest	Center	1	6 N.	14 W.	Faulkner
9	Atoka	2.44	8.2	2–10°	NW. ¼	26	7 N.	14 W.	Faulkner
10	Atoka	2.56	3.4	7° S.	SW. ¼	14	8 N.	14 W.	Faulkner
11	Atoka	2.54	4.6	1–2°	NE. ¼	28	9 N.	13 W.	Van Buren
12	Atoka	2.28	12.8	1–2°	NW. ¼ SE. ¼	32	10 N.	13 W.	Van Buren
13	Atoka	2.38	8.4	1–3°	SW. ¼	23	11 N.	14 W.	Van Buren
14	Atoka	2.34	10.9	1° S.	SW. ¼	3	11 N.	14 W.	Van Buren
15	Atoka	2.16	17.9	1° S.	SE. ¼	25	13 N.	15 W.	Van Buren
16	St. Peter	2.35	10.00	2°	NE. ¼	4	16 N.	15 W.	Searcy
18	St. Peter	2.41	8.2	1°	NW. ¼	14	16 N.	6 W.	Sharp
19	Hale	2.24	13.8	2–4°	NW. ¼ SE. ¼	28	13 N.	6 W.	Independence
20	Hale	2.28	18.1	2–4°	SW. ¼	23	12 N.	6 W.	Independence
21	Atoka	2.44	9.1	1°	NW. ¼	11	11 N.	6 W.	Independence
22	Atoka	2.42	8.2	1°	NE. ¼	34	11 N.	6 W.	Independence
23	Atoka	2.35	10.8	1°	SW. ¼	19	10 N.	5 W.	Jackson
24	Atoka	2.42	7.0	1°	SW. ¼	5	9 N.	5 W.	White
25	Atoka	2.46	6.7	1°	SW. ¼	17	9 N.	5 W.	White
26	Atoka	2.45	4.5	5° S.	SW. ¼ NE. ¼	5	8 N.	5 W.	White
27	Atoka	2.27	12.6	4° N.	SW. ¼ SE. ¼	35	8 N.	9 W.	White
28	Atoka	2.43	8.4	70° N.	NW. ¼ SE. ¼	33	6 N.	12 W.	Faulkner
29	Batesville	2.28	13.3	1–2°	NE. ¼	19	19 N.	22 W.	Carroll
30	Batesville	2.19	17.3	1–2°	NE. ¼	27	18 N.	21 W.	Boone
31	Fayetteville	2.27	14.1	2°	SE. ¼ SW. ¼	3	16 N.	20 W.	Newton
32	Atoka	2.41	9.8	1–2°	NE. ¼	3	13 N.	23 W.	Newton
33	Atoka	2.36	9.2	1–2°	SW. ¼	28	13 N.	23 W.	Newton
34	Atoka	2.22	15.8	1–2°	NE. ¼	21	12 N.	23 W.	Johnson
35	Atoka	2.18	17.4	1–3°	SW. ¼	33	12 N.	23 W.	Johnson
36	Atoka	2.41	8.8	1–3°	SW. ¼	10	11 N.	23 W.	Johnson
37	Atoka	2.12	19.8	1–3°	N. ½	28	11 N.	23 W.	Johnson
38	Hartshorne	2.43	7.3	1–3°	SW. ¼ NW. ¼	3	10 N.	23 W.	Johnson
39	Hartshorne	2.40	7.9	3–6°	Center	22	10 N.	23 W.	Johnson
40	Atoka	2.48	4.1	3° S.	SW. ¼ NE. ¼	34	9 N.	20 W.	Pope
41	Hartshorne	2.46	9.3	1° S.	NW. ¼ SE. ¼	28	8 N.	20 W.	Pope
42	Hartshorne	2.36	10.7	1–3°	NW. ¼ SE. ¼	16	7 N.	21 W.	Yell
43	Hartshorne	2.43	8.3	5° S.	NE. ¼	9	7 N.	22 W.	Logan
44	Atoka	2.51	5.3	7° N.	SW. ¼	14	7 N.	23 W.	Logan
45	Fort Smith	2.38	10.3	3–4°	NW. ¼	11	7 N.	24 W.	Logan
46	Atoka	2.09	20.6	Crest	SE. ¼ NW. ¼	26	7 N.	23 W.	Logan
47	Atoka	2.39	10.9	5° S.	NW. ¼	17	6 N.	22 W.	Yell
48	Atoka	2.66	0.0	Crest	NW. ¼	3	5 N.	23 W.	Yell
49	Atoka	2.54	4.0	85° S.	NE. ¼ NE. ¼	1	5 N.	23 W.	Yell
50	Atoka	2.54	3.7	30° S.	NE. ¼	12	4 N.	23 W.	Yell

Specimen No.*	Type of Sandstone	Density	Porosity	Inclination	Location by Section, Township, Range, and County	Sec.	T.	R.	County
51	Atoka	2.55	2.2	70° S.	S.½	1	4 N.	23 W.	Yell
52	Atoka	2.38	10.4	5° S.	NW. ¼	13	3 N.	23 W.	Yell
53	Atoka	2.52	6.2	60° N.	NW. ¼	36	3 N.	23 W.	Yell
54	Jackfork	2.53	3.0	50–60°	NW. ¼	14	2 N.	23 W.	Yell
55	Jackfork	2.60	0.9	?	NE. ¼ NW. ¼	27	1 N.	25 W.	Montgomery
56	Jackfork	2.51	5.2	Ax. syn.	NE. ¼	36	1 N.	25 W.	Montgomery
57	Crystal Mt.	2.19	17.5	Crest	Center	4	3 S.	25 W.	Montgomery
58	Blaylock	2.18	17.4	?	NE. ¼	19	4 S.	24 W.	Montgomery
59	Blaylock	2.55	2.3	Crest	SW. ¼	7	5 S.	25 W.	Pike
60	Blaylock	2.56	2.9	Crest	E. ½	9	5 S.	25 W.	Pike
61	Stanley	2.45	6.8	1–4°	NE. ¼	10	6 S.	25 W.	Pike
62	Jackfork	2.45	8.2	70° S.	NE. ¼	22	6 S.	25 W.	Pike
63	Atoka	2.48	7.4	80° N.	NE. ¼	23	7 S.	25 W.	Pike
64	Stanley	2.53	3.6	85° S.	SW. ¼	21	7 S.	31 W.	Sevier
65	Stanley	2.55	3.6	70° N.	SW. ¼	31	6 S.	31 W.	Polk
66	Stanley	2.53	4.3	70° N.	SE. ¼ NW. ¼	19	6 S.	31 W.	Polk
67	Stanley	2.59	2.5	Ax. syn.	NE. ¼	7	6 S.	31 W.	Polk
68	Stanley	2.60	3.1	Crest	SW. ¼	18	5 S.	31 W.	Polk
69	Blaylock	2.46	6.6	Crest	Center	36	4 S.	32 W.	Polk
70	Jackfork	2.50	3.8	70° N.	NW. ¼	34	1 N.	30 W.	Scott
71	Atoka	2.54	4.1	70° N.	SE. ¼	24	1 N.	30 W.	Scott
72	Atoka	2.46	5.6	Crest	NE. ¼	10	1 N.	29 W.	Scott
73	Atoka	2.53	4.5	80° S.	SW. ¼	25	2 N.	29 W.	Scott
74	Atoka	2.53	5.3	Crest	SW. ¼	11	2 N.	29 W.	Scott
75	Savanna	2.50	5.4	50° N.	Cen. N½	5	3 N.	29 W.	Scott
76	Savanna	2.42	8.4	15° N.	SE. ¼	29	4 N.	29 W.	Scott
77	Atoka	2.44	8.1	3–4°	SW. ¼ NE. ¼	31	5 N.	29 W.	Logan
78	Atoka	2.41	9.3	6° S.	SW. ¼	14	5 N.	31 W.	Sebastian
79	Fort Smith	2.43	8.4	85–90°	SW. ¼ SW. ¼	13	6 N.	31 W.	Sebastian
80	Hartshorne	2.44	7.3	Crest	NW. ¼	22	7 N.	30 W.	Sebastian
81	Hartshorne	2.44	7.1	2–4°	NE. ¼	32	8 N.	31 W.	Sebastian
82	Hartshorne	2.40	9.6	2° S.	NE. ¼	31	10 N.	30 W.	Crawford
83	Atoka	2.30	13.0	2–4°	NW. ¼	34	11 N.	30 W.	Crawford
84	Atoka	2.36	9.9	2–4°	Cen. N½	22	11 N.	30 W.	Crawford
85	Atoka	2.41	9.1	5–10°	NE. ¼	35	12 N.	30 W.	Crawford
86	Atoka	2.49	7.0	3°	Center	13	12 N.	30 W.	Crawford
87	Atoka	2.25	4.7	2°	NE. ¼	12	13 N.	30 W.	Washington
89	Fayetteville	2.44	8.6	2°	SE. ¼	32	15 N.	30 W.	Washington
90	Atoka	2.52	5.7	70° N.	SE. ¼	25	6 N.	14 W.	Faulkner
1-A	St. Peter	2.65	6.0		SW. of Calamine				Sharp
2-A	St. Peter	2.65	8.9		Near Cave City				Sharp
3-A	St. Peter	2.65	5.9		S. of Maxville				Sharp
4-A	St. Peter	2.65	10.8		Pilot Knob				Izard
5-A	St. Peter	2.65	11.2		Big Creek Bridge				Searcy
6-A	St. Peter	2.65	8.6		Big Creek Bridge				Searcy
7-A	St. Peter	2.65	3.6		Marble City Falls				Newton
8-A	St. Peter	2.65	8.8		Marble City Falls				Newton
9-A	St. Peter	2.65	14.1		½ mi. E. of Bellefonte				Boone
10-A	St. Peter	2.65	10.0		Metalton				Carroll

*Nos. 17 and 88 omitted

NOTE: Modified from Branner, G.C., 1937, Sandstone porosities in Paleozoic region in Arkansas: Bull. Amer. Assoc. Petrol. Geol., vol. 21, no. 1.



(Note: Modified from Branner, G. C., 1937, Sandstone porosities in Paleozoic region in Arkansas: Bull. Amer. Assoc. Petrol. Geol., vol. 21, no. 1.)

Fig. 1. Map of physiographic provinces of Paleozoic area in Arkansas, showing porosities of sandstone.

TABLE II

AVERAGE DENSITY AND POROSITY BY FORMATION
(modified from Branner, 1937)

Formation	*Number of Samples*	*Average Porosity*	*Average Density*	*Regional Average Porosity*	*Regional Average Densities*
Ouachita Mountains					
Crystal Mountain	1	17.5	2.19	5.7	2.49
Blaylock	4	7.3	2.43		
Stanley	6	3.9	2.54		
Jackfork	6	5.1	2.50		
Arkansas Valley					
Atoka	51	8.1	2.41	7.8	2.43
Hartshorne	8	8.4	2.42		
Fort Smith	2	9.3	2.40		
Savanna	2	6.9	2.46		
Ozark Plateaus					
St. Peter	12	8.8	2.65	10.9	2.32
Batesville	2	15.3	2.23		
Fayetteville	2	11.3	2.35		
Hale	2	15.9	2.26		

A show of dry gas from the Benedict No. 1 Fee water well in Saline County, Arkansas, also merits notice, as the gas and fresh water possibly were from Ouachita facies rocks. The well, completed in 1956, at a total depth of 816 feet, was drilled in the southern tip of Saline County, in Sec. 29-3S-15W, about thirty miles southwest of Little Rock. It was located in the Gulf Coastal Plain province in an extension of the Zigzag Mountains or the Saline Basin. The well was drilled with makeshift rotary tools, but little mud was used, and cavings and recirculated material made the cuttings difficult to evaluate. No electrical logs were run. The well started in rocks of the Wilcox (Eocene) Group, but sample collection began at 330 feet in sand and gravel near the base of the Wilcox. The sand and gravel, for the most part, consisted of sub-rounded to rounded fragments of Arkansas Novaculite (or older chert) and quartz.

The Porters Creek Formation of Midway (Paleocene) age was identified at 335 feet and the Clayton (Paleocene) Formation at 400 feet. From about 530 feet the badly contaminated samples contained small fragments of light to dark gray, weathered, mostly angular, dense to slightly translucent Arkansas Novaculite (or older chert) which were assumed to represent Paleozoic rock in place. Fragments of this nature increased at 545 feet but were almost absent at 550 feet. From 550 to 754 feet no samples were available. From 754 feet to the total depth of 816 feet the Arkansas Novaculite (or older chert) fragments were abundant. No other types of rock in the cuttings suggested Paleozoic rock in place.

According to a verbal report from the operator the somewhat indefinite producing depth range would have been in the Paleozoic section. If the gas and water were from Paleozoic rocks they could have been from a fractured Arkansas Novaculite reservoir or from older beds producing by virtue of fracturing or faulting. The operator installed a locally built gas-water separator and used both products in his principal dwelling until he moved from Arkansas a short time later. The well no longer produces gas. Both the length of time the well actually produced gas and the cumulative production are unknown. The subsurface control in the area is so limited that the significance of this gas show, presumably from Ouachita facies rocks, remains unevaluated.

Until a concentrated exploratory effort disproves the premise, the Ouachita Mountain region in Arkansas should be regarded as a possible oil or gas province.

It was not feasible in the preceding text to cite literature sources completely. However, the following reference list should be helpful for those desiring to pursue the subject matter of this paper.

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A GENERAL REPORT ON THE EL PASO NATURAL GAS COMPANY #1 CHEESMAN, SCOTT COUNTY, ARKANSAS

Dudley Stanley*

INTRODUCTION

The El Paso Natural Gas Company No. 1 Cheesman was drilled about six miles east of Waldron in Section 22-3N-28W, Scott County, Arkansas. A total depth of 11,680 feet was reached possibly penetrating the upper Jackfork formation. There were no shows of hydrocarbons encountered while drilling and subsequently the hole was plugged and abandoned. The purpose of this paper is to offer very general information only and not to appraise or evaluate the area.

GEOLOGY

Structure

The No. 1 Cheesman is located in what is called here the Frontal Ouachita Mountain Province, characterized by tightly folded elongate structures and thrust faulting. Specifically it is on the south flank of the Poteau Syncline and north of the Ross Creek Fault. The original drill site was to be in Section 27-3N-28W based on surface features but as a result of seismic work it was moved to Section 22 to test a subsurface structure. This anomaly was verified to the satisfaction of the operator by the changes in the amount of hole deviation as the drilling progressed and by the continuous dip survey which indicated changes in formation dip amounts and direction, and also the changes in direction of hole deviation. Dips taken on outcrops at the drill site average 35° to the northwest. According to the dip survey they tend to decrease from the surface to between 4,000 and 5,000 feet where they are essentially flat. From there to total depth they increase to an average of 18° and reverse the direction of dip to the southwest. Two or more faults were cut in this well as indicated by the dip survey, and although shales exist on both sides of the faults making it impossible to determine their magnitudes, they were probably small. It should be noted here that the Ross Creek Fault must have a very large throw in that the first massive sands in the No. 1 Cheesman at 9362 would probably correlate with the youngest massive sands exposed south of the fault.

Stratigraphy

The well spudded approximately 4,000 feet below the Base of the Hartshorne—Top of the Atoka and at total depth had penetrated into what could be Jackfork and is suggested in this report. This is a point that has to be left up to the individual as I am sure there will be considerable disagreement to the tops suggested and shown in Table I. There were no distinguishing character of the samples to indicate a particular formation, with one possible exception, but rather it is the sequence of the sands and shales which tend to give some correlation with wells in Western Oklahoma where the identity of certain formations have been established. A reduced scale of the electric log with the suggested tops has been included. The one exception in the samples mentioned above was a shale logged at 9830 which was noticeably different and described as a light gray, non-fissile shale with a "crinkled" surface. This same type shale has been described in at least two wells in Western Oklahoma and might possibly be a correlation point. The sands penetrated in this test were all very similar and can be described as very fine to medium grained, angular to sub-angular, light to dark gray, micaceous, tight, well cemented, and at times slightly quartzitic. Two zones showing some low, 8% - 10%, sonic log porosities were sands at 9362 - 9406 and 9836 - 53. The first gave up fresh water while drilling with air and caused the hole to be mudded up, the other did not indicate the presence of hydrocarbons. One of the unanswered questions in this well is the presence of fresh water (140 parts per million) at this depth. Sandstones encountered in this hole occupied only 10% or less of the entire section drilled. The shales other than the one already mentioned were typically gray-dark gray micaceous, with varying amounts of silt. Samples from this well are available from the Arkansas Geological Commission, Little Rock, Arkansas.

*Independent, Amarillo, Texas

EL PASO NATURAL GAS CO.
NO. 1 CHEESMAN
SEC. 23–3N–28W
SCOTT CO. ARKANSAS

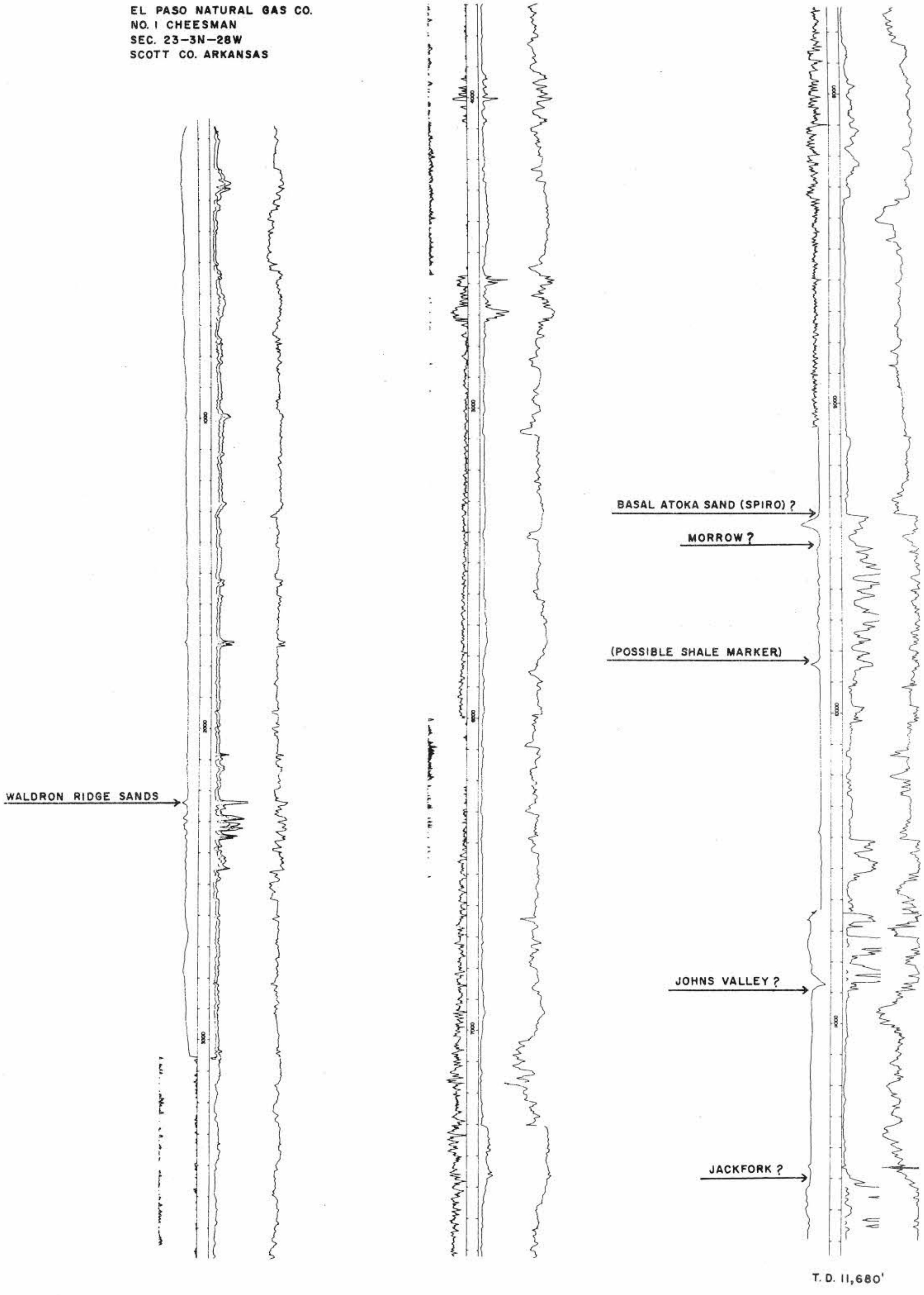


TABLE I

Formation	Drilling Depth
Atoka Shale	0′ - 9,362′
Basal Atoka Sand (Spiro)	9,362′ - 9,447′
Morrow	9,447′ - 10,890′
Johns Valley	10,890′ - 11,523′
Jackfork	11,523′ - 11,680′
	TD 11,680′

DRILLING

Only a general discussion of the drilling operations will be attempted here. A 17½″ hole was drilled and reamed to 3,060′ with mud and 13⅜″ pipe set. Air was used out from under the pipe and a 12¼″ hole was drilled to 9,408′ at which time water was encountered and the hole was mudded up. A fishing job followed and after unsuccessful tries at recovering the drill string, 9⅝″ pipe was set on top of the fish at 8,609′. A whipstock was set inside the casing at 8,401′ and a 8⅝″ side track hole was drilled with mud to 10,672′. Due to the slow penetration rates a 7″ liner was run from 8,124′ to 10,665′ to permit the return to air drilling. A 6⅛″ hole was drilled from 10,665′ to 11,214′ with air but the pipe became stuck, and again the hole was mudded up and a fishing job was attempted. After only partial recovery of the fish, an open hole whipstock was set at 10,759′ and a new hole was drilled to total depth of 11,680′ with mud. Drilling of this well required 160 bits and 320 days, being spudded on September 5, 1961, and completed on July 22, 1962. The time can generally be broken down as 165 days drilling and 155 days in other operations (fishing, reaming, logging, rig repairs, etc.). Hole deviation was maintained very well with a maximum of 7% and an average of less than 4° until the last whipstock was set and then they reached a maximum of 12°. The test was evaluated for shows of hydrocarbons by the use of a mud logging unit while drilling with mud and by the fact that while air drilling it in itself acts as a continuous drill stem test.

SUMMARY

The No. 1 Cheesman although plugged and abandoned with no shows of hydrocarbons is significant in that porous sands were found in an area where there had been considerable speculation on the occurrence of porosity. Also the test confirmed the suspicion that the structure of the subsurface does not necessarily conform to the surface. Last, this test should provide valuable information for future studies of the geology in the area, or in the planning and drilling of future wells.

SINCLAIR #1 RENEAU AND THE POTATO HILLS ANTICLINORIUM

Clarence H. Unruh*

The Potato Hills Anticlinorium in Latimer and Pushmataha Counties, Oklahoma, is probably one of the most complex areas in the Ouachita Mountains. This area has been mapped by various geologists and companies for a number of years with each group arriving at a different interpretation. This writer will not discuss the controversy generated by recent publications since most geologists interested in the area are well acquainted with the differing theories; however, if one accepts the recent presentation of the Ouachitas as an "Autochthonous folded belt" it will help to remove one of the greatest stigmas to exploration in the Ouachita Mountains; that is, that the Ouachita Mountains are underlain by a number of tremendous overlapping thrust sheets. It should also stimulate a new approach to subsurface stratigraphic studies of the Ouachita Mountains. It is highly unlikely that surface mapping will give us a reliable picture of structures at depth but a continued seismic and drilling program will help find the key to unlock the secrets of the Ouachita Mountains.

The Sinclair #1 Reneau is not the first production in the Ouachita Mountains. The South Bald Field, Sec. 5, T-1N, R-15E, discovered in December 1955, has 2 wells with cumulative production of 526 barrels of oil; the West Daisy Field, Sec. 26, T-1N, R-14E, was discovered in December, 1955 and has a cumulative production record of 164 barrels of oil from 1 well; the Potato Creek Field, Sec. 35, T-2S, R-13E, discovered in April, 1956 has a cumulative production of 1,215 barrels from 1 well and the Redden Field in Sec. 9, T-1S, R-14E discovered in April, 1960 has a production of 490 barrels. These fields, although small, point up the fact that hydrocarbons are present in the Ouachita Mountains and have been found with the drill. A list of asphalt deposits and important oil test wells in the Ouachita area is contained in the Ouachita Symposium Text (1959) and in other publications on the area.

*Geologist, Sinclair Oil & Gas Company, Ardmore, Oklahoma

Sinclair #1 Reneau
SE NW, 32-3N-20E
Latimer County, Oklahoma

Elevation: 768 G.L. T.D. 7,097 Feet
Commenced: 5-9-1959 Completed 1-18-1960
Casing Record: 20″ at 104 Feet
13⅜″ at 942 Feet
9⅝″ at 1,843 Feet
4½″ at 2,653 Feet
PBTD 2,623 Feet
Perf: 560/2,340-2,480 Feet

Drilled with cable tools from surface to 942 feet, and rotary tools to total depth.

Drilled with air from 942 to 1,515 feet and 1,843 to 1,998 feet.

DST #1:2265-2315 (Big Fork)/1 hr. 5 mins., gas 4 mins., 150 MCFGPD, decreasing to 72 MCFGPD, Rec. 15′ H/GCM, FP 0#, SIBHP 1110#/1 hr., HH 1160#.

DST #2: 2318-62, ⅝″ T&BHCK, open 1 hr. 5 mins., gas 1,110 MCFGPD, dec. to 846,500 CFGPD, Rec. 100′ GCM, FP 340-245#, FSIP 1130#/1 hr.

DST #3: 2373-2421 (Big Fork) ⅝″ T&BHCK, double pkr., open 1 hr. 5 mins., good blow, vol, decreasing slowly from 1,343 MCF to 1,189 MCF/1 hr.

DST #4: 2423-90 (Big Fork) ⅝″ T&BHC, open 1 hr. 5 mins., gas vol. 2,220 MCF, dec. to 1,961 MCF, Rec. 90′ hvy. drlg. mud, SIBHP 1155-1080#/1 hr., FP 685-635#/1 hr.

DST #5: 2494-2564 (Big Fork-Womble), ⅝″ T&BHC, open 1 hr. 5 min., fair blow gas 2 mins., gas vol. 88 MCF dec. to 7 MCF/3 mins. and stabilized, Rec. 10′ GCM, ISIBHP 720#/1 hr., FSIBHP 555#/1 hr. FP 25-25#.

DST #6: (Big Fork Chert) 2590-2662/ 5 mins. w/fair blow, SI/1 hr., re-opened for 1 hr. w/fair blow, gas in 8 mins., TSTM to a trace in 25 mins., Rec. 60′ GCM, 720′ mdy brackish water, IFP 735#/1 hr., FFP 1180#, ISIBHP 1203#/1 hr., FSIBHP 1180#/1 hr.

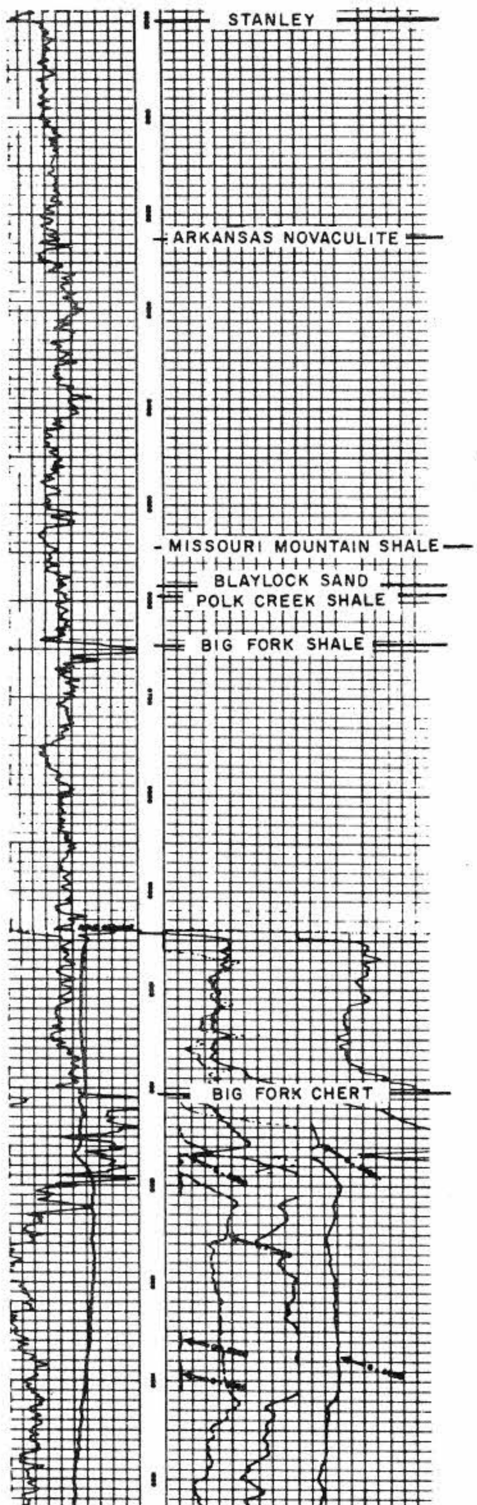
DST #7: 6062-95; failed

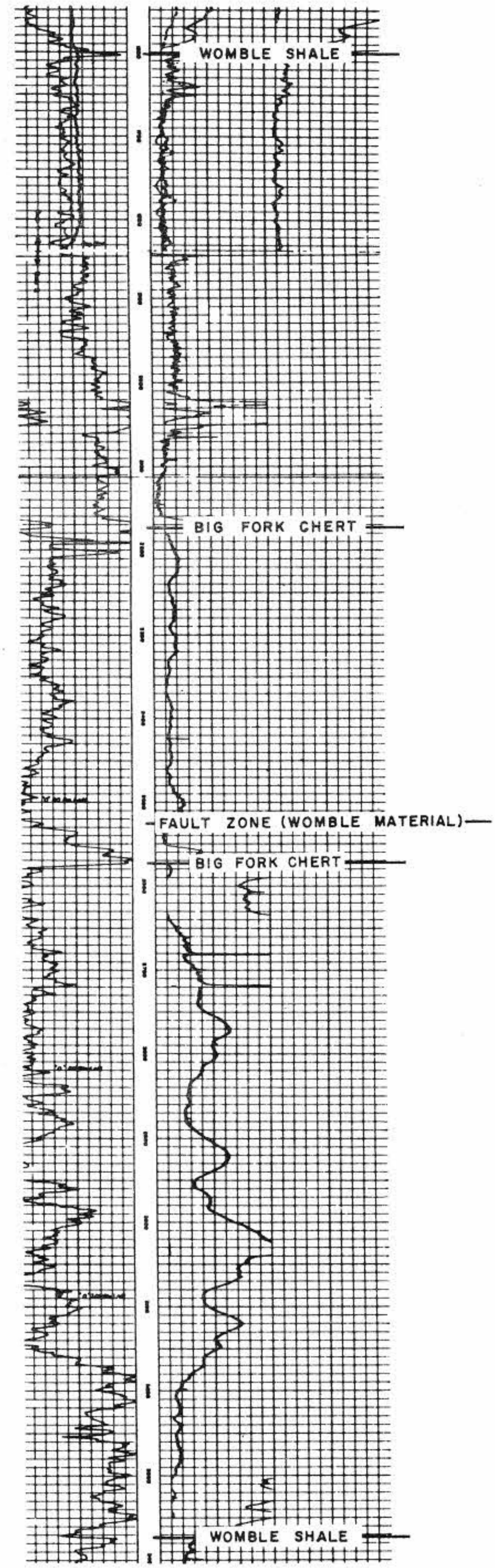
DST #8: 6072-6112; failed, at 6123 tried to blow out.

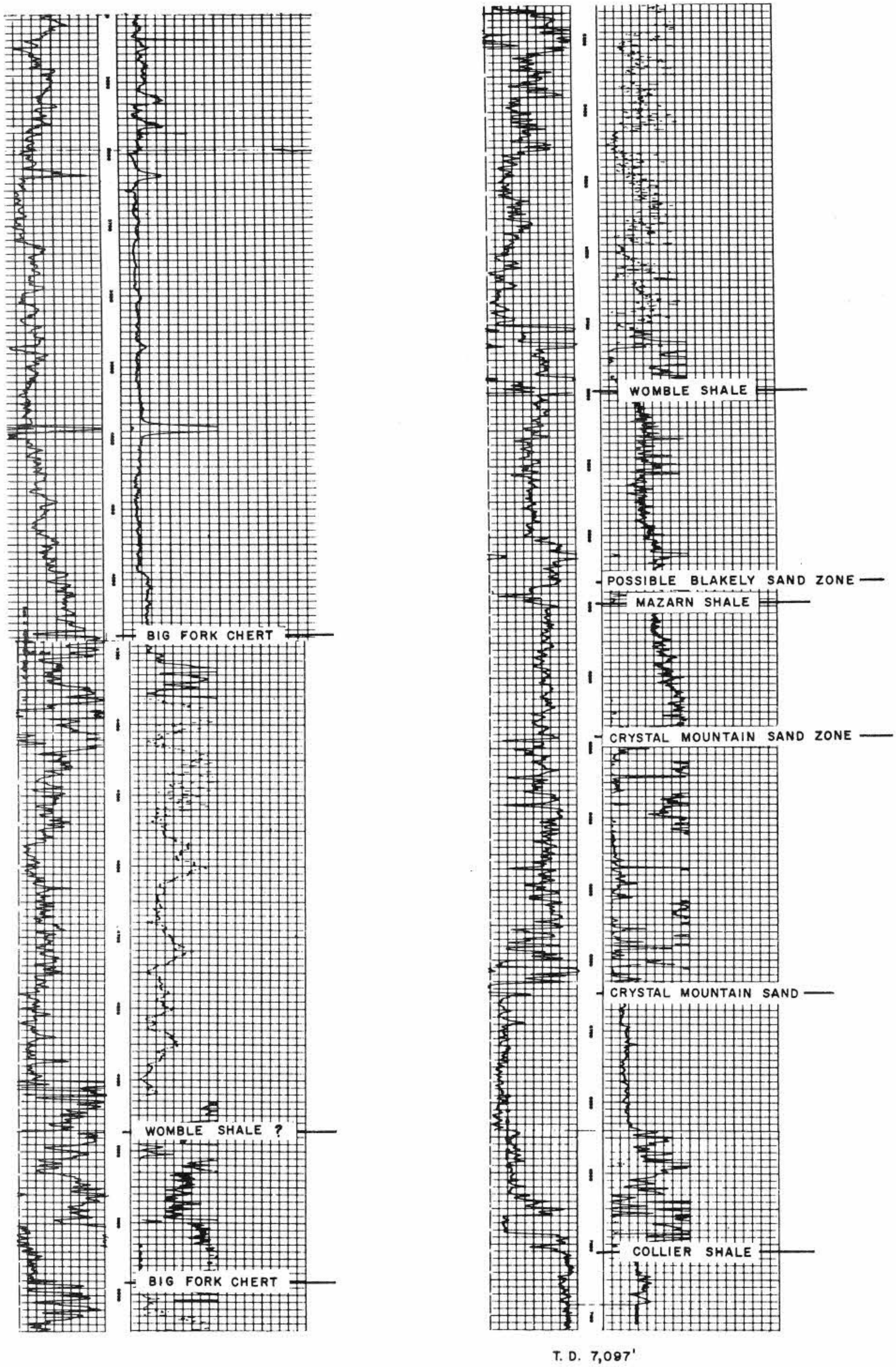
DST #9: 6296-6358, pkr failed.

SINCLAIR OIL & GAS CO.
NO. 1 RENEAU
SEC. 32-3N.-20E
LATIMER COUNTY, OKLA.

(FORMATION TOPS ARE MARKED)






BIG FORK CHERT
WOMBLE SHALE ?
BIG FORK CHERT
WOMBLE SHALE
POSSIBLE BLAKELY SAND ZONE
MAZARN SHALE
CRYSTAL MOUNTAIN SAND ZONE
CRYSTAL MOUNTAIN SAND
COLLIER SHALE
T. D. 7,097'

4 Point Draw Down Test—2,340-2,480 Feet

Choke	Hours	Pressure	Gas Volume
14/64	12	875	802,000
20/64	6	680	1,163,000
24/64	$4\frac{1}{2}$	310	1,624,000
3/4	10	125	1,771,000

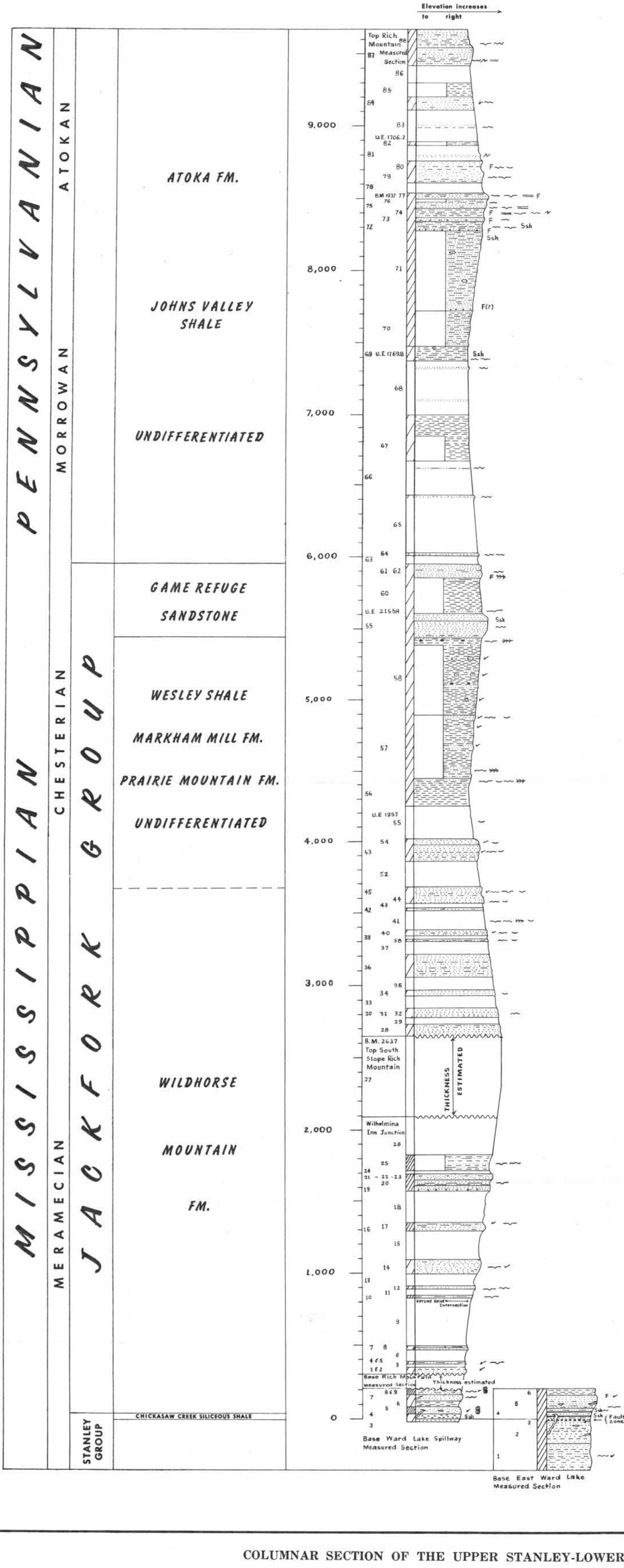
Open Flow Potential: 1,850,000 CFGPD from the Big Fork Chert 2,340-2,410 feet.

Shut in build up pressure from 125-915#/50 minutes.

The following formation tops are the tops as called by the Sinclair geologist that watched the well during drilling operations. Several geologists have questioned the formation determinations and have correlated the lithology at total depth with the Mississippian and even Pennsylvanian. It will suffice to say that the below listed tops are based on Ordovician graptolites and fragmentary chitinozoa found in the lower portion of the well.

Stanley	0-225	
Arkansas Novaculite	225-545	(sample top)
Missouri Mountain shale	545-585	(sample top)
Blaylock sand	585-593	(sample top)
Polk Creek shale	593-645	
Big Fork shale	645-1106	
Big Fork chert	1106-1602	
Womble shale	1602-2174	
Big Fork chert	2174-2526	
Fault zone (Womble material)	2526-2572	
Big Fork chert	2572-3372	
Womble shale	3372-4280	
Big Fork chert	4280-4972	
Womble shale ?	4972-5184	
Big Fork chert	5184-5796	
Womble shale	5796-6068	
Possible Blakely sand zone	6068-6096	
Mazarn shale	6096-6286	
Crystal Mountain sand zone	6286-6648	
Crystal Mountain sand	6648-7011	
Collier shale	7011-7097 T.D.	

The producing interval of Big Fork chert 2,340-2,480 feet is described as interbedded dark brown chert, dolomitic in part, spicular in part, and dark brown hard siliceous shale with some thin dark brown to tan, finely crystalline, siliceous dolomitic streaks. Fine vugular and pinpoint porosity exists with probable fracture porosity.



Sandstone, very-light-gray to olive-gray, hard to friable, clean to argillaceous and micaceous; interbedded gray shale

Sandstone, very-light-gray to white, laminated; conglomerate, containing an invertebrate mold fauna; interbedded dark-gray to grayish-black, fissile to splintery shale and siliceous shale

Shale, dark-gray to grayish-black, some siliceous; gray sandstone interbeds and masses, some fossiliferous if in place

Shale, light-grayish white to light-brownish-gray and light-whitish-gray siltstone

Sandstone, light-gray to white, very-fine-grained, clean, containing invertebrate fossil molds; interbedded gray shale and spiculitic siliceous shale

Shale, dark-gray to grayish-black, splintery to fissile, containing subdiscoidal chert masses; interbeds and masses of carbonaceous sandstone

Sandstone, medium-dark-gray to white, moderately to well sorted, friable to hard, possessing pitted top surface and tracks of bottom organisms; interbedded gray shale

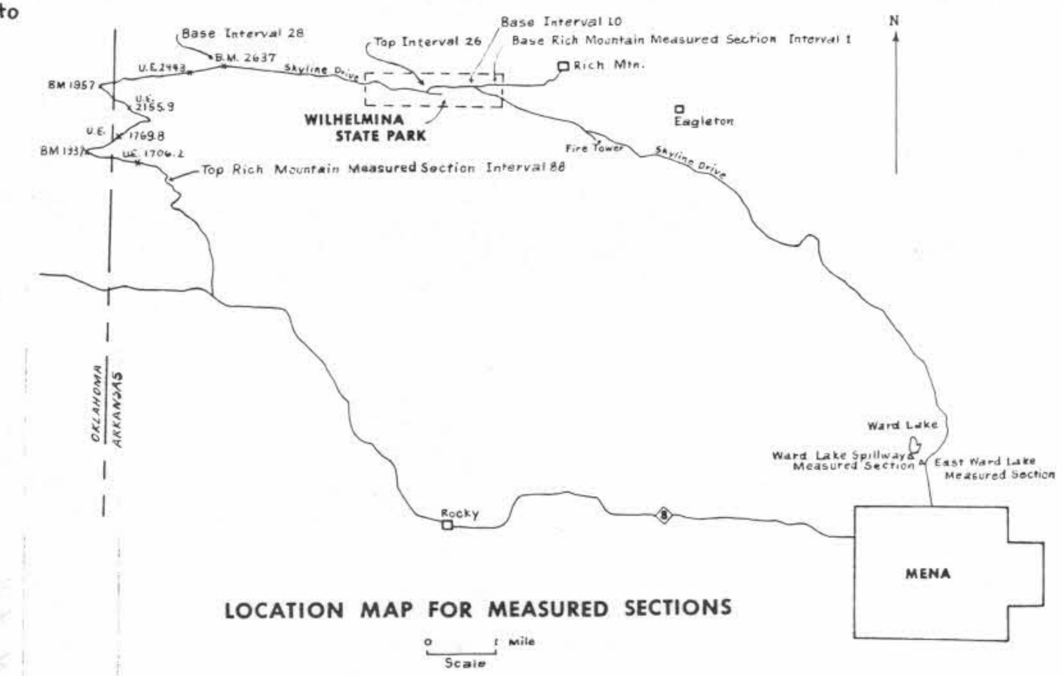
Shale, medium-dark-gray to grayish-black; interbedded olive-gray sandstone
Sandstone, yellowish-gray, moderately sorted, containing quartz granules

Sandstone, medium-light gray to white, well sorted, stylolitic, interbedded gray shale

A maroon shale bed occurs in this interval at the east end of Rich Mountain syncline

Sandstone light-to dark-gray, very-fine to medium-grained, moderately sorted, stylolitic, containing Calamites and, locally, an invertebrate mold fauna; interbedded gray shale

Shale, light-gray to grayish-black, siliceous, containing white specks less than 0.1mm in diameter; interbedded gray, cross-bedded sandstone; quartz veins



LOCATION MAP FOR MEASURED SECTIONS

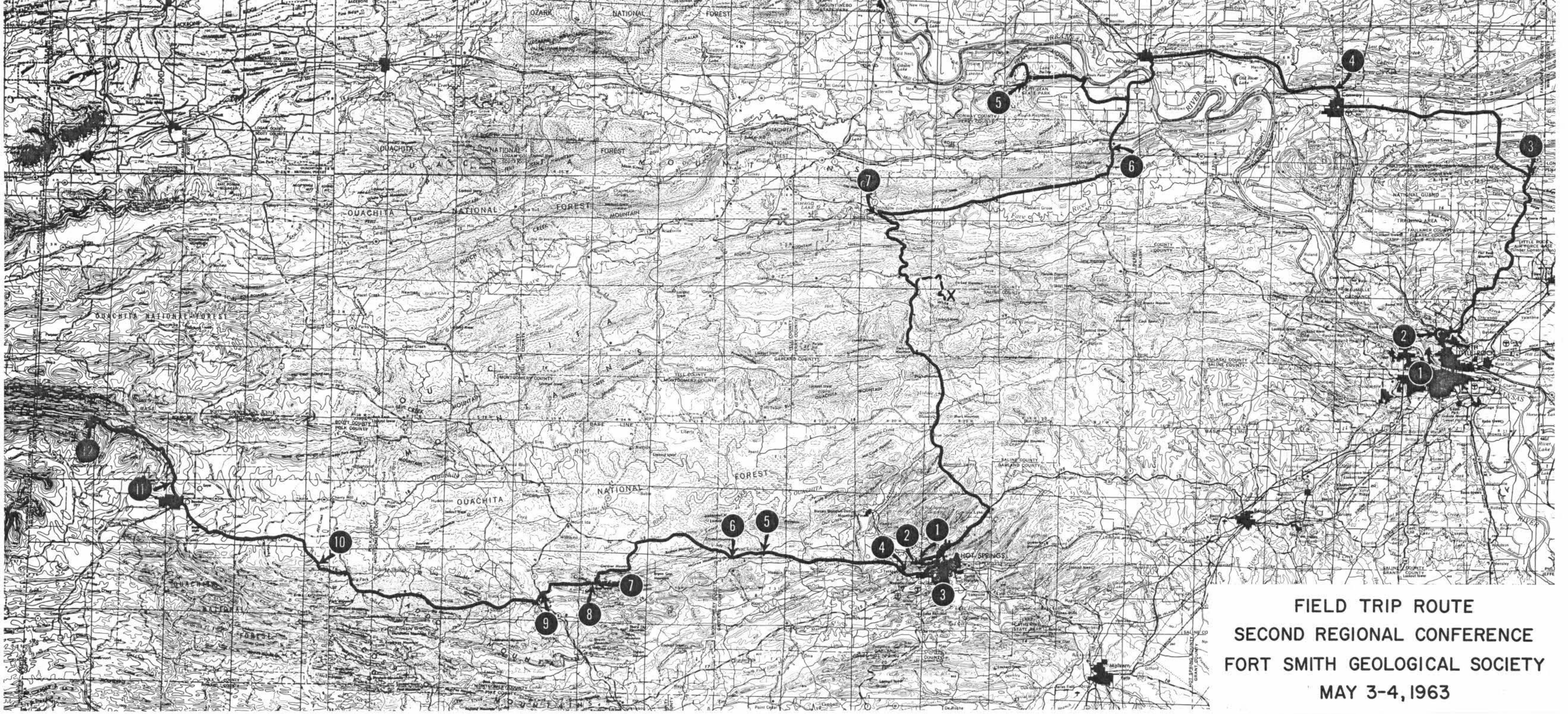
EXPLANATION

- ✓ Layers of carbonized plant fragments prominent in sandstone
- F Molds of invertebrate fragments, especially crinoid or blastoid columnals, present in sandstone
- ⊕ Calamites stems in sandstone
- Trails of benthic organisms on top or bottom surface of sandstone
- Undulating upper surface of sandstones. These overlie a zone of wavy-or cross-lamination that is no more than a few inches thick
- Contorted bedding in sandstone
- Even-bedded sandstone breaking into plates along shaly, carbonaceous or fossiliferous laminae
- Sandstone has oriented and/or non-oriented bottom surface markings
- Sub-ellipsoidal depressions on top surface of sandstone and/or sub-ellipsoidal cavities ~~within~~ beds
- Quartz veins
- Ssh Siliceous shale
- Most distant spacing indicates white sandstone. Color is increasingly darker gray with increasingly close spacing of hachures. Closest spacing indicates dark gray
- 34 Measured section interval number. See Appendix for detailed interval description
- The most poorly exposed intervals are indented
- U.E. 2155.9 Unchecked elevation points which are marked with white paint on roadside rocks and whose positions are plotted on the Location Map are present at the stratigraphic levels shown

COLUMNAR SECTION OF THE UPPER STANLEY-LOWER ATOKA SEQUENCE IN RICH MOUNTAIN SYNCLINE, ARKANSAS AND OKLAHOMA

by

D. R. Seely, 1962



FIELD TRIP ROUTE
SECOND REGIONAL CONFERENCE
FORT SMITH GEOLOGICAL SOCIETY
MAY 3-4, 1963