OKLAHOMA GEOLOGY NOTES

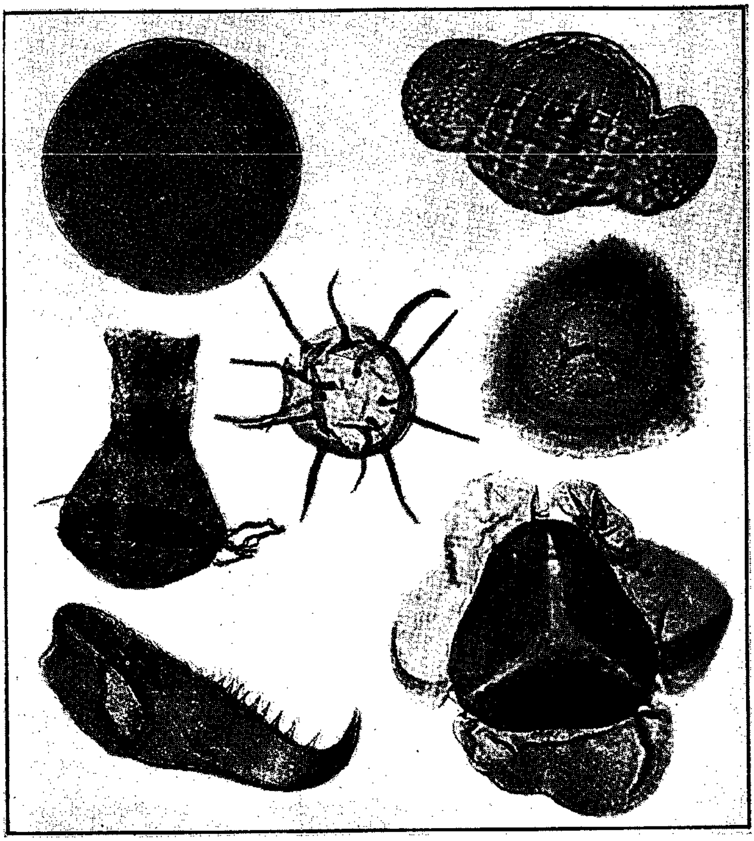

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FIGURE 1. The rock slide area on Mount Scott 0.3 miles rom the divided entrance-exit at the top. For explanation see text.
(Photograph courtesy Bill Dixon, Staff Photographer, Lawton Constitution.)

ROCK SLIDE ON MOUNT SCOTT

RODGER E. DENISON

Because of the relatively moderate climate in the state, geologists in Oklahoma generally disregard the effects of frost or ice wedging. Nevertheless it is sometimes a factor to be considered, as is illustrated by a rock slide which occurred recently on Mount Scott.

Mount Scott is perhaps the best known mountain in Oklahoma. The nearly three-mile-long winding road to the top has provided countless people with the best accessible view of the Wichita Mountains and the surrounding Permian plains.

With an elevation of 2,464 feet, Mount Scott is not the highest point in the Wichita Mountains. It rises some 1,130 feet above Lake Lawtonka, at the eastern base of Mount Scott. To the west, Mount Pinchot and a nearby unnamed peak are the highest points in the mountains but rise less than 600 feet above bordering valley floors.

Mount Scott is capped by porphyritic, generally micrographic, granite. The granite is composed of perthite and quartz with minor amounts of plagioclase, hornblende, augite, magnetite, sphene, zircon, and apatite. The feldspars are generally altered to clays and sericite; the mafic minerals are altered to chlorite. Miarolitic cavities are present and generally contain quartz and feldspar with minor amounts of epidote. The granite has numerous rock inclusions of basic origin in all stages of assimilation. The many road cuts provide excellent exposures of this granite, the inclusions and miarolitic cavities. The base of the mountain is composed of gabbroic rock that is poorly exposed and is nowhere in contact with the road. The contact between these units dips gently to the south and is well marked by relatively dense woods growing on the basic rocks.

During the week of January 4-9, 1960, the road was closed and barracaded because of snow and ice. On Sunday, January 10, after a warming trend the barracades were removed. The last known visit to the top was made on this date. At 5 AM, Tuesday, January 12, the road was reported closed to the Oklahoma Highway Patrol because of a rock slide near the top. No one was on the top at the time of the slide.

The slide occurred in a road cut 0.3 miles from the divided entrance-exit at the top of Mount Scott. The road was completely blocked by numerous large rock fragments and boulders for a distance of approximately 30 yards (fig. 1). The largest mass of rock was reported to measure 9½′ x 18′ x 32′ and was accompanied by many smaller fragments.

This was not a simple boulder slide. The largest rock was actually a portion of the mountain rather than a loose boulder, and when it collapsed it brought along several loose boulders which it had supported. Being hewn from solid granite, the road bed did not collapse, but the asphalt road surface was fractured and pulverized.

The joint pattern, as shown in figure 1, was the controlling factor in limiting and defining the slide area. The nearly vertical joints A and C limited the slide to a relatively short section of road, while the actual plane of sliding was defined by joint B. These joint sets are not local, but may be traced for considerable distances with only slight variations in trend.

The slide debris is characterized by angular fragments of rock (1), essentially portions of the mountain which collapsed, and loose boulders (2) that had rested in the rock mass. The amount of loose boulders appears to have been small when compared with the volume of angular or partially rounded bedrock materials.

The slide was caused by a combination of normal geologic effects. The zone of weakness was initially a fracture surface in the granite dipping approximately 45 degrees toward the road. This fracture surface dates either from the time of initial cooling of the granite or from tectonic effects of later Paleozoic orogeny. It may have been enlarged or weakened by blasting during the construction of the road cut. The fracture enabled weathering, primarily kaolinization of feldspars, to penetrate the granite. The cold, wet weather preceding the slide was the ultimate factor leading to the collapse. The exceptionally wet weather in December supplied water which seeped into the fracture zone. This water, upon freezing, expanded and consequently wedged the rock mass apart. During the warming trend the ice was partially melted and the melted water acted as a lubricant to provide a nearly perfect plane of sliding weakness. The major rock mass collapsed, bringing with it numerous smaller rock fragments and boulders to block the road very effectively.

The road was reopened on March 25, 1960, after the rock had been removed and the road repaired.

ALABASTER CAVERNS

Arthur J. Myers

Alabaster Caverns State Park, which is in an area of karst topography (Myers, 1960, p. 14), is about five miles southwest of Freedom on State Highway 50 in Woodward County, Oklahoma. The cavern underlies parts of sections 28 and 33, T. 26 N., R. 18 W., and has formed in the essentially horizontal Blaine formation, which consists of the following units (in ascending order): Medicine Lodge gypsum, 30 feet thick; unnamed shale, 13 feet thick; Nescatunga gypsum, 13 feet thick; unnamed shale, 7 feet thick; Shimer gypsum, 13 feet thick; unnamed shale, 4 feet thick; and Haskew gypsum, 4 feet thick.

Alabaster Caverns is the largest known gypsum cave in the world. The main chamber is 2,256 feet long, with a surface distance between entrance and exit of 1,420 feet. There are numerous branches from the main chamber; in some cases they are tributary tunnels and in other cases they are tunnels which branch and rejoin. Most lateral openings are small; some are tubular openings about a foot in diameter, whereas others are several feet wide but range in height from only a few inches to a few feet.

Most of the cavern is within the Medicine Lodge gypsum; however, in the Rotunda the floor is at or a little below the top of the underlying Flowerpot shale and at several places the roof is at the base of the Nescatunga gypsum. A small and less extensive chamber lies within the Nescatunga gypsum. The rocks at the surface overlying the cavern are the Shimer gypsum, the unnamed shale below it, and the Nescatunga gypsum (fig. 1). The thickness of overburden ranges from 20 to 40 feet and the maximum depth of the floor of the cave is approximately 80 feet below the surface.

The entrance to the cavern is through a collapse sinkhole on the cliff of Cedar Canyon. The canyon is a narrow, steep-sided valley, about two miles long, which has been eroded into the Flowerpot shale. Cedar Creek drains into Long Creek, which drains into the Cimarron River.

Alabaster Caverns consists of three main sections: a collapse section, a section containing domes in the roof, and a twisting tubular section. Figure 2 is a plan of the cavern showing the locations of the different features. The widths are only approximate, but the dash line is a compass-and-tape traverse of the visitors' route which was made by the writer with the assistance of Richard Hedlund.

The Rotunda and Encampment Room make up the collapse section of the cavern. The Rotunda has the highest ceiling of any part of the cave, approximately 45 feet from floor to ceiling. The floor is at or slightly below the contact of the Medicine Lodge gypsum and underlying Flowerpot shale and the roof is at the base of the Nescatunga gypsum. The floor is littered with large boulders of Medicine Lodge gypsum and the overlying unnamed shale. Many of the boulders are as much as ten feet in diameter.

The cavern narrows between the Rotunda and Encampment Room and the visitors' trail ascends over some of the boulders. Owl Cave Tunnel joins the main chamber at this point. The Encampment Room is entirely within the Medicine Lodge gypsum; the floor is a mass of gypsum boulders

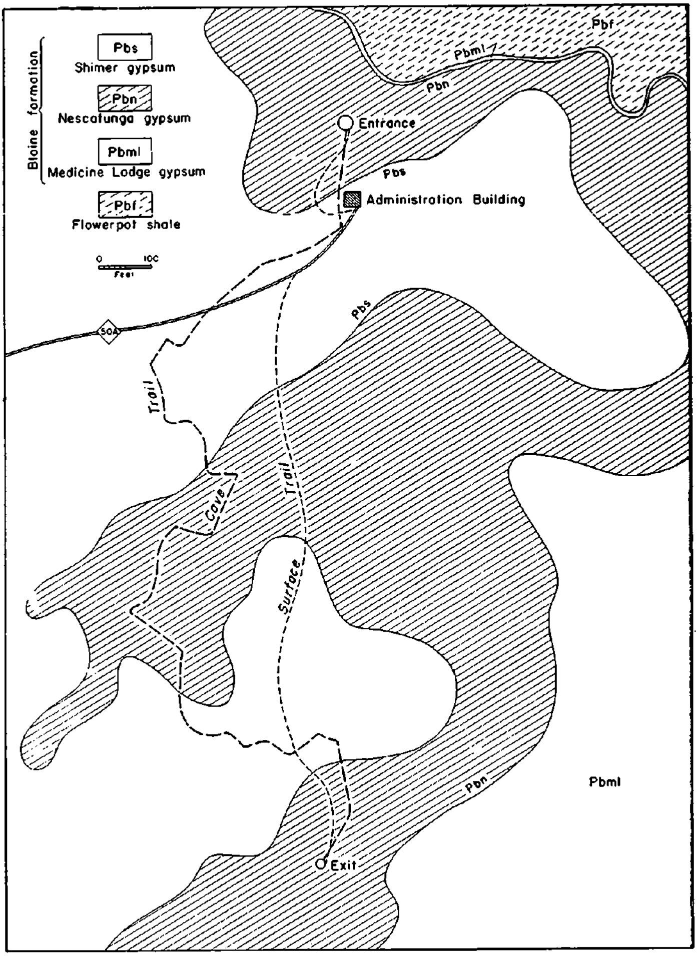

FIGURE 1. Geologic map of the Alabaster Caverns area.

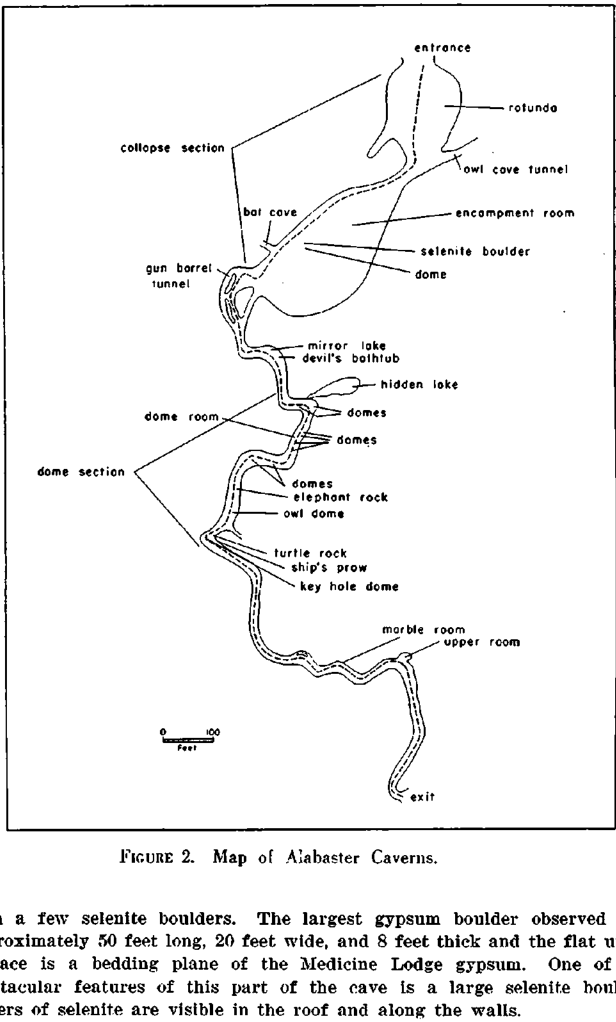

FIGURE 2. Map of Alabaster Caverns.

with a few selenite boulders. The largest gypsum boulder observed was approximately 50 feet long, 20 feet wide, and 8 feet thick and the flat upper surface is a bedding plane of the Medicine Lodge gypsum. One of the spectacular features of this part of the cave is a large selenite boulder. Layers of selenite are visible in the roof and along the walls.

South of the Encampment Room the chamber narrows once again. The original trail led through Gun Barrel Tunnel, which is only a few feet in diameter. Another small tunnel, through which flows a small stream, connects the Encampment Room with the dome section. A man-made passage now parallels Gun Barrel Tunnel and permits a person to walk upright.

The dome section of the cave, eight to ten feet in diameter, is the most

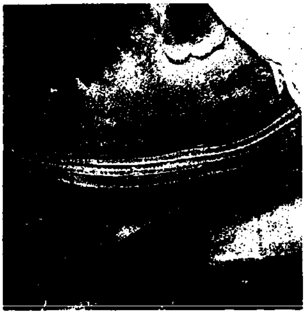

FIGURE 3. Cathedral Dome, a rimmed concavity in the ceiling.

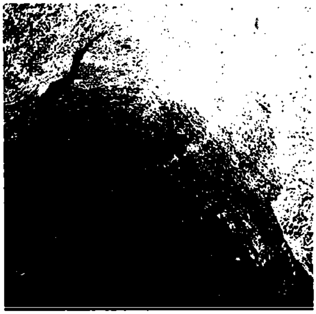

FIGURE 4. Channeled ceiling.

sinuous portion, and is entirely within the Medicine Lodge gypsum. The characteristic features are the domes which have formed in the ceiling. Seven of the ceiling concavities are in the Medicine Lodge gypsum and range from small concave indentions to rimmed openings three to four feet deep. Figure 3 shows Cathedral Dome, a rimmed opening which is about 8 feet in diameter. One of the more picturesque of these is Owl Dome, which has brown stains giving it the appearance of the face of an owl. In three of the domes, the collapse of the roof and overlying shale has resulted in the dome ceiling being at the base of the Nescatunga gypsum. These are broadest in their upper parts as a result of the slumping of the shale. The most beautiful dome is Keyhole Dome, named because of the shape at the upper bedding plane of the Medicine Lodge gypsum. There are several lateral tunnels in this section; one leads to Hidden Lake and another has a small stream which flows into the main chamber. The sharpest turn in the cavern is appropriately named Ship's Prow and leads to the last section of the cave.

The last portion is a gently twisting tube of slightly smaller size within the Medicine Lodge gypsum. Its walls are fine-grained alabaster, the appearance of which has resulted in the descriptive title of Marble Way. A twisting parallel tunnel about a foot in diameter branches and rejoins the main tunnel at several places over a distance of about twenty feet. At one place the collapse of the overlying unnamed shale to the base of the Nescatunga gypsum has formed the upper room. Because of its proximity to the surface and its isolation from the cave proper it is 10 to 15 degrees warmer than the normal cavern temperature. At the terminus the cave connects with the surface through a sinkhole.

A perennial stream flows through the cavern. It is fed by the various lateral tunnels and by seepage through the roof. Following heavy rains the flow of water is increased and, before the building of several dams, was enough to completely fill the cavern.

Malott (1938, p. 323) states that the large caverns of southern Indiana are formed chiefly by surface waters diverted into underground routes. Primitive, poorly integrated, three dimensional passageways develop by phreatic erosion, but surface streams flowing into sinks occupy selected passages and develop the caverns at or slightly above the water table. In the writer's opinion the diversion of surface water to underground routes caused the formation of Alabaster Caverns. In the early stages of diversion the openings are small and controlled by joints. The pattern of the cavern shows evidence for joint control. As erosion continues some tunnels may be abandoned in favor of others. Two streams approximately 1,000 feet south and a third approximately 1,500 feet east of the cavern flow into sinks. Throughout the outcrop area of the Blaine formation such diversions are common. The present exit is through a sink and its collapse probably sealed off the main chamber's connection with the sinks to the south. It seems probable that the sink to the east joins the main chamber through Owl Cave Tunnel. The tubular cavern, the lack of a sponge network, and the downward gradient indicate a vadose origin instead of a phreatic origin as postulated by Bretz (1952). Large amounts of clay are left in the cave following heavy rains. This indicates that the water has material with which to erode the rocks by abrasion as well as by solution.

FIGURE 5. Mound resulting from alteration of alabaster to gypsum.

The channeling in the ceiling of various parts of the cave represents the small early channel. As the flow of water continued, the opening was deepened and widened. Figure 4 shows channeling in the ceiling of the cave. If the photograph is viewed upside-down the configuration is that of a normally eroded gully. Bretz (1952, p. 281) states that the channeling represents a vadose feature that was formed after the cave had been filled with clay following its phreatic origin. According to Bretz (1952, p. 280) the dome-like concavities were formed by solutional attack of phreatic water. These features, however, are not randomly located throughout the cave, but are concentrated in one section which underlies a group of sinkholes. It is the writer's belief that downward percolating water caused the alteration of alabaster to coarse granular gypsum which is more readily eroded. The alteration results in an increase in volume which in some cases causes the formation of mounds at the surface. One such mound is shown in figure 5. During times when the cave was filled with silt-laden water these areas were eroded. The other parts of the cave do not underlie sinkholes and as a result the rock is not so highly altered and is not subject to such erosion.

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An Apology to the U. S. Bureau of Mines

Louise Jordan

In *Oklahoma Geology Notes*, vol. 20, no. 5 (May 1960), p. 121, it was stated incorrectly that the *Minerals Yearbook* volumes are issued several years after the year of the statistics, and that the latest yearbook available is that for 1956. The Bureau of Mines did fall behind for a few years in the publication of the Yearbook, but the six volumes for 1957 and 1958 were released in December, 1959. The Bureau expects to release the 1959 volumes in December, 1960, and plans to maintain and improve upon this schedule in the future.

The Bureau of Mines is to be complimented for the rapid compilation and prompt publication, through the Government Printing Office, of the statistical data on mineral resources. The production of the three volumes (Metals and Minerals [Except Fuels], Fuels, and Area Reports), which contained 2,779 pages for 1958, requires many tedious man-hours of work.

About two months before the bound volumes are released, individual chapters are available as preprints. In addition, preliminary figures on petroleum are available about two months after the close of a subject month through the *Monthly Petroleum Statement*. Preliminary figures for 1959 were made available in *Monthly Petroleum Statement No. 451*, which was released March 3, 1960.

In December of each year. the Bureau of Mines releases a brief mimeographed preliminary report on the mineral industry of each State, estimating the final production figures. This preliminary report also contains final figures for the preceding year. Thus final figures on petroleum are available 11½ months after the close of the year.

LISSATRYPOIDEA CONCENTRICA (HALL), EMEND BOUCOT AND AMSDEN: ILLUSTRATIONS OF THE LECTOTYPE

THOMAS W. AMSDEN

The species *Nucleospira concentrica* was described by Hall (1859, p. 223, pl. 28B, figs. 16-19) who based his description on specimens from the "shaly limestone of the age of the Lower Helderberg group: Decatur county, Tennessee." In 1958 I borrowed Hall's type specimens from the American Museum of Natural History; these include eight specimens bearing the A.M.N.H. catalog number 2196, and labeled "Niagara Group, Meniscus bed, Glades in Decatur County, Tennessee" (these strata were later named the Brownsport formation [Amsden, 1949, p. 3, 6]). A study of the type specimens showed the presence of two species representing different genera. Boucot and Amsden (1958, p. 159-161) designated the specimen which Hall illustrated on plate 28B, figures 16d, 16e, as the lectotype, and made *concentrica* the type of a new genus, *Lissatrypoidea*. Hall's type specimens also included representatives of *Nucleospira* sensu strictu and these were assigned to a new species, *N. raritas* Amsden (1958, p. 157). A complete discussion of this rather complicated nomenclatorial history is given by Amsden (1958, p. 157) and by Boucot and Amsden (1958, p. 160-161). Hall's original illustrations of the lectotype consist only of two small lithographs and therefore this specimen is here re-illustrated in five different views (fig. 1).

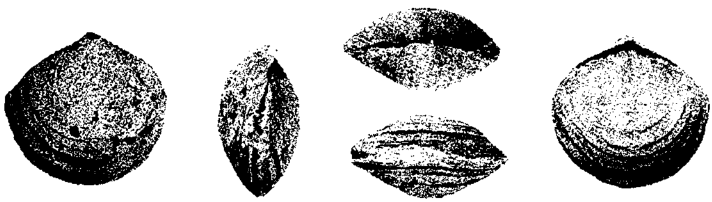

FIGURE 1. *Lissotrypoidea concentrica* (Hall), emend Boucot and Amsden (=*Lissatrypa decaturensis* Amsden 1949); Brownsport formation, western Tennessee. Pedicle, lateral, posterior, anterior and brachial views of the lectotype, x3. This is the specimen illustrated by Hall in 1859, plate 28B, figures 16d, 16e. American Museum of Natural History, catalog number 2196.

Other external and internal views of *L. concentrica* (as *Lissatrypa decaturensis*) may be found in Amsden (1949, pl. 9, figs. 16-23; and 1951, pl. 19, figs. 10-16).

Specimens of *Lissatrypoidea concentrica* are common in the Brownsport formation of western Tennessee and in the Henryhouse formation of south-central Oklahoma. A second species, *L. henryhousensis*, is also present in Oklahoma.

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Reclassification of an Oklahoma Foraminifer

The genus *Tuberitina* was established by Galloway and Harlton in 1928 and was based on the new species *T. bullbacea.* The species was described from specimens from an outcrop of the "Upper Glenn," SW¼ SW¼ NW¼ sec. 20, T. 5 S., R. 1 E., Carter County, Oklahoma, about four miles north of Ardmore. This locality is shown on the map of the southern part of the Ardmore basin as being in the Hoxbar formation above the Anadarche limestone.

Galloway and Harlton placed the new genus in the family Nodosinellidae. In 1958 Miklukho-Maklay established the new family Tuberitinidae for the genus and for several other genera: *Capidulina* Maslov, 1935, *Eotuberitina* new genus, and *Neotuberitina* new genus. The family occurs in Upper Permian rocks. In Osnovy Paleontologii (1959), *Tuberitina* is placed in the Family Parathuramminidae and *Capidulina* Maslov is placed in synonymy with *Tuberitina.*

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—C. C. B.

RECENT EXPLORATION IN THE ARKOMA BASIN AND OUACHITA PROVINCE, SOUTHEASTERN OKLAHOMA

C. B. Branan, Jr. and Louise Jordan

Two geologic provinces in southeastern Oklahoma, the Arkoma basin and the Ouachita Mountains, have been considered of minor interest to the petroleum industry. With the increased demand for and value of natural gas reserves, these two areas have come to the forefront of exploration in Oklahoma in the 1959-1960 period. Two geologically and economically significant tests drilled in Latimer County resulted in natural gas production: one on the Brazil anticline in the McAlester sector of the Arkoma basin, and the other south of the Choctaw fault in the Potato Hills area of the Ouachita Mountains (fig. 1). The Choctaw fault forms the boundary between the basin and the Ouachita Mountains in Oklahoma. North of the fault in the basin lies a series of northeastward- and eastward-trending gentle synclines and narrower more sharply folded anticlines, some of which, called uplifts, are structurally more complex than simple anticlines. South of the Choctaw fault is the area of complexly folded and thrust-faulted rocks of the Ouachita Mountains.

Gas has been produced for local consumption in the McAlester sector of the Arkoma basin for more than fifty years. Production is mainly from the Hartshorne (early Desmoinesian) sandstone, ranging in depth from 500 to 3,500 feet. The wells had initial rock pressures between 150 and 550 psi, yet some of the first wells drilled are still productive. In the Poteau-Gilmore field, eastern Le Flore County, the initial capacities of wells ranged from 250,000 cubic feet to 8,000 cubic feet per day; and initial pressures ranged from 118 to 365 psi (Stone and Cooper, 1929, p. 411, 423).

In the Quinton and Kinta districts of eastern Haskell and western Pittsburg Counties, initial capacities of wells ranged from less than one million to as high as 50 million cubic feet daily. The Quinton field, discovered in 1915, had yielded more than 30 billion cubic feet of gas by the end of 1933 with an average well-head pressure drop from 530 to 78 psi (Dane, Rothrock and Williams, 1938, p. 227). Perhaps this shallow production is of minor importance when compared with what the basin holds in the deeper, thicker, and more numerous Atokan and Morrowan sandstones.

The first significant deep gas production in southeastern Oklahoma was discovered in 1930 in basal Atokan sandstone, called the Spiro sand, by the Red Bank Oil Company No. 1 Fee in sec. 23, T. 9 N., R. 24 E., LeFlore County. The well was drilled on the crest of the Milton anticline to a total depth of 6,300 feet. Gas with an open-flow potential of 5.5 million cubic feet daily was found at a depth of 5,403-5,421 feet. During World War II years, a total of 13 producers was drilled and the area became known locally as the Spiro field (the official name is Cartersville Field). Primarily because the gas has been used for local consumption in nearby Fort Smith, Arkansas, exact recoveries are not known, but the 13 wells have produced in excess of 100 billion cubic feet with a pressure decline of from 1,110 psi to approximateely 750 psi.

In 1958, LeFlore County Gas & Electric Company and Carter Oil Company drilled on the Milton anticline seven miles southwest of Cartersville Field. Gas was found in the Spiro pay at 5,515 feet in the No. 1 McBee Harrison

(SE¼ SE¼ NE¼ sec. 17, T. 8 N., R. 23 E.) Initial open-flow potential of the well was 7.6 million cubic feet of gas per day with a shut-in pressure of 1,110 psi from a net pay 63 feet thick. The well, discovery of the West Milton Field, may be an extension of the Spiro pool of the Cartersville Field and thus the area on the anticline between the fields may be productive.

The second indication that major gas reserves exist in southeastern Oklahoma came in 1952 when The Superior Oil Co. completed its No. 1 Allred in sec. 18, T. 8 N., R. 20 E., Haskell County. The well, located on the North Kinta anticline, has a total of 70 feet of productive Spiro and Cromwell (Morrowan) strata between the depths of 5,600 and 6,100 feet. Combined open-flow potential of the zones was approximately 30 million cubic feet of gas daily. The gas is nearly pure methane (98.5%) as is all other gas in the Arkoma basin. Superior drilled two more producers in the field in 1955. Operators have added four wells, and wells being drilled at two other locations have had successful drill-stem tests. Oklahoma Natural Gas Co. is the gas purchaser. The official field name, now Northeast Kinta, was first East Lona, and later West Kinta.

Lack of a market outlet has been the exploration deterrent in the Arkoma basin. Even with excellent producing wells as indicators, the area remained dormant until May 1959. At this time the Midwest Oil Corp., Fort Worth, Texas, ventured southward into Latimer County to drill deep on the Brazil anticline. The test, No. 1 Orr, near the center of SW¼ sec. 8, T. 6 N., R. 22 E., is within the area of the old Red Oak-Norris Field, and is about 12 miles southeast of the Superior wells on the North Kinta anticline. First production in the Red Oak-Norris Field was from the Gladys Belle Oil Co.'s well drilled in sec. 10, T. 6 N., R. 21 E., in 1912. In 1939, records showed that 18 wells had yielded gas in commercial quantities from the Hartshorne sandstone, ranging in depth from 1,500 to 2,000 feet beneath the surface and extending over a belt 1½ miles wide and 9 miles long. At that time the largest producer recorded was the LeFlore Co. G. & E. No. R.O. 12, McFerran, in SE¼ SW¼ SE¼ sec. 2, T. 6 N., R. 22 E., which had an initial daily flow of 25 million cubic feet at a rock pressure of 555 psi (Hendricks, 1939, p. 287).

The Midwest Oil Corp. and Frankfurt Oil Co. No. 1 Orr (elevation : 600 feet) was drilled to a total depth of 12,650 feet into Mississippian shales. Atokan rocks were encountered at 1,780 feet below the surface and had a drilled thickness of more than 9,800 feet. The Wapanuka limestone (Morrowan) was reached at a depth of 11,643 feet and the Cromwell sand was found between 12,070 to 12,158 feet. Two gas zones were discovered in the Atoka: a mid-Atoka sandstone, called Red Oak by the operators, 135 feet thick from 7,180 to 7,335 feet with open-flow gas potential of approximately 20 million cubic feet daily; and a basal Atokan sandstone, called Spiro, between 11,510 to 11,570 feet with open-flow potential of 17.8 million cubic feet daily. A bottom-hole shut-in pressure of 4,775 psi was recorded in the Spiro sand. The well has been dually completed and a second well is being drilled.

More than any other single event, the drilling of this well created the intensive leasing campaign and the current exploratory drilling in the Arkoma basin. As late as January 1959, acreage could be purchased on any major structure, even the producing ones, for as little as $1.00 per acre. Since the advent of the Midwest well, prices have soared and most of

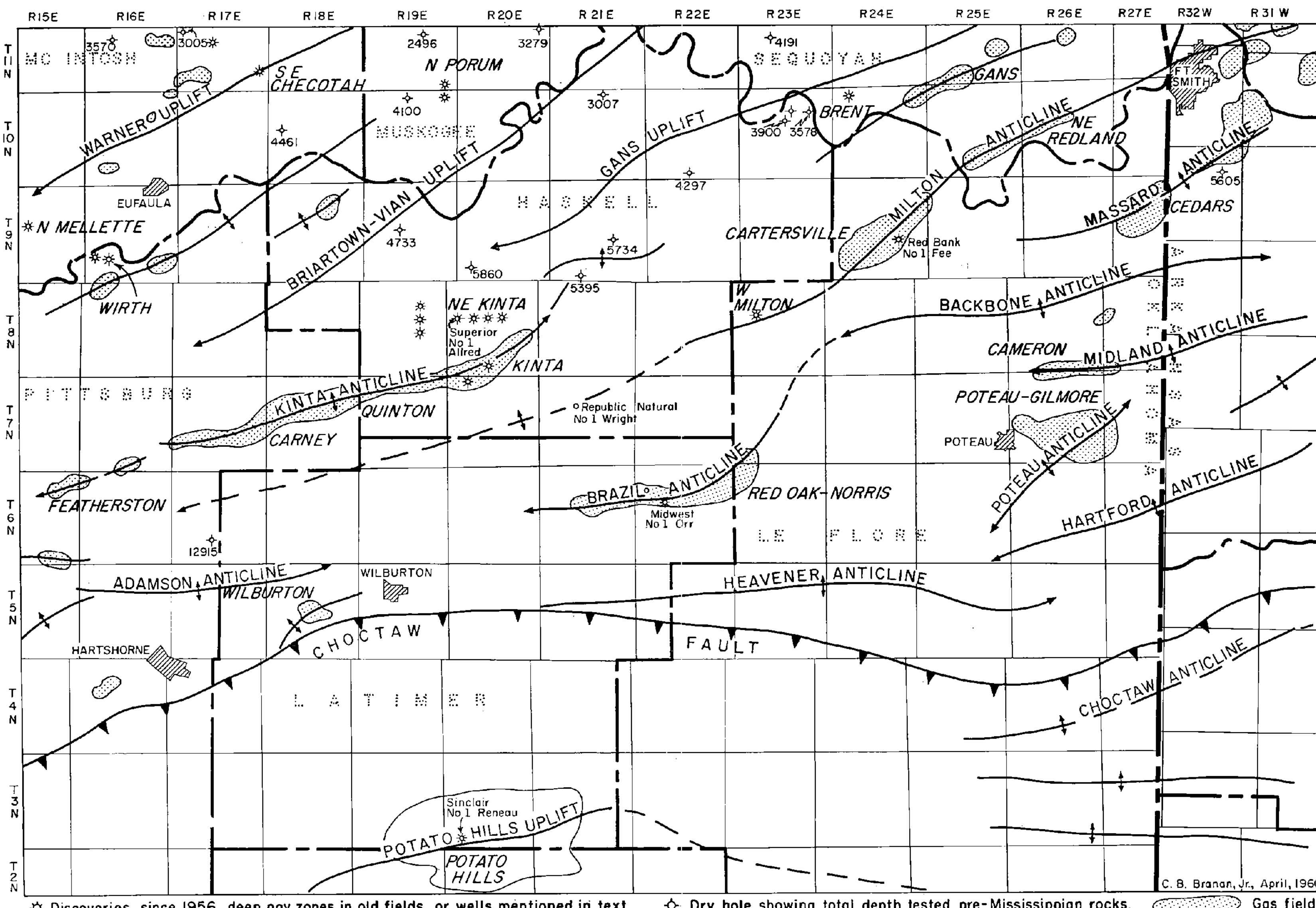

FIGURE 1. Map of McAlester sector of the Arkoma basin showing approximate position of major anticlines and uplifts, and location of gas fields.
(Note: The structure labeled Massard anticline is the *Massard Prairie* anticline.)

the basin proper is under lease. The synclines as well as the anticlines are being leased.

The Midwest well revealed several points of major geologic importance. First, it is possible that structure is only coincident to production. Second, thick sandstones in the Atoka formation pinch out as the section thins northward, indicating possible stratigraphic entrapment of hydrocarbons. Most of the folding in the basin is the result of Late Pennsylvanian or Early Permian diastrophism. The folds on the surface may be only superficial, diminishing with depth as is the situation with much of the folding in the Ardmore basin to the west. Gas could have been trapped long before the folding occurred. Another point of significant interest is that little water has been found in Atokan sandstones. The sandstone normally is either well-cemented and non-porous or it produces gas regardless of structural position. These remarks are only speculations and it is obvious from the lack of well control to deeper zones that geologists have a great deal to learn.

The deepest test in the southern part of the basin, about 8 miles north of the Choctaw fault, is the No. 1 Manschrick, drilled in 1954 by Magnolia Petroleum Company in C SE¼ NE¼ sec. 28, T. 6 N., R. 17 E. In this unsuccessful test, Atokan rocks were 6,564 feet thick; pre-Atokan, post-Arbuckle sequences were 2,242 feet in thickness; and 779 feet of the Arbuckle group were penetrated to a total depth of 12,915 feet.

The second well of significance in 1959 for southeastern Oklahoma is that drilled in southern Latimer County by the Sinclair Oil & Gas Company south of the Choctaw fault in the Ouachita Mountains. This test, the No. 1 Reneau (C SE¼ NW¼ sec. 32, T. 3 N., R. 20 E.) was located in the Potato Hills, an area the structure of which has long been discussed by geologists (Tomlinson, 1959, p. 3). The wildcat was completed for a calculated open-flow potential of 1.85 million cubic feet of gas daily with no water from the Big Fork chert (equivalent to the Viola) at 2,340-2,410 feet. The well, starting in Stanley shale at the surface, penetrated several thrust faults in the Big Fork-Womble section and drilling stopped at a total depth of 7,097 feet. Sinclair geologists report the following information below 1,100 feet (elevation, 768 feet):

1,106-1,602	Big Fork chert (equivalent to Viola, Middle Ordovician)
1,602-2,174	Womble shale, thrust fault at 2,174 feet
2,174-2,526	Big Fork chert (includes gas-productive zone)
2,526-2,572	Fault zone with included Womble shale
2,572-3,372	Big Fork chert
3,372-4,280	Womble shale, thrust fault at 4,280 feet
4,280-4,972	Big Fork chert
4,972-5,180	Womble, thrust fault at 5,180 feet
5,180-5,796	Big Fork chert
5,796-6,286	Womble shale
6,286-6,648	Crystal Mountain sand zone
6,648-7,011	Crystal Mountain sandstone (barren of hydrocarbons)
7,011-7,097 TD	Collier shale

The normal sequence (descending order), in McCurtain County 50 miles to the southeast, is Big Fork, Womble, Mazarn, Crystal Mountain and Collier; 75 miles to the east in Montgomery County, Arkansas, the Blakely sandstone lies below the Womble and above the Mazarn. The lower Womble and underlying formations are considered by Ham (1959, p. 80) to be equivalent to part of the Arbuckle group. In the Potato Hills, Womble shale is the oldest rock exposed and only the upper 106 feet has been measured (Roe, 1955, p. 60). It is a black shale with chert beds closely resembling the Big Fork in the upper portion. In the western Potato Hills, sandstone lenses are present in a short section (Miller, 1955, p. 11). In McCurtain County, the Womble section is about 600 feet thick (Ham, 1959, p. 79) and consists of siltstone and shale with a basal 66-foot section built up of limestone, silty limestone, black shale, and siltstone (Pitt, 1955, p. 24-25). In Arkansas, Womble is mainly black shale about 1,000 feet thick containing thin sandstone beds throughout (Ham, 1959, p. 79). At Black Knob Ridge about 60 miles southwest of the Potato Hills, Harlton (1953, p. 780) reports Womble shale 260 feet thick, containing thin lenses of sandstone, in fault contact at the base.

One Oklahoma City geologist considers the possibility that the section from 5,796 to 7,011 feet in the Sinclair No. Reneau is equivalent to the Womble (and possible Blakely) and that, from 7,011 to total depth, the shale is Mazarn. Many fragments of graptolites were observed in the cuttings from the well, but specific determinations have not been made. A core taken at 6,360 to 6,376 feet recovered seven feet of shale, seven feet of sandstone, and one foot of shale (descending order) and showed a dip of 50°. A dipmeter survey of the well was made but the data are not now available.

The Ouachita facies of rocks south of the Choctaw fault have always presented a formidable problem to geologists of Oklahoma. Pre-Stanley rocks are exposed in only two areas, the Potato Hills and McCurtain County. In the remainder of the mountains, the younger Stanley, Jackfork, Johns Valley and Atoka formations crop out and have an aggregate thickness of approximately 22,000 feet (Cline and Shelburne, 1959, p. 177). The rocks are mostly clastics; shale is predominant in the Stanley, whereas sandstone is predominant in the Jackfork, and sandstone and shale are in about equal proportions in the Atokan. Rocks of the sequence are similar in appearance and contain poor fossil control. Cline and Shelburne (1959, p. 175) have been studying the stratigraphy of the sequence and geological reports on two areas within the mountains will be published this spring by the Oklahoma Geological Survey as Bulletins 85 and 88.

Because of intense folding and repetition of beds due to complicated thrust patterns, the geology of the Ouachitas is difficult to interpret at the surface. In the subsurface, where one drills an eight-inch hole and drill cuttings are the evidence of rock types, problems of interpretation are multiplied. Max Pray's No. 1 Wyrick, test drilled in 1958 in the northeast corner of Atoka County (sec. 26, T. 1 N., R. 14 E.) to a total depth of 12,088 feet is a good example. Stanley shale and sandstone were drilled from surface to 8,200 feet. Arkansas novaculite was recognized from 8,335 to 8,400 feet; Polk Creek from 8,400 to 8,420 feet; Big Fork cherty limestone from 8,420 to 9,098 feet; and Womble shale from 9,098 to 12,088 feet. A dipmeter survey to the depth of 8,420 feet gave the following results: SE dips to 3,795, NW dips to 4,150, SE dips to 6,056, SW dips to 6,922, SE dips to 7,424, NW dips to 7,952, and SW dips to 8,420 feet (Howell and Lyons, 1959, p. 60). This well had several shows of gas and one show of oil.

The Choctaw fault dies out eastward into Arkansas and is not mapped on the surface. In general, the intensity of faulting diminishes from west to east in the mountains. The geology of the Arkansas portion of the mountains is more simple and should be studied in greater detail to solve some of the problems that exist in the Oklahoma portion.

Certainly structural and stratigraphic traps, massive-sandstone reservoirs, known oil and gas production (Howell and Lyons, 1959, p. 58; Chenoweth, 1959, p. 199) and deposits of asphaltite (Ham, 1956) are present in the Ouachita province. In fact, Oklahoma was the leading state in production of grahamite for nearly 25 years in the early part of the twentieth century. Regardless of the multitude of difficulties in unraveeling the geology, the Ouachita Mountains should be an excellent province in which to explore for reserves of hydrocarbons.

Appendix

The data concerning the discovery of fields in the period 1957 through 1959 are listed below in order of completion date.

Redland, Northeast: Stephens No. 2 Brandt (OWWO) NW NW SE 24-10N-25E, Sequoyah County. Elev. 520 GR. Comp. 3-20-57. IP flowing 1,038 MCF/d, choke 2 inches. SITP 1,025. Total depth 6,267 feet in Mississippian. *Hale* (Morrowan) pay, top 5,972, net pay 66 feet.

Porum, North: Phillips No. 1 Hatcher, NE NW SW 36-11N-19E, Muskogee County. Elev. 560 DF. Comp. 6-21-57. IP 1,235 MCF/d gas, wtr. 57 b/d, choke, 25/64 inches. FTP 405. FCP 250. Total depth 4,493 in Arbuckle. *Spiro* (Atokan) pay, top 2,970, net pay 17 feet.

Brent: Carter No. 1 Williams, C NW SE 5-10N-24E, Sequoyah County. Elev. 508 DF. Comp. 10-30-57. IP 2,853 MCF/d gas, choke open, FTP 100, FCP 375, SITP 1,125. Total depth 4,200 feet in Arbuckle. *Cromwell* (Morrowan) pay, top 2,988, net pay, 40 feet.

Checotah, Northwest: Oklahoma Nat. Gas No. 1 Covey, NW NW SE 14-12N-16E, McIntosh County. Elev. 638 DF. Comp. 2-12-58. IPOF 15,400 MCF/d gas, cond 5 b/MMCF. SIP 1,039. Total depth 3,480 feet in Arbuckle. *Gilcrease* (Atokan) pay 2,261-73, 2,288-94, 2,386-94, net pay 26 feet.

Raiford, Southeast: Southern Union Gathering No. 1 Bartleson, NE NE SE NE 19-9N-15E, McIntosh County. Elev. 583 DF. Comp. 3-5-58. IPOF 9,200 MCF/d gas. SITP 1,860. Total depth 4,965 in Hunton. *Cromwell* pay, 4,252-72, net pay 20 feet.

Milton West: Le Flore G & E-Carter No. 1 McBee Harrison, SE SE NW 17-8N-23E, Le Flore County. Elev. 782 GR. Comp. 4-16-58. IPOF 7,642 MCF/d gas. SIP 1,110. Total depth 6,182 in Cromwell. *Spiro* (Atokan) pay 5,515-5,670, net pay 63 feet.

Wirth: Pure Oil No. 1 Bauman, NE NE SW 29-9N-16E, Pittsburg County. Elev. 571. Comp. 2-12-59. IP 3,283 MCF/d gas through one inch choke. Total depth 5,434 feet in Simpson group. *Cromwell* (Morrowan) pay, top 4,385, net pay 40 feet.

Kinta District, deep.: Ambassador Oil et al. No. 1 Davenport, SE NE SW NE 33-8N-20E, Haskell County. Elev. 566 DF. Comp. 7-2-59. IPOF 2,459 MCF/d gas. Total depth 6,235 feet in Mississippian. *Spiro* (Atokan) pay, top 5,523, perforated 5,542-5,570, net pay 24 feet.

Mellette, North: Southern Union Gathering No. 1 Brown, NW SE SW 16-9N-15E, McIntosh County. Elev. 591, Comp. 10-15-59. Dual completion from *Cromwell* (Morrowan) pay, top at 4,114; and from *Hunton* (Devonian-Silurian) pay, top at 4,752. Gas 3,250 MCF/d natural from Cromwell and 2,269 MCF/d through open tubing from Hunton. Total depth 4,865 feet in Hunton.

Checotah, Southeast: Tidewater No. 1 Sizemore-Winkel, C SE SW 25-11N-17E, McIntosh County. Elev. 620. Comp. 12-5-59. IP 1,882 MCF/d gas, choke ¾ inch. Total depth 3,629. *Atokan* sandstone pay, perforated 1,110-1,123.

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A MISSISSIPPIAN CHITINOZOAN FROM OKLAHOMA*

L. R. WILSON AND R. T. CLARKE

The stratigraphic range of the Chitinozoa, a group of problematic fossil animals, has been given as Ordovician-Devonian by Collinson and Schwalb (1955) and as Cambrian-Mississippian by Wilson (1956). The latter more extensive range is based upon fragments of chitinozoan-like fossils from the Nassau shale (Cambrian) of New York and similar fragments from the Chattanooga shale (Mississippian ?) of Arkansas. Despite a thorough search of insoluble residues from both the Nassau and the Chattanooga shales only fragmentary chitinozoan-like fossils have been found and these must be considered of doubtful assignment.

Recently, while preparing a sample of Goddard shale (Mississippian) from the Goddard Ranch in Johnston County, Oklahoma, a single specimen of Chitinozoa was found. This individual is illustrated by the accompanying photomicrographs (plate I). Although only one specimen has been found it probably constitutes the best documented occurrence of Chitinozoa in Mississippian time, and because it is a distinct form, this preliminary note is being published. However, until additonal specimens are found and studied, a name will not be applied to it.

The specimen is 134 microns long and 99 microns wide. The body is urn-shaped with a short copula and a flange at the aboral end. The oral end is 53 microns in diameter and it is truncated. The opening is centrally located and is 30 microns in diameter. The neck is approximately 9 microns long, and is slightly wider at the base than at the top. The length of the copula and aboral flange is 13.7 microns and the diameter of the latter is 25.6 microns.

*Preliminary report of one study being conducted under National Science Foundation Grant No. G6589.

EXPLANATION OF PLATE I

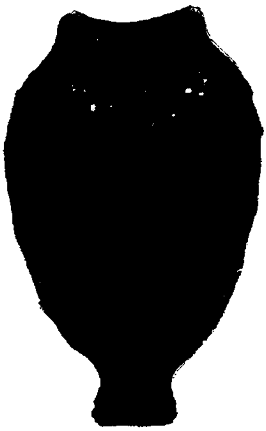
A Mississippian Chitinozoan

FIGURE 1. Chitinozoan from the Goddard shale (Mississippian) showing external structure and some internal structures that are slightly out-of-focus. The top is the oral end and contains the oral aperture. The neck and body together are urn-shaped and at the aboral end is the copula and aboral flange. Total length 134 microns, greatest diameter 99 microns. Slide No. 1, OPC 563.

FIGURE 2. Specimen photographed in median section to show internal structure. Oral aperture is funnel-shaped leading to the neck constriction, or diaphragm. The expansion below is a vestibulum to the body cavity, which is enclosed by a thick translucent wall, and a thinner nearly opaque outer wall. Spines are apparent on the outer edge of the wall. The copula and aboral flange have a central translucent column.

FIGURE 3. Aboral end of specimen showing the lowest part of the body, the copula, and the aboral flange in median longitudinal section. A transparent tegmen is apparent on the right side of the aboral flange and portions of the copula. The aboral flange consists of an inner and an outer ring with a sharp depression between them. An external constriction separates the aboral flange from the copula.

FIGURE 4. Outer wall with scattered spines which rise from bulbose bases. The area between spines is smooth with scattered pits where spines have been broken from the wall.



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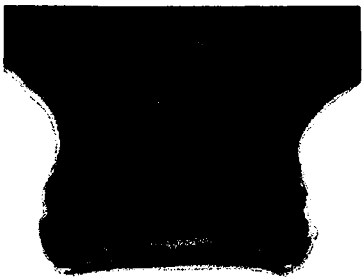

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The entire fossil appears to be covered with a transparent tegmen that is approximately five microns thick. This is best illustrated in figure 3 on the copula and aboral flange. Whether the tegmen is normally transparent, or nearly so, is not known for the specimen was bleached during the preparation process which included treatment with potassium chlorate and nitric acid. It is known from other studies in this laboratory that bleaching or clearing of opaque chitinozoan structures is quite normal when potassium chlorate and nitric acid are employed in preparations. As the Goddard shale sample was subjected to that process it can be assumed that the specimen described was also cleared and that the tegmen was made transparrent. Inside the tegmen are scattered simple spines with bulbose bases. These are oriented toward the oral end as shown in figs. 1, 2, and 4. The spines range from 5 to 7 microns long and their bases are approximately 3.5 microns in diameter.

The internal structure is made clearly apparent by focusing below the outer wall (fig. 2). The oral aperture is funnel-shaped. At the outer end it is 30 microns in diameter and narrows to 12 microns at the inner end where it terminates at the diaphragm. Below the diaphragm opening, which is approximately at the same level as the neck base, a vestibulum to the body cavity is present. This is 10.8 microns long and 36 microns in diameter at its widest point. The body cavity abruptly widens below the vestibulum into a chamber 66 microns in diameter and 60 microns long. When the specimen was first mounted in Clearcol a spherical bubble completely filled the upper part of the cavity indicating that the latter is essentially an elongate sphere. A translucent inner wall 10 to 25 microns thick surrounds the central cavity. Exterior to this is an almost opaque outer wall, 6 to 10 microns thick. The copula and aboral flange contain a central translucent column which flares upward and abuts against the translucent wall which envelops the body cavity (figs. 2, 3). The translucent substance in the aboral flange and copula is slightly lighter than that in the body. The arboral flange is separated from the copula by a constriction and the latter is flared at its base (fig. 3).

The affinity of the Goddard shale chitinozoan is with the family Desmochitinidae and it may be a member of the genus *Desmochitina* although the detailed internal structures of that genus have not been described. The oral and aboral morphology of the Goddard shale specimen suggests that it might represent one unit in a chain-like series such as occurs in *Desmochitina*. Future studies of Chitinozoa should include investigations of cleared specimens. Observations of the Goddard shale specimen, and those of Wilson (1958) on the chitinozoans of the Sylvan shale (Ordovician) show the importance of internal structure in the identification of species. The internal structure of all presently described forms should be studied in an effort to resolve some of the taxonomic problems that are present in closely related genera and species.

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REGRESSIVE EVOLUTION AMONG ERISOCRINIDS

HARRELL L. STRIMPLE

The normal progressive evolution of crinoid calyces is from a high conical shape to a low bowl-like shape with invaginated base. It is necessary also to recognize the existence of regressive evolution.

Endelocrinus matheri (MOORE AND PLUMMER, 1937)—A small partial crown (fig. 1), collected by my good friend, Mr. Claude Bronaugh of Afton, Oklahoma, several years ago from the Brentwood limestone member, Bloyd formation, Morrow series of Greenleaf Lake, southeast of Muskogee, Oklahoma, permits study of the arm structure of the species originally described as *Delocrinus matheri* Moore and Plummer. The holotype of the species came from the same formation at Keough Quarry, north of Ft. Gibson, Oklahoma (sec. 36, T. 16 N., R. 19 E.). The present specimen is unquestionably referred to the species as a hypotype (OU No. 3620). It shows a shagreen surface of fine, twining ridges and depressions on the outer arm surfaces as well as on the dorsal cup.

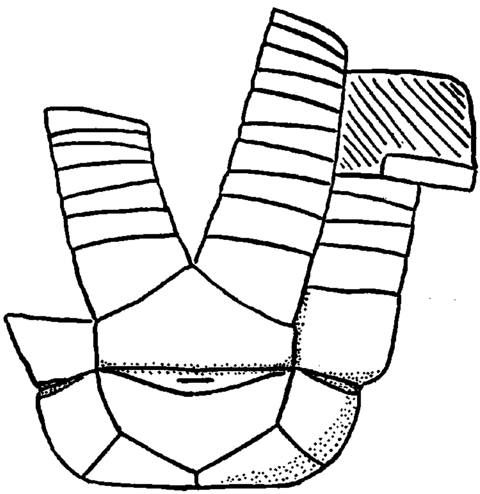

FIGURE 1. Drawing of partial crown of *Endelocrinus matheri* (Moore and Plummer) from left anterior.

In the three rays preserved above the primibrachs, the arms are uniserial. Bifurcation takes place on the slightly elongate first primibrachs. In the right arm of the left anterior ray, there are ten secundibrachs. preserved with no evidence of biserial development. This is not to say that the arms could not become biserial before termination, but the characteristic is that of *Endelocrinus* rather than that of *Delocrinus*. Moore and Plummer

(1940, p. 299) revealed the existence of six to nine secundibrachs that are quadrangular and thereafter become wedge-shaped in *Endelocrinus fayettensis* (Worthen, 1873), the genotype species. The same characteristic has been observed in other species of *Endelocrinus*.

In 1950, I noted the absence of young specimens that could be referred to *Delocrinus*, and conversely the coexistence of numerous small forms referred to *Endelocrinus*. This is readily explained when one realizes that the oldest known species is indeed an *Endelocrinus*. The law of ontogenesis, wherein the young retain the characteristics of the ancestral form, is obviously applicable here.

Other than the difference in lower arm structure, the only difference between *Delocrinus* and *Endelocrinus* is the existence of small, dimple-like depressions at the apices of cup plates. Typical representatives of *Endelocrinus matheri* show this characteristic to a moderate degree.

CHARACTERISTICS OF VARIOUS ERISOCRINIDS—It is desirable to review the fundamental characteristics ascribed to the various genera involved. In all of those considered below, there are five infrabasals, five basals, five radials, ten arms that branch isotomously on the first primibrach (except *Spaniocrinus*) and there may be one anal plate or none in the dorsal cup proper.

Endelocrinus Moore and Plummer, 1940

One anal plate. Dorsal cup is a low basally impressed globe having downflaring infrabasals. Normally the basal invagination is somewhat smaller than in *Delocrinus*. There are sharp depressions at the meeting of cup plates. Approximately one-third the length of the arms is uniserial, thereafter biserial. Maximum development of the genus is in the Missouri series.

Delocrinus Miller and Gurley, 1890

One anal plate. Dorsal cup is a low basally impressed globe having downflaring infrabasals. The first few secundibrachs are quadrangular, thereafter wedge-shaped. The arms are therefore fundamentally biserial and are usually somewhat shorter than those of *Erisocrinus* or *Paradelocrinus*. Maximum development of the genus is in the Missouri series. It has not been observed in the Morrow series.

Exception: *Delocrinus separatus* Strimple (1949b) is flat-bottomed, with subhorizontal infrabasals.

Paradelocrinus Moore and Plummer, 1937

No anal plate, in the strict sense. Dorsal cup is a low basally impressed globe having downflaring infrabasals. First few secundibrachs are quadrangular, thereafter wedge-shaped (based on *P. brachiatus* Moore and Plummer, 1940, Desmoinesian age). The arms are therefore biserial, and are long, as in *Erisocrinus*. Maximum development of the genus is in the Des Moines series.

Exceptions: *Paradelocrinus regulatus* Strimple (1949c), *P. disculus* Strimple (1949c) and *P. subplanus* Moore and Plummer, 1940, all have flat bottoms with subhorizontal infrabasals.

Erisocrinus Meek and Worthen, 1865

No anal plate. Dorsal cup is a truncated cone having subhorizontal infrabasals. May have a shallow flat-bottomed basal depression. Typically the genus has a strongly pentagonal outline when viewed from above or below. First few secundibrachs are quadrangular, thereafter wedge-shaped. There are therefore ten fundamentally biserial arms, normally quite long. Maximum development is in the Missouri series. The genus is not present in the Morrow series. Exception: *Erisocrinus lustrum* Strimple, 1951, has mildly upflared infrabasals.

Stuartwellercrinus Moore and Plummer, 1940

No anal plate. Dorsal cup is a low cone with upflaring infrabasals. Only three infrabasals are reported for the genus; however, only Permian species were known at the time the genus was proposed. One may expect a more advanced stage, such as fusion of certain infrabasals in advanced forms. The upper articulating facets of *S. symmetricus* (Weller), shown by Moore and Plummer (1940, pl. 15, fig.3), are comparable to those of several species of *Erisocrinus* or *Delocrinus*. The arms of the genus are unknown.

Spaniocrinus Wanner, 1924

No anal plate. Dorsal cup has a moderately steep-sided conical form with upflaring infrabasals. There are only five uniserial arms composed of massive, quadrangular brachials. Moore and Plummer, 1940, assigned *Erisocrinus trinodus* Weller, 1909, from the Cibolo limestone, lower Permian, to the genus with reservation. The genus is based on *Spaniocrinus validus* Wanner, 1924, from the Permian of the Island of Timor, and the nature of the upper articulating facets of the radials is not known for that species. Conversely we do not know the arm structure of American species that might be assigned to the genus. I strongly suspect that American forms will be found to have arm structure more comparable to *Erisocrinus* than to *Spaniocrinus*.

Evolutionary Evidence—*Endelocrinus matheri* (Moore and Plummer, 1937), *Paradelocrinus dubius* (Mather, 1915) and *Paradelocrinus aequabilis* Moore and Plummer, 1938, are all from the Brentwood limestone member, Bloyd formation, Morrow series, Lower Pennsylvanian. *P. dubius* is the most prolific form and is highly specialized, having a pronounced basal depression. Considering the condition of the base, it would either have to become regressive or to die out. It may very well have died out. *P. aequabilis* was no doubt produced out of *Endelocrinus* through elimination of the anal plate from the cup proper. Through regressive evolution, that is, by change from a cup with depressed base and downflared infrabasals to a flat-bottomed base with subhorizontal infrabasals, such forms as *Paradelocrinus subplanus* Moore and Plummer, 1940, and the genus *Erisocrinus*, and eventually *Stuartwellercrinus* with upflared infrabasals are developed.

Delocrinus is only slightly different from *Endelocrinus* and could easily have evolved from that genus as previously noted under the discussion of *Endelocrinus matheri*. A typical representative of the genus, *Delocrinus verus* Moore and Plummer, 1940, from the Palo Pinto limestone, Canyon group, Missouri series, is shown by figure 2F. *D. separatus* Strimple (1949b) from the Stull shale member, Kanwaka formation, Virgil series, Upper Pennsylvanian, is shown by figure 2G as an example of regressive evolution within the genus proper. It has a broad flattened base with subhorizontal infrabasals. The evolution of *Delocrinus* to *Paradelocrinus* through the

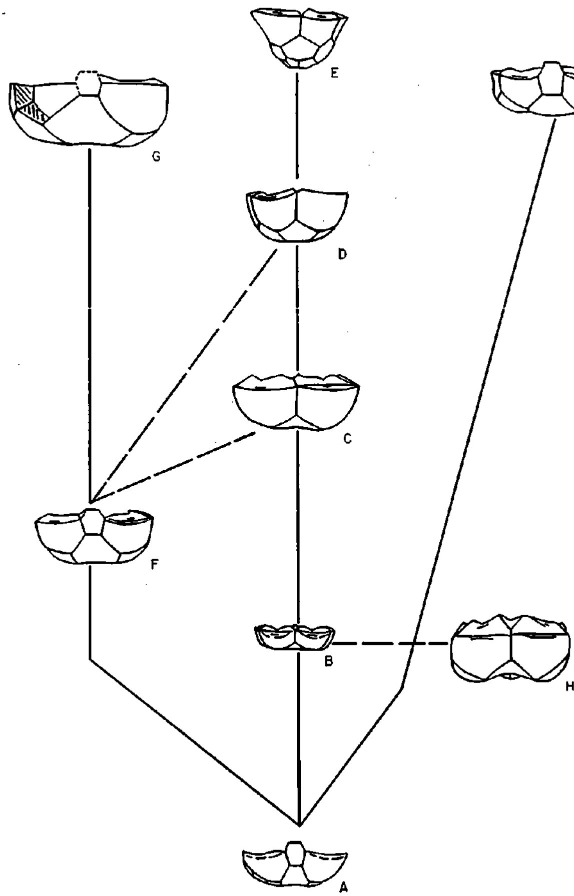

FIGURE 2. Diagrammatic illustration, based on known forms, of evolutionary trends among various Pennsylvanian erisocrinids. A. *Endelocrinus matheri* (Moore and Plummer). B. *Paradelocrinus aequabilis* Moore and Plummer. C. *Paradelocrinus protensus* Moore and Plummer. D. *Erisocrinus typus* Meek and Worthen. E. *Stuartwellercrinus argentinei* Strimple. F. *Delocrinus verus* Moore and Plummer. G. *Delocrinus separatus* Strimple. H. *Paradelocrinus dubius* (Mather). I. *Endelocrinus petalosus* Strimple.

The series A—B—C is normal, progressive evolution, but C—D—E is regressive evolution. The series A—B—H or A—I is progressive evolution. The series A—F is progressive but F—G is regressive. It is recognized that evolution of some forms may come through F—C—D or F—D—E.

elimination of the anal plate was demonstrated by Strimple (1949a).

Erisocrinus is represented by figure 2D, which is a drawing of the syntype of *Erisocrinus typus* Meek and Worthen, 1865, figured by Moore and Plummer (1940, pl. 2, fig. 5). The types are reportedly from Middle Pennsylvanian strata near Springfield, Sangamon County, Illinois. Moore and Plummer reported only four specimens of the species in their Texas collections.

Stuartwellercrinus argentinei Strimple (1949a) is from the Wayandotte limestone formation (Argentine member), Kansas City group, Missouri series, at Kansas City, Missouri. A drawing of the holotype is figure 2E. It is obviously the end result of the regressive evolution, having attained a conical shape.

This is by no means to be considered a final analysis of the erisocrinids, but I do believe it will give a better understanding of the fluid conditions that existed within the family.

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New Theses Added to O. U. Geology Library

The following Master of Science theses were added to the University of Oklahoma Geology Library during the month of April, 1960:

Pennsylvanian of the north flank of the Anadarko basin, by Kenneth E. Gibbons.

Stratigraphy of the Dakota group, northwestern flank of the Canon City embayment, Colorado, by Philip Wienecke Marsh.

New Survey Publications Issued

Two new publications, Circulars 51 and 53, dealing with the geology of southeastern Oklahoma were issued on May 2, 1960, by the Oklahoma Geological Survey.

Circular 51, *Geology of the Cavanal syncline, Le Flore County, Oklahoma*, by Philip K. Webb, consists of 65 pages, 1 figure, and 1 plate. The plate is a colored geologic map of the Cavanal syncline in parts of Tps. 6 and 7 N., Rs. 22, 23, 24, and 25 E., western Le Flore County (including six sections in Latimer County). The report includes four measured stratigraphic sections of the Pennsylvanian Boggy and Savanna formations.

Circular 53, *Geology of the Featherston area, Pittsburg County, Oklahoma*, by Robert E. Vanderpool, consists of 36 pages, 10 figures, and 1 plate. The plate is a colored geologic map covering Tps. 7 and 8 N., R. 17 E., T. 7 N., R. 18 E., and parts of T. 6 N., R. 17 E. and T. 8 N., R. 18 E., northeastern Pittsburg County. The report includes 12 measured stratigraphic sections in the Boggy, Savanna and McAlester formations.

Both documents are available at the Survey offices. Price: $1.75, bound in blue cloth, $1.25, bound in gray paper.

1957 Bibliography

The indispensable *Bibliography of North American Geology*, published by the U. S. Geological Survey, has received its latest addition, the 1957 volume (Bull. 1095). The biblography lists 68 items of Oklahoma geology, of which 10 are abstracts. The bibliography published by Oklahoma Geological Survey in 1958 (Okla. Geology Notes, vol. 18, p. 52-57) lists 186 entries. The State list missed two papers by King and one by Strimple (as well as omitting the 10 abstracts). The Federal list omits articles in trade journals and does not place under Oklahoma many articles significant in the geologic literature of the State.

Of the articles listed in the bibliography, 14 are in the Oklahoma City Geological Society Guidebook or in the Shale Shaker, 16 are Oklahoma Geological Survey documents, eight are in Ardmore Geological Society Guidebook, three each are in the University of Oklahoma geology symposium and World Oil, two in the Bulletin of the American Association of Petroleum Geologists, and one each in 12 journals.

—C.C.B.