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Cover Picture

BAUM LIMESTONE LENTIL

The basal unit of the Antlers Sand (Cretaceous Trinity Group) in south-central Oklahoma is the Baum Limestone Lentil, which crops out in a group of inliers and outliers over an area 15 miles long and 10 miles wide along the edge of the Cretaceous overlap in Johnston, Carter, and Marshall Counties. The unit was originally described as a member of the Paluxy Formation.

The Baum rests unconformably upon the eroded surface of folded Paleozoic strata and Precambrian igenous rocks of the Arbuckle Mountains terrane. It has a maximum thickness of 90 feet and consists of four lithofacies, the principal one of which is a gray to pinkish-gray, fine-grained, massive limestone. The other facies are a basal red clay, a limestone conglomerate, and an arkosic limestone-calcareous arkose sequence.

Lithologic, stratigraphic, and paleontologic studies indicate that the Baum was deposited in a lagoonal environment. The rock materials comprise clastics, derived from the immediate north, and chemically and biologically precipitated carbonates. The presence of charophyte oögonia and some ostracodes indicates fresh-water or brackish-water conditions.

The cover picture is of an exposure of the principal, massive limestone facies of the Baum in a quarry at C NE¼ SE¼ sec. 12, T. 4 S., R. 4 E., Johnston County. Chemical analyses of the rock reveal it to be a high-calcium limestone, with an average calcium carbonate content of 96 percent. The picture is reproduced from a report on the Baum by John Rex Weyland and William E. Ham, published in 1955 as Oklahoma Geological Survey Circular 33.

THE MINERAL INDUSTRY OF OKLAHOMA IN 1966*
(Preliminary)

ROBERT B. McDOUGAL†

Oklahoma's mineral-industry output, valued at an estimated $980 million in 1966, was about $72 million, or about 8 percent, greater than in 1965, according to the Bartlesville, Oklahoma, office of the Bureau of Mines, U. S. Department of the Interior. The substantial gain from the previous year resulted from increased production of petroleum, natural-gas liquids, helium, and stone, and—to a lesser extent—of copper, gypsum, lime, salt, sand and gravel, silver, and tripoli, which overshadowed declines in cement, clays, coal, lead, natural gas, and zinc. Most notable improvement during 1966 was the tremendous stride made in petroleum production, the highest in 28 years. Mineral fuels remained the State's dominant mineral industry, accounting for more than 94 percent of the total 1966 mineral value.

MINERAL FUELS

Coal.—Output of coal continued its declining production trend. The Kerr-McGee Corporation announced that the firm would construct 50 ovens near Stigler in Haskell County to produce metallurgical coke from the company's coal reserves in the area. Each oven is to produce 10 tons of coke in a 24-hour period. Two ovens are to be completed about April 1, 1967, and the remainder are to be finished by July 1. Construction of the ovens will initiate a multimillion-dollar coal-mining and coke-plant operation planned by Kerr-McGee.

In September, the State of Oklahoma asked the Interstate Commerce Commission to order 38 railroads to lower their rates on coal shipped from Oklahoma. The complaint charged that present rates for Iowa destinations are uniform from all Oklahoma origins without regard to distance, cost of service, or other valid factors. The rates from Oklahoma origins are $0.97 to $1.03 per ton, or more, higher on shipments to Iowa than on coal shipped from Kansas to Iowa. As a result of the discriminatory rates, Oklahoma mines have been forced to greatly curtail their operations.

Natural gas.—Preliminary estimates of the marketed output of natural gas in 1966 indicated a 2-percent decrease and a drop of 1 percent in value.

Natural-gas liquids.—Condensable liquids, stripped from natural gas by 74 natural-gasoline plants and 4 cycling plants, reached a new record of 1,507 million gallons. Mobil Oil Corporation converted its plant in Dewey County from a refrigeration process to a refrigeration-absorption process to increase plant capacity.

Allied Chemical Corporation's Union Texas Petroleum Division

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completed construction of its 90-million-cubic-feet-per-day Chaney Dell plant in Major County.

Underground storage capacity for LP gases totaled 2,209,000 barrels at 13 sites at the end of 1966. An additional site will add 250,000 barrels to the capacity in April 1967 when completed for the Sunray DX Oil Company at its Tulsa refinery.

Petroleum.—An estimated 224 million barrels of crude petroleum produced in 1966 was 10 percent greater than in 1965. Not since 1938 has this amount of petroleum been produced in the State. The daily

TABLE I.—MINERAL PRODUCTION IN OKLAHOMA[1]

MINERAL	1965 QUANTITY	1965 VALUE (THOUSANDS)	1966 (PRELIMINARY) QUANTITY	1966 (PRELIMINARY) VALUE (THOUSANDS)
Clays[2] (thousand short tons)	794	$ 806	754	$ 766
Coal (bituminous) (thousand short tons)	974	5,520	850	[3]
Gypsum (thousand short tons)	761	2,343	816	2,398
Helium (thousand cubic feet)	300,992	9,532	340,600	11,922
Lead (recoverable content of ores, etc.) (short tons)	2,813	878	[3]	[3]
Natural gas (million cubic feet)	1,320,995	182,297	1,294,000	179,866
Natural-gas liquids:				
Natural gasoline and cycle products (thousand gallons)	570,129	34,561	572,200	35,476
LP gases (thousand gallons)	894,665	32,208	935,300	37,412
Petroleum (crude) (thousand 42-gallon barrels)	203,441	587,944	224,000	651,840
Salt (thousand short tons)	9	65	10	70
Sand and gravel (thousand short tons)	5,218	6,023	5,400	6,260
Stone (thousand short tons)	16,417	18,071	17,178	20,319
Zinc (recoverable content of ores, etc.) (short tons)	12,715	3,713	[3]	[3]
Value of items that cannot be disclosed: bentonite, cement, copper, lime, silver, tripoli, volcanic ash, and value indicated by footnote 3	----	23,953	----	33,408
Total	----	$907,914	----	$979,737

[1] Production as measured by mine shipments, sales, or marketable production (including consumption by producer).
[2] Excludes bentonite; included with "Value of items that cannot be disclosed."
[3] Included with "Value of items that cannot be disclosed."

petroleum production allowable set by the Corporation Commission was increased in January to 34 percent of the depth-acreage formula to maintain a closer balance with demand. From March through June the daily rate was 38 percent, followed by a drop to 34 percent until September. In October the rate was increased to 42 percent, and for December the rate was placed at 50 percent—the highest rate since adoption of the depth-acreage formula in 1961.

The Oil and Gas Journal reported a total 3,557 exploratory and development wells drilled through November 26, down 14 percent from 4,175 wells for the same period in 1965. A 15-percent increase over 1965 was noted as 441 test wells were drilled during the same period.

On January 1, 1966, *The Oil and Gas Journal* reported that 13 refineries operating within Oklahoma had a total capacity of 417,405 barrels of crude oil per calendar day, an increase from 416,430 on January 1, 1965. In August 1966, the old Wilcox Oil Company refinery at Bristow was dismantled and sold. The plant was acquired by Tenneco Oil Company as part of its purchase of Wilcox Oil Company in 1964. In July, Sequoia Refining Corporation acquired the 35,000-barrel-per-day Ponca City refinery of Cities Service Oil Company. Initially the refinery was part of a $50-million sale of Citgo's Midwest refining and marketing facilities to Gulf Oil Corporation. The marketing properties, including 2,300 service stations, were purchased by Gulf. Phillips Petroleum Company sold its Okmulgee refinery to Oklahoma Cement Company in November. The acquisition was to provide an internal source for asphalt products which, in turn, would provide Oklahoma Cement Company with a more complete line of road-surfacing materials.

HELIUM

Marketable production and value of helium, extracted from natural gas at the Bureau of Mines Keyes plant, increased 13 and 25 percent, respectively.

NONMETALS

The estimated value of nonmetals in 1966 was almost 3 percent more than in 1965.

Total construction outlays increased more than 2 percent to $40.5 million in 1966, according to the Bureau of Business Research, The University of Oklahoma. Based on a 10-month total, housing starts will apparently reach the lowest volume of the past 9 years. Nonresidential building outlay for the first 10 months in 1966 was more than 7 percent greater than in 1965. Public-utilities construction was more than 11 percent ahead of that of the first 10 months of 1965. Public-works construction lagged behind. Increased State highway construction was offset by a decline in other public-works building and resulted in the decline in total public works.

Dewey Portland Cement Company, Division of Martin Marietta Corporation, was scheduled to reopen its Dewey, Oklahoma, plant in September to supply cement for the toll roads in eastern Oklahoma.

However, nearly $190 million in bonds, which the Oklahoma Turnpike Authority had planned to sell to finance construction of proposed toll roads in the State, was not sold due to poor market conditions at the time. As a result, on September 1 the plant reopening of September 6 was postponed indefinitely. The bonds were sold in November, but no further plans for reopening the plant were announced.

Ideal Cement Company reportedly increased the price of cement in Oklahoma and neighboring states to the east and south by 25 cents per barrel.

Cement shipments in Oklahoma are estimated to be about 7 percent less than those of 1965.

METALS

Near Creta in Jackson County, The Eagle-Picher Company strip-mined copper from the Permian redbeds. Silver was recovered as a coproduct.

Output of lead produced in Ottawa County increased from the previous year; however, the value declined from that of 1965. Zinc output from the Oklahoma portion of the Tri-State district also decreased. The price of lead at New York opened in 1966 at 16 cents per pound; however, on May 5 the price declined to 15 cents per pound, and on October 10 the price again fell 1 cent to 14 cents per pound. The price of zinc at East St. Louis remained at 14.5 cents per pound throughout the year.

Smelters.—Three horizontal-retort zinc plants operated in 1966. They were American Metal Climax, Inc., at Blackwell; The Eagle-Picher Company at Henryetta; and National Zinc Company at Bartlesville.

Tri-State district.—More than one-fourth of the district's lead concentrates and zinc concentrates were produced in Kansas in 1966, the remainder being produced from mines in Oklahoma and in southwest Missouri, which reported production for the first time since 1957. American Zinc, Lead & Smelting Company closed its Barbara J. mill near Cardin in the fall, leaving The Eagle-Picher Company as the principal custom milling operator in Oklahoma; hence, Oklahoma data on lead and zinc and southwest Missouri's output must be concealed to avoid disclosure.

Frank Buttram
1886-1966

A pioneer oilman and civic leader in Oklahoma died on December 18, 1966. George Franklin Buttram was born April 2, 1886, on a farm in Love County, at that time in the Chickasaw Indian Nation. He taught school and between times studied at the State Normal School, which is now Central State College. He earned his Bachelor of Science degree in geology at The University of Oklahoma in 1910 and the master's degree in 1912. His thesis was *Glass Sands of Oklahoma.*

He was on the staff of the Oklahoma Geological Survey from November 11, 1911, to September 1, 1914. In December 1914 Frank's report on volcanic dust in Oklahoma was published as Oklahoma Geological Survey Bulletin 13. Dr. Mart P. Schemel has recently visited the deposit characterized by Buttram as a diatomaceous calcareous earth and has confirmed the presence of the rare (for Oklahoma) type of deposit. Buttram had published in 1913 a report on glass sands of Oklahoma. From July through October 1913 he led a team which mapped the Cushing oil field. A detailed report was published in 1914 as Bulletin 18, a truly remarkable work for the time. The structure map was distributed in May 1914 and the complete report of 64 pages and many tables and maps was published in December.

Buttram was an organizer of the Fortuna Oil Company in 1914 and served as its chief geologist. He was general manager of the firm when it was sold in 1918. He thus became wealthy at the age of 32. In 1920 he founded Buttram Petroleum Company to become an independent producer.

Buttram was active in many fields, cattle-breeding, art, music, finance, the First Christian Church, and civic, regional, and alumni affairs. He contributed generously to The University of Oklahoma and other state schools.

Buttram is survived by his widow, the former Merle Newby, by four sons and one daughter, eleven grandchildren, and eight great grandchildren.

In his career he helped found the Independent Petroleum Association of America. He ran for governor of Oklahoma in 1930 and lost when the notorious "Alfalfa Bill" Murray won by a small margin. He was a member of the Oklahoma State Regents for Higher Education and was a regent of The University of Oklahoma for eight years, among his many services to the people of the State. Funeral services were held on December 20, 1966, and burial was in Oklahoma City.

—C. C. B.

Investigation of Selected Lower Pliocene and Pleistocene Deposits in Northwestern Oklahoma

Mart P. Schemel

Introduction

The investigations reported here were initiated to determine the nature of certain Laverne (lower Pliocene) deposits in Beaver County, Oklahoma. The discovery of a relatively rich diatom flora and sponge spicula fauna in the most important deposit led to further search for similar microfossil assemblages in deposits of the same age and in other lake deposits in Beaver and Harper Counties (fig. 1).

The diatom flora of the Laverne deposits identified herein as measured section 1 has been studied by L. R. Wilson and the associated sponge spicules were examined by Carl C. Branson. Preliminary results of their studies were presented at the Fifty-fifth Annual Meeting of the Oklahoma Academy of Science, held in 1966, and will be published in the Academy's proceedings for that year. The results of the present investigation include the measurement and description of six exposures of Laverne deposits (measured sections 1-6) and of three Pleistocene deposits (measured sections 7-9). Microfossils were collected and prepared from three of the measured sections (1, 7, 8), and partial chemical analyses were made of fifteen rock samples from five localities, (table I).

Laverne Deposits

In their account of the geology of Beaver County, Gould and Lonsdale (1926, p. 33) published excerpts from a manuscript by V. V. Waite in which he described lithologic variations and fossils of a limestone ledge that he referred to the Laverne Formation. Two photographs of an exposure in sec. 3, T. 3 N., R. 25 ECM. (fig. 1, measured section 1) were published by Gould and Lonsdale (p. 32) to illustrate the occurrence of the ledge, and this and additional exposures were indicated on their accompanying geologic map. The exposure in sec. 3 is of considerable importance for two reasons. First, it is the only exposure that can be definitely related to Waite's Laverne Formation. Second, this exposure and nearby exposures in the area contain an important lower Pliocene flora and fauna which have been intensely studied.

The first published reference to this exposure is in an account by Cragin (1891) of investigations in an area in what was then known as the "Public Lands" or "No Man's Land" and which is now included in Beaver County. The exposures which he visited were located as being south and southwest of Alpine, a long-since abandoned post office on the south bank of the North Canadian (Beaver) River west of Duck Pond Creek.

From his description of the main exposure, and additional information by Case (1894), there is little doubt that Cragin, and later

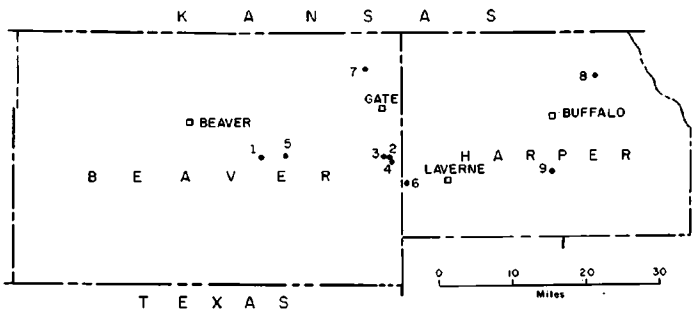

Figure 1. Map of Beaver and Harper Counties, northwestern Oklahoma, showing locations of Pliocene and Pleistocene deposits examined. Numbers are those of the measured sections described herein.

Case, examined and collected fossils from the exposure in sec. 3, T. 3 N., R. 25 ECM. Cragin collected dicotyledenous leaves, diatoms, fish remains, molluscan shells, and a camelid bone. The latter bone he regarded as determining the age of the beds to be Loup Fork. Cragin listed seven forms of leaves from the "Alpine chalk-marls" and six species of diatoms that were identified for him by the Rev. Francis Wolle. This is the first known account of fossil diatoms in Oklahoma.

The localities which were examined by Cragin were visited by Case in 1893. Case (1894) noted that the largest bed of "chalk," and the one from which Cragin collected vertebrate and plant remains, was located about 4 miles up a small tributary of the North Canadian (Beaver) River, called "Gypsum Creek." This name does not appear on any available maps of the area, but this, plus additional data on the exposure, identifies it as the one illustrated by Gould and Lonsdale. Case collected numerous well-preserved dictyledonous leaves which were deposited at the University of Kansas.

A small collection of leaves collected by Case was studied and a description published by Berry (1918). He described six species of dicotyledonous leaves and concluded that the flora was probably upper Miocene in age, although he noted there was a possibility that it was lower Pliocene.

Stirton (1935) published a new species of Tertiary beaver collected in 1931 by a University of Kansas field party in the area. The collection was made from an exposure downstream (north) of the main "chalk" deposit, referred to as the Beaver Quarry locality and described in detail by Hesse (in Chaney and Elias, 1936, p. 55-56).

The most recent paper pertaining to the Beaver County Laverne exposure is by Chaney and Elias (1936), which includes a chapter on vertebrate remains by Hesse. The main deposit is referred to as a diatomaceous marl, which seems to be an approximate term. Chaney and Elias (1936, p. 14-15) included a list of thirty-seven species of diatoms identified by A. K. Lohman from samples of the deposit. Hesse referred the marl and associated beds to the "Lavern Zone" of the "Ogallala

formation." The evidence of fossil leaves, diatoms, and vertebrates indicated that the deposits were lower Pliocene.

A measured section of this rather important deposit has never been published, and a visit to it revealed the reason. The beds are steeply dipping (approximately 45°) and the exposure is largely a dip slope (measured section 1). Measurements of units above and below the main deposit are reasonably accurate, but the thickness of the eroded diatomaceous marl is uncertain. Units below the bed were measured at the southern (upstream) end of the deposit and those below at the northern (downstream) end. The diatomaceous marl was sampled in three five-foot units which were analyzed in the laboratory. The calcium carbonate content ranged from 76.8 to 93.9 percent. The acid-insoluble residues of samples are largely composed of siliceous diatom frustules and sponge spicules.

The *Geologic map of Beaver County* (Gould and Lonsdale, 1926) shows four areas indicated as "Late Tertiary limestone and fine clay containing fossil leaves," which were referred to in their text (p. 33) as examples of exposures of the Laverne Formation. One of these localities, the one illustrated (p. 32) in sec. 3, T. 3 N., R. 25 ECM., has already been discussed. The other area of exposures south of the North Canadian River is indicated in the extreme eastern part of the county, in T. 3 N., R. 28 ECM. Two areas of limited exposures are shown north of the North Canadian River in Quaternary dune sand deposits in T. 4 N., Rs. 26, 27 ECM. These three areas were visited to identify and sample the strata included in the Laverne Formation as originally published.

Three exposures of the Laverne Formation were located in T. 3 N., R. 28 ECM., in sec. 4 (measured section 2), sec. 5 (measured section 3), and sec. 10 (measured section 4). The strata in the three exposures are similar in that the thicker unit of each is a light-gray, white or buff, calcareous, clayey shale or clay which is capped by one or more thin limestone or hard calcareous clay beds containing numerous small gastropods. Each section has, however, unique features. Section 2 has a zone of silicified wood immediately overlying the clay unit, section 3 has a dark-gray to black, hard, flintlike shale in the limestone-shale unit overlying the clay unit, and section 4 has a zone of undeterminable stemlike fossils in poorly bedded gray shale overlying the clay unit.

The different lithologies were sampled at the three exposures, and interval samples were taken of the thick clay-shale units. Chemical analyses of the clay units showed a range of 6.7 to 23.1 percent calcium carbonate (table I). Hydrochloric acid-insoluble residues were examined but neither diatom frustules nor sponge spicules were observed.

The areas of limited exposures north of the North Canadian River were visited but no exposures of light-colored limestones or clays were observed. The areas are largely covered by dune sands, with widely scattered exposures of dune sands, Tertiary sand and gravels, and Permian redbeds.

Chaney and Elias (1936, p. 11) noted that only a few fragmentary leaves were collected from the large exposure of diatomaceous marl

which yielded the earlier collection by Case (measured section 1). Additional leaves and seeds were collected by Elias approximately 3½ miles east of sec. 5, T. 3 N., R. 26 ECM. from a flint bed that caps marl. This exposure was measured and sampled (measured section 5) and several fossils were collected. The marl unit consists largely of calcium carbonate; no chemical analysis was made but little residue remains after treatment with hydrochloric acid. The insoluble residues from two interval samples and four random block samples were examined, but neither diatom frustules nor sponge spicules were observed.

Waite's manuscript has been lost, and the excerpts published by Gould and Lonsdale (1926, p. 33) did not include the description or designation of a type locality (Schemel, 1967). Subsequently authors have noted that the type locality is presumed to be in the vicinity of Laverne, Harper County, Oklahoma. Myers, in an account of the geology of Harper County, included a photograph (1959, p. 50, fig. 11)

TABLE I.—PARTIAL CHEMICAL ANALYSES OF SAMPLES
(Analyses by Kenneth A. Sargent, Oklahoma Geological Survey)

SAMPLE NUMBER	THICKNESS (FEET)	INSOLUBLE RESIDUE (PERCENT)	CALCIUM CARBONATE (PERCENT)	TOTAL
		Measured Section 1 (diatomaceous marl)		
1	5	17.6	76.8	94.4
2	5	6.4	86.4	92.8
3	5	1.6	93.9	95.5
		Measured Section 2 (calcareous shale)		
1	5	82.9	7.4	90.3
2	5	81.1	10.6	91.7
3	5	80.3	15.0	95.3
4	5	87.2	6.7	93.9
		Measured Section 3 (calcareous shale)		
1	5	68.4	19.2	87.6
2	5	69.0	21.9	90.9
3	5	77.2	12.4	89.6
		Measured Section 4 (calcareous clay)		
1	0.2	64.7	23.1	87.8
		Measured Section 6 (calcareous shale)		
2	2	69.6	16.7	86.3
4	2	61.2	29.1	90.3
5	2.5	48.0	44.8	92.8
6	2.5	71.6	20.3	91.9

of a Laverne exposure approximately 4 miles west of Laverne, in sec. 23, T. 26 N., R. 26 W. The strata at this exposure consist of light-gray, clayey, calcareous shales and resistant calcareous shales or limestones. These beds were measured and sampled (measured section 6), but neither diatom frustrules nor sponge spicules were observed in the insoluble residues.

PLEISTOCENE DIATOMACEOUS LAKE DEPOSITS

In the course of the investigation of the Laverne deposits, three localities of Pleistocene deposits in the same geographic area were studied (measured sections 7, 8, 9). One of these localities had been previously noted as an exposure of diatomaceous deposits, the other two localities are lake deposits with a Pleistocene molluscan and vertebrate fauna which was investigated on the chance that diatoms and sponge spicules might be present.

Buttram (1914), in an account of volcanic dust in Oklahoma, described a calcareous deposit of material resembling volcanic dust which was found to contain numerous diatoms. For this reason he termed it a calcareous diatomaceous earth. This exposure, north of Gate in sec. 1, T. 5 N., R. 27 ECM., Beaver County, was measured and sampled (measured section 7). The strata at this exposure crop out in a horseshoe-shaped pattern at the head of an intermittent northward-flowing stream. The strata dip at about 15° away from the central area in every direction except northward. Buttram (1914, p. 40) interpreted this as a dome structure due to a "slight local uprising of the surface formations."

The deposit is a light-gray to white, highly calcareous, chalklike rock quite similar to the Laverne diatomaceous marls (measured sections 1, 2) except that it is somewhat harder and shows distinct stratification. In addition, there are zones of small gastropods and scattered vertebrate bones and teeth throughout the deposit. The hydrochloric acid-insoluble residues contain numerous frustules of diatoms, siliceous spicules of sponges, and shards of volcanic ash (dust). The diatoms have been examined by L. R. Wilson and among them apparently are types restricted to Pleistocene deposits.

Some Pleistocene lake deposits in other areas contain both diatoms and sponge spicules and it was decided to investigate the localities of the Bar M local fauna described from Harper County by Taylor and Hibbard (1955). The fauna is known from two areas of gray lake silts in the vicinity of Buffalo. Locality 1 of Taylor and Hibbard is northeast of Buffalo in sec. 13, T. 28 N., R. 22 W. This is the main locality of the Bar M local fauna, which here consists of molluscan shells and a number of scutes of an extinct armadillo. Locality 2 of Taylor and Hibbard is south of Buffalo in sec. 13, T. 26 N., R. 23 W., where lake deposits contain only molluscan shells. Uncertainty over the age of the deposits led to the securing of a carbon-14 dating on molluscan shells from locality 1. The date of 21,360± 1,250 B. P. was obtained, which gives a late Wisconsinan age to the lake deposits and associated fossils at locality 1 (Myers, 1965).

Both localities were visited, measured, and sampled; section 8 is locality 1 and section 9 is locality 2. The silty clays from locality 1 yielded numerous diatom frustules and siliceous sponge spicules; the clays from locality 2 were barren of microfossils.

DIATOMS IN VOLCANIC ASH DEPOSITS

Ham, in the section on the geology and petrology of volcanic ash in the report on cellular products from volcanic ash by Burwell, noted (1949, p. 81) that diatom tests, although observed in every sample studied, formed a minute part of each sample. Ham's table XII (p. 78), which summarizes the mineral composition of the samples examined, shows diatoms to be present in all samples, but in only three are they sufficiently abundant for the calculation of a weight percentage. Cuts of eleven of Ham's fourteen samples were located in the Survey laboratory and reexamined. As expected, diatoms were found in all samples, but they were exceedingly rare. It is relatively difficult to segregate and isolate the diatoms from the volcanic glass shards and the quartz which make up the bulk of these ash deposits.

Burwell and Ham's laboratory numbers for the reexamined samples are listed below. Detailed information is given in their report.

Beaver County:	4698, 4699, 4700
Blaine County:	5428
Garvin County:	4813
Haskell County:	1660, 1665
Hughes County:	4326, 4327
Wagoner County:	3245
Woodward County:	9425

MEASURED SECTIONS

Section 1
SW¼ NE¼ sec. 3, T. 3 N., R. 25 ECM.
Beaver County

Exposure in field, in relatively broad valley, on the east side of intermittent creek. Exposure approximately 500 feet long by 30 feet high. Strata dip N. 45° W., at 30° to 40°. Top of section is to the north (downstream). Eroded surface is approximately dip slope of main bed. Measured September 1966.

	THICKNESS (FEET)
Limestone or hard clay shale, dense, flintlike, buff to brown; conchoidal fracture; weathers white	0.2
Shale, clayey, buff; poorly bedded	3.0
"Chalk," diatomaceous marl, white, extremely fine-grained, calcareous; thickness of unit estimated; deeply eroded but not slumped. Sampled in three 5-foot units, numbered 1 (top) to 3 (bottom); analyses given in table I	15.0
Shale, clayey, dark-brown to black; plant fragments	0.3
Shale, "chalky," light-gray, highly calcareous; discontinuous	0.25
Shale, clayey, poorly bedded, greenish and purplish interbedded	1.8
Shale, clayey, greenish; poorly bedded; some purple layers	2.8

Note: This is the exposure of the ledge illustrated by Gould and Lonsdale (1926, p. 32) as an example of the Laverne Formation of V. V. Waite. It is apparently the Alpine locality of Cragin (1891) and certainly the "Gypsum Creek" locality of Case (1894) as well as the main locality of fossil plants of Chaney and Elias (1936) and the Cragin locality of Hesse (in Chaney and Elias, 1936).

Section 2

SE¼ SE¼ sec. 4, T. 3 N., R. 28 ECM.

Beaver County

Exposure in field, at east side of intermittent stream, exposed just west of abandoned north-south section-line road. Exposure 35 feet high, approximately 100 feet long. Main unit slumped and weathered. Strata dip N. 40° W. at 25°. Section trends north-south. Measured September 1966.

	THICKNESS (FEET)
Shale, clayey, light-gray; slumped	4.0
Shale, clayey, buff	1.0
Limestone or hard clay; hard buff ledge, weathers light gray; scattered small gastropods	0.25
Fossil-wood zone, silicified wood, persistent for about 20 feet. [Collection OPC 1171]	0.2
Shale, clayey, buff to white, calcareous; slumped. Sampled in four 5-foot units, numbered 1 (top) to 4 (bottom), analyses given in table I	20.0

Section 3

NW¼ SE¼ sec. 5, T. 3 N., R. 28 ECM.

Beaver County

Exposure in low hill, traversed by lease road extending north-south across east-west exposure. Main portion of exposure slumped and poorly exposed. Strata dip N. 45° W., at approximately 35°. Measured September 1966.

	THICKNESS (FEET)
Limestone or calcareous clay shale, hard, flintlike dark-brown; weathers tan; somewhat nodular	1.0
Shale, clayey, dark-brown to buff	0.5
Shale, dark-gray to black, hard, flintlike	0.25
Limestone or calcareous clay, hard, tan to dark-gray; nodular; numerous small gastropods	0.2
Shale, clayey, light-gray, fossiliferous; numerous relatively large gastropods; some pelecypods (?)	1.1
Limestone or calcareous clay, brown	0.25
Shale, clayey, light-green, calcareous; poorly bedded; slump exposure. Sampled in three 5-foot units, numbered 1 (top) to 3 (bottom); analyses given in table I	15.0

Section 4

Near C sec. 10, T. 3 N., R. 28 ECM.

Beaver County

Exposed in field in small draw; exposure approximately 15 feet long by 3 to 4 feet high. Dips toward northwest. Measured September 1966.

	THICKNESS (FEET)
Limestone or calcareous clay, gray; weathers white; hard ledge; numerous small gastropods. Sample 1 includes total thickness; analysis given in table I	0.2
Shale, light-gray, calcareous; poorly bedded; numerous stemlike fossils	1.7
Shale, clayey, light-gray, calcareous; poorly bedded	2.0

Section 5

SW¼ NW¼ sec. 5, T. 3 N., R. 26 ECM.

Beaver County

Exposure extends north-south along cliff break above valley alluvium on the west side of Duck Pond Creek. Beds irregular, dip N. 20° E., at 15° to 20°. Exposures are largely a dip slope, which is covered by angular, irregular flintlike blocks. Measured October 1966.

	THICKNESS (FEET)
Shale, clayey, greenish-gray	10.0+
Shale, clayey, light-gray to white	0.3
Shale, clayey, greenish-gray	3.0
"Flint" ledge, hard, buff; weathers white; conchoidal fracture. One plant leaf and one fish scale collected	0.3
"Chalk," light-gray to white, highly calcareous, fine-grained; slightly bedded. Sampled in two 1.5-foot units	3.0
Clay, blocky, light-gray, calcareous; grades into unit below	1.0
Shale, greenish-gray; slumped; base not exposed	4.0

Note: This is the exposure from which Elias collected fossil leaves and seeds (Chaney and Elias, 1936, p. 11).

Section 6

Sec. 23, T. 26 N., R. 26 W.

Harper County

Exposure in field. Outcrop trends north-south for about 100 feet. Strata dip toward northwest at about 15°. Measured September 1966.

	THICKNESS (FEET)
Shale, calcareous, light-gray to white; forms hard ledge; numerous small gastropods	0.5
Shale, clayey, light-gray, soft, calcareous. Sample 2; analysis given in table I	2.0

Shale, moderately well-bedded, gray, calcareous. Sample 3	0.5
Shale, clayey, soft, gray, calcareous. Sample 4; analysis given in table I	2.0
Interbedded calcareous clayey shale and hard calcareous shale, or limestone that forms ledges. Sample 5 is upper 2.5 feet, sample 6 is lower 2.5 feet; analyses given in table I	5.0

Section 7

NW¼ sec. 1, T. 5 N., R. 27 ECM.

Beaver County

Outcrop north of Gate. Exposure at head of intermittent stream near the center of the section. Unusual feature is that the strata dip away from a central area at angles of from 15° to 25° in all but a northerly direction (downstream). The result is an apparent "dome" in the open valley area. The strata vary considerably in thickness due to erosion. Measured October 1966.

	RANGE OF THICKNESS (FEET)
Sand and gravels, buff	0-20
Shale, clayey to sandy, buff to greenish-gray; poorly bedded	0-30
"Chalk" (marl?), highly calcareous, light-gray to white; weathers blocky; numerous small gastropods and rare vertebrate bones. Sampled in five 3-foot units, numbered 1 (top) to 5 (bottom)	0-15
Shale, poorly bedded, light-gray, calcareous; base not exposed	0-30

Note: This is the exposure described by Buttram (1914, p. 40), as a "calcareous diatomaceous earth" that resembles volcanic dust.

Section 8

NW¼ sec. 13, T. 28 N., R. 22 W.

Harper County

Northeast of Buffalo, exposed on both sides of dammed creek east of an abandoned north-south section-line road. Measured October 1966.

	THICKNESS (FEET)
Clay, silty, dark- to medium-gray; eroded upper surface	2.0
Clay, silty, medium- to dark-gray; gradational to units above and below	2.0
Clay, silty, light- to medium-gray; base not exposed	2.0

Note: All units have numerous mollusks. This is the main locality of the Bar M fauna of Taylor and Hibbard (1955).

Section 9

SW¼ sec. 13, T. 26 N., R. 23 W.

Harper County

Exposure on east side of route 183, south of Buffalo. Measured October 1966.

	THICKNESS (FEET)
Shale, clayey, reddish; eroded upper surface	5.8
Clay, silty, medium-gray, weathered. Sampled in three 5-foot units, special sample of 1-inch dark clay at top of unit	15.0

Note: Silty clay has numerous mollusks. This is the secondary locality of the Bar M local fauna of Taylor and Hibbard (1955).

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Palynological Correlation of the Henryetta Coal, Oklahoma

W. C. Meyers*

The spore assemblage of the Henryetta coal of the Senora Formation (Des Moines Series) is compared to that of the Croweburg coal of northeastern Oklahoma, studied by Wilson and Hoffmeister (1956). The comparison is based upon a series of 2-inch segment samples cut from a fresh coal face in the Black Diamond mine (SE¼ sec. 34, T. 12 N., R. 3 E.), Okmulgee County, Oklahoma (Meyers, 1963).

Stratigraphy

The Henryetta coal has been extensively mined near Henryetta and Coalton, Okmulgee County. Trumbull (1957) mapped the coal reserves in the mining area and reported the thickness to range from 28 to 42 inches, with an average of 36 inches. Through much of the area a clay parting is present near the middle of the seam. However, this parting is absent at the Black Diamond mine.

Trumbull classified the Henryetta coal as a high-volatile A- and B-ranked coal, with an average fixed-carbon content of 53 percent.

The Henryetta coal occurs approximately 200 feet below the top of the Senora Formation (Taff, 1901). Taff's original description does not designate a type locality but the formation was named for the old post office at Senora in southern Okmulgee County. The original description stated that the upper part of the Senora Formation contains blue clay shales and brown sandy shales exposed on hills capped by the Calvin Sandstone.

In the section at the Black Diamond mine, the buff-colored shales and sandy shale above a clay-ironstone concretion zone grade upward into the massive Calvin Sandstone. Here the Henryetta coal is 38 inches thick and occurs 31 feet below the Calvin Sandstone.

The Senora Formation is about 800 feet thick in Okmulgee County and conformable with the underlying Stuart Shale in the vicinity of the Canadian River (Oakes, 1963). Northward, the Senora Formation is believed to overlap the Stuart Shale and rest unconformably upon the Boggy Formation, from southwestern Muskogee County northward into Kansas.

Stratigraphic correlations in the area of investigation are complicated because shelf limestones rapidly thin and pinch out south of the Arkansas River. Branson (1954) stated that, during much of Desmoinesian time, the margin between shelf and basin deposition corresponded approximately to the present position of the Arkansas River.

Oakes' work (1953) indicated that the Calvin Sandstone is equivalent to the lower Fort Scott Limestone. Similar stratigraphic position

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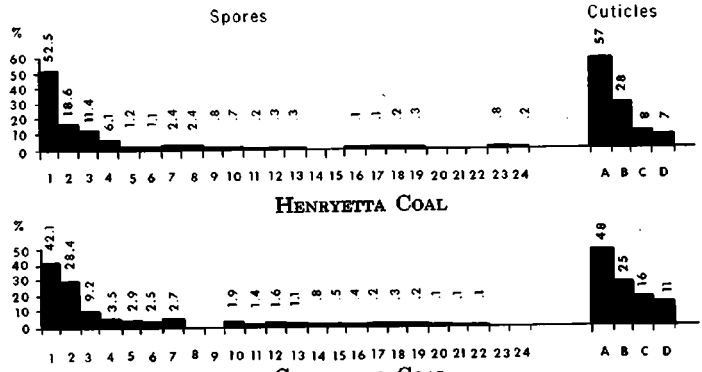
related the Croweburg and Henryetta coals but no precise correlation was indicated.

CORRELATION

The variations of dominant spore genera in the Croweburg and vertically adjacent coals were determined by Wilson and Hoffmeister (1956). The abundance of dominant spore genera is most alike in the Henryetta and Croweburg coals.

Spore histograms (fig. 1) show the relative abundance of the recognized palynological species and the great degree of similarity



(modified from Wilson and Hoffmeister, 1956)

Spore Species

1. Lycospora punctata
2. Laevigatosporites minutus
3. Florinites pellucidus
4. Endosporites ornatus
5. Laevigatosporites desmoinesensis and L. ovalis
6. Calamospora hartungiana
7. Laevigatosporites globus and L. punctatus
8. Apiculatisporis latigranifer
9. Lycospora brevijuga
10. Triquitrites bransonii
11. Cirratriradites intermedius
12. Punctatisporites orbicularis and P. obliquus
13. Granulatisporites verrucosus and G. granularis
14. Punctatisporites dentatus
15. Triquitrites dividuus
16. Triquitrites crassus
17. Raistrickia crinita
18. Calamospora straminea
19. Granulatisporites deltiformis
20. Raistrickia grovensis
21. Calamospora decora
22. Laevigatosporites minimus
23. Calamospora breviradiata
24. Calamospora flexilis

Cuticle Types

A. Long rectangular cells
B. Structureless types
C. Short thickened rectangular cells
D. Hexagonal cells

Figure 1. Histograms of relative percentages of spore and cuticle assemblages from the Henryetta and Croweburg coals. The Croweburg histograms constitute a composite of nine localities.

between the Henryetta and Croweburg coals. Many species are common to both, and, of the 48 species in the Henryetta coal, 35 were reported from the Croweburg coal by Wilson and Hoffmeister (1956).

The standard deviation was calculated for the six most abundant species in Wilson and Hoffmeister's nine Croweburg coal localities. The percentage value of four of the species from the Henryetta coal is within one standard deviation of variation of that species in the Croweburg coal localities. The two most abundant species, *Lycospora punctata* and *Laevigatosporites minutus*, were within 1.4 and 2.2 standard deviations, respectively. These two species total 71.1 percent of the composite Croweburg coal spore assemblage, 71.1 percent of that of the Henryetta coal. The Henryetta and Croweburg coals are closely related upon the basis of the statistical comparison of the most abundant species.

The plant-cuticle histograms (fig. 1) indicate a similar pattern of abundance but this is difficult to evaluate because little is known about the stratigraphic distribution of cuticle types.

The two coal assemblages differ in the minor spore elements and by the presence of 2.4 percent of *Apiculatisporis latigranifer* in the Henryetta coal. These differences are considered to be of minor importance and mark the Croweburg-Henryetta seam as one of the more uniform coals.

The Henryetta coal has 19 species in common with the Colchester coal of Illinois. Kosanke (1950) reported that *Lycospora* and *Laevigatosporites* are the dominant genera in the Colchester coal. This is also true of the Henryetta coal. Several species, reported by Kosanke (1950) as having limited stratigraphic ranges, occur in both coals. Perhaps the most important of these is *Schopfites colchesterensis*, which in Illinois is restricted to the Colchester coal. Other forms which are present in the Henryetta-Croweburg coal have restricted stratigraphic ranges that approximate or overlap those of the Colchester coal. These are *Triquitrites inusitatus, Raistrickia crocea, R. grovensis, Punctatisporites foveatus,* and *P. quaesitus*. The presence of these diagnostic spore types, and other numerous species in common, indicates that the Henryetta coal of Oklahoma is palynologically related to the Colchester coal of Illinois.

SPORE SUCCESSION IN THE HENRYETTA COAL

The major spore successional trends (fig. 2) in the Henryetta coal are: (1) decreasing abundance of *Lycospora punctata* from the base towards the top of the seam; (2) maximum abundance of *Laevigatosporites minutus* near the center of the coal, with decreasing abundance towards the upper and lower coal boundaries; (3) maximum abundance of *Florinites pellucidus* near the middle of the coal; (4) large influx of *Endosporites ornatus* in the top six inches of the coal.

The spore succession of the Henryetta coal is similar to that reported from the Croweburg coal by Wilson and Hoffmeister (1956). Some of the minor successional trends developed in the Croweburg coal, like that of *Laevigatosporites desmoinesensis* and *Laevigatosporites punctatus,* are not so evident in the Henryetta coal.

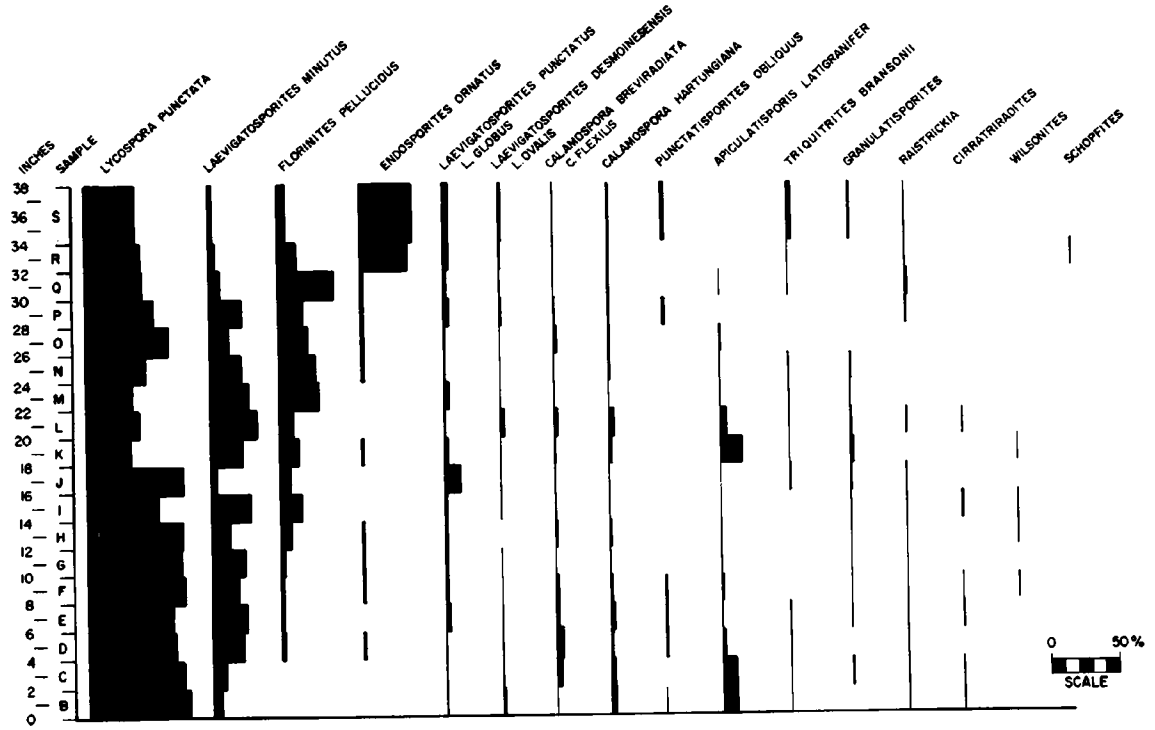


Figure 2. Histograms of relative percentages, showing spore succession in the Henryetta coal at the Black Diamond mine.

The successional trends of the Henryetta coal follow a sequence evident in some other Oklahoma coals in which the lower parts of the seams are dominated by nonsaccate forms and the upper portions are commonly dominated by saccate forms. The nonsaccate forms consist of spores from calamarians, lycopods, and ferns. During the early stages of coal-swamp development the nonsaccate forms appear to have grown abundantly in the swamp. As the swamp developed, there was generally an influx of saccate cordaitalean spores and lycopod spores, such as *Endosporites*.

SUMMARY

The Henryetta coal is correlated with the Croweburg coal upon the basis of: (1) a large number (35) of species common to both coals; (2) similar percentages of the most abundant species; and (3) similar fossil succession. The correlation of the Croweburg coal is extended approximately 40 miles southward from the northeast corner of Okmulgee County to the vicinity of Dewar.

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RÉSUMÉ OF NEW NOMENCLATURE PUBLISHED IN OKLAHOMA GEOLOGY NOTES

January 1966 through December 1966

The following is a list of new taxa published in *Oklahoma Geology Notes* during 1966. Previous lists were published in January 1962, December 1963, February 1965, and February 1966.

NAME	AUTHOR	VOLUME	PAGES
Brachiopoda			
Eridmatus, n. gen.	Branson	26	75- 78
E. texanus, n. comb.			
Cephalopoda			
Reticuloceras wainwrighti, n. sp.	Quinn	26	13- 20
Peytonoceras, n. gen.*	Saunders	26	43- 48
P. ornatum, n. sp.*			
Crinoidea			
Paracromyocrinus, n. gen.	Strimple	26	3- 12
P. vetulus, n. comb.*			
Metacromyocrinus gillumi, n. sp.*			
Synarmocrinus fundundus, n. sp.			
Indocrinidae, n. fam.	Strimple	26	80- 84
Metaindocrinus, n. gen.*			
M. cooperi, n. sp.*			
Isoallagecrinus, n. gen.	Strimple	26	99-111
I. eaglei, n. sp.			
Desmacriocrinus, n. gen.			
D. weldenensis, n. comb.			
Metallagecrinus, n. gen.*			
M. quinquebrachiatus, n. comb.*			
Ectoprocta (Bryozoa)			
Ceramopora? unapensis, n. sp.	Ross	26	218-224
Ostracoda			
Isochilina kamara, n. sp.	Creath	26	243-246
I. obesiporosa, n. comb.			
Plantae (microfossils)			
Cappasporites, n. gen.	Urban	26	111-114
C. distortus, n. sp.			
Trace fossils			
Scalarituba? atoka, n. sp.	Branson	26	236-239

* Not an Oklahoma form.

New Theses Added to O. U. Geology Library

The following master's theses were added to The University of Oklahoma Geology Library in January 1966:

Pennsylvanian Chonetidina of Oklahoma, by Touran Soltanzadeh Iranpanah.

A study of the basement conditions of the Norman dam site area, Cleveland County, Oklahoma, by Satish K. Sharma.

The following doctoral dissertation was also added:

Structural charge site influence on the interlayer properties of expandable three-layer clay minerals, by Raymond L. Kerns, Jr.

NOTE

In the description of the Texarkana sheet of the **Geologic Atlas of Texas** (Oklahoma Geology Notes, vol. 27, no. 1, January 1967, p. 13) the price of the map was erroneously given as $2.00 per copy. The correct price is $2.50 per copy.

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