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OKLAHOMA GEOLOGY NOTES

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Cover Picture

RATTLESNAKE BLUFF

Rattlesnake Bluff, an exposure of a 90-foot-thick tuff bed with thinner tuffs beneath, overlooks the swimming hole in the recreation center of Beavers Bend State Park in McCurtain County. The thickest tuff layer in the bluff is the lowermost of three or four such beds in the Tenmile Creek Formation. The first appearance of tuff layers is about 270 feet above the base of the formation in the Mississippian Stanley Group of Oklahoma and Arkansas.

This photograph is from Oklahoma Geological Survey Guide Book XI, *Guide to Beavers Bend State Park*, by W. D. Pitt and C. B. Spradlin, which is available for purchase from the Survey, $1.00.

—P. W. W.

Statistics of Oklahoma's Petroleum Industry, 1966

John F. Roberts

Exploratory wells were drilled in all but nine counties of Oklahoma during 1966 (fig. 1). The concentration of discoveries, extensions, outposts, and new pay horizons was in northwestern Oklahoma in Beaver, Ellis, Roger Mills, Woods, and Woodward Counties. This area had a 40-percent success ratio, whereas the state-wide success ratio was 28 percent for exploratory wells. Tonkawa completions were the most numerous, followed by Morrow and Chester, plus completions in the Council Grove, Oswego, and Cottage Grove.

During the past three years the major exploratory effort has moved westward from north-central to northwestern Oklahoma, and in 1966 to western Oklahoma. The goals have been various Pennsylvanian sands as they thin to extinction or undergo facies change within the hinge zone or on the northern shelf of the Anadarko basin.

Exploration continued in the Arkoma basin, but at the slowest pace in several years. However, several significant dry-gas discoveries were made in Atokan and Morrowan sands.

The 22 giant fields in Oklahoma are listed in table I. A field is a "giant" when the estimated ultimate recovery exceeds 100 million barrels of oil. These giants produced 45 percent of Oklahoma's oil

Table I.—Giant Oil Fields of Oklahoma, 1966

Field	1966 Production (1,000 bbls)	Cumulative Production (1,000 bbls)	Estimated Reserves (1,000 bbls)	Number of Wells
Allen	2,636	99,414	20,586	1,470
Avant	240	105,178	1,823	500
Bowlegs	952	146,691	13,309	172
Burbank	10,655	457,881	42,119	1,306
Cement	2,671	120,665	14,335	1,524
Cushing	3,499	430,955	24,045	1,850
Earlsboro	623	138,530	1,470	172
Edmond West	1,961	117,494	12,506	579
Elk City	404	59,055	40,945	275
Eola-Robberson	3,632	70,795	54,205	484
Fitts	1,324	122,394	4,606	592
Glenn Pool	4,153	287,464	32,536	1,267
Golden Trend	13,440	310,300	184,700	1,740
Healdton	3,036	253,575	16,425	2,160
Hewitt	3,764	178,554	26,446	1,425
Little River	441	132,541	2,459	121
Oklahoma City	1,922	729,802	40,198	450
Seminole	1,115	169,867	7,133	259
Sho-Vel-Tum	30,712	742,835	158,288	7,849
Sooner Trend	11,496	51,139	49,504	1,929
St. Louis	1,406	199,879	10,121	648
Tonkawa	439	129,331	4,000	193

Source: Oil and Gas Journal, vol. 65, no. 5, January 30, 1967.

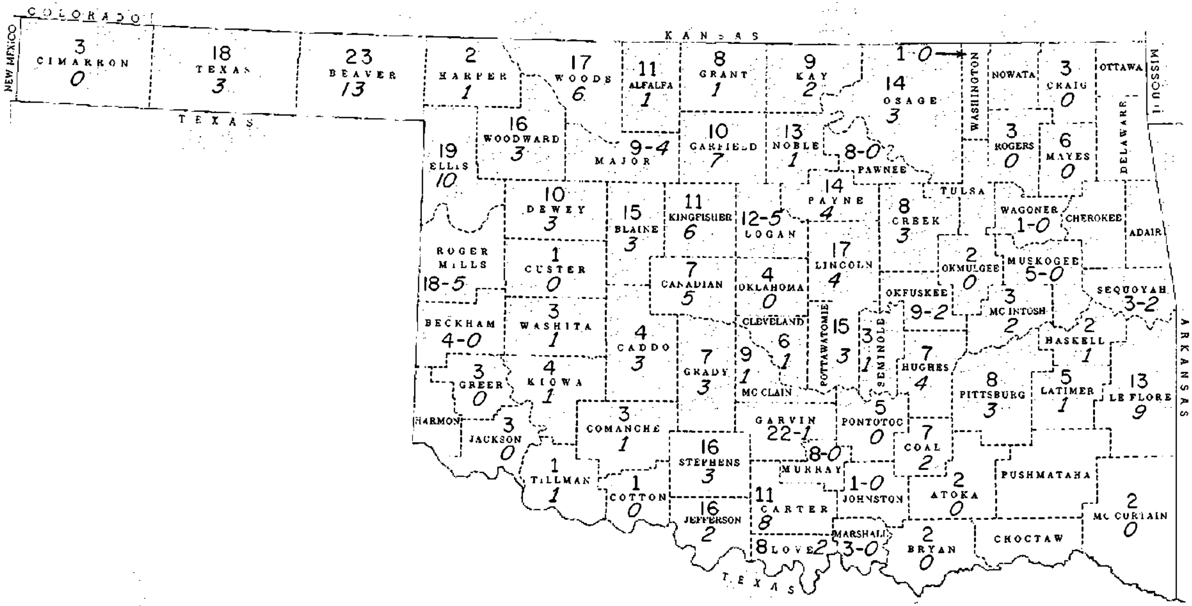


Figure 1. Exploratory drilling, by counties, during 1966. Vertical figures give the number of exploratory wells drilled; slant figures give the number of successful completions. No wells were drilled in Adair, Cherokee, Choctaw, Delaware, Harmon, Nowata, Ottawa, Pushmataha, and Tulsa Counties.

Table II.—Drilling Activity in Oklahoma, 1966

	1966					1965	1967
	CRUDE	GAS	DRY	SERVICE	TOTAL	TOTAL	FORECAST
All wells							
Number of completions	1,843	561	1,329	379	4,112	4,515[1]	3,924
Footage					18,441,323	20,044,602	17,462,000
Average footage					4,485	4,440	
Exploration wells							
Number of completions	73	65	383		521	443[1]	518
Percentage of completions	14.0	12.5	73.5		100		
Footage					3,150,032	2,567,860[1]	
Average footage					6,048	5,796	
Development wells							
Number of completions	1,770	496	946	379	3,591	4,072	3,406
Percentage of completions[2]	55.1	15.4	29.5		100		
Footage					15,291,291	17,476,742	
Average footage					4,258	4,292	

Source: Oil and Gas Journal, annual forecast and review issue, vol. 65, no. 5, January 30, 1967, and no. 12, March 20, 1967.
[1] Includes 25 exploration wells added to previously reported total.
[2] Excludes service wells.

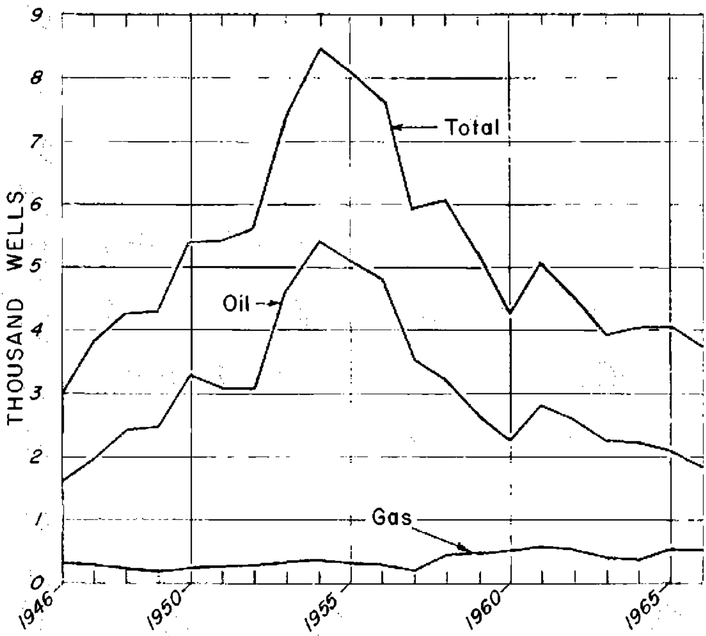


Figure 2. Graph showing total wells drilled, oil wells completed, and gas wells completed in Oklahoma, 1946-1966. Source: Oil and Gas Journal.

during 1966; they account for 53 percent of the State's estimated ultimate yield and contain 47 percent of the remaining reserves.

Table II summarizes drilling activity during 1966. This information appears annually in the last January issue of the *Oil and Gas Journal.* However, this year revision of the preliminary tabulations was necessary, and the March 20, 1967, issue (vol. 65, no. 12) presents the final and official well-completion data of the AAPG Committee on Statistics of Drilling.

Table III lists cumulative and yearly production and value of all hydrocarbons to January 1, 1967. Total value of these items is $23.3 billion.

Table IV compares hydrocarbon production of the past two years. Production of crude oil, lease condensate, and natural-gas liquids in 1966 exceeded 1965 production because of increased allowables during the latter half of the year. Preliminary figures indicated a decrease in natural-gas production during 1966, but more current data, issued by the American Gas Association, indicate an increase of 8.9 percent, as shown in figure 3.

TABLE III.—CUMULATIVE (THROUGH 1955) AND YEARLY (1956-1966) MARKETED PRODUCTION AND VALUE OF PETROLEUM, NATURAL GAS, NATURAL GASOLINE, AND LIQUEFIED PETROLEUM GAS IN OKLAHOMA[1]

	CRUDE PETROLEUM		NATURAL GAS		NATURAL GASOLINE AND CYCLE PRODUCTS		LIQUEFIED PETROLEUM GAS	
YEAR	VOLUME (1,000 BBLS)	VALUE ($1,000)	VOLUME (MMCF)	VALUE ($1,000)	VOLUME (1,000 GALS)	VALUE ($1,000)	VOLUME (1,000 GALS)	VALUE ($1,000)
Through 1955	7,230,010	11,443,269	12,977,332	1,378,370	14,420,482	890,729	3,673,364	120,097
1956	215,862	600,096	678,603	54,288	489,963	26,543	579,101	23,427
1957	214,661	650,423	719,794	59,743	460,644	25,329	587,140	21,824
1958	200,699	594,069	696,504	70,347	440,798	26,029	657,114	25,822
1959	198,090	578,423	811,508	81,151	448,353	29,443	675,869	27,070
1960	192,913	563,306	824,266	98,088	531,995	33,074	762,258	32,409
1961	193,081	561,866	892,697	108,016	521,237	33,358	817,082	30,141
1962	202,732	591,977	1,060,717	135,772	552,795	35,764	838,903	25,223
1963	201,962	587,709	1,233,883	160,405	555,467	35,131	810,894	28,981
1964	202,524	587,320	1,323,390	166,747	554,053	34,011	880,804	28,055
1965	203,441	587,944	1,320,995	182,297	570,129	34,561	894,665	32,208
1966[2]	224,000	651,840	1,294,000	179,866	572,200	35,476	935,300	37,412
	9,479,975	$17,998,242	23,833,689	$2,675,090	20,118,116	$1,239,448	12,112,494	$432,669

[1] Figures from: Minerals Yearbooks of the U. S. Bureau of Mines. Totals for crude petroleum differ from those compiled by the U. S. Bureau of Mines and the American Petroleum Institute principally because of the exclu sion from U. S. B. M. and A. P. I. compilations of an estimated production of 26,355,000 barrels for the years 1905-1906.

[2] Preliminary figures for 1966.

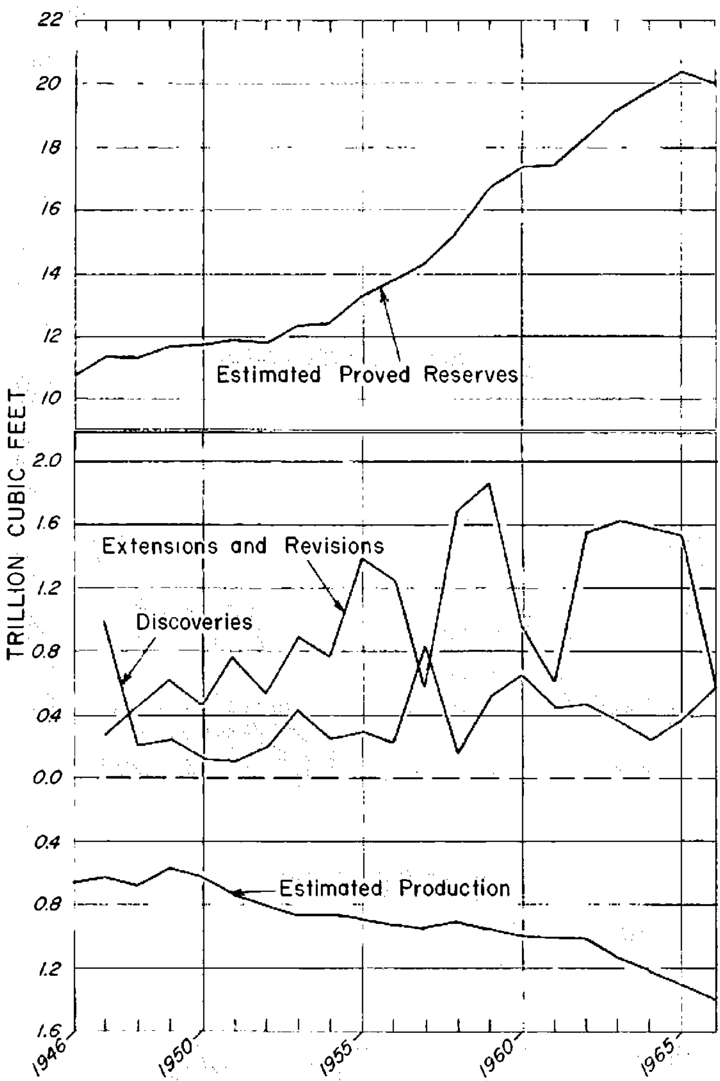


Figure 3. Graph showing statistics on estimated proved reserves of natural gas in Oklahoma, 1946-1966. Estimated production is plotted in reverse direction (increasing downward) to indicate subtraction from reserves. Source: American Gas Association, annual reports.

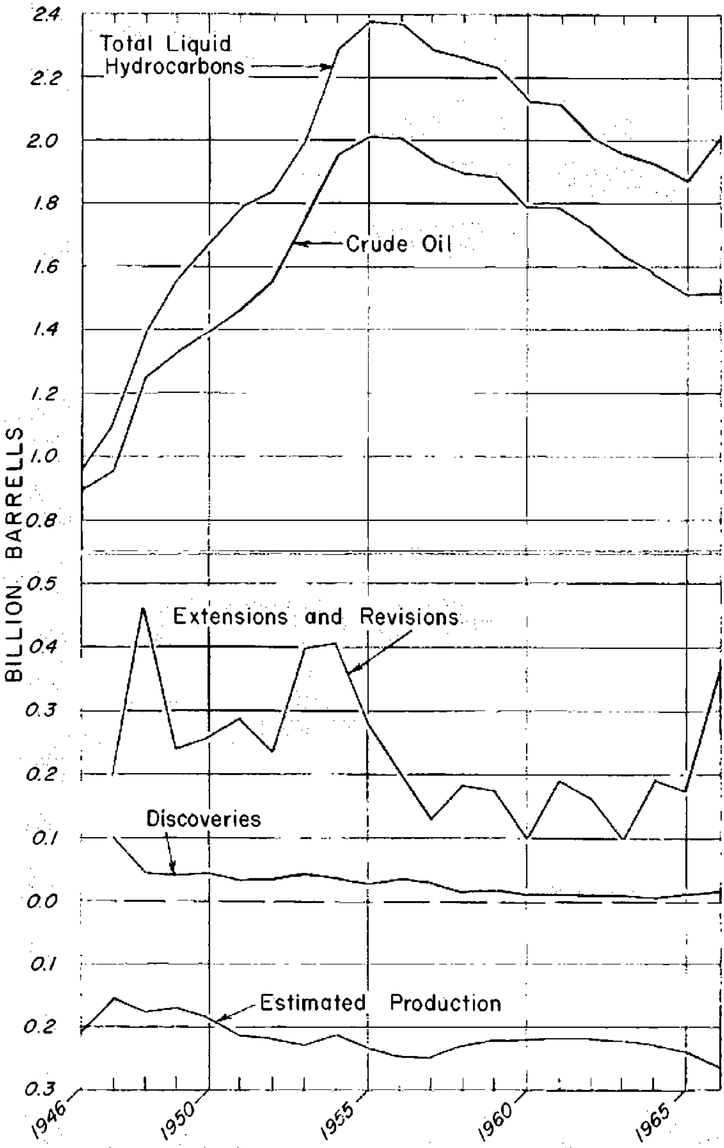


Figure 4. Graph showing statistics on estimated proved reserves of total liquid hydrocarbons in Oklahoma, 1946-1966. Estimated production is plotted in reverse direction (increasing downward) to indicate subtraction from reserves. Source: American Petroleum Institute, annual reports.

TABLE IV.—HYDROCARBON PRODUCTION IN OKLAHOMA, 1965-1966

	END OF 1965	END OF 1966
Crude oil and lease condensate		
Total annual production (1,000 bbls)[1]	203,441	224,000
Value ($1,000)[1]	587,944	651,840
Cumulative production 1891-year (1,000 bbls)	9,255,975	9,479,975
Daily production (bbls)[2]	557,373	614,847
Total number of producing wells[2]	80,000	81,477
Daily average per well (bbls)	7.0	7.5
Oil wells on artificial lift (estimated)[2]	76,200	77,477
Natural gas		
Total annual marketed production (MMCF)[1]	1,320,995	1,294,000
Value ($1,000)[1]	182,297	179,866
Total number of gas and gas-condensate wells[2]	7,100	7,841
Natural-gas liquids		
Total annual marketed production (1,000 gals)[1]	1,464,794	1,507,500
Value ($1,000)[1]	66,796	72,888

[1] Item for 1965 is U. S. Bureau of Mines final figure. Item for 1966 is U. S. Bureau of Mines preliminary figure.

[2] World Oil, annual forecast and review issue, vol. 164, no. 3, February 15, 1967.

Estimated proved reserves of liquid hydrocarbons (fig. 4) showed the first increase over the previous year since 1955 and reached the highest level since 1962. Part of the increase is accounted for by slight increases in discoveries, but most is from upward revision of reserves in known reservoirs.

Oklahoma continues to rank third in the nation in estimated reserves and production of natural gas, following Texas and Louisiana. This position is maintained despite a slight loss in estimated total reserves, due to the production of more natural gas than was discovered and added by extensions and revisions.

Progress in Topographic Mapping in Oklahoma

Carl C. Branson

Topographic mapping in the State has been greatly accelerated, partly by speedier Federal programs and partly because State agencies (Highway Department and Water Resources Board) have put funds into cooperative projects. The last of the 15-minute quadrangles was issued this year (Weatherford quadrangle). This scale is no longer considered adequate, and all maps now in progress are 7½-minute quadrangles (scale 1:24,000).

Complete coverage of the State at 1:24,000 would require 1,213 published quadrangles; of this number 245 are now available, and 266 are in preparation. At the present rate Oklahoma should be covered in about 10 years.

The maps of the 30-minute series, of which 27 were published from 1896 to 1912, are now considered of little value and are being allowed to go out of print. About half of their area is now covered by later, larger-scale maps, either published or in preparation.

An area equal to 321 7½-minute quadrangles is within published 15-minute quadrangles. The total area covered by 7½- or 15-minute quadrangles is equal to 838 quadrangles at the 1:24,000 scale. In addition, 18 15-minute quadrangles were mapped at 1:24,000 standards but published at 1:62,500. These conceivably will be converted.

Work is progressing on border quadrangles in adjacent states. Along the Texas border at the Red River all quadrangles are published except 14 7½-minute sheets which are in preparation. The Texas sheets in the Panhandle bordering Oklahoma would number 39, of which 9 are published, plus 2 at 1:62,500; 5 are in preparation. None of the 4 on the New Mexico side is published or in preparation and none of the 8 in Colorado. Along the border in Kansas are 59 1:24,000 sheets, of which 21 are published, and 2 15-minute sheets. On the Missouri border all 4 sheets are published. On the Arkansas border 12 1:24,000 sheets are published, 4 are in preparation and 1 15-minute sheet is published of a total of 24 adjacent 7½-minute areas.

Since February 1967, six 7½-minute quadrangles have been published (fig. 1). Forty-three have been issued in "advance proof" and can be expected to be in print shortly.

Large areas of the State are not covered by topographic maps, or are covered only by the old 30-minute series (fig. 2). Many of these areas are now being mapped on 7½-minute sheets, as are some areas that have 15-minute map coverage (compare figs. 1, 2).

The U. S. Geological Survey issues an *Index to Topographic Mapping in Oklahoma,* copies of which can be obtained from the Oklahoma Geological Survey free of charge. The index outlines and identifies by name all published topographic maps available as of February 1967. The topographic maps published since that date are outlined and identified in figure 1. Figure 1 also shows areas for which 7½-minute sheets are now being prepared. Figure 2 is a synopsis of the U. S. G. S.

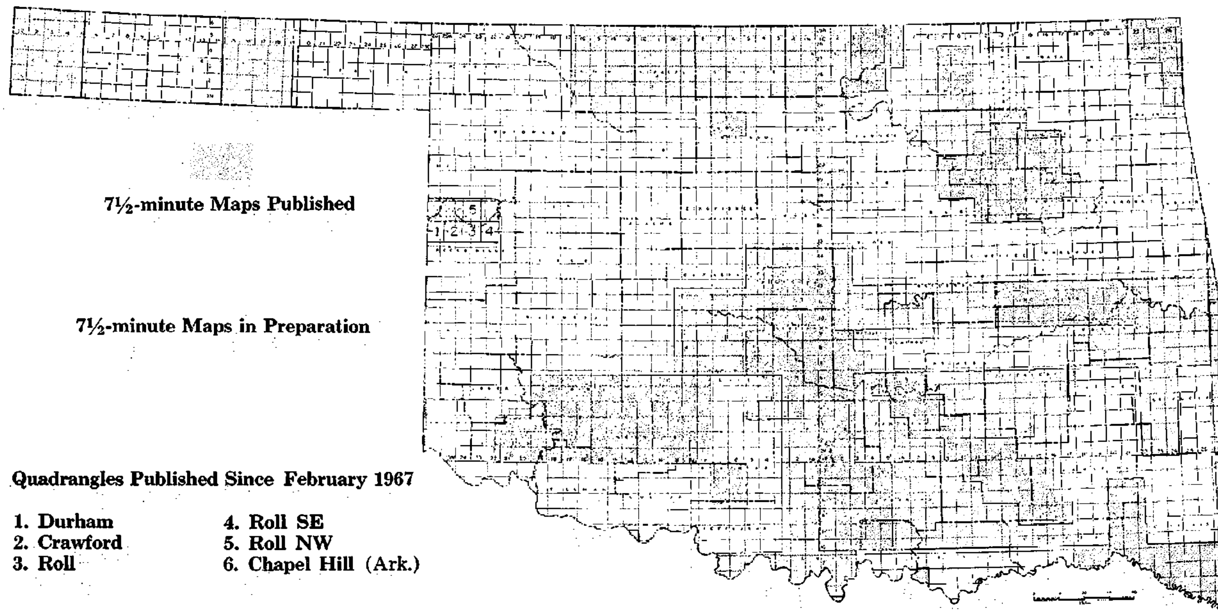


Figure 1. Map showing 7½-minute topographic map coverage in Oklahoma.

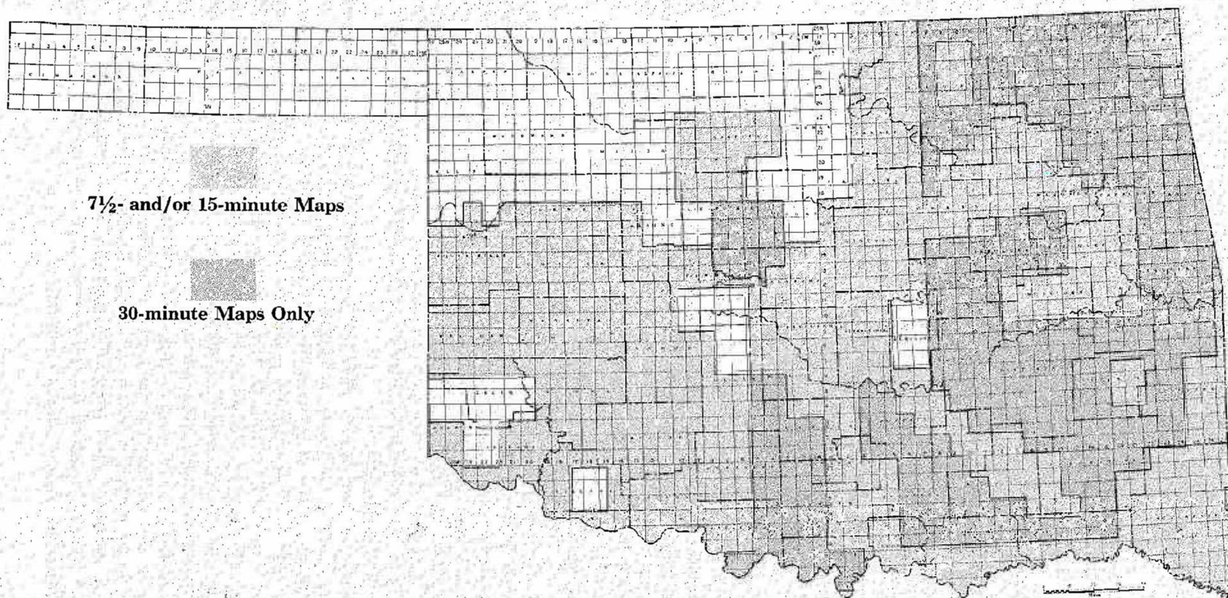


Figure 2. Synopsis of U. S. G. S. Index to Topographic Mapping in Oklahoma.

index, showing all the areas for which coverage is available and at what scales.

All available U. S. G. S. topographic maps may be purchased through the Oklahoma Geological Survey at 50 cents per sheet. In addition, 2-degree sheets (scale 1:250,000) of the Army Map Service (issued by U. S. G. S.) are available for the entire State at 75 cents per sheet. Thirteen AMS sheets include all of Oklahoma and portions of adjacent states. Discounts are given at the rate of 20 percent for map orders of $20 or more, and 40 percent for orders of $100 or more.

A new service is now provided in that a few maps issued before 1962, most of those issued that year, and all of those issued since 1962 are available without contours or woodland overprint. This service provides base maps with land net, culture and drainage, which are useful to a large number of agencies. One 15-minute sheet (Bethel) can be obtained in shaded relief and is a striking map for showing geologic structure and geomorphology.

McIntosh County Report Published

Oklahoma Geological Survey Bulletin 111, *Geology and Petroleum of McIntosh County, Oklahoma,* was published in July 1967. The report comprises two parts dealing with the petroleum geology and surface geology of the county. Included in the discussion of surface geology are mineral and natural resources other than petroleum, surface structure and stratigraphy, and paleontology, as well as the general geography of the area.

Part I, *Geology and Mineral Resources of McIntosh County,* by Malcolm C. Oakes and others, is of particular interest to the layman, as in it are described the geological and geographical setting of much of Eufaula Reservoir, one of the State's major recreation areas and a source of water and hydroelectric power. Also informative to the general public is the description of ground water and other economic resources in the county, such as building stone (Bluejacket Sandstone), coal, and clay and shale deposits which could be used in brick and tile manufacturing.

Petroleum Geology of McIntosh County, part II of the bulletin, by Terry Koontz, is based on electrical logs, "drillers' logs," and core data from the wells described. Of principal interest to the petroleum industry, this section contains a summary of oil and gas production in the county from 1912 through the present. Strata ranging in age from Cambrian through Late Pennsylvanian have been encountered in wells drilled in the county, and Koontz includes a discussion of the general subsurface stratigraphy in his portion of the report.

Bulletin 111 is 88 pages long with 13 illustrations, in addition to 4 plates in the back-cover pocket; the plates include a geologic map, structure map, outcrop sections of Pennsylvanian rocks, and an electric-log cross section. The appendix contains descriptions of the 117 measured sections used in compiling part I of the report. Sale price is $5.00, paper-bound, and $6.00, cloth-bound.

Structural Control of Canadian River in Western Oklahoma

Harold A. Brown

INTRODUCTION

The area discussed in this report encompasses more than 4,000 square miles in western Oklahoma (fig. 1) and is bounded on the west by the Texas-Oklahoma state line and on the east by the east line of R. 14 W. The north and south boundaries are the north line of T. 21 N. and the south line of T. 13 N., respectively. Southern Ellis, northern Roger Mills, and all of Dewey Counties are included in the area. The Canadian River flows eastward across the area, dividing it nearly in half. The North Canadian River flows southeastward across the northeast corner of the project area, and the Washita River flows east-southeastward across the southwest quarter.

The surface is slightly rolling and slopes gently S. 50° E. The Canadian River and associated tributaries have cut downward, sharply dissecting the land surface with steep-sided, V-shaped canyons. The present channel of the Canadian River is about 450 feet below the north divide, which is from 2 to 18 miles away, and about 300 feet below the south divide, which is generally less than 3 miles away but is as much as 12 miles distant at a few places.

The dip of the near-surface strata in the area is toward the southeast at less than 1 degree, and, because of the low dip, the surface geology reveals little about the shallow subsurface structure. In such a situation, the question arises as to whether subsurface structures can be revealed by stream patterns. If stream drainage can be related to structure, much time and expense can be saved in the selection of promising seismograph prospects for petroleum exploration. The conclusion of this study is that the course of the Canadian River does reveal such structural control in this area.

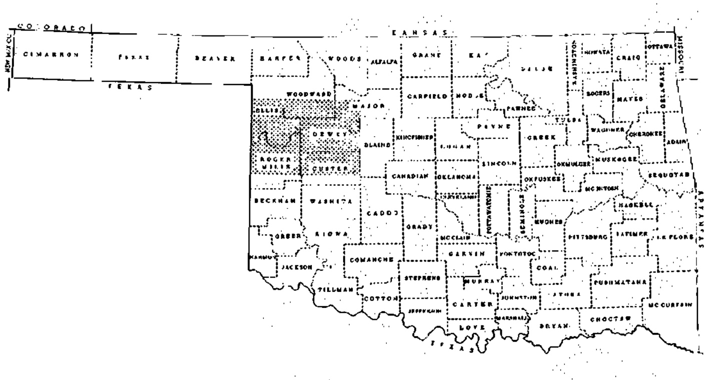


Figure 1. Index map showing location of study area.

STRATIGRAPHY

The near-surface rocks in the area are red shale, quartzose sand and conglomerate, and anhydrite and salt (no salt is exposed at the surface). Figure 2, a typical electric log for the area, illustrates the stratigraphic sequence immediately beneath the surface. The exposed rock units are, in ascending order: the Permian Blaine anhydrite, Dog Creek Shale, Marlow Formation, Rush Springs Sandstone and the Cloud Chief Formation; the Pliocene Laverne and Ogallala Formations; and various sandstone and gravel units of Pleistocene age. The Blaine anhydrite crops out in the northeast corner of the area and is at a depth of about 900 feet in the western part. The base of the Blaine is the shallowest horizon that can be reliably correlated on electric logs throughout the area.

SURFACE DRAINAGE

The Canadian River originates in the Sangre de Cristo Mountains in northeastern New Mexico. It flows eastward across the Texas Panhandle, following a generally straight course, and enters the western part of Oklahoma where it forms the boundary between Ellis and Roger Mills Counties. The river forms three anomalous U-shaped bends across the area before leaving at the southeast corner, beyond which it follows a straight southeasterly course.

Aerial photographs reveal the braided nature of the river channel, indicating that the sediment load exceeds the transport capacity of the water. It may be that a greater volume of water travels under the surface than within the channel; Reed and Longnecker (1932, p. 13) reported that the river bed is notorious for its treacherous quicksands. According to Lobeck (1939, p. 193), the braided channel and the absence of downcutting classifies the Canadian River as mature and not youthful, despite the steep banks and poorly developed flood plain.

The drainage area of the river is narrow. It is less than 20 to 25 miles wide throughout the area and narrows downstream instead of widening. Logically, the principal source of the water that incised the channel may have been the mountains in New Mexico rather than local rainfall. Alexander (1965, p. 5) and Birchum (1963, p. 5) reported that the Thornthwaite climate classification places this area in the subhumid, mesothermal province, with a deficiency of moisture in all seasons. The mean annual precipitation is 24.3 inches, based upon 27 years of record. Apparently the river has a much greater function carrying water through the area than draining local rainfall, a characteristic typical of rivers in arid to semiarid regions.

The drainage divides of the Canadian River (fig. 3) generally parallel the U-shaped bends in the river. This concordance is apparently a result of the youthfulness of the tributary system. Because of the flat-lying beds, the drainage pattern is dendritic throughout the area, with all of the tributaries downcutting their channels and extending headward. Typically, a principal tributary of the Canadian River has a straight course with a few short tributaries. Three areas exhibit exceptions to this rule (T. 17 N., R. 16 W.; T. 17 N., R. 20 W.; T. 17 N., R. 22 W.). In these areas the streams form fan-shaped dendritic

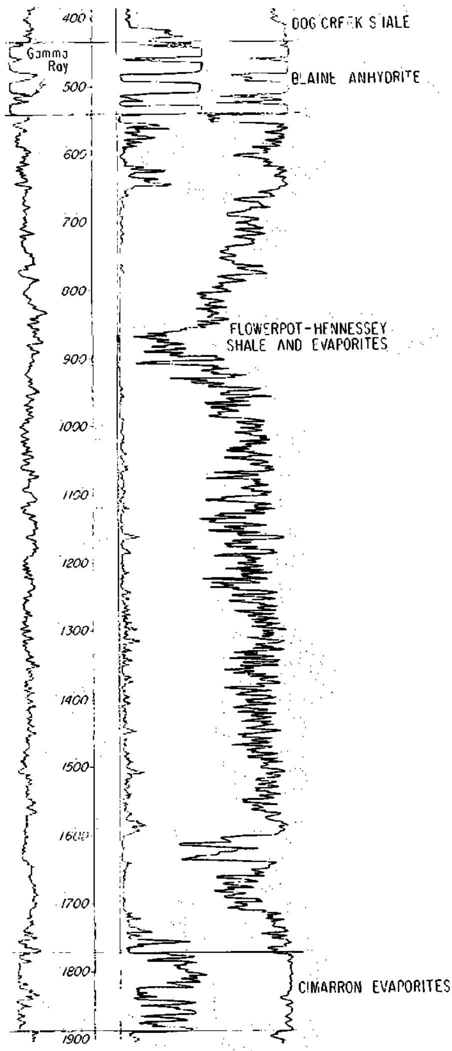


Figure 2. Typical electric log, showing near-surface stratigraphic units. Log is of the Mobil Oil Co. 1 Cree well, NW¼ SE¼ sec. 12, T. 18 N., R. 21 W., Ellis County. K. B. elevation, 2,032 feet. T. D., 11,455 feet.

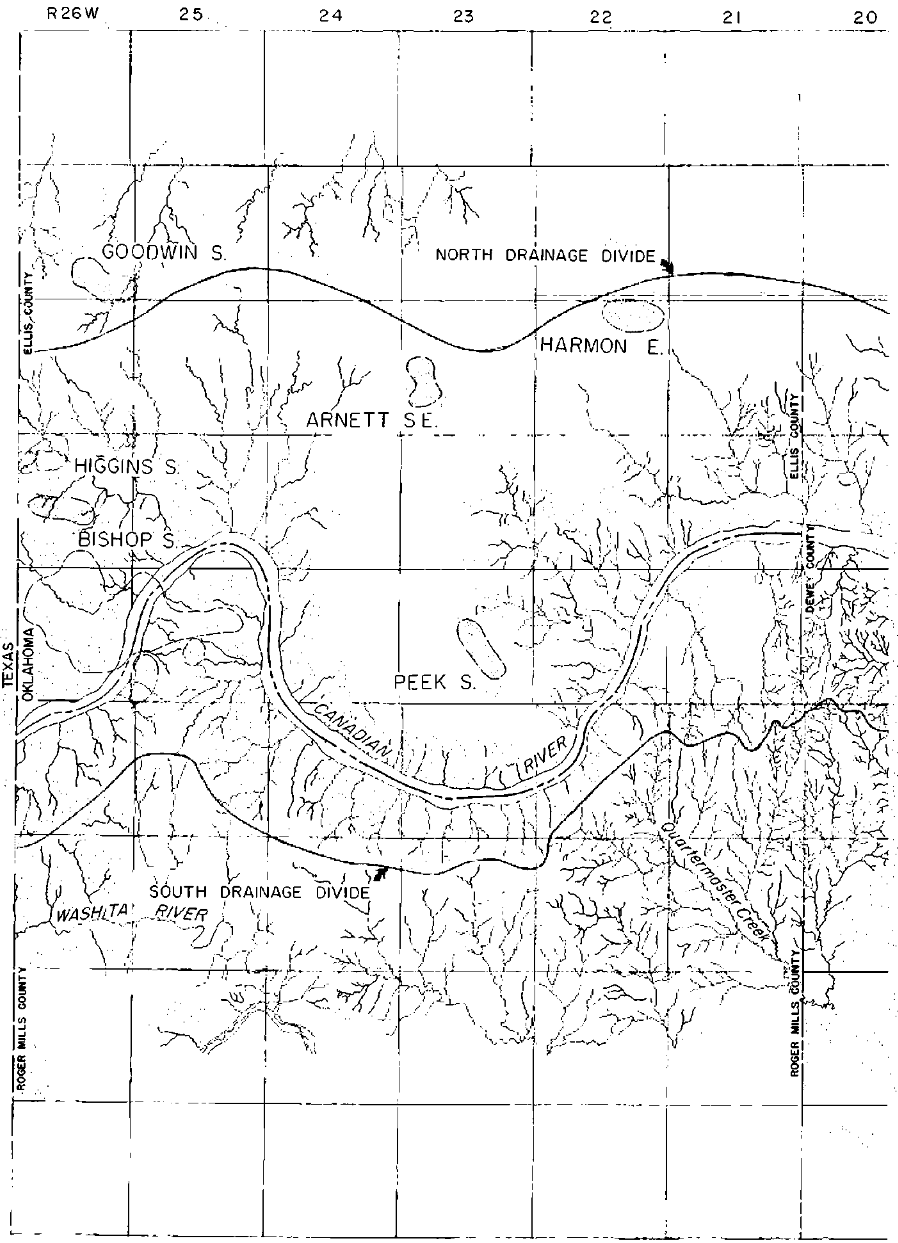
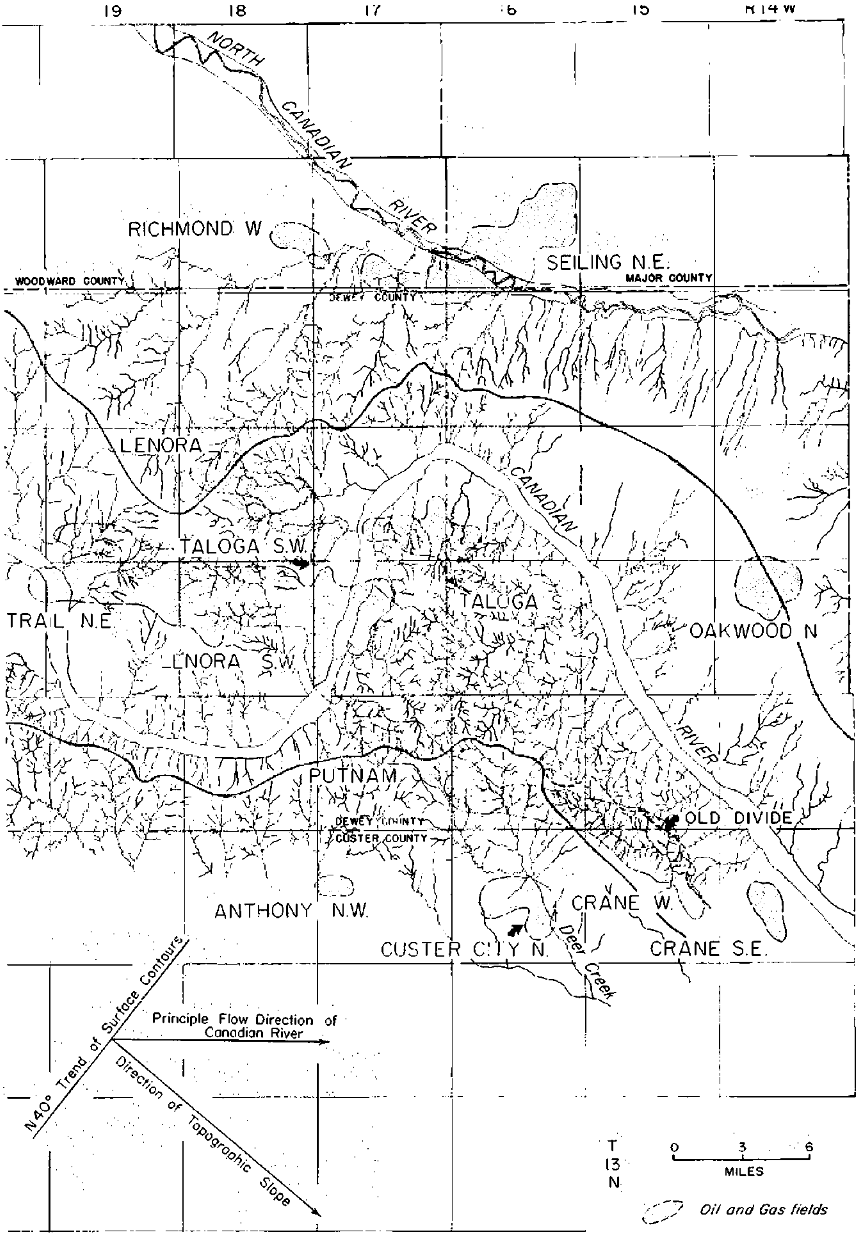


Figure 3. Drainage map of study area.



19
18
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T 13 N
NORTH CANADIAN RIVER
RICHMOND W
SEILING N.E.
WOODWARD COUNTY
MAJOR COUNTY
DEWEY COUNTY
LENORA
CANADIAN
TALOGA S.W.
TALOGA
TRAIL N.E.
OAKWOOD N
LENORA S.W.
RIVER
PUTNAM
OLD DIVIDE
DEWEY COUNTY
CUSTER COUNTY
ANTHONY N.W.
CRANE W.
CUSTER CITY N.
Deer Creek
CRANE S.E.
N40° Trend of Surface Contours
Principle Flow Direction of Canadian River
Direction of Topographic Slope
0
3
6
MILES
Oil and Gas fields

patterns associated with areas of collapse in the underlying evaporite beds.

Drainage is poorly developed in part of southern Ellis County (centered on T. 19 N., R. 23 W.) and eastern Dewey County (centered on T. 17 N., R. 14 W.) because of porous sand on the surface.

The average direction of flow in the Canadian River is eastward, with a gradient of 4 to 5 feet per mile. The U. S. Geological Survey topographic maps (Clinton and Woodward 1:250,000 quadrangles) indicate that the surface slopes S. 50° E., with a gradient of 15 to 20 feet per mile. The angle between the direction of surface slope and the direction of river flow is about 40° (indicated by diagram on fig. 3). The other major streams of the area, the North Canadian and the Washita, have less sinuous courses; the gradient of the Washita is about 15 feet per mile, or nearly that of the topographic slope. The analysis of stream behavior suggests that the channel of the Canadian River is older than those of the other streams and is more influenced by irregularities in the subsurface strata than by topographic effects. The analysis of the structure on the base of the Blaine anhydrite (fig. 4) supports this interpretation.

In the near geologic future the Canadian River will probably straighten its course so that its gradient will more nearly approximate the topographic slope. A contributing factor to the adjustment will be the capture of the Canadian by Quartermaster Creek in T. 16 N., R. 22 W. When this happens, the adjustment will presumably be rapid and the water in the Canadian River will flow directly through the Washita River drainage system.

STRUCTURE ON THE BASE OF THE BLAINE ANHYDRITE

The Blaine anhydrite is a shallow marker bed which occurs in the subsurface throughout the area and crops out in the northeast corner of the area. Because it is shallow lying (less than 900 ft.), structure mapped on the base of the Blaine should indicate surface structure, except where collapse due to solution of post-Blaine evaporites has altered the structural relationships. The regional dip is southeastward, which is nearly the trend of the topographic slope. North of T. 17 N. the rate of dip is about 9 feet per mile and the contours form irregular noses, domes, and anticlines with low relief. South of T. 17 N. the rate of dip is about 26 feet per mile. Except for the North Custer City and Northwest Anthony structures, only southeastward-plunging noses are apparent in the region of steeper southeastward dip into the Anadarko basin. Along the narrow east-west trend underlying T. 17 N., a northwest-southeast structural grain is apparent. This narrow trend is also a belt of maximum flexure, where jointing is expected to be most intense. Joints or fractures may have had a profound influence on the course of the Canadian River. The river flows across the length of the flexure trend and it is apparent that the river course has been influenced by the structural grain.

As pointed out earlier, east and west of the report area the course of the Canadian River is generally straight, lacking the U-shaped meanders present over the trend of maximum flexure. An examination of the structure map on the base of the Blaine anhydrite published by Jordan and Vosburg (1963, map A of pl. 3) suggests an explanation. This structure map covers the entire Anadarko basin area and shows that the trend of maximum flexure underlying T. 17 N. bends southwestward in western Roger Mills County and crosses southern Hemphill and northern Wheeler Counties, Texas. Northwest of this trend, in northern Hemphill County and all of Roberts County, Texas, the noses, domes, and anticlines are equally as irregular and as low in relief as are those in Oklahoma north of T. 17 N. Apparently, the straight course of the Canadian River across Roberts and Wheeler Counties, Texas, reflects the absence of significant structural grain, and the anomalous bends in Oklahoma are due to the juncture of the stream course with the trend of maximum structural flexure. To the east, in southeastern Dewey County, Oklahoma, the straight southeasterly course may be due to the topographic slope, which is concordant with the strike of the outcropping beds.

TABLE I.—LIST OF WELLS USED IN CROSS SECTIONS
(See figs. 5, 6)

NUMBER	NAME	LOCATION		COUNTY
		Section A-A′		
1.	Goff 1 Blaylock	NE SW	19-14N-21W	Roger Mills
2.	Mutual 1 Wilson	NE SE	1-16N-21W	Roger Mills
3.	Sun 1 Martin	NW SE	3-17N-21W	Roger Mills
4.	Mobil 1 Cree	NW SE	12-18N-21W	Ellis
5.	Mobil 1 Winters	SW NE	9-19N-20W	Dewey
6.	Morgan 1 Gerbeling	NW NW	19-20N-20W	Woodward
		Section B-B′		
7.	Hunt 1 Croft	SE NW	18-15N-17W	Custer
8.	Morton 1 Elder	SE	22-16N-18W	Dewey
9.	Pet. Inc. 1 Merrick	S2 N2	23-17N-18W	Dewey
10.	Jones & Pellow 1 Seal	SW SW NE	3-17N-18W	Dewey
11.	Amerada 1 Green	SW NE	21-18N-18W	Dewey
12.	Shell 1 Sheldon	NW SE	8-18N-18W	Dewey
13.	Goff 1 Pickering	SE NW	32-19N-18W	Dewey
14.	Stanolind 1 Harper	NE NE	21-19N-18W	Dewey
		Section C-C′		
15.	Hill 1 Dearing	SE NW	23-17N-26W	Ellis
16.	Hill B-1 Dearing	E2 NW	25-17N-26W	Ellis
17.	Hill A-1 Meeks	SE NW	31-17N-25W	Roger Mills
		Section D-D′		
18.	Mobil 1 Cox	SE NW	18-17N-17W	Dewey
19.	Continental 1 Kouns	NW SW	17-17N-17W	Dewey
20.	Apache 1 State Shell	NE SW	16-17N-17W	Dewey
		Section E-E′		
21.	Jennings 1 Stump	NW SE	9-20N-18W	Woodward
22.	GMC 1 Arthaud	NW SE	34-21N-18W	Woodward
23.	Shell 1-25 Winter	SW NE	25-21N-18W	Woodward
24.	Shell 1-20 Huffman	SW SW	20-21N-17W	Woodward

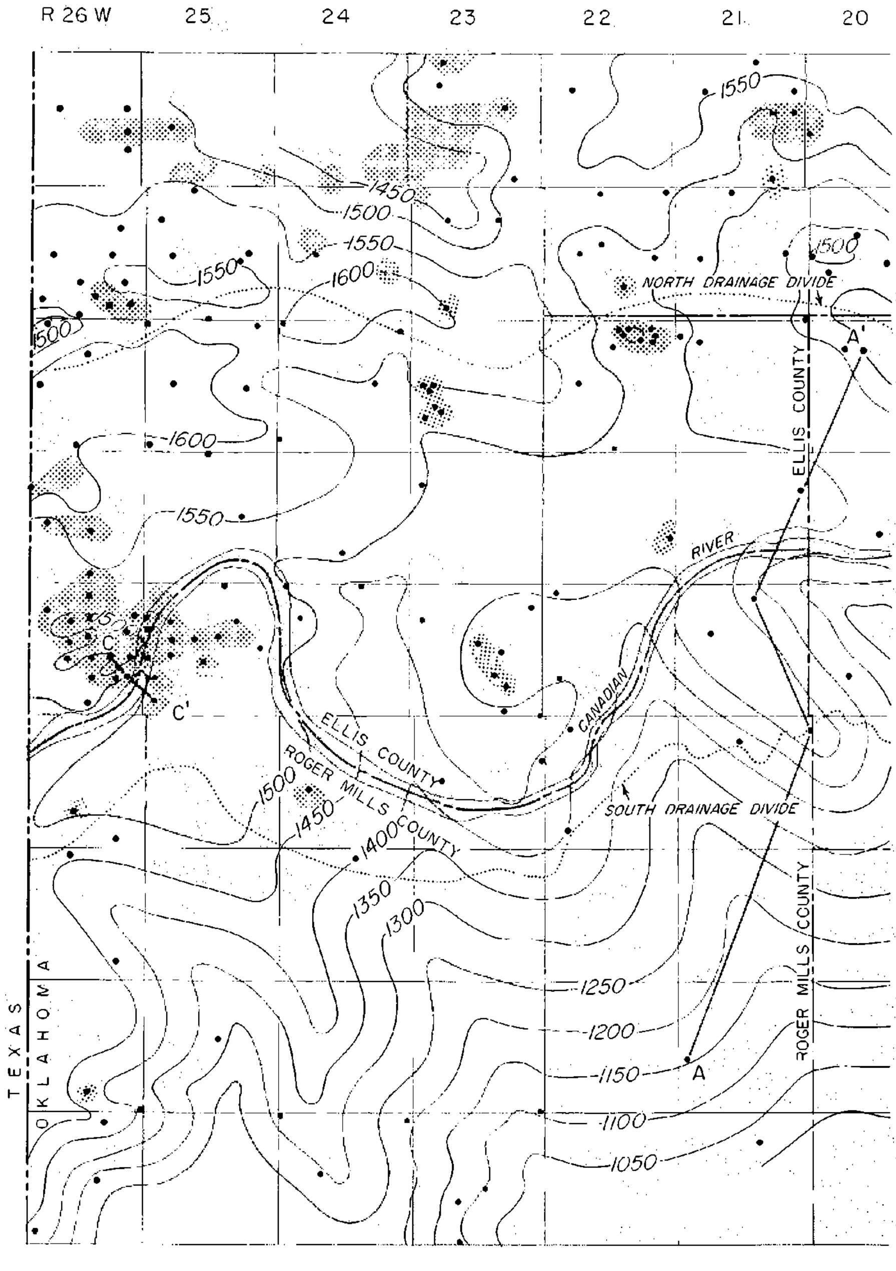
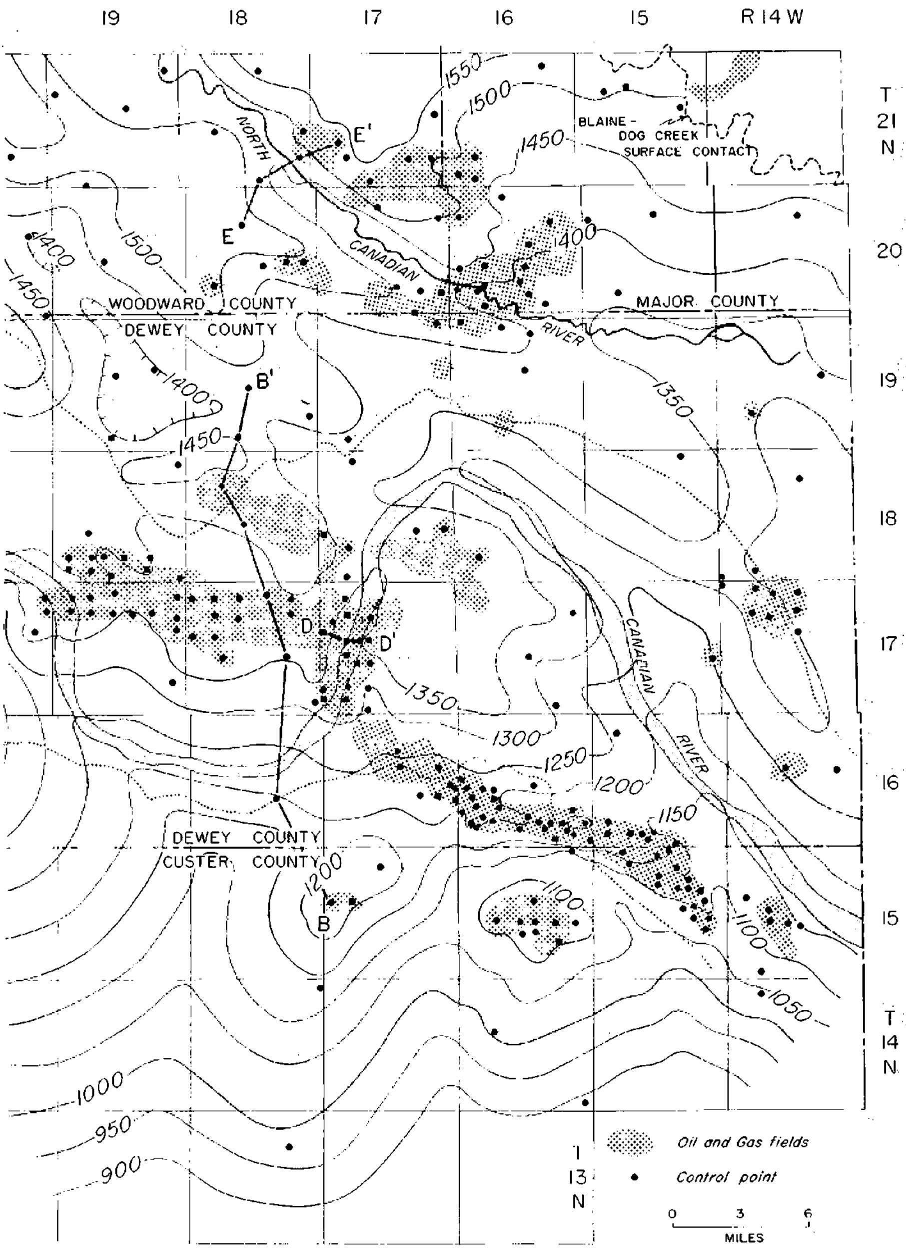


Figure 4. Structure map of study area. Reference surface is base of Blaine anhydrite; contour interval, 50 feet;



datum, mean sea level. Cross sections A-A′ and B-B′ are shown in figure 5; C-C′, D-D′, and E-E′ in figure 6.

The south divide of the Canadian River has no apparent relationship to structure. The north divide, however, generally overlies an east-west structural ridge between the Canadian and North Canadian Rivers.

Each bend in the river is underlain by a structural low, or syncline, which plunges parallel to the stream channel. Structural cross sections C-C′ and D-D′ of figure 6 show that the lows are deep-seated and not a result of near-surface collapse. Cross section C-C′ crosses a syncline south of the South Bishop field (fig. 4). The Hill B-1 Dearing well (well 16) in sec. 25, T. 17 N., R. 26 W., is low on all horizons from the base of the Blaine through the Heebner shale (?), which is found at about 7,200 feet. Control on deeper beds is not available. Cross section D-D′ crosses a syncline in the Southwest Lenora field, where the Continental 1 Kouns well (well 19) in sec. 17, T. 17 N., R. 17 W., is structurally low on all horizons at least as deep as the Heebner shale (?) at 6,800 feet. The Heebner (?) is a Pennsylvanian black shale marker near the top of the Missouri Series. The synclines apparently originate deep in the rock section, but the cause is unknown.

A similar syncline is shown under the North Canadian River in Tps. 20, 21 N., Rs. 17, 18 W., by cross section E-E′ (fig. 6). Here the deeper beds are not low in the center of the syncline, suggesting evaporite solution and bed collapse between the Blaine and Cimarron anhydrite.

Cross sections A-A′ and B-B′ of figure 5 are surface profiles related to the surface stratigraphy. The stratigraphic data are taken from various published and unpublished sources (Kitts, 1965, 1959; Alexander, 1965; Birchum, 1963). These sections show the southerly dip component with no apparent meaningful irregularities near the river. Three terrace levels along the river course are shown.

Structural contours on the base of the Blaine anhydrite indicate five domelike features which are considered reliably located because of adequate well control (fig. 4). Four of the structures produce oil or gas: North Custer City, T. 15 N., R. 16 W.; Northwest Anthony, T. 15 N., R. 17 W.; South Bishop, T. 18 N., R. 26 W.; and Southeast Arnett, T. 19 N., R. 23 W. The nonproducing structure is in Tps. 19, 20 N., R. 20 W. Drainage patterns are incompletely shown on figure 3 over the nonproducing structure and the Northwest Anthony structure, and drainage has not developed over the Southeast Arnett structure because of loose sand at the surface. Drainage patterns of streams flowing across the South Bishop and North Custer City structures show nothing anomalous. Most other oil and gas fields in the area are primarily stratigraphic reservoirs, unassociated with structural closure. However, prominent structural noses underlie some fields, such as Lenora (T. 18 N., R. 18 W.), Southwest Lenora (T. 17 N., R. 18 W.), North Oakwood (T. 17 N., R. 14 W.), and West Crane (Tps. 15, 16 N., R. 15 W.). Again, stream drainage patterns are not irregular, except for that overlying West Crane (T. 15 N., R. 15 W.).*

* The Lenora, Southwest Lenora, South Taloga, Southwest Taloga, Northeast Trail, and West Crane fields are now combined in the Putnam field.

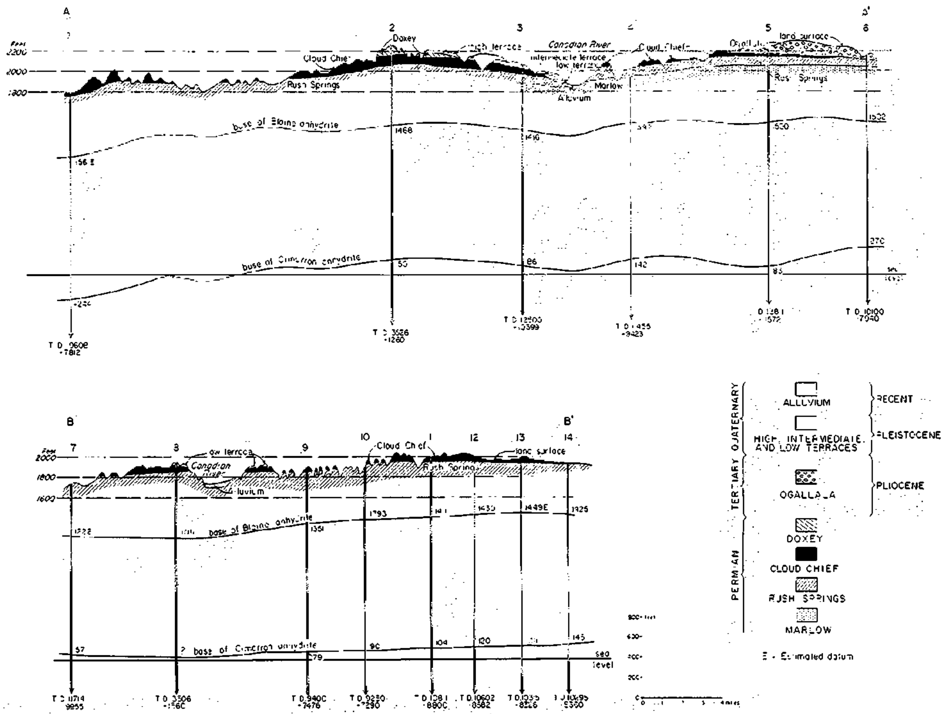


Figure 5. Cross sections showing relations of stratigraphic units to surface topography. Lines of sections are shown in figure 4; wells are identified by number in table I.

This anomaly is attributed to stream capture rather than to structural influence. The southeastward-flowing segment of the stream parallels Deer Creek and other streams to the southwest, suggesting that all southeastward-flowing streams were on the southwest side of an ancient divide (dashed line, fig. 3) at some time in the past. Northeastward-flowing streams were confined to the other side (northeast) of the ancient divide. Erosion and headward extension of the northeastward-flowing stream cut through the ancient divide and captured the nearest stream, causing a southwestward shift of the divide to the present position (solid line).

All river tributaries in the area are youthful and actively downcutting their channels from a previous superposition. The streams must have originated on a nearly flat Ogallala surface and, because of their youth, may not have had time to become structurally adjusted, and hence, are poor indicators of structural development.

The course of the Canadian River is structurally adjusted but the courses of its tributaries are not. This is probably because it is a mature stream that has had more time to react to the structural attitude of the underlying Permian beds.

Melton (1959) discussed stream superposition and structural adjustment of stream drainage. He pointed out (p. 356-358) that the course of the Washita River through the Arbuckle Mountains in southern Oklahoma gives little indication of the complex underlying structure because the river has downcut its channel from previous superposition on flat overlying Cretaceous beds, which have since been eroded away. The river course has not yet had time to become structurally adjusted. The time required to reach structural adjustment depends upon the resistance of the bedrock to erosion. This concept is apparently applicable to western Oklahoma.

AGE OF CANADIAN RIVER COURSE

Reed and Longnecker (1932, p. 39-42) described a sequence of three terrace levels in Hemphill County, Texas, along the Canadian River course. They reported the age of these beds as "early Pleistocene." These levels apparently correspond to the "high," "intermediate," and "low" terrace deposits along the Canadian in Oklahoma, which were mapped and described by Kitts (1965, 1959), Alexander (1965), and Birchum (1963). The oldest terrace (high terrace) contains Pearlette ash in Dewey County (Kitts, 1959, p. 15), and it is probable that the high terraces throughout the area are of Kansan age. No evidence of older Nebraskan sediments has been found. The ages of the younger intermediate and low terraces are possibly Illinoian and Wisconsin, respectively.

High-terrace sand and gravel are mapped along the course of the Canadian River as far east as the northwest portion of T. 17 N., R. 16 W. (Alexander, 1965). From this point southeastward, only intermediate and low terraces are found. These observations indicate that the course of the river west of T. 17 N., R. 16 W., is at least as old as Kansan and that the course to the southeast is younger. This may

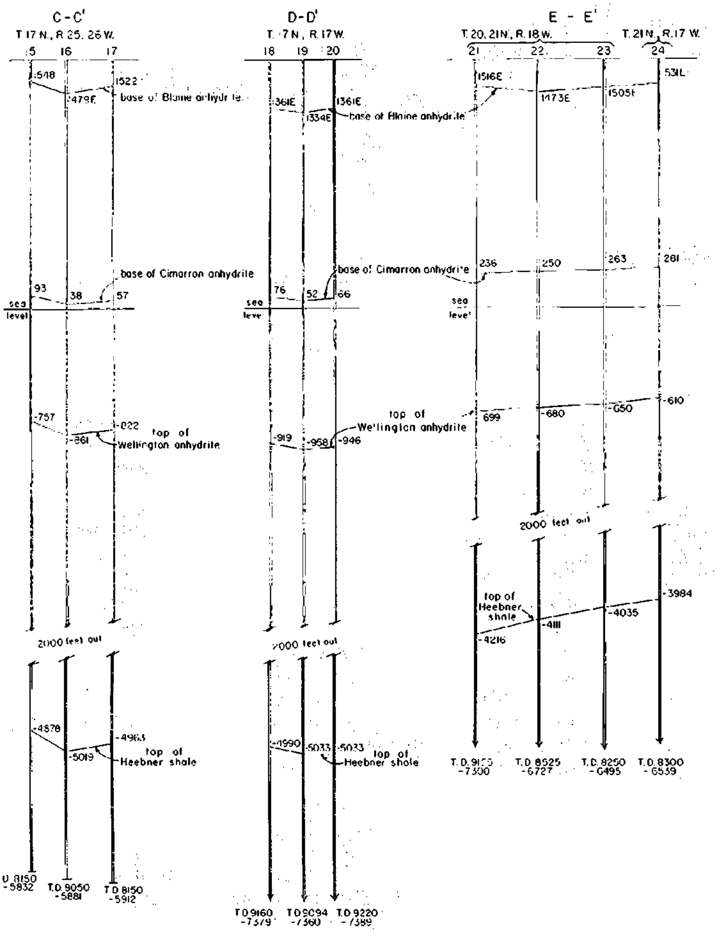


Figure 6. Cross sections showing synclinal structural depressions beneath courses of the Canadian River (sections C-C′, D-D′) and the North Canadian River (section E-E′). Lines of sections are shown in figure 4; wells are identified by number in table I.

explain why the river-divide area becomes narrower downstream (overfit) instead of wider.

East of T. 17 N., R. 16 W., the location of the abandoned Kansan channel is not known. However, Myers (1962) and Fay (1959) reported that the highest gravels scattered over the countryside are probably of Kansan age. Most likely these gravels are remnants of abandoned Kansan stream deposits, described by Myers (1962) as trending from the northwest corner of Harper County through the southeast portion of Woodward County and lying between the North Canadian and Cimarron Rivers, which parallel each other. After the channel became filled with silt and sand, surface runoff eroded the Cimarron and North Canadian River systems into the less permeable Permian beds on each side of the abandoned Kansan course. Myers further reported that the present courses of the Cimarron and North Canadian Rivers are no older than Illinoian, and possibly only Wisconsin.

The course of the Canadian River southeast of T. 17 N., R. 16 W., may also be no older than Illinoian. It is likely that the abandoned Kansan stream described by Myers and the Canadian River joined at some point in eastern Dewey County or western Blaine County. The silt and sand fill in the southeastward-flowing Kansan channel apparently had the same effect on the Canadian River as it did on the surface runoff that now flows into the North Canadian and Cimarron Rivers. This effect was to make the stream seek a new course across less permeable bedrock which would erode more easily than the permeable channel fill. The result is that southeast of T. 17 N., R. 16 W., the Cimarron, North Canadian, and Canadian Rivers have the following aspects in common:

1. All are probably the same age (Illinoian or Wisconsin).
2. All parallel each other and flow southeastward, which the older (Kansan) Canadian River channel does not. The rivers parallel each other for a considerable distance before emptying into the Arkansas River in eastern Oklahoma.
3. The southeastward flow direction is nearly the same as the topographic slope. The older portion of the Canadian River, as pointed out earlier, does not flow in this direction.

CONCLUSION

The present course of the Canadian River west of T. 17 N., R. 16 W., is the oldest course (Kansan) of any river in central-western and northwestern Oklahoma. Because it is older, the river has had more time to become structurally adjusted and is more influenced by bedrock structure than by topography. Other major streams, including the Canadian River southeast of T. 17 N., R. 16 W., are younger than Kansan and are possibly more influenced by topography than by bedrock structure.

Drainage patterns of the youthful tributaries of the Canadian River are poor indicators of subsurface structure. The tributaries are apparently now downcutting their channels and have not had time to adjust structurally. Domelike structures mapped on the base of the

Blaine anhydrite are not associated with anomalous tributary drainage patterns.

ACKNOWLEDGMENTS

A. J. Myers gave much time and valuable advice during the preparation of this report. Aerial photographs of the study area were provided by the Oklahoma Geological Survey, and the Pan American Petroleum Corporation made available the electric logs.

References Cited

Alexander, W. B., 1965, Areal geology of southern Dewey County, Oklahoma: Okla., Univ., unpublished Master of Science thesis, 42 p.

Birchum, J. M., 1963, Areal geology of northwestern Dewey County, Oklahoma: Okla., Univ., unpublished Master of Science thesis, 33 p.

Fay, R. O., 1959, Pleistocene course of the South Canadian River in central western Oklahoma: Okla. Geol. Survey, Okla. Geology Notes, vol. 19, p. 3-12.

Jordan, Louise, and **Vosburg, D. L.**, 1963, Permian salt and associated evaporites in the Anadarko basin of the western Oklahoma-Texas Panhandle region: Okla. Geol. Survey, Bull. 102, 76 p.

Kitts, D. B., 1959, Cenozoic geology of northern Roger Mills County: Okla. Geol. Survey, Circ. 48 [pt. 1], p. 5-26.

__________1965, Geology of the Cenozoic rocks of Ellis County, Oklahoma: Okla. Geol. Survey, Circ. 69, 30 p.

Lobeck, A. K., 1939, Geomorphology, an introduction to the study of landscapes: New York, McGraw-Hill Book Company, Inc., 731 p.

Melton, F. A., 1959, Aerial photographs and structural geomorphology: Jour. Geology, vol. 67, p. 351-370.

Myers, A. J., 1962, A middle Pleistocene stream channel: Okla. Geol. Survey, Okla. Geology Notes, vol. 22, p. 224-229.

Reed, L. C., and **Longnecker, O. M., Jr.**, 1932, The geology of Hemphill County, Texas: Texas, Univ., Bur. Econ. Geology, Bull. 3231, 96 p.

Devonian-Silurian Subsurface Map in Press

Oklahoma Geological Survey Map GM-14, *Geologic Maps and Stratigraphic Cross Sections of Silurian Strata and Lower Devonian Formations in Oklahoma,* is now in press. The large map (scale 1:750,-000), showing the surface and subsurface distribution and thickness of Silurian and Lower Devonian strata, six smaller thickness and distribution maps (scale 1 = 60 miles), and two stratigraphic cross sections were compiled by Thomas W. Amsden and T. L. Rowland, using cores as the source for both petrographic and paleontologic data.

The Lower Devonian formations studied were the Haragan, Bois d'Arc, Frisco, and Sallisaw; a thickness and distribution map of the Woodford Shale (Upper Devonian-Lower Mississippian) is also included. Examination of the faunal content of these rocks, chemical analyses, and thin-section and X-ray-diffraction studies permitted the subdivision of the Hunton Group in the subsurface into major units and revealed that the Devonian rocks of the group are more extensive than had been believed.

Trace Elements in Oklahoma Coals

Carl C. Branson

U. S. Geological Survey Bulletin 1117-D, *Distribution of Minor Elements in Some Rocks in the Western and Southwestern Regions of the Interior Coal Province*, contains data on the analysis of 48 samples of coal ash by emission spectrography; 24 samples are from Pennsylvanian rocks of eastern Oklahoma. The coal beds sampled were the Upper Hartshorne in Latimer, Haskell, and Le Flore Counties; Lower Hartshorne in Haskell County; McAlester-Stigler in Pittsburg, Haskell, and Sequoyah Counties; Secor in Pittsburg and McIntosh Counties; a rider coal above the McAlester-Stigler in Sequoyah County; Croweburg in Okmulgee, Rogers, and Craig Counties; and the "Forsythe coal above the Broken Arrow bed," which may be the Iron Post coal, in Craig County.

The ashes of these coals contained beryllium up to 0.01 percent; boron to 0.8; titanium to 2.2; vanadium to 0.37; chromium to 0.10; cobalt to 0.054; and nickel, copper, zinc, gallium, germanium, molybdenum, tin, yttrium, and lanthanum. Weathered coals contain much higher percentages of these elements, notably beryllium, yttrium, and lanthanum, than do unweathered samples. In the authors' opinion, " . . . the coals studied thus far could not be considered an economic source of the minor elements. However, these coals might serve as an emergency source in the event of a national crisis" (p. 2).

They conclude that drainage of the Pennsylvanian sea was southwestward and that solutions bearing minor elements were depleted southward. I cannot concur with these conclusions. The "drainage directions" of the Desmoinesian sea are more probably current directions, and, as for southward depletion of solutions bearing minor elements, some of these elements move in the environment and become fixed to carbon molecules. They can be expected to be concentrated in permeable coal, adjacent to the tops and bottoms of thicker beds and in thin unworkable seams.

Data are sparse; the report is a promising beginning but needs to be supplemented with more precise sampling. The paleogeographic map (fig. 3, p. 30) is drawn from the Schuchert atlas published in 1955, but maps made before 1940 are unreliable now. On page 4, locality 13 should read "Sallisaw"; on page 7, the Iowa coal should be Mammoth. By no means exhaustive, the report points the way for further interesting work and for investigations which might lead to commercial deposits.

Reference Cited

Zubovic, Peter, Sheffey, N. B., and Stadnichenko, Taisia, 1967, Distribution of minor elements in some rocks in the western and southwestern regions of the Interior coal province: U. S. Geol. Survey, Bull. 1117-D, 33 p.

Protest Against Names for Trace Fossils

Carl C. Branson

Proliferation of binomials for trace fossils is especially apparent in the careful and thorough compilations of Häntschel (1962, 1965). The futility of applying names to many of these objects is shown by the ridiculous use of the name *Zoophycos* for Ordovician to Miocene trace fossils, considered by me to be in most cases inorganic sedimentary structures. A case in point of an unnecessary name is *Taenidium? maeandriformis* Müller, 1966, from Saxony. This name clearly is a synonym of *Scalarituba missouriensis* Weller, 1899, a name given a trace fossil from the Northview Sandstone (Early Mississippian) of southwestern Missouri (Weller, 1899). The Saxon form is from Lower Carboniferous (Kulm), and the holotype is illustrated in Müller's paper by a sketch (text-fig. 1), a photograph of eight metameres (fig. 2), and a photograph of a long trail (pl. 1) in a graywacke. Weller's paper is not cited nor is E. B. Branson's (1938), nor mine (1966).

The other form described (*Mixoteichichnus coniungus*) is a feeding burrow from the Lower Muschelkalk (Triassic) and does not deserve a name.

References Cited

Branson, C. C., 1966, Sole marks in Atoka rocks of platform facies: Okla. Geol. Survey, Okla. Geology Notes, vol. 26, p. 236-239.

Branson, E. B., 1938, Stratigraphy and paleontology of the Lower Mississippian of Missouri: Mo., Univ., Studies, vol. 13, nos. 3, 4.

Häntschel, Walter, 1962, Trace fossils and Problematica, **in** Miscellanea, **pt. W** of Treatise on invertebrate paleontology: Geol. Soc. America and Univ. Kansas Press, p. 177-245.

————1965, Vestigia invertebrorum et problematica: Fossilium Catalogus, I: Animalia, Pars 108, 140 p.

Müller, A. H., 1966, Neue Lebensspuren (Vestigia invertebratorum) aus dem Karbon und der Trias Mitteldeutschlands: Geologie, Jahrgang 15, p. 712-725.

Weller, Stuart, 1899, Kinderhook faunal studies; I, The fauna of the vermicular sandstone at Northview, Webster County, Missouri: Saint Louis, Acad. Science, Trans., vol. 9, p. 9-51.

New Theses Added to O. U. Geology Library

The following doctoral dissertations were added to the University of Oklahoma Geology Library during June 1967:

Palynology of Quaternary terraces and floodplains of the Washita and Red Rivers, central and southeastern Oklahoma, by Thomas Alden Bond.

Carbonate petrology of the Foraker Formation (Lower Permian), north-central Oklahoma, by Ataolah Mogharabi.

—L. F.

Appraisal of *Oklahoma Geology Notes*

The editorial policy of the Oklahoma Geological Survey is currently undergoing critical review, with the view to effecting major revisions that will, we hope, enable the Survey to contribute more effectively to the development of the State. Among the aspects of this appraisal is the role of the *Oklahoma Geology Notes*. The Survey staff is in general agreement that, because of the excessive effort needed to produce the *Notes*, fewer issues per year would be desirable. With fewer issues, the content will be reduced by about 30 percent, and new guidelines will be needed for the selection of material for publication.

We, therefore, ask the readers to assist us in this matter by making recommendations toward a more viable and useful periodical. We would like to know what kinds of articles are of most interest, whether there is objection to reducing the number of issues to that of a quarterly or a bimonthly (with, of course, appropriate adjustment for unexpired subscriptions), and, most important, what we have done wrong in the past. We desire the most candid statements upon the last point. We believe that this periodical has a definite function in the dissemination of information not otherwise easily given out, and, if we have neglected to utilize this medium fully, now is the time to rectify this neglect. A few solid brickbats, although painful, will give us something concrete with which to build. Please send your comments to:

Mr. Alex. Nicholson, Geologist-Editor
Oklahoma Geological Survey
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