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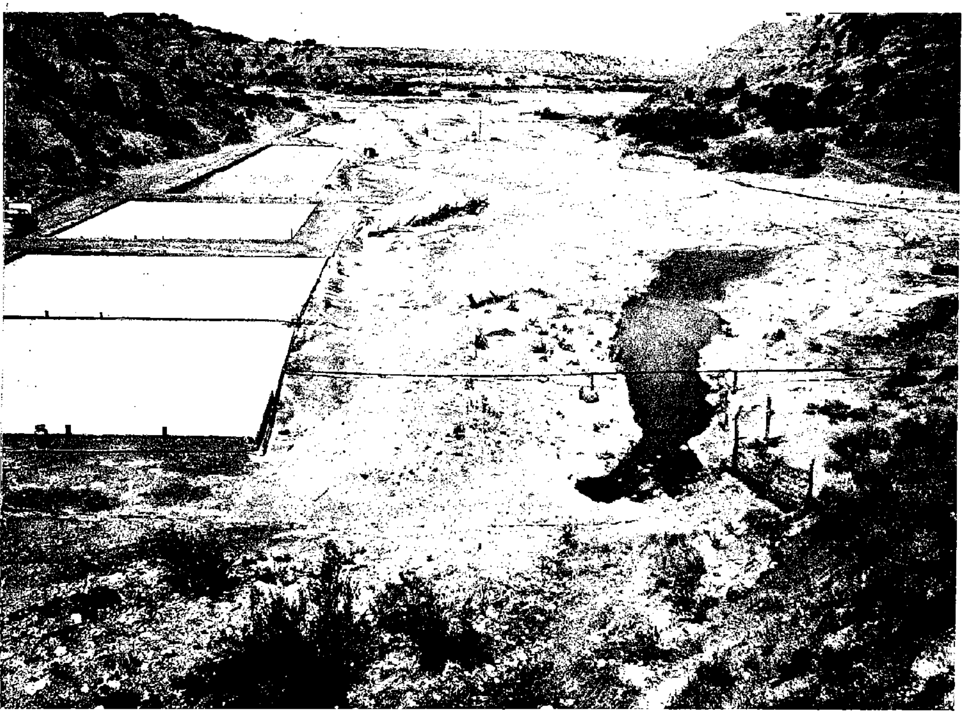
OKLAHOMA GEOLOGY NOTES



SALT EVAPORATION PANS, HARMON COUNTY

OKLAHOMA GEOLOGICAL SURVEY • THE UNIVERSITY OF OKLAHOMA • NORMAN, OKLAHOMA

Cover Picture

MINERAL INDUSTRIES OF OKLAHOMA

SALT

Salt production has probably been continuous in Oklahoma since pre-Columbian time, thus establishing it as the oldest of the Oklahoma mineral industries, but it is now a minor aspect of the mineral economy of the State. It accounts for less than 0.01 percent of the total value of the annual mineral production. Oklahoma salt is produced by evaporation of brines from springs or wells and by gathering of encrustations on salt plains. It is used principally for stockfeed and as recharger in water softeners.

Despite these facts, the potential contribution of the salt resources to the economy of the State is enormous. An estimated 21.6 million million tons are present in the Permian beds of western Oklahoma (Jordan and Vosburg, 1963). As the area of western Oklahoma develops industrially, this resource can fill the increasing consumer needs for conventional salt products. In addition, it is a valuable raw material for chemical industries. The salt strata themselves serve still another important function. Successful industrial development depends in large part upon the efficient distribution of petroleum fuels, which, in turn, depends upon adequate storage facilities. Large storage facilities are most easily and economically made by the solution of salt to form cavities in salt beds. To date, four such cavities have been constructed in western Oklahoma. Total storage capacity is now more than 300,000 barrels, all used for liquefied petroleum gases. With advancing technology, salt cavities will undoubtedly be adapted for storage of other gaseous and liquid products.

The cover picture is of the salt evaporation pans in Salton Gulch, northern Harmon County, operated by the Salton Salt Co.

Reference Cited

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.

—A. N.

Distances Within the State of Oklahoma

Arthur J. Myers and David L. Vosburg

The dimensions of Oklahoma are inconsistently reported in popular source books. The *World Almanac* for 1961 states that the dimensions of Oklahoma are 585 (sic) miles long and 210 miles wide, whereas the *Oklahoma Almanac* for 1961 gives the width of Oklahoma at the northern border as 464 miles and at the southern border as 481 miles. Other dimensions given are the length of the eastern border with Missouri and Arkansas as 222 miles and that of the western border with Texas and New Mexico as 166 miles.

The principal source of inconsistency is the failure to specify the termini of the line along which a distance is measured, or to describe the configuration of the line if it is not a straight one. Because of the inadequacy of popular sources in this respect, a number of straight-line distances were computed by the authors and are reported here. Except for distances between points G and H and between points H and I (fig. 1; table III), all distances are either north-south along lines of longitude or east-west along lines of latitude.

In order to make the computations used herein, it was necessary to determine the latitude and longitude of various points along the border. In doing so we found that the north edge of Oklahoma is not exactly along the 37th parallel, that the west edge of the Panhandle is not at the 103d meridian, and that the south edge of the Panhandle is not at parallel 36°30′, although most maps of the State give this impression because they are at scales too small to show the divergences that exist.

In fact, the borders with adjacent states have had quite a history

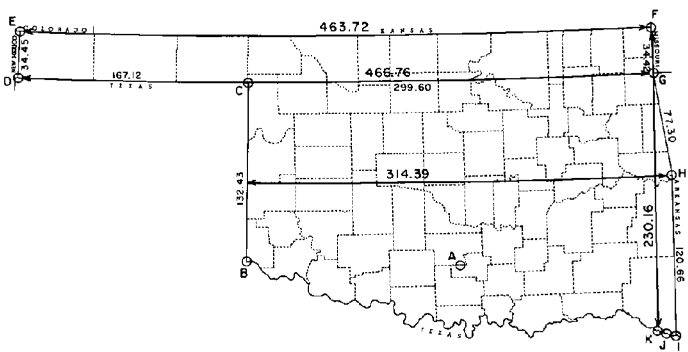


Figure 1. Map of Oklahoma showing geographic positions and distances in statute miles between points. Larger numbers indicate distances between arrow heads, smaller numbers between circles. Area of point A is illustrated in figure 3, of point H in figure 5, and of points I, J, and K in figure 6.

(Douglas, 1923). Early observations of geographic positions within what is now Oklahoma were generally of a reconnaissance nature. These observations were mostly by various parties during the geographical and military surveys west of the 100th meridian (table I).

More specific work was carried out in 1857 by A. H. Jones and H. H. C. Brown of the Department of the Interior in establishing the western border of Indian Territory along the 100th meridian. Similarly, in 1877 H. E. McKee, also of the Department of the Interior, resurveyed the border between Arkansas and adjacent Indian lands.

The southern border of Oklahoma is now established as the south bank of the Red River. This boundary was in dispute for many years, Texas claiming to the middle of the river. The Assistant Attorney General of the United States on April 29, 1897, rendered an opinion that the boundary between Indian Territory and the State of Texas was the line of the middle of the main channel of the Red River as it existed when Texas was annexed to the United States in 1845. Briefs in a suit by Oklahoma against Texas were submitted to the United States Supreme Court at its October term in 1920. A decision rendered April 11, 1921, reaffirmed a former decision making the south bank the boundary (Douglas, 1923, p. 151-152).

TABLE I.—EARLY OBSERVATIONS OF GEOGRAPHIC POSITIONS IN OKLAHOMA*

DATE	PRINCIPAL OBSERVERS	AREA VISITED
1807	Lt. Pike	Arkansas River
1845-47	Lts. Albert and Peck	Canadian River
1849	Capt. Marcy	Texas to Fort Sill north to Canadian River and west into Texas
1849	Lt. Michler	Red River
1849	Lt. Simpson	Canadian River
1850	Lt. Woodruff	North Fork of the Canadian River
1850-51	Capts. Sitgreaves, Woodruff	Northern border
1851	Capt. Pope	Panhandle—Salt Fork of the Arkansas River to Fort Gibson
1852	Capts. Marcy, McClellan	North Fork and Prairie Dog Town Fork of Red River
1853	Lt. Whipple	Canadian River
1854	Capt. Pope	Red River near Fort Washita
1857	Col. Johnston (War Dept.)	Texas Panhandle to Fort Supply to northern border east to Missouri
1874	J. J. Major (Interior Dept.)	Western Panhandle

*Compiled from Wheeler, 1889, map facing page 412.

The western border of Oklahoma with the Texas Panhandle was from the Red River north along the 100th meridian to its intersection with parallel 36°30′ north latitude. In 1892 the State of Texas employed an astronomer to determine the location of the 100th meridian. As a result of his work, the old "initial monument" established in 1859 was determined to be at longitude 100°00′45.11″ and latitude 34°34′ 43.4″. In 1902 a survey by the General Land Office for the United States placed the position of the "initial monument" at 100°00′44.24″, or 3,699.7 feet west of the 100th meridian. From this survey the computed position of the 100th meridian was determined, and a stone post, 10 x 10 x 45 inches, was placed 1,563 feet north of the Red River on the computed position of the 100th meridian (Douglas, 1923, p. 153-154). In 1903 the General Land Office retraced the 100th meridian northward from the Red River to parallel 36°30′ and observed at the north end a difference of only 0.22″ between the position determined from astronomical observations and that brought north from the Red River.

For more than 50 years there was a dispute between the State of Texas and the United States as to which branch of the Red River was the main stream. Texas claimed that it was the North Fork and the United States claimed that it was the Praire Dog Town Fork. This area between the two forks and east of the 100th meridian was known as Greer County, an area of more than 2,360 square miles. After years of litigation, the United States Supreme Court on March 16, 1896, decreed that the area east of the 100th meridian and between the two forks of the Red River did not belong to Texas. An act of Congress on May 4, 1896, established Greer County, Texas, as Greer County, Oklahoma (Douglas, 1923, p. 151-152).

The south edge of the Panhandle was fixed by statute at latitude 36°30′. It was surveyed in 1860 by the General Land Office, and 16 monuments were erected. A later survey found the west end to be at latitude 36°29′58″ (Douglas, 1923, p. 154).

The west edge of the Panhandle of Oklahoma was set at the 103d meridian.

The northern border of Oklahoma with Colorado was surveyed in 1858, and at the 103d meridian a stone post, 30 x 10 x 8 inches, was set in a pile of rock. In 1902 Congress authorized a resurvey of the entire line between the State of Colorado and the territories of New Mexico and Oklahoma. The work was done by H. B. Carpenter in 1902-1903. In places the "Carpenter line" is considerably north of the previous survey and in other places considerably south. The east end of the "Carpenter line" is more than half a mile north of the 1858 survey (Douglas, 1923, p. 200).

The northern border of Oklahoma with Kansas was surveyed in 1857. The initial point on the 37th parallel was found from astronomic observations of the Kansas-Missouri boundary in longitude 94°40′26.3″. In 1902 two boundary stones on the Oklahoma-Kansas line were located by triangulation. Boundary stone 160 is a sandstone post 5 x 12 x 20 inches, projecting 9 inches above ground; marked "160" on the top, "K" on the north side, and "IT" on the south side; and is located at latitude 36°59′45.98″ and longitude 97°54′ 01.98″. A similar stone marked "193" is at latitude 36°59′54.73″ and longitude 97°57′16.45″. In 1906 the U. S. Geological Survey determined the position of the southwest corner of Kansas at latitude 36° 59′55.2″ and longitude 94°37′03.3″ (Douglas, 1923, p. 191).

The eastern border of Oklahoma with Missouri was determined by a line along the meridian which passes through the middle of the mouth of the Kansas River, with its southern end at parallel 36°30′. This line (western border of Missouri) was surveyed in 1823 and a large stone post was set to mark the southwest corner of that state. In 1906 the U. S. Geological Survey determined this position as latitude 36°29′58.0″ and longitude 94°37′02.9″ (Douglas, 1923, p. 178).

The border between Oklahoma and Arkansas was established by treaties. The eastern border of the Choctaw Nation was fixed by treaty on January 20, 1825, as beginning on the Arkansas River and 100 paces east of Fort Smith, running due south to the Red River. A treaty between Arkansas and the Cherokee Nation signed May 6, 1826, confirmed the line previously established with the Choctaws and extended this line due north to the Arkansas River, thence in a direct line to the southwest corner of Missouri. That portion of the eastern boundary south of the Arkansas River was surveyed and marked in 1825, and that portion between the Arkansas River and the southwest corner of Missouri in 1832. A resurvey of the boundary from Fort Smith southward was begun in 1857. After the new line had been run 8 miles due south, the surveyors were directed to retrace the line of the previous survey. A new survey, authorized in 1875 and completed in 1877, showed that the previous border diverged to the west

A

B

Figure 2. Photographs of Oklahoma initial point, a stone post set in 1870, which marks the intersection of the Indian meridian and base line.

A. View from southwest. Indian 1954 triangulation station is in foreground.

B. Close-up of Indian 1954 triangulation station.

both southward and northward from Fort Smith. The boundary mark of 1825 on the Red River was 4 miles 16 chains (one chain=66 feet) west of a line due south from Old Fort Smith. The divergence north and south added more than 200 square miles to Arkansas. The boundary near Fort Smith was changed by an act of Congress on February 10, 1905, to its present position (fig. 5). Beginning at the point on the south bank of the Arkansas River where the previous line crossed the stream, the line now runs southwestward along the south bank of the Arkansas River to the mouth of the Poteau River, up the middle of the Poteau River to the mouth of Mill Creek, up the middle of Mill Creek to the previous boundary. This last change added to Arkansas about 0.2 square mile of Indian Territory which was on the east side of the Arkansas River (Douglas, 1923, p. 157-160).

The division of Indian Territory (Oklahoma) into the section-township-range system began in 1870 with the subdivision of the Chickasaw lands into quarter sections authorized by an act of Congress

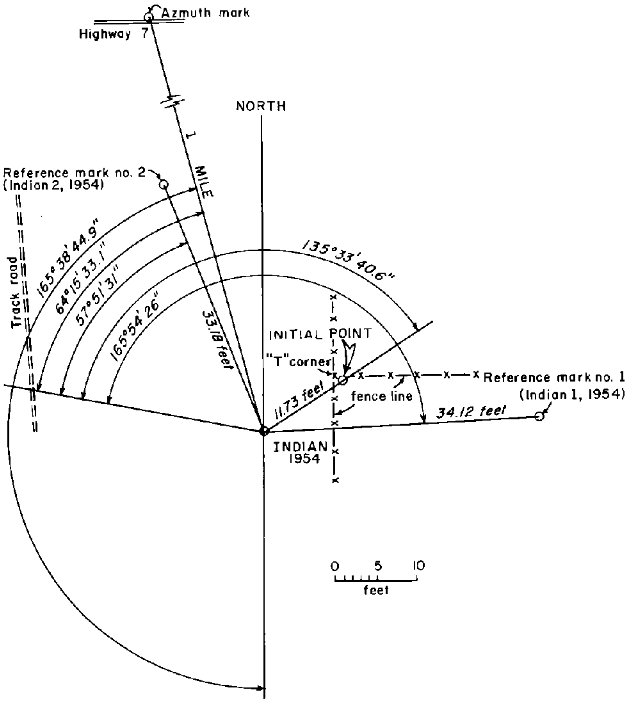


Figure 3. Plot of Indian 1954 triangulation station and Oklahoma initial point.

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NORTH AMERICA

DEPARTMENT OF COMMERCE
U. S. COAST AND GEODETIC SURVEY
Form 525
Rev. Aug. 1948

DESCRIPTION OF TRIANGULATION STATION

NAME OF STATION: INDIAN STATE: Oklahoma COUNTY: Garvin-Murray

CHIEF OF PARTY: R.L.E. & R.A.G. YEAR: 1955 Described by: F. A. Martin

NOTE.*	HEIGHT OF TELESCOPE ABOVE STATION MARK 5 METERS.†				HEIGHT OF LIGHT ABOVE STATION MARK METERS.		
2	Surface-station mark, Underground-station mark — DISTANCES AND DIRECTIONS TO AZIMUTH MARK, REFERENCE MARKS AND PROMINENT OBJECTS WHICH CAN BE SEEN FROM THE GROUND AT THE STATION						
	OBJECT	BEARING	DISTANCE feet	DISTANCE meters	DIRECTION‡ °	′	″
	1E6TT (OKLA. GEOD. S.)				00	00	00.0
12a	Reference Mark No. 2	NW	33.18	10.113	57	51	31
16a	Azimuth Mark	NW	(1.0 mile)		64	15	33.1
	Cross on rock	NE	11.73	3.575	135	33	40.6
12a	Reference Mark No. 1	E	34.12	10.399	165	54	26

Detailed description:

The station is located about 7½ miles west of Davis and 1 mile south of Hoover and State Highway 7. It is near the stone marking the intersection of the Base Line and the Indian Meridian. the initial point for the original land surveys. The station mark is 23 feet east of the center of a track road and 13 feet southwest of a "T" fence corner. It is set in outcropping bedrock and is stamped INDIAN 1954.

Reference Mark No. 1 is 25 feet east of a north-south fence line and 5 feet south of an east-west fence line. It is set in outcropping bedrock and is stamped INDIAN NO 1 1954.

Reference Mark No. 2 is 30 feet northwest of a "T" fence corner and 18 feet east of the center of a track road. It is set in outcropping bedrock and is stamped INDIAN NO 2 1954.

The cross on the rock marking the intersection of the Base Line and the Indian Meridian is found on the top of a boulder that projects 3½ feet and is 12 inches by 16 inches at the top. It is 35 feet east of the center of the track road and 1½ feet southeast of the "T" fence corner.

The azimuth mark is 52 feet north of the center of State Highway 7, 2 feet south of a witness post and 1½ feet west of a power line pole. It is set flush and is stamped INDIAN 1954.

To reach the station from the railroad depot in Davis go west on U.S. Highway 77 and State Highway 7 for 0.2 mile to their junction; continue west on State Highway 7 for 7.1 miles to the Roady Grocery Store on the left; continue west on the highway for 0.15 mile to a cattle guard on the left. (Azimuth mark 0.1 mile west of the cattle guard on the north side of State Highway 7.) Turn left across the cattle guard and go southerly for 0.15 mile to a locked gate in a north-south fence line. (Key may be obtained from the house just south of the gate.) Pass thru gate and follow track road southerly for 0.45 mile to a gate; pass thru gate and keep left, main road, for 0.5 mile to the station mark, reference marks and the rock on the left.

The station was marked in 1954 and was occupied in 1955.

*Refer to notes in manuals of triangulation and state publications of triangulation. ‡Direction-angle measured clockwise, referred to initial station.
†To nearest meter only, when no trigonometric leveling is being done.
16—56302-1 U. S. GOVERNMENT PRINTING OFFICE

Figure 4. Horizontal control data sheet (U. S. Coast and Geodetic Survey, 1959) with description of Indian 1954 triangulation station and supporting reference marks. Plot of stations is shown in figure 3.

ONTROL DATA
he
ıdetic Survey
N 1927 DATUM

340971 STATION 1007
ARK-OKLA-TEX DIA NI 14-6
LAT: 34°-30' 35°-00'
LONG: 97°-00' 97°-30'

ADJUSTED HORIZONTAL CONTROL DATA

NAME OF STATION: INDIAN YEAR: 1955

STATE: Oklahoma LOCALITY: Red River Area, Ardmore Section

Second-ORDER Triangulation SOURCE: G-11681 FIELD SKETCH: Okla. No. 13

GRID DATA	COORDINATES (Feet)	PLANE AZIMUTH θ (OR Δα) ANGLE	MARK
STATE: Okla. ZONE: S CODE: 3502	x 2,226,856.73 y 427,846.17	165° 13' 06" + 0 25 39	AZIMUTH MARK
STATE: ZONE:	x y		

GEODETIC DATA	POSITION		SECONDS IN METERS	ELEVATION
	LATITUDE: 34° 30' 24."1238	NORTH		METERS
	LONGITUDE: 97 14 49.2184	WEST		FEET

TO STATION	GEODETIC AZIMUTH (From south)	DISTANCE (Meters)
	SECOND-ORDER	
TT 1E 6 OGS	101°23'11."72	6,797.126
TABLE HILL USGS	128 54 28.22	29,183.554
BRADY	175 08 40.21	14,535.749
	THIRD-ORDER	
AZIMUTH MARK	165 38 44.9	

FORM 281 (11-15-57) USCOMM-DC 8121

on April 8, 1864. The Chickasaw lands were bordered on the north by the Canadian River, on the east by the land of the Choctaw Nation, on the south by the Red River, and on the west by leased Indian lands.

> The surveyors were instructed to select a suitable initial point in the center of the Chickasaw lands, or in the vicinity of Fort Arbuckle, and perpetuate it by a suitable monument, and from this point to establish a principal meridian and base line, to be known by the designation of "The Indian Base Line and Meridian" (Drummond, 1871).

The point was established and marked with a stone post, which is still standing (fig. 2). On the west side of the post are the initials IM and on the north side the date 1870. The post is approximately at latitude 34°30′ and longitude 97°15′. All of Oklahoma except the Panhandle has been surveyed from this meridian and base line.

During the fiscal year 1870-1871, approximately 1,350,107 acres was subdivided into 65 townships, and the surveyors then proceeded to subdivide the townships into 160-acre tracts. By 1879, most of Oklahoma west of the 96th meridian, except the Panhandle, had been so surveyed.

Figure 1 is a map of Oklahoma showing the locations of Coast and Geodetic Survey triangulation stations, of points determined by us from recently published topographic maps, and of the Indian initial point. Table II contains the latitudes and longitudes of the points shown on figure 1.

The triangulation net west of the 98th meridian was adjusted, beginning in 1927. The adjustment involved 12,500 miles of arcs in 16 closed loops. Later the net east of the 98th meridian, which involved

TABLE II.—LATITUDE AND LONGITUDE OF POINTS SHOWN ON FIGURE 1

POINT	NAME	LATITUDE N	LONGITUDE W
A*	Indian (11.73′ SW of Oklahoma IP)	34° 30′ 24.1238″	97° 14′ 49.2184″
B*	Kidder	34° 34′ 39.797″	100° 00′ 04.069″
C*	Northeast Texas	36° 29′ 59.560″	100° 00′ 00.000″
D*	Texhomex	36° 30′ 01.582″	103° 00′ 06.835″
E*	Boundary Monument 1900 (Oklahoma-New Mexico-Colorado)	37° 00′ 00.473″	103° 00′ 06.631″
F*	Oklahoma-Kansas-Missouri	36° 59′ 54.752″	94° 37′ 03.737″
G*	Oklahoma-Missouri-Arkansas	36° 29′ 57.920″	94° 37′ 03.498″
H*	Oklahoma-Arkansas Initial Point	35° 23′ 17.552″	94° 25′ 51.631″
I†	Oklahoma-Arkansas-Texas	33° 38′ 17.70″	94° 29′ 08.90″
J†	Gunn Lake (south side)	33° 36′ 56.46″	94° 31′ 30.11″
K†	Mud Lake (southeast of)	33° 39′ 35.41″	94° 39′ 18.30″

*Location from U. S. Coast and Geodetic Survey, 1959.
†Location determined from U. S. G. S. topographic maps; scale, 1:24,000.

13,000 miles of arcs in 26 loops, was adjusted. The North America datum for these adjustments is the Meades Ranch station, in Kansas, the position of which is latitude 39°13′26.686″ north, longitude 98° 32′30.506″ west. First-order triangulation in Oklahoma (1927 datum) was published in 1935 and includes seven first-order arcs (Shmidl, 1935). Triangulation has continued, and in 1955 Indian triangulation station (marker is stamped "Indian 1954") was established. Its position is latitude 34°30′24.1238″ north, longitude 97°14′49.2184″, which is 11.73 feet from the stone post set in 1870 by the original survey party (point A, figs. 1-4).

TABLE III.—DISTANCES IN THE STATE OF OKLAHOMA*

(All distances are straight-line distances; all are along lines of longitude or latitude, except distances G—H and H—I)

From: Point	From: Name	To: Point	To: Name	Distance (Statute miles)
B	Kidder	C	Northeast Texas	132.43
C	Northeast Texas	D	Texhomex	167.12
D	Texhomex	E	Boundary monument 1900	34.15
E	Boundary monument 1900	F	Oklahoma-Kansas-Missouri	463.72
F	Oklahoma-Kansas-Missouri	G	Oklahoma-Missouri-Arkansas	34.42
G	Oklahoma-Missouri-Arkansas	H	Oklahoma-Arkansas initial point	77.30
H	Oklahoma-Arkansas initial point	I	Oklahoma-Arkansas-Texas	120.66
G	Oklahoma-Missouri-Arkansas (Maximum east-west distance entirely within Oklahoma†)	D	Texhomex	466.76
H	Oklahoma-Arkansas initial point (Maximum east-west distance excluding the Panhandle)		Longitude of Northeast Texas (point C)	314.39
H	Oklahoma-Arkansas initial point (Distance from the longitude of the most easterly point in Oklahoma to the longitude of most westerly point)		Longitude of Texhomex (point D)	483.87
J	Gunn Lake (Distance from the latitude of the most southerly point in Oklahoma to the latitude of the most northerly point)		Latitude of Oklahoma-Kansas-Missouri (point F)	233.20
K	Mud Lake (Maximum north-south distance entirely within Oklahoma†)	F	Oklahoma-Kansas-Missouri	230.16

*Points refer to figure 1.

†See sample computations.

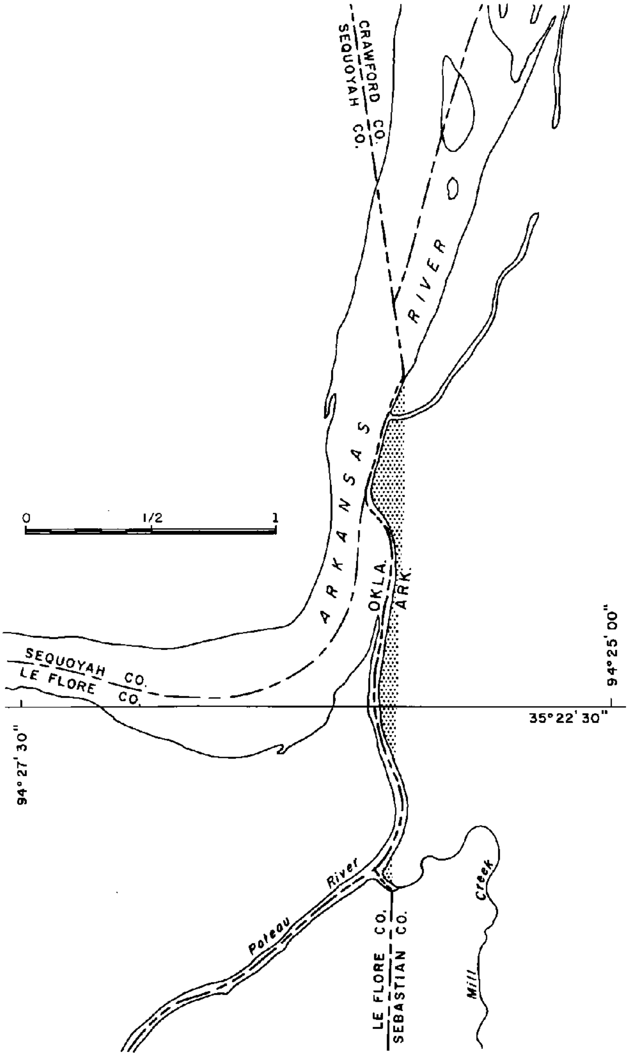

Figure 5. Map of the state boundary near Oklahoma-Arkansas initial point (point H, fig. 1). Stippled area east of the Arkansas River was transferred from Indian Territory to Arkansas in 1905 by an act of Congress.

The southwest corner of Oklahoma is the Kidder monument (point B, fig. 1). Established in 1902 by the General Land Office and marked with a stone post 10 x 13 x 45 inches with 18 inches above ground, it was resurveyed in 1923 and marked with a standard disk station mark "Kidder 1902" (Shmidl, 1935, p. 95).

The "Northeast corner of Texas" (point C, fig. 1), established in 1928, is a concrete monument with a base 30 inches square and 24 inches in the ground. The base is surmounted by a galvanized iron form 18 inches in diameter at the top, 24 inches in diameter at the base, 42 inches high, and filled with concrete. The form is set 9 inches into the base and extends 33 inches above ground. The monument is marked "The Supreme Court of the United States, Northeast Corner of Texas, 1928" (Shmidl, 1935, p. 118).

"Texhomex" (point D, fig 1), established in 1931, is a standard disk station mark, set in a red sandstone post projecting about 6 inches above ground at a point common to the states of Oklahoma, Texas, and New Mexico (Shmidl, 1935, p. 115-116).

"Boundary-monument-1900" (point E, fig. 1), resurveyed in 1922, is marked by a large stone monument, surrounded by a pile of rock, and is the point common to Oklahoma, New Mexico, and Colorado (Culley, 1940, p. 143).

The boundary monument "Oklahoma-Kansas-Missouri" (point F, fig. 1), was surveyed in 1935. The boundary monument is made of rock with a round concrete top. It has a brass plate on the south side with the inscription "Oklahoma 1907" and a brass plate on the north side with the inscription "Kansas 18, state corners 50 feet east of center of monument" (U. S. Coast and Geodetic Survey, 1959).

The boundary monument "Oklahoma-Missouri-Arkansas" (point G, fig. 1) was surveyed in 1935. It is marked by a 2-foot-square concrete monument 4 feet high resting upon a 3-foot-square concrete base that projects 1 foot above ground. A stone, set in the top of the monument, is 5 by 12 inches and extends 12 inches above the concrete. The stone has "Misr" cut in the north side and "Ark" on the south side. The monument has "Missouri 1821" molded in the north side, "Oklahoma 1907" in the west side, and "Arkansas 1836" in the south side, and "Erected by Ozark Culture Club 1915" in the east side (U. S. Coast and Geodetic Survey, 1959).

Oklahoma-Arkansas initial point (point H, figs. 1, 5) was established in 1885 and resurveyed in 1915. The monument is of gray limestone 4 feet high, 4 feet square at the base, and 17½ inches square at the top, which is surmounted by a capstone 17½ inches square and 17 inches high. It is marked "Initial Point" on its north face, "Arkansas" on its east face, "Choctaw" on its west face, and "1858" on its south face (Shmidl, 1935, p. 81).

Figure 6 is a map of southeasternmost Oklahoma and the adjacent areas of Oklahoma and Texas. The latitudes and longitudes of three points shown on figure 6 were determined from the following U. S. G. S. topographic maps (scale, 1:24,000): Oklahoma-Arkansas-Texas (point I, fig. 1) from Foreman, Ark.-Okla.-Tex. (1951); Gunn Lake (point J, fig. 1) from De Kalb, Tex.-Okla. (1951); and Mud Lake (point K,

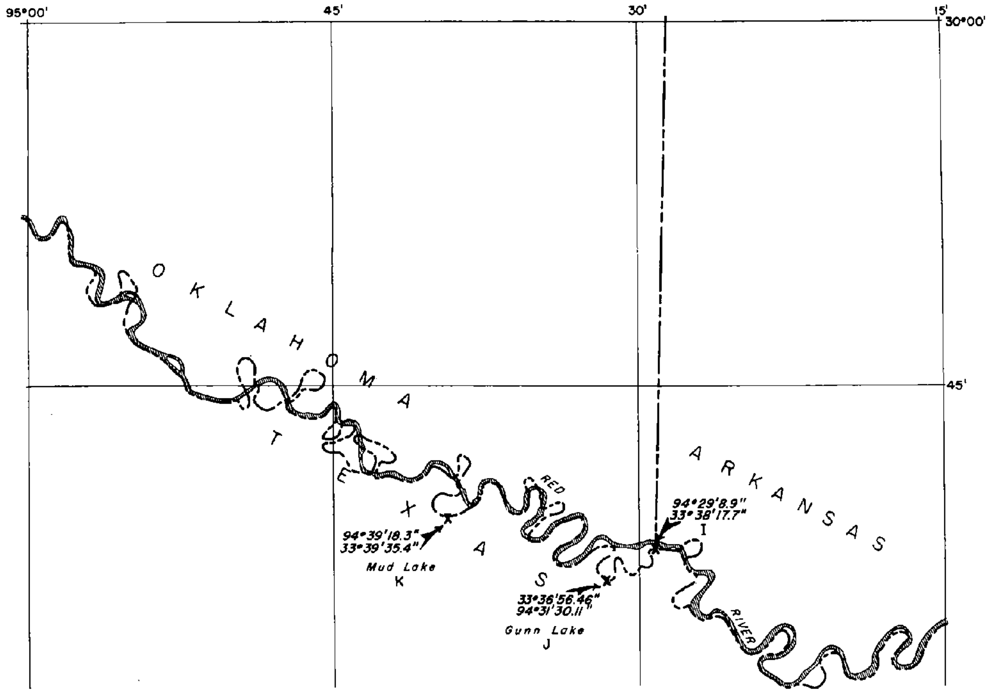

Figure 6. Map of the southeastern corner of Oklahoma. Point I is common to Oklahoma, Arkansas, and Texas. Point J (Gunn Lake) is the southernmost point in Oklahoma. Point K (Mud Lake) is the southern end of the longest north-south line wholly within Oklahoma (the crossing of the boundary loop immediately south of the Red River is disregarded).

fig. 1) from De Kalb NW, Tex.-Okla. (1951). The south edge of the oxbow Gunn Lake is the most southerly point in Oklahoma, but a line extended northward at this longitude passes into Arkansas. The most southerly point from which a line can be extended northward and remain in Oklahoma is from the south edge of the oxbow Mud Lake.

Table III is the measurement of distances within the State of Oklahoma computed from geographic positions indicated by letters on figure 1 and listed in table II.

According to data from the Map Information Office of the Federal Board of Surveys and Maps, the highest point in Oklahoma is on Black Mesa in extreme western Cimarron County at an elevation of 4,978 feet. The lowest point in the State is along the Red River in extreme southeastern McCurtain County at an elevation of 300 feet. The approximate mean elevation in Oklahoma is 1,300 feet.

SAMPLE COMPUTATIONS

The distances between points in Oklahoma as given above were computed by determining the differences in latitude or longitude and converting to statute miles according to the values given in table 4 of U. S. Geological Survey Bulletin 650 (Douglas, 1916).

Computation of an east-west distance:

The maximum east-west distance across the State (fig. 1) is from point G (Oklahoma-Missouri-Arkansas) to point D (Texhomex) at latitude 36°30′:

Longitude of point D	103°00′06.835″	
Longitude of point G	94°37′03.489″	
Difference	8°23′03.337″	= 30,183.337″

At latitude 36°30′, 1 second of arc equals 81.65 feet, hence:

$$30{,}183.337 \times 81.65 = 2{,}464{,}489.46 \text{ feet} = 466.76 \text{ miles}$$

Computation of a north-south distance:

The maximum north-south distance lying wholly within Oklahoma (fig. 1) is from point K (Mud Lake) northward to the latitude of point F (Oklahoma-Kansas-Missouri):

Latitude of point F	36°59′54.752″	
Latitude of point K	33°39′35.41″	
Difference	3°20′19.342″	= 12,019.342″

The value of feet per second of arc along a meridian increases progressively northward from the equator; hence the total distance in seconds is converted into feet by increments:

IN LATITUDE	DISTANCE (SEC)		VALUE (FT/SEC)		DISTANCE (FT)	
33	1,224.590	×	101.08	=	123,781.55720	
34	3,600.000	×	101.09	=	363,924.00000	
35	3,600.000	×	101.11	=	363,996.00000	
36	3,594.752	×	101.13	=	363,537.26976	
				Total	1,215,238.82696	= 230.16 miles

References Cited

Culley, F. L., 1940, Triangulation in New Mexico: U. S. Coast Geod. Survey, Spec. Pub. 219, 306 p.

Douglas, E. M., 1923, Boundaries, areas, geographic centers and altitudes of the United States and the several states: U. S. Geol. Survey, Bull. 689, 234 p.

__________ 1916, Table 4—Values in feet of seconds of latitude and longitude, *in* Gannet, G. S., Geographic tables and formulas: U. S. Geol. Survey, Bull. 650, p. 29-31.

Drummond, Willis, 1871, Report of the Commissioner of the General Land Office for 1871: U. S. 42nd Cong., 2d sess., House Executive Doc. 1505, vol. 3, no. 1, p. 49, cf. p. 329.

Shmidl, L. E., 1935, First-order triangulation in Oklahoma (1927 datum): U. S. Coast Geod. Survey, Spec. Pub. 190, 145 p.

Sutcliffe, W. D., 1934, First-order triangulation and traverse in Arkansas: U. S. Coast Geod. Survey, Spec. Pub. 187, 99 p.

U. S. Coast and Geodetic Survey, 1959, Horizontal control data, Oklahoma, vol. 3: Washington, D. C., U. S. Coast Geod. Survey.

Wheeler, G. M., (in charge), 1889, Geographical report, vol. 1 of Report upon United States geographical and geological explorations and surveys west of the one-hundredth meridian: Washington, U. S. Govt. Printing Office.

Surficial Occurrences of Petroleum-Impregnated Rocks

Oklahoma Geological Survey Map GM-8, *Petroleum-Impregnated Rocks and Asphaltite Deposits of Oklahoma,* compiled by Louise Jordan, was issued October 16, 1964. The map is printed at a scale of 1:750,000 with a green overprint on a gray base. On it are indicated the locations of reported occurrences of petroliferous rocks at the surface and to depths of less than 500 feet in 34 counties of southern and eastern Oklahoma. Included among the occurrences are shallow oil fields, rock outcrops, surface seeps, water wells in which crude oil has been reported, and asphaltite quarries, mines, and prospects.

Accompanying the map is a 16-page booklet listing approximately 280 occurrences by counties with a brief résumé of the available information on each. The résumés are keyed to a bibliography of 49 published and unpublished sources.

The map and booklet are issued in a 9½- by 12-inch envelope, price $1.00.

Gravimetric, Magnetic, Seismic, and Earth-Current-Potential Profile Study of Webbers Falls Reef, Muskogee County, Oklahoma

J. A. E. Norden, D. A. Kotila, and G. C. Glaser

INTRODUCTION

A geological investigation of a Morrowan (Pennsylvanian) reef outcrop, about four miles northwest of the town of Webbers Falls, Muskogee County, Oklahoma (Kotila, 1963), presented the problem of the determination of the subsurface extent of the reef mass. The outcrop covers an area in the SW cor. sec. 34, T. 13 N., R. 20 E., and is traversed by a recently cut road, known as McCully's Road, connecting to the town of Webbers Falls (figs. 1, 2). The full extent of the reef bioherm is not exposed by the road cut, a considerable part being covered by the Bloyd Formation (Pennsylvanian), with the reef development wedged into it.

The purpose of the geophysical investigation was to delineate the subsurface boundary of the reef bioherm by means of magnetic, gravimetric, and earth-current-potential surveys. Earlier magnetic surveys in Adair County, Oklahoma, successfully demonstrated the utility of the magnetometer in delineation of a reef mass (Norden and others, 1963). This success encouraged us to run a reconnaissance magnetic profile across the Webbers Falls bioherm.

In order to have an exact control on the location of the geophysical observation stations, it was necessary to make a plane-table survey of McCully's Road, along which the geophysical transverses were planned. Magnetic observation stations were laid out along the road with plane-table control for direction and distances between the stations. Upon two occasions, during these geophysical surveys, the senior author received field assistance from P. J. Cannon, J. M. Clayton, and J.M. Markas, students in the School of Geology of The University of Oklahoma, which assistance is gratefully acknowledged.

MAGNETIC SURVEY

In the magnetic survey a Ruska type V-3 vertical magnetometer, serial no. 5708, was used. The instrument sensitivity was set at 10.07 gammas per scale division. The temperature correction factor was +0.1 gamma per 1°C. Twenty-eight magnetic stations were established (indicated by the prefix M in text and figures). On figure 3 is a plot of the observed field data, after corrections for temperature, diurnal, and geomagnetic latitudinal and longitudinal variations and after reduction to the magnetic base station. The magnetic-anomaly curve shows a slight rise toward the reef outcrop and, across the outcrop itself, it indicates a decrease in the vertical intensity. The minimum value of this decrease in intensity is between stations M-12 and M-13. The magnetic-relief decrease here is about 4 gammas. Magnetic susceptibilities of samples of the reef mass and of the surrounding Bloyd

Formation were measured by using a magnetic-susceptibility bridge, model MS-3*. The magnetic susceptibility of the reef sample was found to be 0.85 $\times 10^{-6}$ cgs unit and that of the Bloyd Formation sample to be 12.90 $\times 10^{-6}$ cgs unit. These measurements give a susceptibility contrast of 12.05 $\times 10^{-6}$ cgs unit, which, in the Earth's magnetic field of $H=0.515$ oersted, would produce a polarization contrast of 6.206 $\times 10^{-6}$ cgs unit. A polarization contrast of this value would produce a theoretical difference of about 4 gammas in the vertical magnetic intensity. The correspondence between the theoretically computed value and the actual field value of the magnetic-relief decrease above the reef outcrop may indicate that the magnetic-relief decrease across the reef outcrop is attributable to the magnetic sus-

*Geophysical Specialties Co., Hopkins, Minn.

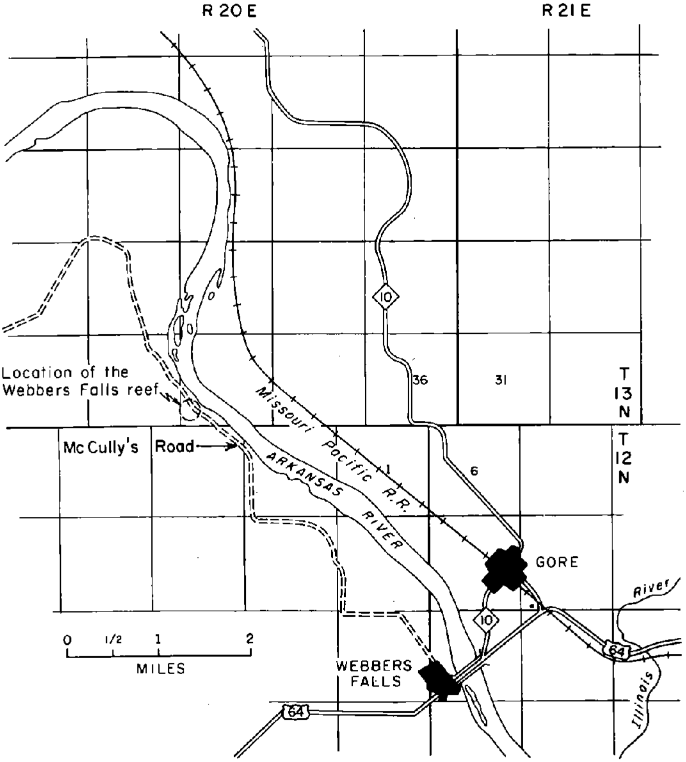

Figure 1. Map of Webbers Falls area showing location of reef mass in SW¼ sec. 34, T. 13 N., R. 20 E., Muskogee County, Oklahoma.

ceptibility and polarization differences existing between the reef and the surrounding Bloyd Formation. The overlying Bloyd Formation above the subsurface peripheral wedge of the reef mass limits the possibility, with the existing weak polarization contrast, of having the reef effect more distinctly manifest itself. Thus the magnetic-relief decrease can be noticed only on the actual surface outcrop of the reef and the problem of the peripheral boundary condition remains to be answered by the gravimetric survey.

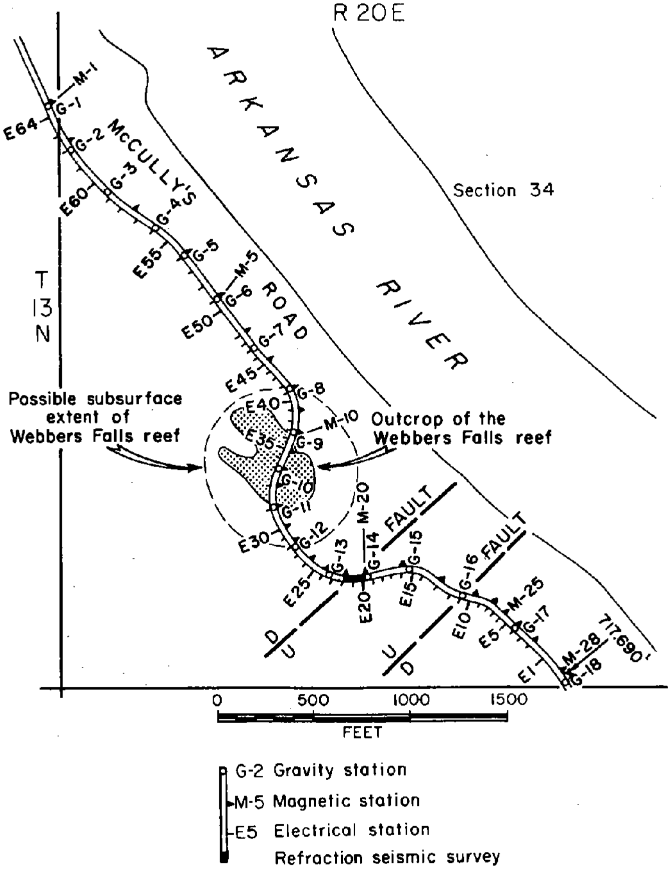

Figure 2. Map of SW¼ sec. 34, T. 13 N., R. 20 E., showing locations of geophysical observation stations along McCully's Road. Geophysical profiles are shown on figure 3.

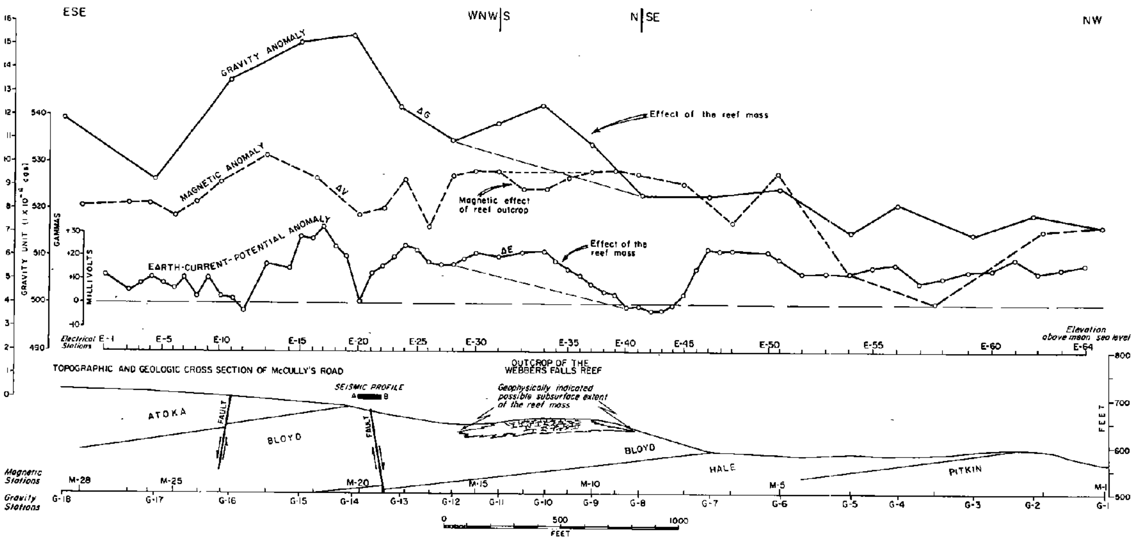

Figure 3. Geophysical-anomaly profiles and geologic cross section across Webbers Falls reef mass.

GRAVIMETRIC SURVEY

A Romberg-LaCoste no. 17 gravimeter was used for the gravimetric survey. The sensitivity factor of this instrument was 0.0835 milligal per scale division. Eighteen gravity stations were established along McCully's Road (indicated by the prefix G in text and figures). To survey the elevation of the gravity stations with the possible highest accuracy, an engineer's level, GK 1-C (Kern & Co., Ltd., Aarau, Switzerland), was used. Elevation of the stations was surveyed to one-thousandth of a foot accuracy, and the values were tied to a U. S. Army Corps of Engineers bench mark of 717.690 feet near gravity station G-18. Field density for Bouguer and terrain corrections was determined by the field survey and reduction method suggested by L. L. Nettleton (1939). Observed field data, after corrections for drift, and for free-air, Bouguer, terrain, and latitude effects, were reduced to the base station, and the Bouguer-anomaly values were plotted above the gravity stations marked along the topographic and geologic profile (fig. 3).

The Bouguer-anomaly curve shows a distinct manifestation of the reef-mass effect between gravity stations G-8 and G-12. The relative-gravity maximum appears at station G-10. The relative-relief contrast at this station is about 2.6 Gravity Units (2.6×10^{-4} cgs unit). The gravity anomaly may support the assumption that the reef mass has an extent between stations G-8 and G-12, a length of approximately 800 feet. The density of the reef sample measured 2.77 gm/cc and that of the surrounding Bloyd Formation measured 2.15 gm/cc, yielding an assumed density contrast of 0.62 gm/cc for theoretical computations. With the theoretical assumption of a disc-shaped reef mass, having a radius of 400 feet and a solid angle ω equal to 5.8, the effect of such a disc of material with a thickness t of 35 feet and for a density contrast σ of 0.62 gm/cc, according to the formula given by Ramsey (1940),

$$G = 2.03 \times \omega \times \sigma \times t \qquad (1)$$

would be

$$G = 2.55 \text{ G.U. } (2.55 \times 10^{-4} \text{ cgs unit}).$$

This computed value agrees closely with the observed gravity-relief contrast at station G-10. From the theoretical computation, it is assumed that the reef mass may continue downward below the station G-10 to about 35 feet.

Between stations G-13 and G-14, as well as between G-16 and G-17, the gravity profile indicates the possibility of faulting. Stations G-14, G-15, and G-16 are on an upthrown block, on which the Atoka and Bloyd Formations are exposed at the surface. The upthrown position of this block is also indicated by the magnetic anomaly between magnetic stations M-20 and M-25.

EARTH-CURRENT-POTENTIAL SURVEY

To complement the magnetic and gravimetric surveys across the Webbers Falls reef, an additional earth-current-potential survey was run. From theoretical consideration one may expect a resistivity contrast between the reef limestone and the surrounding Bloyd Shale. On the other hand, an earth-current-potential survey may render qualitative control of the possible faulting of near-surface formations (Norden and King, 1962). Such a survey was made with a Geovolt apparatus manufactured by the Georator Corporation, Manassas, Virginia. Potential differences were tested at various intervals with porous pot electrodes. With polarization differences noted, the potential differences are shown as progressive addition along the profile (fig. 3). Sixty-four stations were established across the Webbers Falls reef along McCully's Road (indicated by the prefix E in text and figures). The resistive reef mass in the Bloyd Formation shows a definite variation of the potential across it. By construction of an average potential slope on the Bloyd Formation across the reef, the maximum potential variation from this slope was found to be +18 millivolts. In the electrical survey the manifestation of the reef effect may be noticed on the profile between electrical stations E-28 and E-40. The earth-current potential anomaly shows a close agreement with that of the gravimetric survey across the reef. Faulting in the vicinity of gravity station G-13 and G-16 may be correlated with the potential drop around these stations. The sudden drop of the potential at station E-47 may be interpreted as a contrast of conductivity between the Bloyd and Hale Formations. The sharp indication of possible faulting of the near-surface formation between stations E-19 and E-21 suggested further quantitative geophysical control of this interval, and this part of the profile was tested by a seismic-refraction survey.

SEISMIC-REFRACTION SURVEY

A one-hundred-foot seismic-refraction test line A-B (fig. 3) was laid along McCully's Road between stations E-20 and E-22. Seismic-refraction recording was made by an Engineering Seismograph, model MD-1, made by the Geophysical Specialties Company, Minneapolis, Minnesota. With a sledge hammer used for the source of energy, in general, the depth penetration is at least one-third of the maximum hammer distance. The time-distance plot of the seismic-refraction P breaks along the test line A-B is shown in figure 4.

Two seismic media were recognized:

V_1 medium, average velocity 870 ft/sec

V_2 medium, average velocity 2,325 ft/sec

The V_1 low velocity indicates a weathered surface with loose, crushed rock as road cover on it. The V_2 velocity is considered to be the speed along the upper section of the Bloyd Shale. The time-distance plot shows a step-up time displacement in the 40- to 50-foot interval along the line. Step-up time was found to be $\Delta t = 0.012$ sec. The step-up time recording is the indication of the fault displacement within the interval referred to above.

The geological displacement may be computed by

$$D = \Delta t \times \frac{V_1 \times V_2}{\sqrt{V_2^2 - V_1^2}} \qquad (2)$$

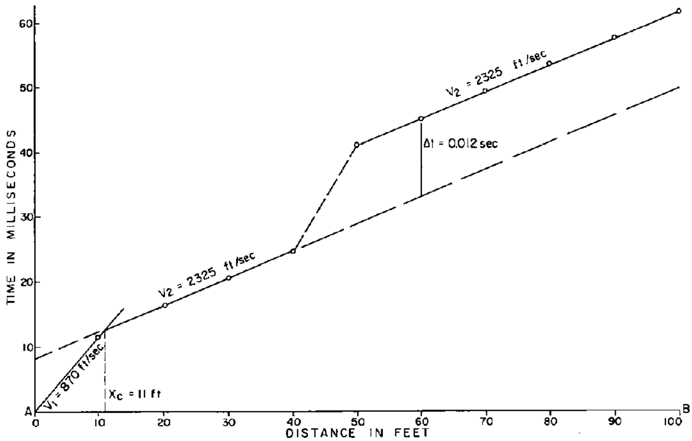

Figure 4. Time-distance plot of seismic-refraction P breaks across the fault between electrical stations E-20 and E-22 (figs. 2, 3).

By substitution of the recorded data into equation (2), the geological displacement was computed to be 11.3 feet in the Bloyd Formation having the downthrown side in the 50-100-foot interval.

The thickness of the low-velocity V_1 medium was determined by

$$Z = \frac{X_c}{2} \times \sqrt{\frac{V_2 - V_1}{V_2 + V_1}} \qquad (3)$$

where X_c is the critical distance, equal to 11 feet.

By the use of equation (3), the thickness of the low-velocity V_1 medium from A to about 40 feet along the line was computed to be 3.7 feet.

CONCLUSIONS

The gravimetric, magnetic, seismic, and earth-current-potential surveys across the Webbers Falls reef yielded new evidence of the usefulness of geophysics in geological study of the near-surface reef formations in Muskogee County, Oklahoma. In the delineation of the boundary of a shallow-subsurface reef mass, precision-gravimetric and earth-current-potential surveys may yield valuable information. In the case of the Webbers Falls reef, Muskogee County, the magnetometer, owing to the low polarization contrast between the reef and the surrounding Bloyd Formation (Morrowan, Pennsylvanian), could detect only the surface outcrop boundaries of the reef. Faulting indicated by magnetic, gravimetric, and earth-current-potential surveys, at one place in the vicinity of the reef was checked and confirmed by a seismic-refraction survey; the displacement was found to be 11.3 feet.

References Cited

Kotila, D. A., 1963, Quantitative faunal analyses and carbonate petrology of the Morrowan reefs in northeastern Oklahoma: Unpublished manuscript.

Nettleton, L. L., 1939, Determination of density for reduction of gravimeter observations: Geophysics, vol. 4, p. 176-183.

Norden, J. A. E., and **King, J. E.,** 1962, Geophysical detection of faulting, south Sparks area, Lincoln County, Oklahoma: Okla. Geol. Survey, Okla. Geology Notes, vol. 22, p. 219-223.

Norden, J. A. E., Langton, J. M., and **Hancock, J. M., Jr.,** 1963, Magnetic profile across the Watts reef, Adair County, Oklahoma: Okla. Geol. Survey, Okla. Geology Notes, vol. 23, p. 221-223, 252.

Ramsey, A. S., 1940, An introduction to the theory of Newtonian attraction: London, Cambridge Univ. Press, p. 36.

Geophysical Maps of Oklahoma Issued by Survey

On October 17, 1964, the Oklahoma Geological Survey issued the first large-scale gravity and magnetic maps of Oklahoma. These are the first such maps to utilize extensively high-quality detailed information provided by industry and the first to be printed in color on a township-range-section base. The maps are:

Map GM-6. *Vertical-intensity magnetic map of Oklahoma,* by V. L. Jones and Paul L. Lyons.

Map GM-7. *Bouguer gravity-anomaly map of Oklahoma,* by Paul L. Lyons.

The maps and an accompanying text are the result of a compilation undertaken by the Geophysical Society of Tulsa with the cooperation of the oil industry, the U. S. Coast and Geodetic Survey, and U. S. Geological Survey. Designing, drafting, and printing of the maps were undertaken by the Oklahoma Geological Survey with the assistance of the Society. The maps are also being included in the *Proceedings of the Geophysical Society of Tulsa* (vol. 8, 1961-1964).

Each map is printed at a scale of 1:750,000 (ca. 12 miles to 1 inch) with contour intervals of 5 milligals for the gravity map and 100 and 200 gammas for the magnetic map. The contour lines are printed in red on a black base. The 15-page text, written by Paul L. Lyons, V. L. Jones, and Peter Jacobsen, Jr., includes a general discussion of each map and descriptions of the 20 positive and 12 negative named anomalies shown on the maps; in addition, basic data are given for 88 gravity base stations in Oklahoma.

The set of two maps and accompanying text are issued in a 9½-by 12-inch envelope at $2.50 per set. Single maps map be purchased for $1.00 each.

Baum Limestone Lentil of Antlers Sand

Carl C. Branson and Richard Schmitz

The Baum Limestone is a lentil of fresh-water limestone and clays in the Trinity Group of southern Oklahoma. The unit was known to geologists and the name used informally for some years before Wayland (1954, p. 2402) formally named it the Baum Limestone Member of the Paluxy Formation. The type locality was designated as the hill in NE¼ SE¼ sec. 36, T. 3 S., R. 3 E., Carter County. The name is that of the former village 1½ miles west of the locality. The member (of Paluxy Formation) was given as 41.5 feet thick and included 17.5 feet of pink and red clay in the base.

Tomlinson recognized the unit in 1926 as basal limestone of the Trinity Formation (Tomlinson, 1926, figs. 2, 3) and realized its relationship to Paleozoic formations. Tomlinson (1952, p. 3, 4, pls. 2, 3, 5) used the name Baum Limestone and showed the Baum Limestone on maps.

The concept of the Baum Limestone as defined by Wayland was outlined from but one measured section, the type section in section 36 east of Baum. In the type area and along U. S. Highway 70, as well as in other sections, the basal part of the Trinity Group consists of maroon clay of varying thickness, succeeded by greenish-gray clay locally, but at most places overlain by white marl. At other places the basal Baum is a unit of algal heads, and in the Ravia area the basal beds are arkosic.

Some might argue that the maroon and greenish-gray clays are not part of the Baum Limestone Member, but are pre-Baum Paluxy. Forgotson (1958) showed that the Paluxy of the type area is not the Paluxy of Oklahoma but that the Oklahoma Trinity sand should be called Antlers Sand. The Baum should include the basal clays and should be called the Baum Lentil of the Antlers Sand.

We do not believe, as Wayland did, that the maroon clay is detrital clay from underlying Pennsylvanian beds, but that it was derived regionally from Paleozoic units and washed into the lagoonal fresh-water environment.

The Baum Limestone Lentil of the Antlers Sand is a fresh-water deposit of limited distribution in Johnston County, and small areas in adjacent Carter and Marshall Counties, Oklahoma. Wayland and Ham (1955) stated that the limestone and clay contain *Atopochara trivolvis, Clavator harrisi,* and *Metacypris*. Dr. Sylvester-Bradley (personal communication) suggested the possibility that the *Metacypris* could be *Theriosynoecum,* a genus described by Branson from the Morrison Formation of Wyoming. A sample from the type section of the Baum (ca. 500′ W of center of E line sec. 36, T. 3 S., R. 3 E.) was examined by Schmitz, and it proved to have specimens of *Cypridea,* as well as abundant charophyte oögonia. We collected 13 additional samples and found that charophyte oögonia occur in the marly zone below the limestone at three localities, and in the pale maroon clay below the marly zone in the type section, 40 feet below the limestone in sec. 11, T. 4 S., R. 4 E., and in the greenish-gray clay at that locality. The marly and maroon zone proved barren of charophyte oögonia and ostracodes in other sampled sections (sec. 2, T. 4 S., R. 5 E., sec. 4, T. 4 S., R. 5 E., sec. 25, T. 4 S., R. 3 E.).

At present charophyte oögonia are known in abundance in the marly zone at the base of the massive limestone, as well as below the algal zone at one locality. Charophyte oögonia and *Cypridea* occur in the pinkish clay below the marly zone in the type section. Charophyte oögonia occur in the marly basal limestone in section 11 and in the maroon clay 40 feet lower, and the maroon clay yielded one specimen of *Cypridella*?. One charophyte oögonium was found in the marly zone in sec. 3, T. 4 S., R. 4 E.

The genus *Cypridea* has been restudied by Sylvester-Bradley (1949), who designated *Cypris granulosa* Sowerby, 1836, as lectotype species. Vanderpool (1928) described the new variety (subspecies) *Cypridea tuberculata gypsumensis* from the De Queen Limestone Member of the Trinity Group in southwestern Arkansas. Peck (1941, p. 297-298) examined the type specimens and referred the subspecies to *Cypridea wyomingensis* Jones, 1893. Some of our specimens are similar to that species. At least two other species of *Cypridea* occur in our material.

Fresh-water snails occur in the marly bed and the pink clay in the type section. These were determined by Schmitz as *Gyraulus* sp., *Physa montanensis,* and *Mesoneritina,* all from the lower units in the type section. These are similar to Kootenai forms figured by Yen (1951).

Charophytes found in the Baum Lentil are *Atopochara trivolvis* Peck, 1938 (first described from Trinity beds at 530 feet in a well near Madill, Marshall County, about 15 miles from our localities), *Clavator harrisi* Peck, 1941 (described from the Draney Limestone and reported from Trinity beds in wells in Texas), *Perimneste corrugata* Peck, 1941 (Peterson Formation and reported from Lower Cretaceous in a well in Terrell County, Texas), and *Stellatochara mundula* (Peck) 1941 (Draney Limestone of Idaho). These species indicate an Aptian age for the Baum Lentil.

Sirna (1963) reported the occurrence of *Atopochara trivolvis* and *Clavator harrisi,* as well as a new species of *Atopochara, A. reticulata,* and a species of *Chara* in marly beds of Aptian age in the hills east and southeast of Rome.

The occurrence of *Atopochara trivolvis* at 530 feet in the Magnolia Rutherford no. 3 (variously given as Rutland Trust Co., W. Rutland Trust Co., and West Rutland Trust Co., on Corporation Commission logs), sec. 30, T. 5 S., R. 6 E., Marshall County, points to another lentil of fresh-water sediment in the Antlers Sand in that area. The well was a dry hole in SE¼ SE¼ NW¼ of the section. The unit from 523 to 540 feet was logged as "hard lime" and was said to be just above the Arbuckle sand. Drillers logs of adjacent wells do not show a limestone at this depth.

References

Branson, C. C., 1958, No Paluxy in Oklahoma?: Okla. Geol Survey, Okla. Geology Notes, vol. 18, p. 15.

Forgotson, J. M., Jr., 1957, Stratigraphy of Comanchean Cretaceous Trinity Group: Amer. Assoc. Petroleum Geologists, vol. 41, p. 2328-2363.

Peck, R. E., 1938, A new family of Charophyta from the Lower Cretaceous of Texas: Jour. Paleontology, vol. 12, p. 173-176.

__________ 1941, Lower Cretaceous Rocky Mountain nonmarine microfossils: Jour. Paleontology, vol. 15, p. 285-304.

__________ 1957, North American Mesozoic Charophyta: U. S. Geol. Survey, Prof. Paper 294-A, 44 p.

Sirna, Giuseppe, 1963, Aptian Charophyta of southern Latium: Univ. Roma and Consiglio Nazionale Ricerche, Geologica Romana, vol. 2, p. 279-290.

Swain, F. M., and **Brown, P. M.**, 1964, Cretaceous Ostracoda from wells in the southeastern United States: North Carolina Dept. Conservation Development, Bull. 78, 55 p.

Sylvester-Bradley, P. C., 1949, The ostracod genus **Cypridea** and the zones of the Upper and Middle Purbeckian: Geologists' Assoc., London, Proc., vol. 60, p. 125-153.

Tomlinson, C. W., 1926, Buried hills near Mannsville, Oklahoma: Amer. Assoc. Petroleum Geologists, Bull., vol. 10, p. 138-143.

__________ 1952, Study of Paleozoic structure and stratigraphy of the Arbuckle and Ouachita Mountains in Johnston and Atoka Counties, Oklahoma: Ardmore Geol. Soc., Guidebook, Field Trip, Apr. 25-26, p. 1-5.

Vanderpool, H. C., 1928, Fossils from the Trinity Group (Lower Comanchean): Jour. Paleontology, vol. 2, p. 95-107.

Wayland, J. R., 1954, Baum Limestone Member of Paluxy Formation, Lower Cretaceous, southern Oklahoma: Amer. Assoc. Petroleum Geologists, Bull., vol. 38, p. 2400-2406.

Wayland, J. R., and **Ham, W. E.**, 1955, General and economic geology of the Baum Limestone, Ravia-Mannsville area, Oklahoma: Okla. Geol. Survey, Circ. 33, 44 p.

Yen, Teng-Chien, 1951, Fresh-water mollusks of Cretaceous age from Montana and Wyoming: U. S. Geol. Survey, Prof. Paper 233-A, 20 p.

New Theses Added to O. U. Geology Library

The following Master of Science thesis was added to The University of Oklahoma Geology Library in October 1964.

Areal geology of the southwest Pickens area, Pushmataha County, Oklahoma, by John P. Woodson.

Reticulatia AND *Squamaria* IN GEARYAN ROCKS OF OKLAHOMA

CARL C. BRANSON

The productid genus *Reticulatia* Muir-Wood and Cooper, 1960, is based upon type species by original designation *Productus huecoensis* R. E. King, 1931. The holotype of the species is from the "Lower Gym formation" of the Hueco Mountains, El Paso County, Texas. The Gym of the type area has been proven to be mainly Ordovician and Silurian, and the type actually came from the Hueco Limestone in the upper part of the "lower division" of P. B. King (1945). R. E. King also reported the species from the upper part of the Wolfcamp Formation of the Glass Mountains.

The species embraces many of the specimens referred to *Dictyoclostus americanus* by various authors. Muir-Wood and Cooper (1960, p. 284) referred specimens from the Brownville Limestone of Kansas and Oklahoma, from the Florena Shale and Foraker Limestone of Kansas, from the Red Eagle Formation of Oklahoma, and from the Hughes Creek Formation of Nebraska to the species. They also referred *Dictyoclostus newelli* R. H. King, 1938, to *Reticulatia*. The species occurs in the Graham Formation (Cisco, Early Virgilian) of McCulloch County, Texas.

Reticulatia occurs in the Red Eagle Limestone in the abandoned part of the quarry south of U. S. Highway 60 east of Burbank, Osage County. Four specimens (OU 62) are characteristic (pl. I, fig. 1). Muir-Wood and Cooper placed *Dictyoclostus americanus* Dunbar and Condra, 1932, in synonymy with *Productus huecoensis* R. E. King, 1931. Upon available evidence it is not clear that the names are synonyms, and Dunbar and Condra's name (not just a new name, as they stated on page 218, but a new species, as they stated on the explanation to plate 34) is here retained. The designated holotype is from

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Explanation of Plate I

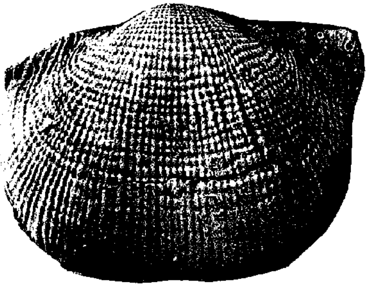
Figures 1-4. Reticulatia americana **(Dunbar and Condra), x1.**

1. **Exterior of ventral valve, OU 62. Red Eagle Limestone, Osage County.**
2. **Exterior of ventral valve, OU 4531. Brownville Limestone, Admire, Kansas.**
3. **Interior of dorsal valve, OU 4531. Brownville Limestone, Admire, Kansas.**
4. **Interior of dorsal valve, OU 4533. Coffeyville Formation, Seminole County.**

Figures 5-6. Squamaria welleri **R. H. King, x1.**

5. **Exterior of ventral valve, OU 4532. Putnam Formation, Callahan County, Texas.**
6. **Interior of dorsal valve, OU 4532. Putnam Formation, Callahan County, Texas.**

(Photographs by Jan Cannon)



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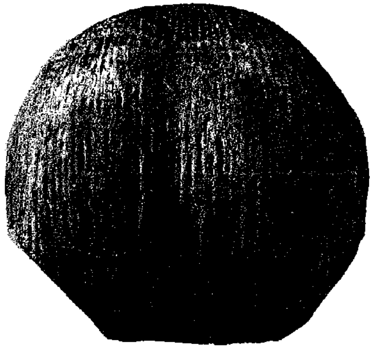

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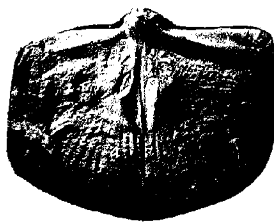

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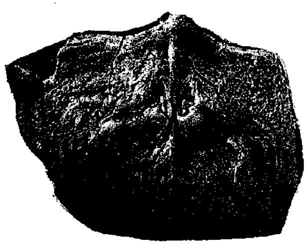

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the Aspinwall Limestone of the Admire Group, two figured paratypes are from the Stine Shale in the Admire, and one is from the Americus Limestone of the Council Grove Group. The text (p. 220) stated that the species occurs in the Missouri Series.

We have four shells from the Red Eagle Limestone of Pawnee County, one (OU 814) from the Americus Limestone of NE¼ sec. 1, T. 18 N., R 5 E., Payne County, three (OU 329) from the Kinney Limestone at NE cor. sec. 23, T. 29 N., R. 3 E., Kay County, two (OU 85) from the lower part of the Foraker Formation in NW¼ sec. 10, T. 24 N., R. 5 E., Osage County, three (OU 164) from the Dover Limestone in sec. 13, T. 28 N., R. 7 E., Osage County, two (OU 840) from the Neva Limestone in SW¼ sec. 26, T. 26 N., R. 5 E., Osage County, and one (OU 847) from a limestone bed below the Little Hominy Limestone (Pawhuska Formation, Virgilian) in SE¼ sec. 34, T. 27 N., R. 8 E. We also have specimens (OU 4531) from the Brownville Limestone at Admire, Kansas (pl. I, figs. 2, 3).

A specimen of *Reticulatia* (OU 1247) from the Belle City Limestone was figured by me (Branson, 1961, p. 128, fig. 1). Specimens from the Coffeyville Formation are from Seminole County (pl. I, fig. 4).

Hoare (1961, p. 50-52) referred specimens from the Cabaniss Group of Missouri to *Reticulatia huecoensis* and has transferred his *Dictyoclostus tiawahensis* of the Tiawah Limestone to *Reticulatia.* The identification of *R. huecoensis* is here questioned and the generic assignment of *R. tiawahensis* is not believed established. If either is correct, the range of *Reticulatia* is extended downward into equivalents of the Senora Formation.

Large productids of the genus *Squamaria* Muir-Wood and Cooper, 1960, occur in Oklahoma. The type species is *S. moorei* Muir-Wood and Cooper, 1960, from the Talpa and Grape Creek Formations of Texas. *Productus ivesi* Newberry, 1861, was transferred to the genus by Muir-Wood and Cooper (1960, p. 288). They suggested (p. 289) that *Dictyoclostus welleri* R. H. King, 1938, also may belong to the genus. Specimens at hand, including a brachial interior, support that assignment. Our material (OU 4532) is from the Putnam Formation one mile west of Putnam, Callahan County, Texas (pl. I, figs. 5, 6).

Specimens from Oklahoma in our collection are from the upper

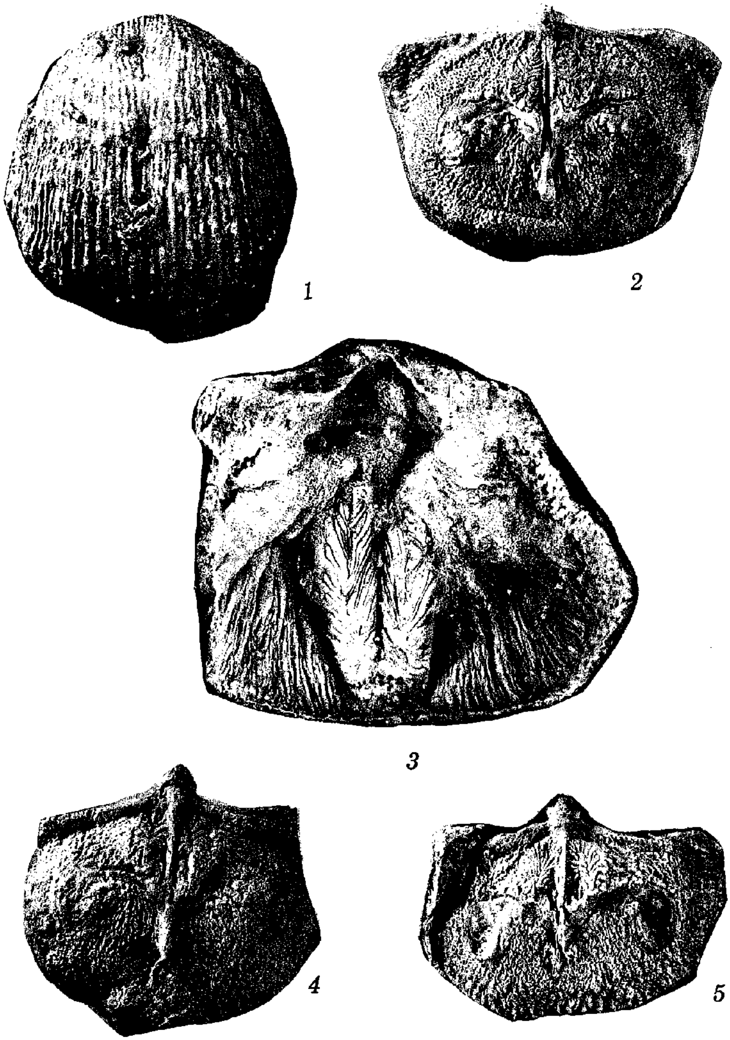
Explanation of Plate II

Figures 1-5. Squamaria moorei **Muir-Wood and Cooper, 1960, Fort Riley Limestone. Quarry at Uncas, Kay County, Oklahoma.**

1. **Exterior of ventral valve, x1. OU 4898.**
2. **Interior of dorsal valve, x1. OU 4524. (Collected by Stephen Hall).**
3. **Interior of ventral valve, x2. OU 4898.**
4. **Interior of dorsal valve, x1. OU 91.**
5. **Interior of another dorsal valve, x1. OU 4524. (Collected by Stephen Hall).**

(Photographs by Jan Cannon)

Plate II



part of the Fort Riley Limestone, weathered out of the waste heaps from the oölitic limestone in the quarry at Uncas (SE¼ SE¼ sec. 22, T. 27 N., R. 3 E.), Kay County, Oklahoma. One lot (OU 91) consists of six specimens. One of these has the trifid cardinal process and retains the sharp, prominent median septum on the middle third of the brachial valve. The shell surface of the pedicle valve carries about 50 somewhat irregular costae, many of which bifurcate on the trail and on the lateral slopes. Those of the umbonal area are crossed by concentric wrinkles, which, with the costae, form a distinct reticulate pattern. Short stout spines set irregularly upon the costae are numerous on the anterior area in front of the umbonal region and form an irregular band or row near the front margin.

A lot of six specimens from the same locality (OU 4898), collected by Marie Kennedy and acquired with the Harlow collection, contains a dorsal interior. It has all the characteristics of the genus—petaloid brachial ridges, median septum in front of the cardinal process, and dendritic adductor scars lateral to the median septum (pl. II, fig. 3). A partial pedicle interior displays a prominent, large, elevated pair of adductor scars, each with irregular rods converging anteriorly. The ridged diductor scars occupy a large portion of the anterior.

Stephen Hall has presented us with a lot of additional specimens from the same locality and horizon (OU 4524). One specimen is an unusually fine brachial interior (pl. II, fig. 2). The Fort Riley specimens bear scattered small spines on the anterior slope and abundant small spines on the lateral anterior slopes. They are referable to *S. moorei.*

The Oklahoma record is of *Squamaria* confined to the upper part of the Chase Group and of *Reticulatia* occurring in the Missouri Group, Virgil Group, Admire Group, Council Grove Group, and in the lower part of the Chase Group.

References Cited

Branson, C. C., 1961, **Reticulatia** in the Belle City Limestone: Okla. Geol. Survey, Okla. Geology Notes, vol. 21, p. 128.

Dunbar, C. O., and **Condra, G. E.,** 1932, Brachiopoda of the Pennsylvanian System in Nebraska: Nebr. Geol. Survey, Bull. 5, 2d Ser., 377 p.

Hoare, R. D., 1961, Desmoinesian Brachiopoda and Mollusca from southwest Missouri: Mo., Univ., Studies, vol. 36, 260 p.

King, P. B., 1945, Geology of Hueco Mountains, El Paso and Hudspeth Counties, Texas: U. S. Geol. Survey, Oil and Gas Inv., Prelim. Map 36.

King, R. E., 1931, Faunal summary and correlation of the Permian formations with description of Brachiopoda, **Pt. 2 of** The geology of the Glass Mountains, Texas: Texas, Univ., Bull. 3042, 245 p., 44 pls.

King, R. H., 1938, New Chonetidae and Productidae from Pennsylvanian and Permian strata of north-central Texas: Jour. Paleontology, vol. 12, p. 257-279, pls. 36-39.

Muir-Wood, Helen, and **Cooper, G. A.,** 1960, Morphology, classification, and life habits of the Productoidea (Brachiopoda): Geol. Soc. America, Mem. 81, 447 p.

Techniques of Palynology—Part II
Microscope-Slide Preparation of Modern Spores and Pollen*

L. R. Wilson and G. J. Goodman

INTRODUCTION

Several techniques are prevalent among palynologists for the preparation and study of modern spores and pollen. The processing technique and curating of voucher specimens used in the palynological laboratory of the Oklahoma Geological Survey were described in Part I of this paper (Wilson and Goodman, 1963). The present part deals with the preparation of microscope slides from spore and pollen preparations. The same slide-making technique is also employed in the preparation of permanent fossil palynological materials except that in certain cases the fossils are best mounted in media other than glycerine jelly.

CLEANING THE PROCESSED SAMPLE

Generally a processed sample of modern spores and pollen contains an excess of sporange parts or other tissues and in many cases a large amount of silt that has settled out of the atmosphere upon the flowers. This latter condition is commonly encountered in semiarid and arid areas like western Oklahoma. The presence of silt in a microscope-slide preparation generally will render it unsatisfactory for study. Several techniques for removing silt are: by solution in hydrofluoric acid, by heavy-liquid separation, and by swirling the preparation in a watch glass. The last technique is generally the simplest and does not damage the spores or pollen. In figure 1 the schematic diagram illustrates how the prepared spore or pollen sample is treated in making a microscope slide.

The removal of extraneous material in prepared spore and pollen preparations by the swirling technique requires the use of several watch glasses, a medicine-dropper type of pipette, a wash bottle containing distilled water, and a compound microscope. The prepared sample (step 1, fig. 1) is placed in a watch glass (step 2, fig. 1). Generally a glass 3 inches in diameter is sufficiently large. With the watch glass resting upon a piece of white paper, revolve it slowly until the sediment is concentrated and rising in the vortex of the swirling current (step 3, fig. 1). With the medicine dropper, extract the rising sediment and place it in a second watch glass (step 4, fig. 1). Repeat the swirling and extraction until only the heaviest sediment remains in the first watch glass. Then check the remaining residue under a microscope using low-power optics to determine if all spores or pollen grains have been removed. Generally only silt and other heavy material remain in the center of the watch glass, but, if spores or pollen

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grains are still present, add distilled water from the wash bottle and continue the swirling and extraction. After the first separation of the sample has been made, add distilled water to the second watch glass (step 5, fig. 1) and proceed as in the first separation, placing the extract in a third watch glass. If the extract in the third watch glass is clean, then the sample is ready for slide making (step 6, fig. 1). If the preparation still contains debris, continue washing, swirling, and

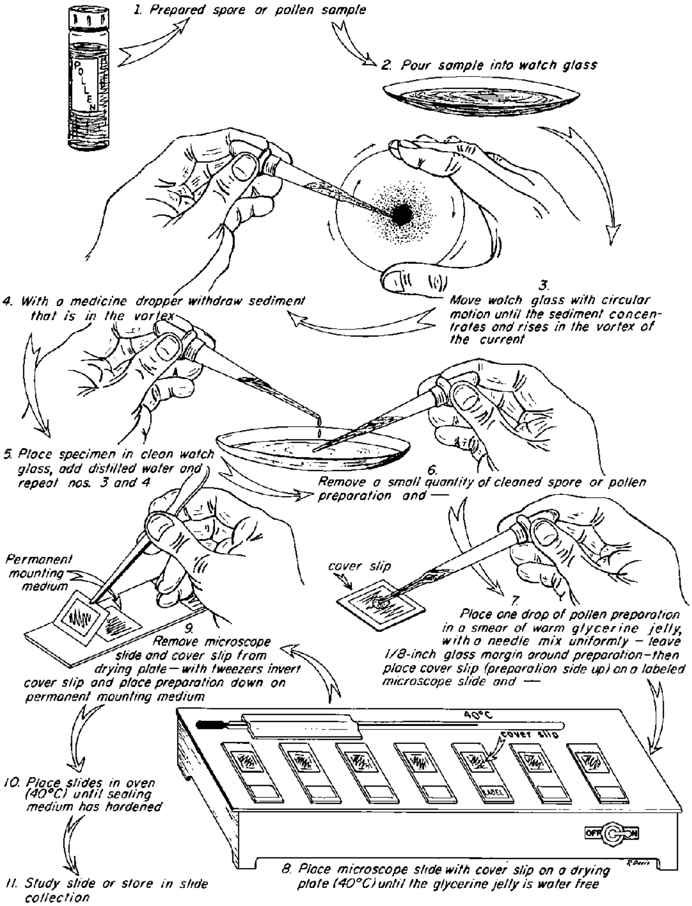

Figure 1. Schematic diagram showing procedure for making permanent microscope-slide preparations of modern spores and pollen grains.

extracting until a satisfactory sample is obtained. With a little practice, the technician soon becomes adept in the above procedure, and clean usable microscope slides can be made from the residue.

MICROSCOPE-SLIDE MOUNTS

The mounting medium that is to be used must be determined at this point in the procedure. For permanent mounts, glycerine jelly is generally used in this laboratory because it appears to affect the shapes of the spores and pollen grains less than do most other mountants and its optical qualities are satisfactory for most species. However, glycerine jelly desiccates in a few years if not protected by a seal. The technique of making the permanent glycerine jelly mounts described below has been used here for eight years, and the slides have remained visibly unchanged.

If the specimens are to be photographed and it is not necessary to retain them on permanent mounts, distilled water gives excellent definition for photomicrography. A drop of cleaned pollen preparation placed upon a microscope slide and covered with a number 0 cover slip is satisfactory for the average time needed for taking a picture. If more time is required, the addition of a small drop of glycerine to the preparation on the slide will retard evaporation.

The first step in smear-slide preparation is to wash the microscope slides and cover slips with alcohol. When dry, the slides are labeled and laid upon a white surface with a cover slip resting upon each slide. A quantity of glycerine jelly should be melted in a double boiler and be readily available at the preparation bench.

A small drop of glycerine jelly is then lifted with a glass rod from the double boiler and spread uniformly on a cover slip; leave at least ⅛-inch margin of glass. Upon the warm smear, place a drop of concentrated spore or pollen preparation and distribute it uniformly in the glycerine jelly. A warm needle appears to be the best instrument for mixing (step 7, fig. 1).

Place the microscope slide and cover slip (preparation side up) upon a warming plate, the temperature of which is not more than 40°C (step 8, fig. 1). Allow the water in the glycerine jelly several hours or preferably overnight to evaporate. When the slides are cooled, the preparation is either "tacky" or nearly hard.

Remove the slides from the warming plate and with tweezers lift each cover slip from its microscope slide, place a drop of permanent mounting medium upon the slide, invert the cover slip so that the preparation side is down, and gently lower it at an angle onto the permanent mounting medium (step 9, fig. 1). Several types of permanent mounting media can be used, but preference in this laboratory is for Harleco Synthetic Resin because it dries quickly and does not appear to discolor with age.

The slides then are returned to the warming plate or are placed in an oven set at 40°C. One or two days' drying is sufficient for permanent setting of the mounting medium.

The cleaned spore or pollen preparation can be returned to its vial and have acetic acid added before being placed in storage.

The process of slide making described above has an advantage of being a technique whereby a large number of permanent slides can be completed at one time. Desiccated smear preparations readily permit the use of oil-immersion optics because the specimens are oriented next to the cover slip.

Reference Cited

Wilson, L. R., and **Goodman, G. J.**, 1963, Techniques of palynology—Part I. Collection and preparation of modern spores and pollen: Okla. Geol. Survey, Okla. Geology Notes, vol. 23, p. 167-171, 1 fig.

Geologic Index Maps Issued by Survey

On October 16, 1964, the Oklahoma Geological Survey issued *Index to geologic mapping in Oklahoma—Supplement 1,* by Carl C. Branson and Louise Jordan, priced at $1.00. This supplement updates the information given in the first index published in 1961.

Two maps are included:

Map IA. *Surface mapping, 1901-1963.*
Map VI. *Subsurface mapping, 1961-1963.*

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