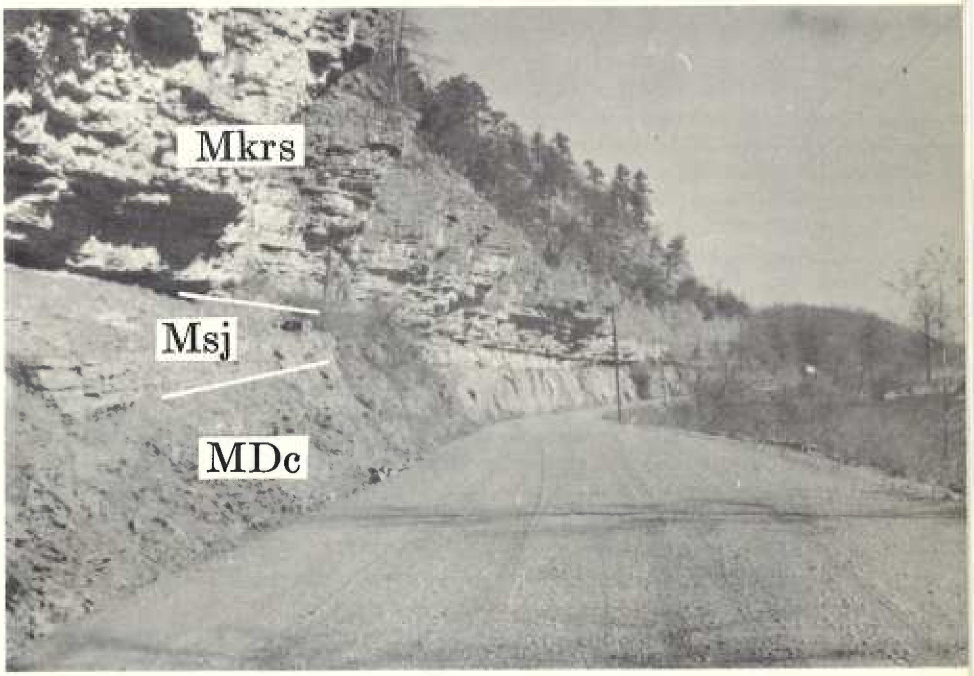
OKLAHOMA

GEOLOGY NOTES

OKLAHOMA GEOLOGICAL SURVEY
THE UNIVERSITY OF OKLAHOMA • NORMAN, OKLAHOMA



$2.00 per year, $0.25 per copy

JUNE 1963

Volume 23, Number 6

Cover Picture

MISSISSIPPIAN ROCKS IN NORTHEASTERN OKLAHOMA

Hanging Rock on Illinois River

The photograph on the cover, taken by John M. Stark, Jr., shows the sequence of units exposed along the Illinois River at the "Hanging Rock" locality northeast of Tahlequah, Oklahoma, in sec. 5, T. 18 N., R. 23 E.

The lowest unit exposed above road level here is the Noel Shale Member of the Chattanooga Formation (MDc). It is a black, fissile, carbonaceous, pyritic shale. It is characteristically jointed and the joint surfaces are stained yellow, red, and brown by iron oxides.

The overlying St. Joe Limestone (Msj) rests disconformably upon the Noel Shale and is succeeded disconformably by the Reeds Spring Formation. The St. Joe thins eastward in this locality from 12 feet to zero, pinching out near the telephone pole in the right center of the picture.

Reeds Spring Formation (Mkrs) consists of alternate beds of fine-grained, thin-bedded limestone and blue-gray chert. Thickness in this locality is approximately 100 feet. The Reeds Spring is resistant to erosion and forms nearly vertical cliffs throughout the area. The massive, white Keokuk Chert caps the bluffs formed by the Reeds Spring Formation.

—G. G. H.

Statistics of Oklahoma's Petroleum Industry, 1962

Louise Jordan

In 1962, the Anadarko and Arkoma basins were active areas for exploration and development in Oklahoma and in the Midcontinent area. Deep drilling in the Anadarko basin resulted in the discovery by Pure Oil Company of the Clinton Lake sand (Atokan in age) at depths from 14,925 to 15,070 feet with 7.5 million cubic feet of gas daily and 22 barrels of condensate per milllion from the No. 1 Spieker (sec. 12, T. 11 N., R. 20 W.), northwestern Washita County. In southeastern Washita County north of the Wichita fault complex, Gulf Oil Corporation found a good show of gas in rocks of Morrowan age at a depth of 16,660 to 16,704 feet in the No. 1 Tabor (sec. 24, T. 8 N., R. 15 W.), indicating that reserves of hydrocarbons are to be found in the deep Pennsylvanian section of the Anadarko basin. To the southeast in the Chitwood field of Grady County, gas was recovered from the Mobil Oil Company No. 1 Craddock at a calculated open flow of 45,000,000 cubic feet of gas daily with 227 barrels of condensate per million from three Bromide (Ordovician) sandstones, all below 16,000 feet. This well set a new production-depth record for the State, which, however, was surpassed by that of the second producer in the new zone for the field where previous production was from Springer sandstones. The bottom of the perforations in the Third Bromide sand of the No. 1 Miller (sec. 28, T. 5 N., R. 6 W.), a north offset to the Craddock well was at 17,076 feet. The well is the third deepest producer of hydrocarbons in the United States.

Along the northern shelf of the Anadarko basin, decline of development in the Dover-Hennessey area of Kingfisher County was offset by exploration in the northwestern part of the county with discovery of additional productive zones in the lower part ("Osage") of the Mississippi lime, in the Misener, and in the Hunton (Devonian-Silurian). Extension of exploration into all of Garfield County resulted in 13 new fields with five productive zones. One of the more active areas in Oklahoma was the Putnam-Lenora district of Dewey County, where a 30-mile-long Oswego limestone bank is being exploited.

Table I.—Estimated Proved Reserves in Oklahoma, 1961-1962*

	END OF 1961	END OF 1962	CHANGES 1961-1962
Crude oil (1,000 bbls)	1,787,429	1,728,268	−59,161
Natural-gas liquids (1,000 bbls)	329,180	347,003	+17,823
Total liquid hydrocarbons (1,000 bbls)	2,116,609	2,075,271	−41,338
Natural gas (MMCF)	17,350,924	18,358,738	+1,007,814

*American Petroleum Institute, the American Gas Association and the Canadian Petroleum Association annual report.

TABLE II.—HYDROCARBON PRODUCTION IN OKLAHOMA, 1961-1962

	END OF 1961	END OF 1962
Crude oil and lease condensate		
Total annual production (1,000 bbls)[1]	193,081	198,502
Value ($1,000)[1]	561,886	577,641
Cumulative production, 1891-year (1,000 bbls)[1]	8,419,477	8,617,979
Daily production (bbls)[2]	525,573	545,359
Total number of producing wells	80,814[1]	80,098[3]
Daily average per well (bbls)[3]	6.5	6.8
Wells flowing naturally at end of year (estimated)[2]	3,775	3,750
Oil wells on artificial lift (estimated)[2]	81,048	77,795
Natural Gas		
Total annual marketed production (MMCF)[1]	892,697	964,100
Value ($1,000)[1]	108,016	117,600
Total number of gas and gas-condensate wells[2]	6,278	6,218
Natural-gas liquids		
Total annual marketed production (1,000 gals)[1]	1,338,319	1,363,200
Value ($1,000)[1]	63,499	65,900

[1]Item for 1961 is U. S. Bureau of Mines final figure. Item for 1962 is U. S. Bureau of Mines preliminary figure: U. S. Bureau of Mines, Mineral Industry Surveys Area Report IV-151, **also in** Okla. Geology Notes, vol. 23, p. 23-25.

[2]**World Oil,** 1963 forecast-review issue, vol. 156, no. 3, February 15, 1963.

[3]**Oil and Gas Journal,** annual review-forecast issue, vol. 61, no. 4, January 28, 1963.

In the Arkoma basin of eastern Oklahoma, new discoveries were made in the Spiro and other Pennsylvanian sandstones, but commercial production from Devonian-Silurian rocks and shows in the Arbuckle (Ordovician) indicate that stratigraphically older rocks and deeper drilling may uncover more reserves.

Interest in exploring the Arbuckle section (Ordovician) has increased in many parts of the State because of hydrocarbon production found during 1962 in the Healdton field of Carter County, North Norman field of Cleveland County, Cleveland field of Pawnee County, and the Pettit and West Wildhorse areas of Osage County. A natural-gas well completed in Arbuckle rocks is being tested at the Pan American Petroleum Corporation wildcat (sec. 36, T. 8 N., R. 22 E.) in the Arkoma basin in Haskell County; and gas is being produced from Arbuckle rocks (a new-zone discovery), at depths from 13,870 to 15,400 feet, in sec. 4, T. 8 S., R. 3 E., of the Southeast Marietta field of Love County.

Among the states, Oklahoma, in 1962, ranked third in production of natural gas, fourth in the production of crude oil, and fifth in natural-gas-liquid production. As is the case for the United States, Oklahoma produced more hydrocarbon liquids than it discovered in the year. According to the American Petroleum Institute, gross additions to proved reserves of crude oil and natural-gas liquids (that is, extensions of fields, revisions of previous estimates, and new field

Table III.—Drilling Activity in Oklahoma, 1962

	1962						1961	1963
	CRUDE	CONDENSATE	GAS	DRY	SERVICE	TOTAL	TOTAL	FORECAST
All wells								
Number of completions	2,605	95	477	1,379	647	5,203[1]	5,845[2]	5,082
Footage	10,126,846	797,161	2,928,134	5,530,356	1,085,063	20,467,560	20,332,408	20,000,000
Average footage	3,887	8,391	6,139	4,014	1,677	3,934	3,749	
Exploration wells								
Number of completions	70	17	45	301		433	529	480
Percentage of completions	16.2	3.9	10.4	69.5		100.0		
Footage	457,122	155,752	345,251	1,594,808		2,552,933	2,816,413	
Average footage	6,530	9,162	7,672	5,298		5,896	5,324	
Development wells								
Number of completions	2,535	78	432	1,078	647	4,770	5,316	4,602
Footage	9,669,724	641,409	2,582,883	3,935,548	1,085,063	17,914,627	17,515,995	

Source: **Oil and Gas Journal,** annual review-forecast issue, vol. 61, no. 4, January 28, 1963.
[1]Cable, 919; rotary, 4,284.
[2]Cable, 1,331; rotary, 4,514.

discoveries) amounted to 177,281,000 barrels, whereas 1962 production was 218,619,000 barrels, or a net decline in total proved reserves of 41,338,000 barrels. On the other hand, reserves of natural gas increased 1,007,814 million cubic feet with gross additions of more than 2,000,000 million cubic feet, of which 1,567,182 million cubic feet was attributed to extensions and revisions, and 462,997 million cubic feet to new discoveries. If the trend continues another year, Oklahoma will surpass Kansas in reserves of natural gas, becoming third ranked behind Texas and Louisiana.

Underground storage capacity for LP gases was further increased

TABLE IV.—GIANT FIELDS OF OKLAHOMA*

FIELD, (PRIMARY COUNTY)	1962 PRODUCTION (1,000 BBLS)	CUMULATIVE PRODUCTION (1,000 BBLS)	ESTIMATED RESERVES (1,000 BBLS)	NO. OF WELLS	YEAR OF DISCOVERY
Allen (Pontotoc)	1,390	91,001	8,999	914	1927
Avant (Osage)	258	104,190	2,810	592	1904
Bowlegs (Seminole, Pontotoc)	1,240	142,360	17,640	180	1927
Burbank (Osage)	14,296	408,155	66,845	1,531	1920
Cement (Caddo)	3,533	108,792	16,208	1,590	1917
Cushing (Creek)	2,629	418,427	36,573	1,790	1912
Dover-Hennessey (Kingfisher)	8,945	21,374	178,626	480	1958
Earlsboro (Seminole)	272	136,672	3,328	84	1930
Edmond, West (Oklahoma)	707	111,726	18,274	537	1943
Elk City (Beckham)	937	56,398	53,602	292	1947
Eola-Robberson (Garvin)	3,444	55,619	44,381	474	1920
Fitts (Pontotoc)	930	120,704	6,296	441	1953
Glenn Pool (Creek)	3,490	272,111	37,889	1,603	1905
Golden Trend (Garvin)	10,730	228,568	91,432	2,320	1944
Healdton (Carter)	2,513	241,359	28,641	2,176	1913
Hewitt (Carter)	2,550	166,479	28,521	1,437	1949
Little River (Seminole)	339	131,064	3,926	141	1937
Oklahoma City (Oklahoma)	2,381	721,475	48,525	503	1928
Seminole (Seminole)	726	165,892	9,108	259	1926
Sho-Vel-Tum (Carter, Stephens)	24,350	597,723	202,277	3,477	1914
St. Louis (Pottawatomie)	1,440	194,040	15,960	543	1925
Tonkawa (Kay, Noble)	273	128,023	1,977	120	1921
Total (MM bbls)	87.37	4,622	922	21,484	

*Oil and Gas Journal, annual review-forecast issue, vol. 61, no. 4, January 28, 1963, p. 175-176.

by completion of two new facilities, one in a Wellington salt layer in Grant County for 150,000 barrels of butane, and one in a Cimarron salt layer in Beaver County for 35,000 barrels of LP gas.

Marketable production of helium in 1962 extracted from natural gas at the Keyes plant of the Federal Bureau of Mines was 291,567,000 cubic feet or 7 percent below the previous year. The value was 74 percent greater owing to a price increase from $19 to $35 per thousand cubic feet in November 1961 under the Helium Act of 1960. In mid-October the 400-mile pipeline from Bushton, Kansas, to Amarillo, Texas, was completed, and much of the subsequent production was used to fill the line.

Table IV is a list of the 22 giant fields of Oklahoma; that is, those fields which will produce more than 100 million barrels of crude oil.

TABLE V.—STRIPPER WELLS IN OKLAHOMA, 1960-1961

	END OF 1960	END OF 1961*
Number of stripper wells	65,688	68,740
Production (1,000 bbls)	95,054	116,058
Abandonments	2,384	2,546
Average daily production per well (bbls)	3.96	4.63
Producing acres	1,168,484	1,212,700
Reserves estimated at end of year (1,000 bbls)		
Primary	602,464	725,275
Secondary	594,494	570,665
Total	1,196,958	1,295,940

*__Oil and Gas Journal,__ 1962, Number of stripper wells still rising: Oil and Gas Jour., vol. 60, no. 44 (Oct. 29), p. 103, from annual stripper-well survey prepared jointly by the Interstate Oil Compact Commission and the National Stripper Well Association.

TABLE VI.—EXPLORATORY PRODUCERS AND DRY HOLES DRILLED IN OKLAHOMA, 1953-1962*

	NO. OF PRODUCERS	NO. OF DRY HOLES	TOTAL TESTS	FOOTAGE	AVERAGE DEPTH (FEET)
1953	228	736	964	4,095,415	4,248
1954	190	754	944	3,984,353	4,221
1955	205	718	923	3,934,360	4,263
1956	266	863	1,129	4,827,949	4,276
1957	200	823	1,023	4,305,680	4,209
1958	282	914	1,196	4,670,946	3,905
1959	238	843	1,081	4,442,912	3,110
1960	260	674	934	4,210,821	4,508
1961	250	616	866	3,978,322	4,594
1962	257	546	803	3,747,798	4,667

*__Lahee, F. H.,__ 1962, Statistics of exploratory drilling in the United States, 1945-1960; and American Association of Petroleum Geologists annual June issues.

Crude-oil production from these fields amounted to 43.9 percent of the State's 1962 production. The estimated ultimate production of the giant fields amounts to 5,544 million barrels, or 51 percent of that of all fields in Oklahoma. The remaining reserve of the giants is 922 million barrels, or 41.1 percent of future crude-oil production in Oklahoma.

In table VI is listed the total number of producers (crude, gas, and condensate) and dry holes resulting from exploratory drilling during the last ten years. Wildcat drilling has decreased in Oklahoma during the last four years, 1959-1962, a peak of 1,196 holes having been drilled in 1958. The ratio of success in exploratory drilling was 32.0 percent in 1962 and 28.9 percent in 1961, whereas that in the United States was 18.38 and 17.92 percent in the respective years. The average depth per well increased from 4,594 to 4,667 feet in Oklahoma.

The U. S. oil industry last year drilled fewer exploratory wells than in any other year since 1950. And its success ratio, although slightly better than the 1961 results, was the second poorest since 1948.

New Theses Added to O. U. Geology Library

The following Master of Science theses have been added recently to The University of Oklahoma Geology Library:

Petroleum geology of T. 19 N., R. 6 W., Hennessey area, Kingfisher County, Oklahoma, by Ataolah Mogharabi.

Petroleum geology of the Bryant area, Okmulgee, Okfuskee, and McIntosh Counties, Oklahoma, by Carl D. Musgrove.

A study of fracture and drainage patterns in northern Cleveland County, Oklahoma, by Gary F. Stewart.

Geology and ground water of Amargosa Valley, Nevada and California, by George E. Walker.

A doctoral dissertation, *Palynology of the Mineral coal (Pennsylvanian) of Oklahoma and Kansas,* by James B. Urban has also been added.

Another doctoral dissertation, *The subsurface geology of the McAlester basin, Oklahoma,* by Ralph Willard Disney, which was completed but restricted in 1960, has been released and is now available.

National Gem and Mineral Show in Oklahoma City

The Oklahoma Mineral and Gem Society will host the national show to be presented by the American Federation of Mineralogical Societies and the Rocky Mountain Federation of Mineralogical Societies. Collections from many parts of the country will be exhibited in the 4-H Club building on the Oklahoma State Fair Grounds, Oklahoma City, from June 13 through June 16, 1963.

Individuals and dealers will display collections of minerals, jewelry, fossils, and artifacts, and some of the best collections in the country are expected at this national showing. Admission will be $1.00 for adults and $0.50 for high school students. Children under 12 will be admitted free.

The theme of the Oklahoma Geological Survey exhibit at this show will be *Economic Resources of Oklahoma Arranged by Geologic Periods*. Raw products quarried throughout the State will be shown, as well as many examples of the commercial products obtained therefrom. A booth has been reserved for display of publications of the Survey, and orders for these publications will be taken.

Further information about the National Gem and Mineral Show can be obtained from Mrs. Domer L. Howard, 1229 NW 47th Street, Oklahoma City, Oklahoma.

—K. S. J.

The Oklahoma Rockhound's Directory

The following is a list of rock and lapidary shops in and near Oklahoma.

Oklahoma

Anderson's
Medford

Cardin's Rock Shop
729 East Walnut
Cushing

DubLee Rocks & Gems
4731 S. Columbia Place
Tulsa

Geological Enterprises
Box 926
Ardmore

Glen's Originals
2401 South 17th St.
Chickasha

C. J. Hibbert
5108 N. Beaver
Bethany

Clyde Lee
Mountain View

O K Fossils
P.O. Box 7234
Tulsa

Painton's Rockery
Fairview

Pastime Lapidary
7408 E. 11th St.
Tulsa 12

Pickard's Rock Shop
Calumet

The Rangers Motel
Seiling

Sooner Lapidary
1005 East Idaho
Norman

Windle's Rock Shop
Rt. 2, Box 173
Bartlesville

Out-of-state

Beach's Rock Shop
R-2
Murfreesboro, Arkansas

Boodle Lane Minerals
Box 331
Galena, Kansas

Fossil Supply Co.
6507 Sondra
Dallas 14, Texas

Roy D. Humble
2219 Lamont
Dallas, Texas

Lovelace Rock & Mineral Shop
2610 Armory Road
Wichita Falls, Texas

Mahaffey's Nevada Rock Shop
1329 West Allison St.
Nevada, Missouri

Mallison Gem Co.
3816 Kushla
Dallas 16, Texas

Oscar E. Monnig
29 Chelsea Drive
Ft. Worth 15, Texas

Jimmie & Robt. Peck
3011 Spurlock
Dallas, Texas

A Morphologic Study and Emendation of *Vesicaspora* Schemel, 1951*

L. R. Wilson and B. S. Venkatachala†

The Paleozoic pollen genus *Vesicaspora* Schemel, 1951, is presently known from the Secor, Weir-Pittsburg, and Iron Post coals of the Des Moines Series and from the Dawson coal of the Missouri Series of Oklahoma's Pennsylvanian System. A similar stratigraphic distribution is evident in Kansas, Missouri, and Iowa (Schemel, 1951). *Vesicaspora* and closely related forms have been observed in the Upper Carboniferous rocks of France (Alpern, 1959) and Permian rocks of Australia (Balme and Hennelly, 1955), Germany (Leschik, 1956), South-West Africa (Leschik, 1959), Tanganyika (Hart, 1960), and India (Bharadwaj, 1960).

Palynological studies in Oklahoma have revealed differences in the structure of *Vesicaspora* from that described by Schemel (1951); consequently a detailed examination of specimens from the type locality was undertaken. Some of the slides and coal samples used by Schemel in his study of the plant microfossils in the Mystic coal seam of Iowa are in the palynological collection at the Oklahoma Geological Survey. These slides are the same as were used by him in the writing of a major honors thesis (1946) at Coe College, Cedar Rapids, Iowa, under the direction of L. R. Wilson. These slides, although quite usable, were augmented in the present investigation by others made from the coal samples. Hundreds of specimens have been examined on the old and new slides, and the photomicrographs reproduced in this paper have been taken with a Leitz Ortholux microscope, using oil immersion optics and Adox KB14 film. Additional studies were made under phase microscopy with a Zeiss photomicroscope.

Vesicaspora (Schemel, 1951) here emended

Type species:—*Vesicaspora wilsonii* Schemel, 1951.

Emended generic diagnosis.—Pollen grains bilateral, oval to circular in polar view; central body spherical, not discernible in many cases in distal polar view, distinct when viewed in lateral, oblique, and proximal polar positions; exposed portions of central body laevigate to finely granulose; saccus oval to circular in proximal or distal views, laevigate in surface view, infrareticulate, enveloping the central body in equatorial region, proximal cap and sulcus area free, saccus distally inclined in oblique and lateral compressions; sulcus fusiform

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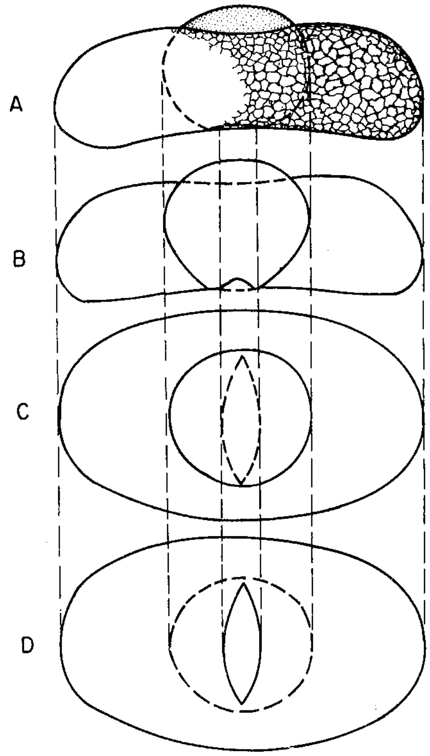
*One project supported by National Science Foundation Grant G-22083.
†B. S. Venkatachala, Birbal Sahni Institute of Palaeobotany, Lucknow, India, takes this opportunity to thank the United Nations Technical Assistance Organization for providing him a fellowship during the tenure of which the present work at the School of Geology, The University of Oklahoma, was completed.



Text-figure 1. Morphological interpretation of Vesicaspora (Schemel, 1951) here emended

A. Side view with proximal side at top of sketch showing saccus attachment, spherical central body and proximal cap, and distally inclined saccus with infrareticulate meshes.

B. Sectional view of "A" showing the sulcus.

C. Proximal polar view showing subcircular (spherical) central body and the saccus attachment on proximal side.

D. Distal polar view showing attachment of the saccus on the distal side, and the sulcus.

or irregular in outline, extending almost across central body at right angles to the long axis of the grain.

Discussion.—Schemel (1951, p. 748) described the pollen of *Vesicaspora* as follows: ". . . both bladder [saccus] and body are ellipsoidal in outline, with the bladder widest at right angles to the long dimensions of the body, in transverse view (relatively rare), the bladder is ellipsoidal with slight sulcus indentation and the body is tri-

(text continued on page 148)

Explanation of Plate I

Vesicaspora wilsonii **(Schemel) here emended**

All photomicrographs were taken with oil immersion optics.

Figure 1. Three pollen grains in tetrad arrangement; the fourth is detached, resulting in slight disarrangement of the normal position of the others. An unopened sulcus is seen on the distal side of the pollen in the lower right position. 40 x 29.4 microns, 41.2 x 29.4 microns, 36.7 x 27.4 microns. Mystic coal, OPC 407 C-3-2.

Figure 2. Polar view showing proximal surface; 46.2 x 39.8 microns, central body 37.8 microns, sulcus 6.3 microns. Mystic coal, OPC 407 C-5-3.

Figure 3. Same as figure 2, but at a lower focal plane, showing distal sulcus.

Figure 4. Distal polar view showing ill-defined sulcus; 37.8 x 37.3 microns. Mystic coal, OPC 407 C-4-2.

Figures 5, 6. Distal polar view showing the subcircular central body and prominent and partly torn sulcus. 43.5 x 31.3 microns, central body 21.2 microns, sulcus 6-8 microns wide. Mystic coal, OPC 407 C-4-1.

5. Lower focal plane showing infrareticulation of saccus.

6. Higher focal plane showing smooth exterior surface of saccus.

Figures 7-9. Proximal polar view showing subcircular central body, the sulcus extending across central body; note compression fold on proximal side of the pollen. Figures 8, 9 are in progressively lower focal planes showing the nature of the sulcus. 39.15 x 25.23 microns, central body 20 microns, sulcus 6-8 microns wide. Mystic coal OPC 407 C-4-3.

Figure 10. Proximal polar view showing the surface structure of central body. The sulcus shows faintly upon distal side. 37.8 x 27.3 microns. Mystic coal, OPC 407 C-2-1.

Figure 11. Same as figure 10, but at a lower focal plane, showing infrareticulations; sulcus obscure.

Figure 12. Proximal polar view showing large central body and a prominent well-developed sulcus. This specimen is subcircular and has a relatively larger central body than most specimens observed. This type is considered here as a variant from the normal. 33.8 x 29.48 microns, central body 26.2 microns, sulcus 4-6 microns wide. Mystic coal, OPC 407 C-1-2.

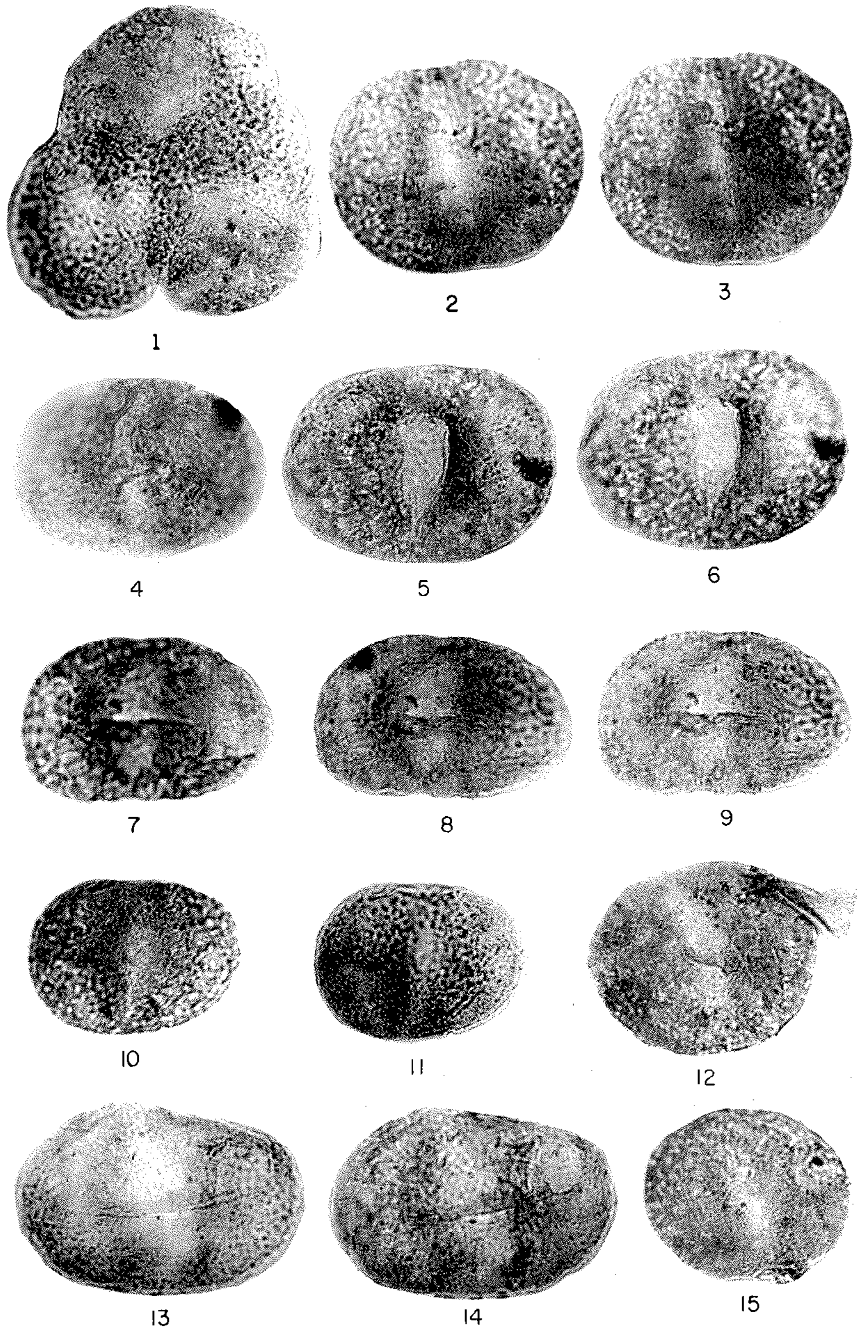
Figures 13, 14. Proximal polar view showing the central body and the sulcus; note compression fold across the specimen. 44.1 x 27.3 microns, central body 21.2 microns, sulcus 6.3 microns wide. Mystic coal, OPC 406 C-2-3.

13. Higher focal plane.

14. Lower focal plane.

Figure 15. Proximal polar view showing the central body and saccus attachment; the line of attachment is prominently seen on the left side of the specimen. 33.6 x 29.4 microns. Mystic coal, OPC 407 C-2-2.

Plate I



Explanation of Plate II

Vesicaspora wilsonii **(Schemel) here emended**

All photomicrographs were taken with oil immersion optics.

Figure 1. Obliquely oriented pollen showing sulcus on the central body; edge of saccus along the equator. 39.15 x 28.71 microns. Mystic coal, OPC 407 C-7-2.

Figure 2. Obliquely oriented pollen showing the proximal area of the central body, the equatorial proximal attachment of the saccus, and partially covered distal sulcus; granulose ornamentation on the body seen on the proximal cap. A *Laevigatosporites* fragment overlaps on the lower left part of the saccus. 34.8 x 26.1 microns, central body 20.7 microns. Mystic coal, OPC 406 C-3-3.

Figure 3. Obliquely oriented pollen showing the proximal part of the central body at top and the inclined saccus appearing nearly bisaccate owing to lateral folding; sulcus is completely covered by the overhanging saccus. 33.6 x 25.2 microns. Mystic coal, OPC 407 C-1-3.

Figure 4. Obliquely oriented pollen in proximal surface view showing sulcus indistinctly on distal side, and profile view of central-body cap. 33.8 x 26.1 microns. Mystic coal, OPC 407 C-7-3.

Figure 5. Same as figure 4, but at a lower focal plane, showing laevigate surface and infrareticulations on the saccus.

Figure 6. Obliquely oriented pollen with proximal surface in view showing saccus attachment to the central-body cap and sulcus indistinct on distal surface. The monosaccate nature of the genus is clearly exhibited in this specimen. 35.67 x 27.84 microns, central body 21.76 microns. Mystic coal, OPC 406 C-1-1.

Figure 7. Obliquely oriented pollen with proximal surface in view showing central body and the bladder attachment; the sulcus is seen on the distal side. 39.15 x 27.84 microns, central body 25.86 microns. Mystic coal, OPC 406 C-5-1.

Figure 8. Same as figure 7, but at a lower focal plane.

Figure 9. Obliquely oriented pollen showing proximal cap free of the saccus, distal sulcus, and attachment of saccus in equatorial region. 43.5 x 27.84 microns, central body 26.1 x 22.76 microns. Mystic coal, OPC 407 C-8-2.

Figure 10. Obliquely oriented pollen showing granulose proximal cap free of the saccus, and the distally inclined saccus lobes with compression folds. The nature of the compression folds demonstrates the monosaccate character of the genus. 40.89 x 27.84 microns, central body 26.1 microns. Mystic coal, OPC 406 C-1-2.

Figure 11. Same as figure 10, but at a lower focal plane.

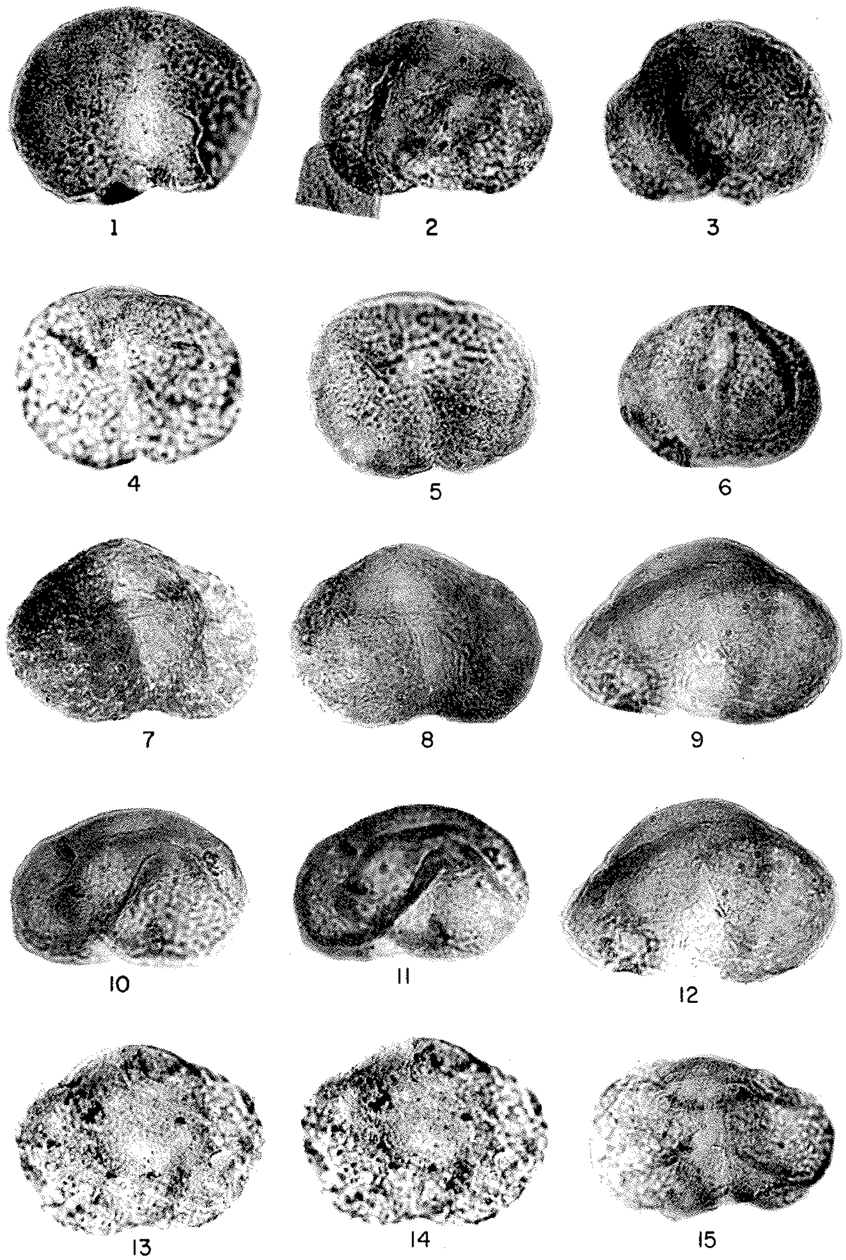
Figure 12. Same as figure 9, but at a higher focal plane.

Figure 13. Obliquely oriented pollen with the proximal cap in profile showing attachment of the saccus; specimen slightly overmacerated. 39.6 x 29.4 microns, central body 27.3 x 21.2 microns. Mystic coal, OPC 407 C-7-4.

Figure 14. Same as figure 13, but at a higher focal plane.

Figure 15. Obliquely oriented pollen with proximal cap at top of the photomicrograph showing the position of the central body and its attachment to the saccus; sulcus on distal side indistinct. 41.2 x 25.2 microns. Mystic coal, OPC 407 C-5-4.

Plate II



angular in outline." From the above description and Schemel's figures 1 and 3 (1951, p. 748), it appears that the central body is ellipsoidal in polar view and triangular in oblique and lateral views. His illustrations are line drawings, and no subsequent photomicrograph was published. A reinterpretation of the morphology is illustrated in figure 1A-D. The central body is spherical, and the line of saccus attachment is subequatorial on the proximal side and along the sulcus on the distal side. The monosaccate nature of the saccus is demonstrated in specimens illustrated in plate I, figures 1-15. Schemel's (1951) description of the genus indicates that it is monosaccate. Later authors (Alpern, 1959; Bhardwaj, 1960; Jizba, 1962; Hart, 1960; Potonié, 1958) described *Vesicaspora* as a bisaccate pollen. In several instances, owing to oblique orientation, lateral flattening of the pollen, and the inclination of the saccus, a bisaccate appearance is simulated (pl. II, figs. 2-15).

The following species belong to *Vesicaspora* Schemel, 1951, here emended.

1. *Vesicaspora wilsonii* (Schemel) emended.
   Remarks.—Schemel (1951) did not designate a holotype specimen; however he stated (p. 743) that the types are in his personal collection. If no holotype is designated by Schemel, the authors suggest that the specimen illustrated here in plate I, figures 5, 6 be designated as the neotype. The specimen is from the same material from which Schemel's original studies were made.
2. *Vesicaspora schaubergeri* (Potonié and Klaus, 1954) Jizba, 1962.
   Holotype:—Potonié and Klaus, 1954, specimen illustrated in plate 10, figure 7.
3. *Vesicaspora ovata* (Balme and Hennelly, 1955) Hart, 1960.
   Holotype:—Balme and Hennelly, 1955, specimen illustrated in plate 5, figure 49.

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Schemel, M. P., 1946, Plant microfossils and correlations in the Mystic coal seam: Coe College, unpublished honors thesis, 18 p., 2 pls.

__________ 1951, Small spores of the Mystic coal of Iowa: Amer. Midland Naturalist, vol. 46, p. 743-750, 4 figs.

A Giant Crystal of Quartz

In 1958, a large pegmatite body, with a surface exposure of 36 by 44 meters, was discovered at the survey mark of Akdžvyilyau, in the middle of the northwest Tarbagatai coarse-grained leucocratic granite. The pegmatite body has the form of an asymmetrically zoned concave lens, having in general a north-northwestward (350°) strike, with dip angles of 30°-45° in the southern part and 20° in the northern part, along the northeast strike.

The characteristic features of this granite, which contains the pegmatite body, are albitization, enrichment in quartz, and coarse-grained crystals. The asymmetrical zonation is well expressed, especially in the northern part of the pegmatite body where the zones are pegmatitic, monomineralic-microclinic, and blocky, made up by the large blocks of quartz and microcline-perthite. In the southern part of the pegmatite body the quartz core is directly in contact with the granite altered by metasomatism and at some places contains the separate blocks of microcline-perthite.

The main mass of the pegmatite body consists of a quartz core, made of nontransparent, white to gray, solid quartz. The vertical thickness of the quartz core is more than 10 meters (the deep bore hole down to 10 meters was still in the quartz core).

At the contact of the quartz core with granite, the latter bears microscopically observable traces of replacement. The quartz growing into the granite forms a structure similar to graphic structure. Microscopic observations determined that the quartz is not a monocrystal but is a granular aggregate with subsequent loss of separate masses of aggregate. According to a number of indications, this is a case of graphic structure created by metasomatism.

In the northeastern part of the pegmatite body the upper part of a large cavity, 9 by 3 meters at the top, was uncovered. This cavity is at the contact of the quartz core and a zone of microcline-perthite. At the center of the clay-filled cavity, a giant quartz crystal, reaching

7.5 meters along the *c* axis and 1.6 meters along the *a* axis, was discovered. The weight of the crystal was estimated at 70 tons*.

The facets of the crystal belong to a prism, and two rhombohedrons are involved. At the northwest side of the crystal is a well-developed knob, faceted by the rhombohedrons *R* and *r*; the southeastern part of the crystal is not crystallized externally, and it has traces of crushing and gliding. It seems that the crystal had grown from the quartz core but had subsequently cleaved off as a result of tectonic movements.

The prism facets are irregular with typical quartz striae, the spacing between individual striae reaching 5 cm. The facets of the rhombohedrons are smooth. The crystal is formed of gray semi-transparent quartz, with numerous gas and liquid inclusions. It also includes broken pieces of pink microcline. On the facets are prolific crusts of the light-green muscovite, gilbertite.

The clay, in which the crystal is buried, contains broken fragments and crystals of microcline, apatite, quartz (morion, smoky quartz, and some transparent quartz). The dimensions of these crystals are varied. Next to the small crystals are many large ones up to 0.8-1.0 meter along the *c* axis, and these are excellently crystallized. Characteristic for all crystals in the cavity are zonal structure, numerous fractures, and abundance of broken-off and subsequently regenerated crystals.

The zonation is expressed by alternation of different colors and also by fixed layers of mica, which separate one zone of quartz from another; side by side with the color zonation is a segmentation of crystals. Inside of many crystals are broken pieces of quartz, similar to the quartz of the core.

It seems that zonation is a result of an irregular process of crystallization, which was caused by an irregular influx of solution and by changing of the character of the solution and the environment. The latter finds its expression in the appearance of the differently colored crystal zones and in the development of mica layers. Only under conditions of a prolonged inflow of the feeding solution could the giant crystals, as well as the numerous other crystals, possibly be formed.

The cavities in which the described crystals have originated have seemingly been formed as a result of dissolution of the quartz core by alkaline solutions. The silica brought in by the solution has been recrystallized in the form of the above-described quartz crystals, the

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*Largest quartz crystals found:

10 tons at Volini, USSR: B. Ya. Osadchev, 1946, Priroda, no. 10, p. 60-62.

14 tons at Kazakhstan, USSR: O. P. Komazov, 1951, ZVMO, vol. 80, fasc. 2, p. 153.

40 tons in Brazil: D. F. Campbell, V. D. Johnson, S. P. D. Butler, see note by D. P. Grigoriev, 1947, Priroda, no. 2, p. 59-60. [Grigoriev apparently cited: Campbell, D. F., 1946, Quartz crystal deposits in the state of Goiaz, Brazil: Econ. Geology, vol. 41, p. 773-799; and Johnston, W. D., Jr. and Butler, R. D., 1946, Quartz crystal in Brazil: Geol. Soc. America, Bull., vol. 57, p. 601-650.]

walls of the disintegrating quartz core serving as a "primer" for the formation of newly originating crystals.

The above article is by G. A. Yurgenson of the Transbaikal Scientific Exploratory Institute of the Siberian Division of the Russian Academy of Science, and it was published in Vsesouiznogo Mineralogicheskogo Obschestvo, Zapiski, Series 2, vol. 90, no. 6, p. 747-748, 1961. The journal is the bulletin of the All-union Mineralogical Society, commonly abbreviated ZVMO. The translation was made in February 1962 by Slobodan Bozovich, graduate student in geology at The University of Oklahoma, and the translation was checked by M. K. Elias.

Large quartz crystals are of interest in Oklahoma because of the existence here of some large crystals. An article by Thomas R. Polk (Large smoky quartz crystals from the Wichita Mountains, Oklahoma: Okla. Acad. Science, Proc., vol. 29, p. 41-42, figure 1, 1948) described two quartz crystals found in the government quarry operated during construction of the dam for Lake Altus. The larger crystal is 1 foot 5 inches long and weighs 75 pounds. The crystals occur in miarolitic cavities in granite. They are indeed large, but are pygmies as compared to the Russian crystal.

—C. C. B.

Recent Articles on Morrowan Problems

Henbest has recently designated type sections for the Pitkin Limestone, the Hale Formation, the Cane Hill Member, the Prairie Grove Member, the Bloyd Formation, the Brentwood Limestone, the Woolsey Member, the Kessler Limestone, and the Greenland Sandstone Member of the Atoka Formation.

In a companion article Henbest gave the name Dye Shale to the unit above the cap rock of the Baldwin coal and below the Kessler Limestone, and gave the name Trace Creek Shale to the uppermost member of the Bloyd.

In an article on fossil amphibians, Romer ascertained that the embolomere described by Moodie as from the Coal Measures of Washington County, Kansas, actually came from the Baldwin coal of Washington County, Arkansas. The three articles are:

Henbest, L. G., 1962 [1963?], Type sections for the Morrow series of Pennsylvanian age, and adjacent beds, Washington County, Arkansas: U. S. Geol. Survey, Prof. Paper 450-D, art. 130, p. D38-41.

Henbest, L. G., 1962 [1963?], New members of the Bloyd Formation of Pennsylvanian age, Washington County, Arkansas: idem, art. 131, p. D42-44.

Romer, A. S., 1963, The larger embolomerous amphibians of the American Carboniferous: Harvard, Museum Comp. Zoology, Bull., vol. 128, p. 415-454.

—C. C. B.

OÖLITES AND ALGAL AGGREGATES OF THE WEST SPRING CREEK FORMATION (ORDOVICIAN), ARBUCKLE MOUNTAINS, OKLAHOMA

MARTIN W. SCHRAMM, JR.

INTRODUCTION

This paper gives the results of a preliminary investigation made in an attempt to assess the stratigraphic value of oölite occurrences in the West Spring Creek Formation of Ordovician age (Arbuckle Group) in a portion of the Arbuckle Mountains of Oklahoma. Sampling and measurement of eleven successive stratigraphic intervals in which megascopically visible oölites or algal concretions occurred were conducted in the excellent road cut along U. S. Highway 77, W½ SW¼ sec. 19, T. 2 S., R. 2 E.

Samples were thin-sectioned and photomicrographed to illustrate the variability of oölitic structures at different stratigraphic horizons. As an outcome of the study, an algal origin for some of the structures is suspected.

MICROSCOPIC FEATURES OF BEDS

The following is a detailed description of the photomicrographed specimens illustrated on plates I to IV. Only one photomicrograph was prepared for each sample. Except where noted, the illustration is representative of microscopic features observed throughout the sample collected. Reference may be made to the generalized section for the stratigraphic position of each bed discussed. Due to the small scale to which the section is drawn, each bed is represented by a line. The thickness of each bed is given in the detailed description.

DISCUSSION

The writer can only postulate as to which structures are of chemicophysical origin (oölites) or which are organic (algal). Amsden (1960, p. 166-167) illustrated the difference between oölites of the Keel Member and algal coatings of the Ideal Quarry Member of the Chimneyhill Formation (Hunton). The algal structures tend to be crinkled, producing irregular bodies with concentric banding, whereas the oölites are spherical with marked radial structures. Amsden did not find, to the writer's knowledge, aggregates of oölites and other forms encompassed by an algal coating, such as observed in the West Spring Creek Formation. Bradley (1929), in a critical study of oölites from various parts of the Green River Formation, was unable to find conclusive evidence to support an earlier hypothesis that they were formed by algae, despite their intimate association with algal reefs. He was, however, able to show structures of algal "pebbles" that are wholly analogous to those of large *Chlorellopsis coloniata* reefs, thus clearly distinguishing them from inorganic oölites. Aggregates similar to those observed in the West Spring Creek were shown by Bradley to be oölites. These aggregates undoubtedly represent second and third generation oölite granules and pebbles which have been transpor-

(text continued on page 162)

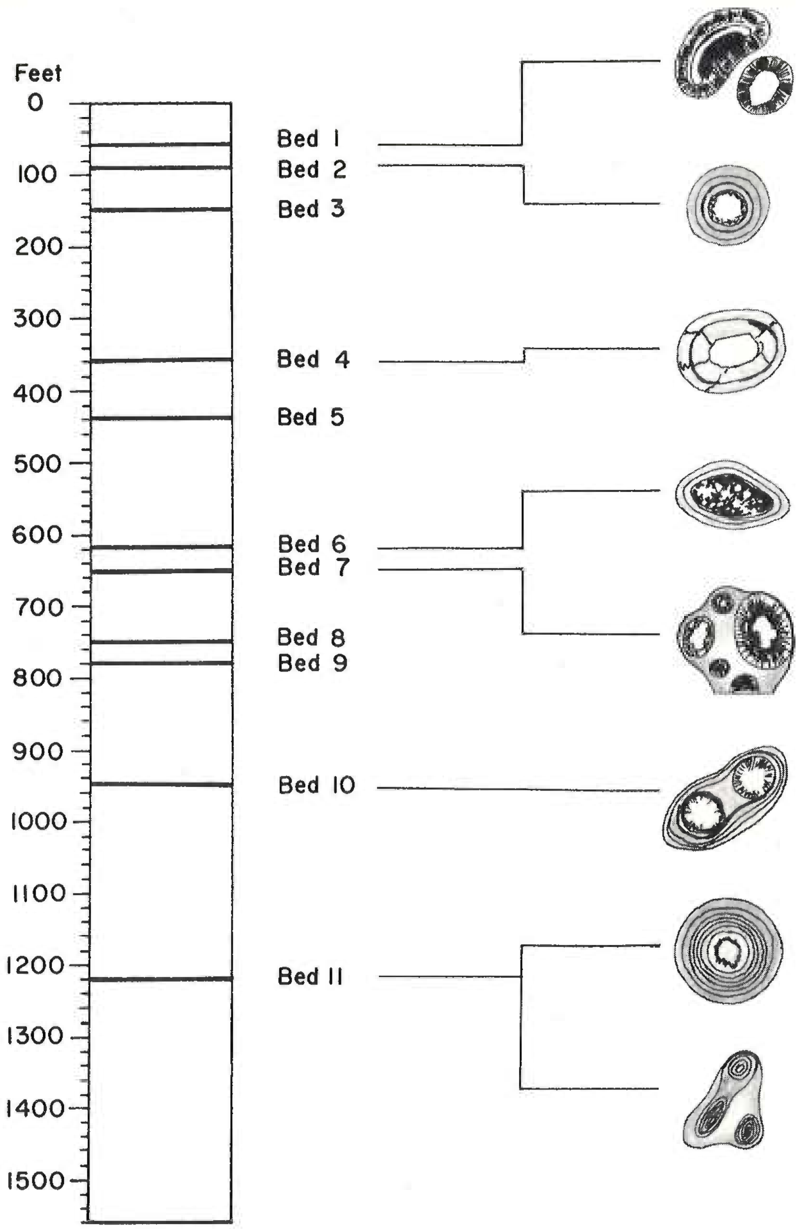


Figure 1. Generalized section of the West Spring Creek Formation in road cut along U. S. Highway 77, W½ SW¼ sec. 19, T. 2 S., R. 2 E. Strike N55°W, dip 55-58°SW.

Explanation of Plate I

Figures 1, 2. Bed 1 (6 inches).

1. Photomicrograph (x11.25), showing oölites with a pronounced radial structure. The oölites conform to the shape of the core. Note conformity to fossil-fragment nucleus in center of figure. Quartz grains are common, many acting as nuclei. No concentrically developed oölite was observed in the slide.
2. Photomicrograph (x11.25), showing radial structure of oölite about a quartz nucleus.

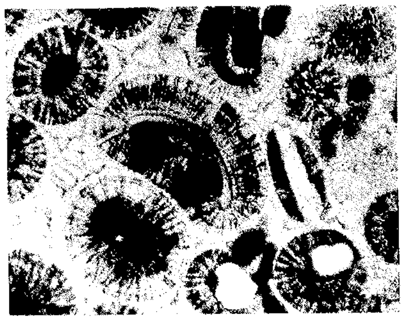
Figures 3, 4. Bed 2 (1 foot 3 inches).

3. Photomicrograph (x11.25), showing only observed concentrically banded structure in specimen. The oölite is not representative of bed 2, but is similar to those oölites common to bed 11 (pl. IV, figs. 3, 4). The remainder of the specimen is composed of rounded quartz grains and reworked granules of microcrystalline calcite.
4. Enlarged view of the oölite in figure 3, showing nucleus of sparry calcite.

Figures 5, 6. Bed 3 (1 to 2 inch sandstone pebble at top of sandstone bed).

5. Photomicrograph (x11.25) of sandstone, showing subangular quartz grains with silt cement.
6. Enlargement of figure 5, showing undulatory algal structures between sand grains. Concentric coating was not observed on individual grains.

Plate I



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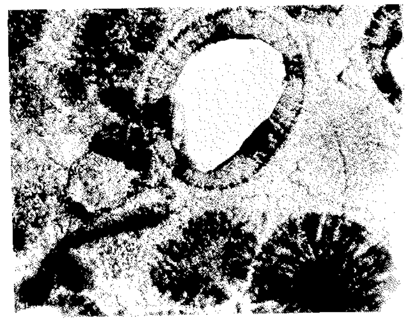

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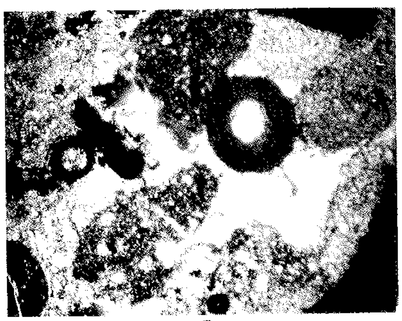

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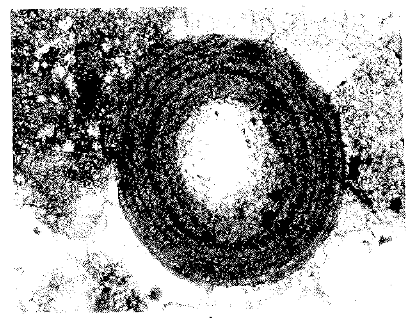

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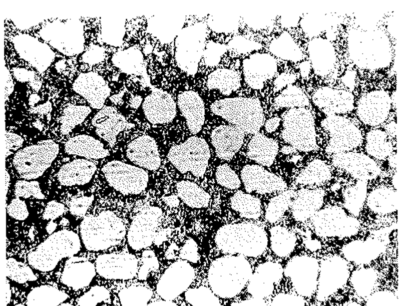

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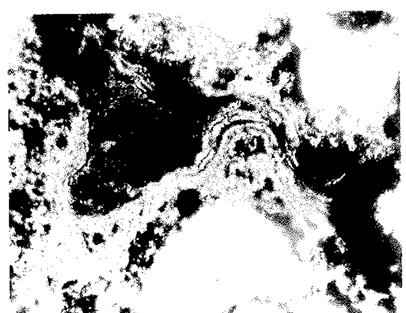

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Explanation of Plate II

Figures 1, 2. **Bed 4 (11 inches).**

1. **Photomicrograph (x11.25), showing a typical calcite development around floating sand grains. Both concentric and radial growth features are absent. The origin is probably primarily inorganic.**
2. **Detail of oölite in upper right of figure 1. Tension cracks appear to have formed, perhaps as the result of quartz overgrowth of the nucleus.**

Figures 3, 4. **Bed 6 (ranges 1 to 2 feet).**

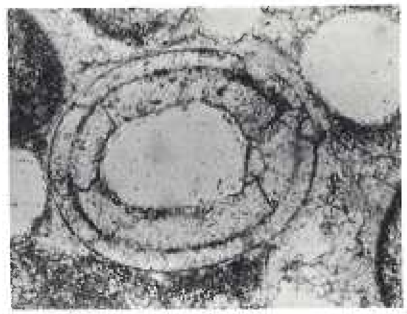
3. **Photomicrograph (x11.25), showing vague banded coating, of questionable chemicophysical origin, around second generation granules composed of coarsely crystalline calcite.**
4. **Enlarged view of figure 3.**

Figures 5, 6. **Bed 7 (4 feet).**

5. **Photomicrograph (x11.25), showing amoeba-shaped granule containing first generation oölites and smaller granules. The oölites have a pronounced radial pattern. Narrow bands with radiate pattern, which normally encrust the aggregate, are believed to represent a second or third generation inorganic precipitate indigenous to this bed.**
6. **Detail of oölite shown in figure 5. This oölite is probably allogenically derived.**

Plate II


1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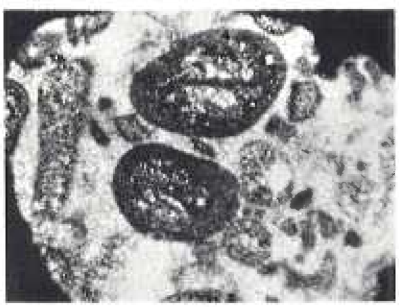
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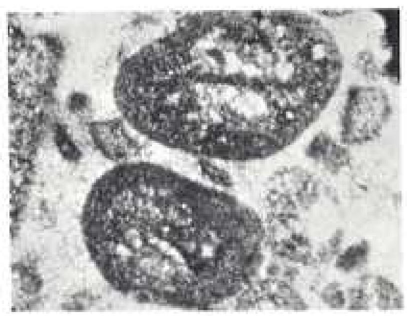
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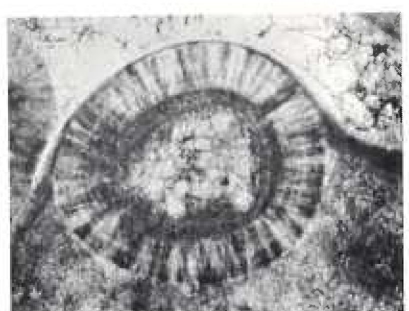
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Explanation of Plate III

Figures 1 - 4. **Bed 7 (4 feet).**

1. **Photomicrograph (x11.25) showing dual development of stylolite in oölite rock. Oölites are vertically displaced in the manner of fault displacements.**
2. **Close-up of terminus of stylolite showing inorganic insoluble residue.**
3. **Photomicrograph (x11.25) of third generation oölite granule common to the bottom of bed 7. Narrow double banding around aggregate is believed to be an algal coating.**
4. **Photomicrograph (x11.25) showing another example of aggregates encrusted by an algal coating.**

Figure 5. **Bed 8 (1 foot 10 inches).**

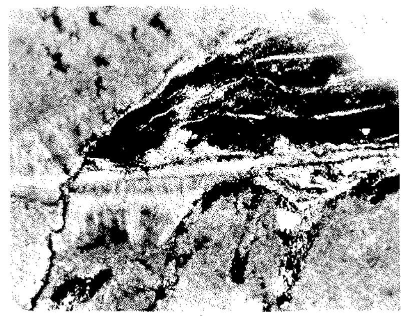
5. **Photomicrograph (x11.25) of limestone microbreccia. Dark subangular particles of microcrystalline calcite float in a groundmass of coarse sparry calcite. No spherule was observed.**

Figure 6. **Bed 9 (1 foot 8 inches).**

6. **Photomicrograph (x11.25) showing dislocation cracks in limestone microbreccia. The cracks were filled with coarsely crystalline cement during diagenesis of the rock.**

Plate III

1



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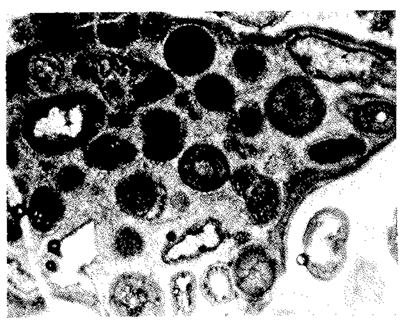

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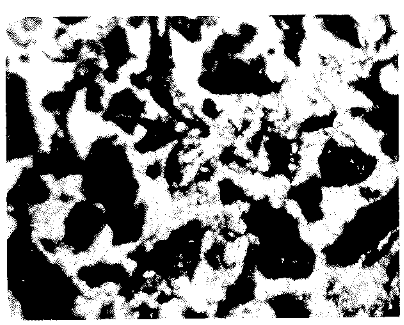

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Explanation of Plate IV

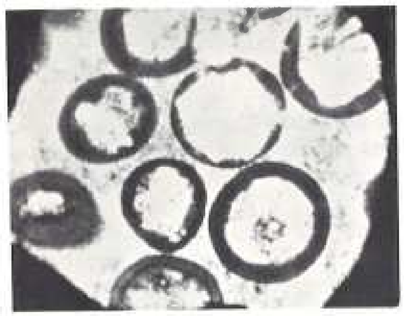
Figures 1, 2. **Bed 10 (3 feet 6 inches).**

1. **Photomicrograph (x11.25) showing oölites formed concentrically around sparry calcite cores. Corrosion of the concentric layers suggests secondary calcitization.**
2. **Photomicrograph (x11.25) showing what may be algal coatings encompassing oölites.**

Figures 3 - 6. **Bed 11 (4 feet).**

3. **Photomicrograph (x11.25) showing large concentrically developed oölite and other oölites typical of this bed.**
4. **Detail of spherical oölite shown in figure 3. The nearly perfect sphericity and smoothness of rim suggest inorganic origin rather than algal growth despite the lack of radial structure.**
5. **Photomicrograph (x11.25) showing reworked generations of oölites common to bed 11.**
6. **Photomicrograph (x11.25) in which algal encrustation appears to have been totally responsible for aggregation of the oölites.**

Plate IV



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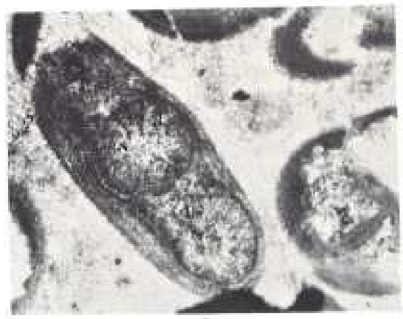

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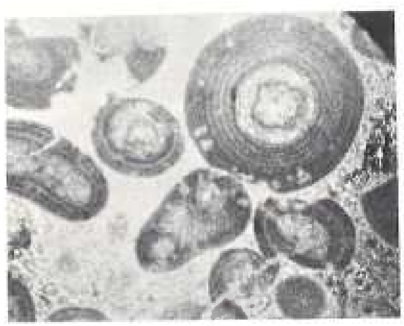

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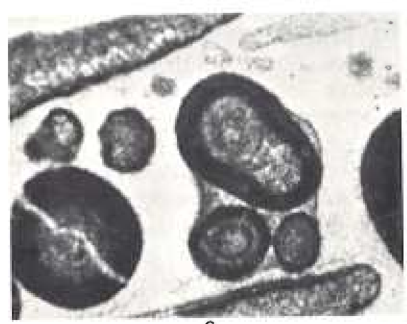

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ted and reworked from older units. Either generation may have an algal coating.

In the West Spring Creek Formation, the eccentrically disposed encrustations which encompass one or more oölites, spherulites of unknown affinities, or pebbles of reworked oölites and which display no radial structure have an algal rather than a chemicophysical origin. Spherules having irregular, crinkled rims, despite the lack of radial structure, are in all probability oölites.

To the right of the generalized section (fig. 1) are pictorial representations of the more significant identifiable characteristics of the important oölite beds in the outcrop studied. Beds 7, 10, and 11 are characterized by second and third generation reworked oölites, which are probably encrusted with algal material. The incorporated oölites in beds 7 and 10 display vague to fair radial patterns about calcite nuclei. Beds 2, 6, and 11 are characterized by concentrically developed oölites with calcite nuclei. The oölite in bed 2 was the only one observed in the sample collected; hence, it is not representative, although its presence suggests lateral proximity to an oölitic facies of that bed. Oölite nuclei in beds 1 and 4 are predominantly quartz grains, some of which appear to have developed minor quartz overgrowths. Those oölites in bed 1, however, differ from those in bed 4 in that a radial pattern prevails and fossil fragments are of secondary importance as nuclei. The oölite structure in bed 4 is atypical, displaying neither radial nor concentric characteristics. Its features are highly distinctive and readily identifiable.

No photomicrograph was made for a sample from bed 5, which was a 3-foot 3-inch bed of "birdseye" limestone. Microscopic examination failed to show oölitic or algal structures to which calcite flecks could be related.

CONCLUSIONS

The results of this study are twofold: (1) algae participated in the precipitation of coatings around some oölites, reworked oölite pebbles, and granules in the West Spring Creek Formation, and (2) cursory examination of algal aggregate and particularly oölite structures shows a distinct type differentiation within the section studied. Some structures appear to be stratigraphically nonrecurrent, at least within the West Spring Creek Formation.

Whether or not these structures have stratigraphic value as identifying characteristics can only be ascertained by more detailed sampling and intensive study of each oölite bed, and by similar studies and comparison with sections of the West Spring Creek elsewhere in the Arbuckle Mountains.

This work was conducted as a term project in Geology 233 at The University of Oklahoma, under the direction of Dr. L. R. Wilson who kindly made the photomicrographs.

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Julius Rex McGehee

1905-1963

Rex McGehee was born to Mr. and Mrs. J. C. McGehee on September 17, 1905, in Chickasha, Oklahoma. He attended the grade school and high school there. His parents moved to Norman and Rex entered The University of Oklahoma. There he was initiated into Kappa Alpha social fraternity. He was a member of the Jazz Hounds, Pick and Hammer Club, and Sigma Gamma Epsilon, and an associate member of Sigma Xi. He graduated with the degree of Bachelor of Science in Geology in June, 1930. He served as paleontologist with Oklahoma Geological Survey, working with Dr. C. E. Decker, who named a trilobite for him (*Lonchodoma mcgeheei*).

Rex went to the University of Illinois and did graduate work from 1931 to 1933 and served as assistant stratigrapher for the Illinois State Geological Survey.

In October 1933, McGehee joined Shell Oil Company, and he rose in the company throughout the 30 years he remained with Shell. He served in St. Louis, Effingham, Centralia, Tulsa, Calgary, and Denver. He had been a member of the American Association of Petroleum Geologists since 1930, of the Geological Society of America since 1956, and of local societies such as Tulsa Geological Society and Rocky Mountain Association of Geologists.

Rex was married to Merrie Mae Southworth on September 4, 1943. Their daughter Merrie Ann was born in 1947, and Nancy Alice in 1952.

Rex's hobbies were golf and photography. In his career he was a leader and inspiration for many young men whom he trained or advised in stratigraphy. He had innumerable friends and admirers.

Rex had suffered from coronary weakness for some time, but the sudden fatal attack was unexpected and was a great shock to his family and friends.

As is normal with major-oil-company geologists, his publications are few, but his are high in quality.

Pre-Waterways Paleozoic stratigraphy of Alberta Plains, in Clark, L. M., Alberta Symposium, Amer. Assoc. Petroleum Geologists, Bull., vol. 33, p. 603-613, April 1949; *revised*, 1954, *in* Western Canada sedimentary basin—a symposium: Amer. Assoc. Petroleum Geologists, p. 131-142.

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—C. C. B.

Ground Water in Caddo County and Adjacent Areas

Circular 61, *Ground-water resources of the Rush Springs Sandstone in the Caddo County area, Oklahoma,* by Harry H. Tanaka and Leon V. Davis, U. S. Geological Survey, was issued by the Oklahoma Geological Survey on May 6, 1963. The circular deals with the occurrence and use of ground water in Caddo County and parts of adjacent counties in which the Rush Springs Sandstone is the principal aquifer. The document comprises 63 pages, 11 figures, and 2 colored plates. Plate I is an outcrop-distribution map of the Rush Springs Sandstone. Plate II is a water-table map of the Caddo County irrigation area. Price of the publication is $2.25 paper bound.

OKLAHOMA GEOLOGY NOTES

Volume 23 June 1963 Number 6

IN THIS ISSUE