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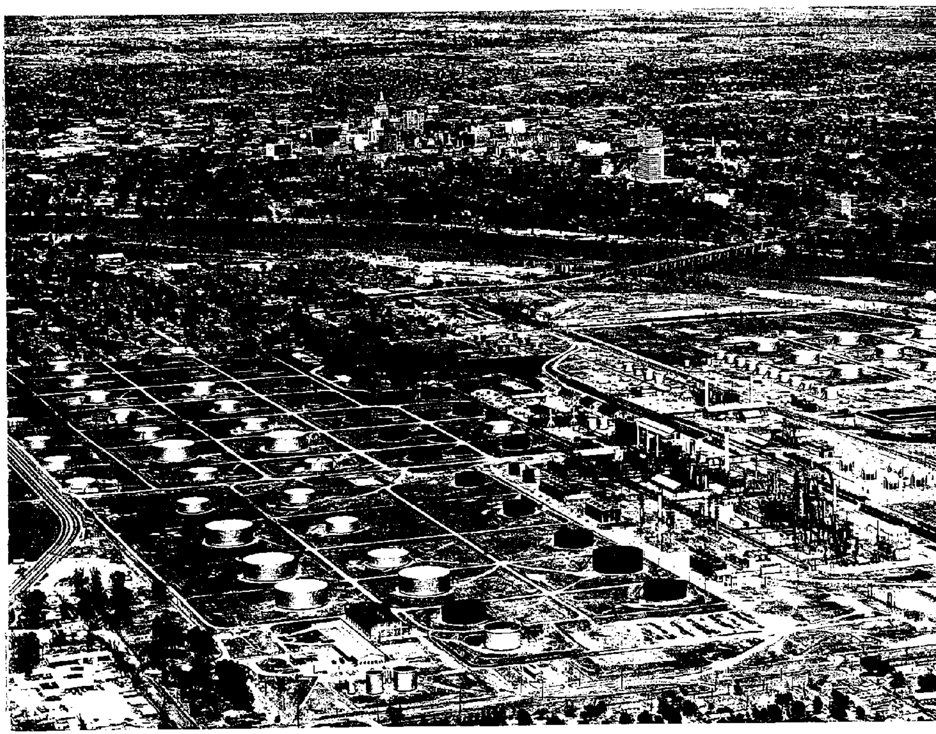

OIL REFINERY, TULSA COUNTY

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

Cover Picture

MINERAL INDUSTRIES OF OKLAHOMA

PETROLEUM

More than 90 percent of the value of Oklahoma's annual mineral production comes from mineral fuels, making the State one of the leading energy producers in the nation. Despite the progressively expanding production of natural gas and natural-gas liquids, crude petroleum still accounts for more than 70 percent of Oklahoma fuel production. The State ranks fourth among the petroleum-producing states, a position which it has held since 1946, at which time it was displaced from third place by Louisiana. Cumulative production of crude petroleum in Oklahoma through 1963 was about 8.8 billion barrels, approximately 12 percent of the national figure. Currently, more than 80,000 wells in 67 counties yield about 200 million barrels annually, valued at about $590 million. Estimated proved reserves amount to about 1.6 billion barrels, about 5.5 percent of the nation's reserves. Twenty-two giant fields (more than 100 million barrels total yield) account for about half the production and reserves.

The value of petroleum to the economy of the State is incalculable, for the dollar value of the produced material is a mere hint of the benefits derived from auxiliary activities which are vital to petroleum production, from exploration and drilling to refining and marketing. At the end of 1963, Oklahoma had 13 refineries in operation with a total capacity of 411 thousand barrels of crude daily. Pictured on the cover is the West Tulsa Plant of Texaco Inc. In the background is "The Oil Capital of the World," Tulsa.

—A. N.

(Photograph courtesy of Texaco Inc.)

New Species of *Goniopholis* from the Morrison of Oklahoma*

Charles C. Mook†

Introduction

In November of 1948 the late Dr. J. W. Stovall, of The University of Oklahoma, sent me photographs of the skull of a goniopholid crocodilian in The University of Oklahoma Stovall Museum Collection, from the Morrison Formation of Cimarron County, Oklahoma. These photographs were the occasion of some correspondence about the specimen, which was later sent to me by Dr. David B. Kitts for study and description. I wish to express my thanks to Dr. Kitts for the opportunity of studying and describing this fine specimen.

The specimen, OUSM 39-1-S8, consists of a well-preserved skull, with most of the component parts preserved, but showing a moderate amount of vertical compression.

The genus to which the skull must be ascribed is clearly *Goniopholis* of Owen. The species, as noted by Dr. Stovall, resembles *G. gilmorei* Holland, but, as was also noted by Stovall, certain of the anatomical details appeared to be slightly, but definitely, different. The specimen is therefore referred to a new species, which is called *Goniopholis stovalli* in honor of Stovall.

Goniopholis stovalli, new species
Figures 1, 2

Diagnosis.—The size is medium to small. The premaxillary region of the snout, anterior to the lateral notches, is extremely short in proportion to its breadth. The external narial aperture is short and broad. The premaxillomaxillary notches are deep. The orbits are of medium size, approximately equalling that of the supratemporal fenestrae, and are subtriangular. The interorbital plate is relatively broad and essentially flat, with a definite drop in level from this plate to the posterior end of the snout, much as in the living caimans.

The nasal bones are slender and they terminate anteriorly on the upper surface of the snout definitely posterior to the external narial aperture. The anterior process of the frontal is short and broad; it ends over the eleventh maxillary teeth.

The supratemporal fenestrae are of medium size and are subtriangular. The interfenestral plate is narrow and its edges are uprolled. The fenestrae are definitely closer to the orbits than they are to the posterior border of the cranial table.

On the palate the maxillaries occupy much more space than the palatines. The premaxillary fenestrae are double in character. The posterior

* Contributions to the Osteology, Affinities, and Distribution of the Crocodilia, No. 48.

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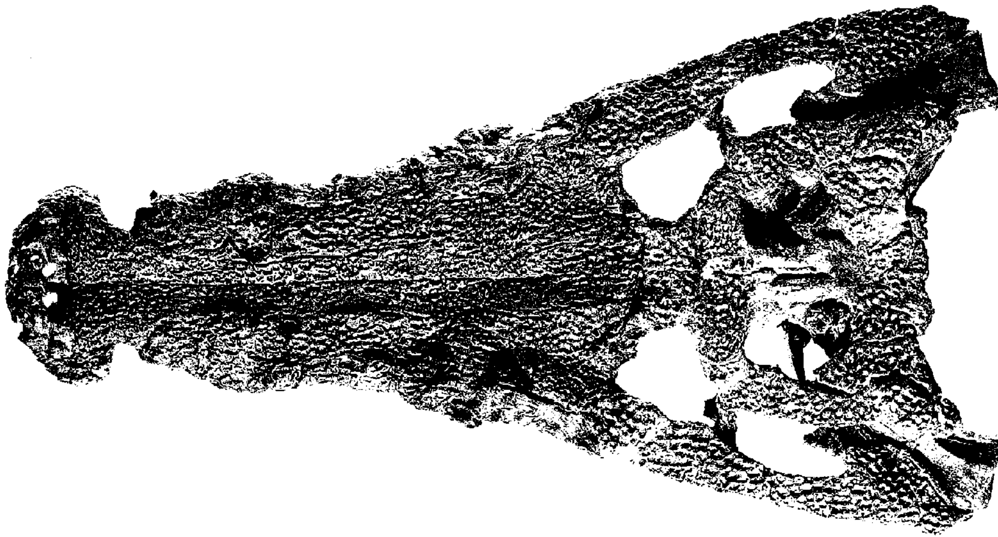


Figure 1. Goniopholis stovalli, **new species. Type, skull, OUSM 39-1-S8. Superior view, about one-third natural size.**

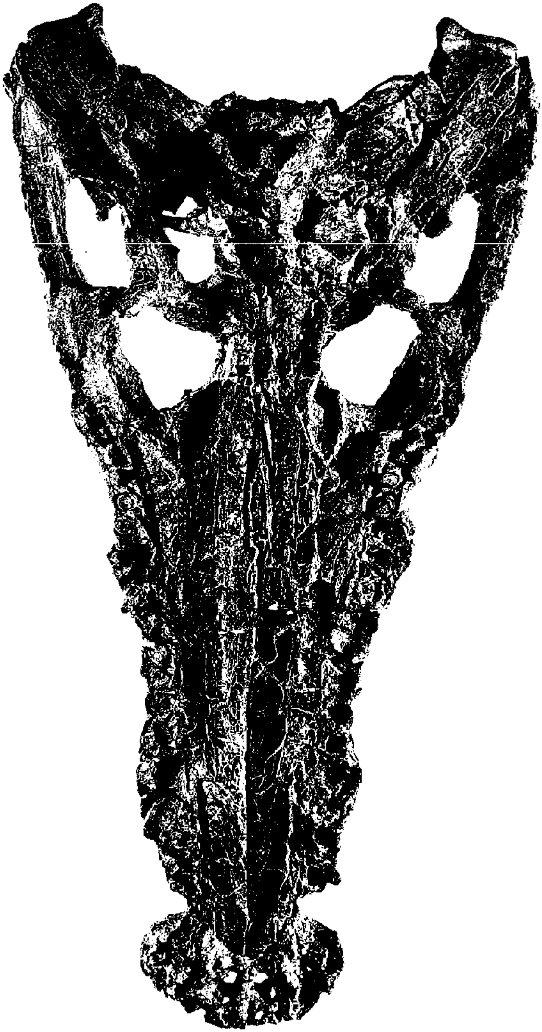


Figure 2. Goniopholis stovalli, new species. **Type, skull, OUSM 39-1-S8. Inferior view, about one-third natural size.**

processes of the premaxillaries are short. The palatine fenestrae are relatively short and broad; they extend forward to the level of the twelfth maxillary teeth.

Five alveoli are present in each premaxillary; of these, number 3 is the largest, numbers 1, 2, 4, and 5 being approximately equal in size. Each maxillary has nineteen alveoli, of which numbers 4 and 10 are the largest. The articular processes of the quadrate bones are short.

Additional description.—The anterior lower teeth almost penetrate the external narial aperture. The snout expands in breadth slightly from the level of the notches to that of the fourth maxillary teeth, then contracts slightly, then expands slightly and steadily to the level of the orbits.

The nasal bones broaden slightly at the level of the notches. The prefrontal bones are short; their anterior ends are slightly posterior to the level of the tip of the anterior process of the frontal. The lacrimal bones are large. The postorbital bar was buried in the flesh, resembling the condition in the living crocodilians. The premaxillary fenestrae are close to the anterior premaxillary alveoli. The premaxillomaxillary sutures on the palate extend backward to the level of the first maxillary teeth. Together they form a broad V.

Of the premaxillary alveoli, numbers 1 and 2, and 4 and 5 are close together, 2 and 4 are separated from the larger 3. All of the maxillary teeth appear to have had separate alveoli.

Comparisons with other species of Goniopholis.—*Goniopholis stovalli* resembles *G. felix* and *G. gilmorei* in having the supratemporal fenestrae separated from the posterior border of the cranial table by a considerable space. It resembles *G. gilmorei* in general shape but not in details. It resembles *G. gilmorei* and to some extent *G. kirtlandicus* in that the external narial aperture is definitely broader than long. It also resembles *G. gilmorei* in that the premaxillary expansion is short and broad and the premaxillaries are deep.

The new species differs from *G. kirtlandicus* in having much smaller supratemporal fenestrae. The fact that the type skulls are approximately the same size shows that the difference in size of the fenestrae is not due to individual age-stage differences. Also these fenestrae are separated from the posterior border of the skull by a greater space. The tapering of the snout posterior to the premaxillary notches is greater in total extent but is more gradual. It differs from *G. felix* in that its external narial aperture is much broader than long (in *G. felix* it is nearly circular). It also differs from *G. felix* and *G. kirtlandicus* in having deeper premaxillary notches. The premaxillary expansion is greater than in *G. felix.*

Measurements.—The following are the measurements of *Goniopholis stovalli,* specimen OUSM 39-1-S8.

	LENGTH (MM)	BREADTH (MM)
Tip of snout to occipital condyle	417	
Snout	273	
Skull across fifth maxillary teeth		136
Skull across snout at base		215

	LENGTH (MM)	BREADTH (MM)
Skull across last alveoli (est.)		219
Cranial table	99	
Cranial table anteriorly		156
Cranial table posteriorly		183
Right orbit	83	71
Left orbit	85	74
Interorbital plate		83
Right supratemporal fenestra	85	75
Left supratemporal fenestra	85	76
Right palatine fenestra		81
Left palatine fenestra		85
Interfenestral plate		52
External narial aperture	11	29

RATIOS

$$\frac{\text{Length of snout}}{\text{Length of skull}} \quad 0.654$$

$$\frac{\text{Breadth of snout at base}}{\text{Length of snout}} \quad 0.787$$

$$\frac{\text{Breadth of skull across 5th maxillary teeth}}{\text{Length of skull}} \quad 0.326$$

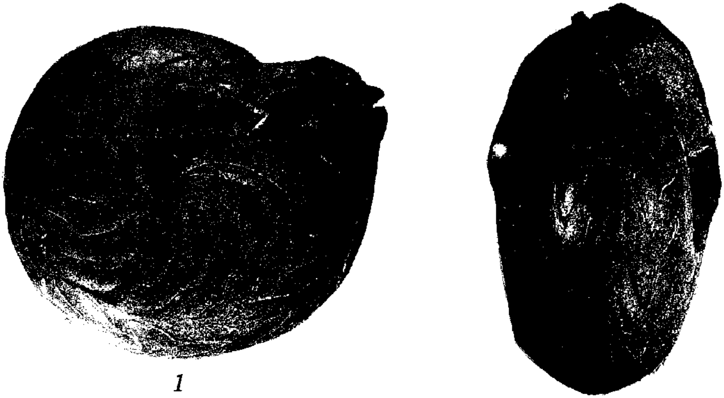
Large Specimen of *Goniatites*

Carl C. Branson

The first Oklahoma fossil described (other than *Edestus vorax,* which no doubt came from Illinois) was *Goniatites choctawensis.* The specimen was described by Shumard in 1863 and the species was redescribed by Branson, Elias, and Amsden in 1959. Most of the specific names of *Goniatites* in the United States have been reduced to synonymy with *G. choctawensis.*

A large specimen collected by Allen Graffham from the Delaware Creek Member of the Caney Shale has been obtained for our collection (OU 4445). It came from the Ebe ranch in NW¼ sec. 1, T. 2 N., R. 6 E., Pontotoc County, Oklahoma. A search of the literature for records of large specimens showed the following maximum diameters:

	MM
Neoholotype, Delaware Creek Shale, Pittsburg Co., Okla.	25.0
Moorefield Shale, Arkansas (Girty, 1911, p. 144)	25.0
Barnett Shale, San Saba Co., Texas (Plummer and Scott, 1937, p. 113)	26.2
Delaware Creek Shale, Oklahoma (Girty, 1909, p. 60)	44.0



1

2

Goniatites choctawensis **(OU 4445), x1**

Figure 1. Lateral view of conch.
Figure 2. Another view of the same specimen.

(Photographs by Jan Cannon)

	MM
White Pine Shale, Nevada (Youngquist, 1949, p. 297)	51.0
Delaware Creek Shale, Pontotoc Co., Okla. (OU 4445)	62.2
Meramecian, Rockcastle Co., Ky. (Miller and Furnish, 1940).	66.5

Girty stated (1909, p. 59) that a fragment indicated a diameter of 70 mm. The largest measurable conch is the specimen from Kentucky, and the present one from Oklahoma is slightly smaller (figs. 1, 2).

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Eogonioloboceras in North America

W. B. Saunders*

The ammonoid *Eogonioloboceras* occurs in Russia and Europe in rocks of late Viséan (Librovitch, 1960) and/or early Namurian age (Kullmann, 1962). In the United States it has only recently been identified and its wide geographic distribution and narrow stratigraphic range been recognized. Representatives of the genus, including one new species, have been recovered from youngest Mississippian age rocks of Texas, Oklahoma, Arkansas, and California.

Librovitch (1957) included two forms of *Goniloboceras, G. atratum* and *G. asiaticum,* in a new genus, *Eogonioloboceras,* with *E. asiaticum* as the type species. As was pointed out by Librovitch (1940) *E. atratum* is strikingly similar to *Girtyoceras meslerianum* in the general shape of the external suture; test ornamentation, particularly the constrictions; and the general shape of the conch. Many of these same features are shared by *Girtyoceras limatum.* The conch of typical Girtyoceratidae is cadicone in young growth stages, is subdiscoidal in later stages, and develops an acute venter at maturity. It may be that *Eogonioloboceras atratum* belongs in *Girtyoceras,* although available specimens do not possess the characteristic acute venter.

Girtyoceras burmai Miller and Downs, 1950, from the upper Mississippian Barnett Formation of West Texas was referred to *Eogonioloboceras* by McCaleb, Quinn, and Furnish (1964, p. 22). At the same time, they indicated that specimens from Arkansas, Oklahoma, and central Texas are also referable to *Eogonioloboceras burmai.*

The Arkansas specimens were collected from the Fayetteville Formation in Washington County. These fossils range from 5 mm to 67 mm in diameter. They differ from *E. burmai* in several respects and appear to represent a new species.

Eogonioloboceras furnishi Saunders, new species
Plate I, figures A-F

Eogonioloboceras furnishi is represented by seven casts replaced by calcite and pyrite, and one large external mold preserved in a concretion; the largest cast (UA 154-1) is designated as the holotype (pl. I, figs. D, E). Although the greatest diameter of the holotype is approximately 24 mm, the venter is partly eroded. The largest portion providing a complete measurement is 20 mm in diameter, 11 mm high, 8 mm wide, and has an umbilical diameter of 1.5 mm. The conch is subdiscoidal and involute; the venter is narrowly rounded. In transverse section the whorl is semielliptical, the weakly convex flanks attaining maximum width near the umbilicus. A striking characteristic of this species is the gently depressed area surrounding the umbilicus in younger specimens (pl. I, fig. F). This species is more openly coiled in young growth stages, but early in the development of the fourth

*Geology student, University of Arkansas.

whorl overlapping begins, so that by adolescence the earlier whorls are nearly covered by the later ones. An umbilical shoulder develops at approximately 24 mm.

Shell material adheres to several of the specimens and preserves test ornamentation, which is represented by transverse, medium-spaced (0.15 mm to 0.20 mm on the holotype) raised growth lines. These form a broad, shallow, lateral sinus, a gentle ventrolateral salient, and a faint ventral sinus. The surface of the internal mold is smooth on all specimens; constrictions or markings of any sort are absent.

The external suture (pl. I, fig. C) at a conch height of 11.5 mm consists of a rounded median saddle bounded on either side by a V-shaped, asymmetrical ventral prong, slightly concave dorsad on the upper ventral and convex dorsad on the lower dorsal sides. This curvature is not present on younger specimens (pl. I, figs. A, B). The first lateral saddle is asymmetrically V-shaped with a rounded apex. The ventral side of the first lateral lobe is straight or slightly convex dorsad; the dorsal side is sinuous and somewhat swollen dorsad. The second lateral saddle is broad and shallow. The umbilical slope area is exceedingly thin and the second lateral lobe is correspondingly narrow but has a rounded apex.

Remarks.—Eogonioloboceras furnishi differs from *E. burmai* in that the conch is consistently higher and wider in relation to the diameter of the specimen (H/D and W/D = 0.62 and 0.42, respectively). The internal mold of *E. furnishi* lacks the transverse lines present on the venter of *E. burmai,* and the external suture of *E. burmai* exhibits a narrower ventral lobe and a deeper, more acute first lateral saddle at corresponding diameters.

Eogonioloboceras furnishi may be distinguished from *E. atratum* and *E. asiaticum* by the shape of the external sutures. (Both *E. atratum* and *E. asiaticum* have shallower ventral lobes, generally much deeper and more acute first lateral saddles, and more symmetrical, lobate first lateral lobes.) The H/D ratio of *E. furnishi* is consistently

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Explanation of Plate I

Eogonioloboceras furnishi **Saunders, new species, collected from the Mississippian Fayetteville Formation, Washington County, Arkansas.**

Figure A. External suture of topotype, UA 154-2, at a diameter of 4.2 mm, x33 approximately.

Figure B. External suture of topotype, UA 154-3, at a diameter of 10 mm, x8.8 approximately.

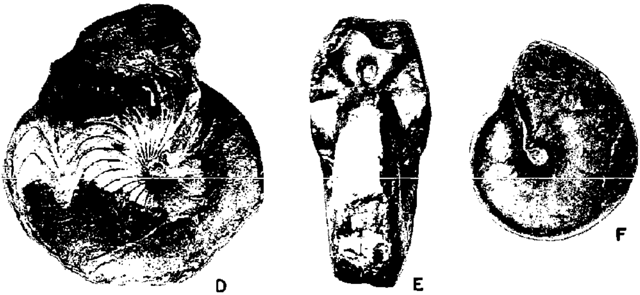
Figure C. External suture of holotype, UA 154-1, at a diameter of 20 mm, x4.7.

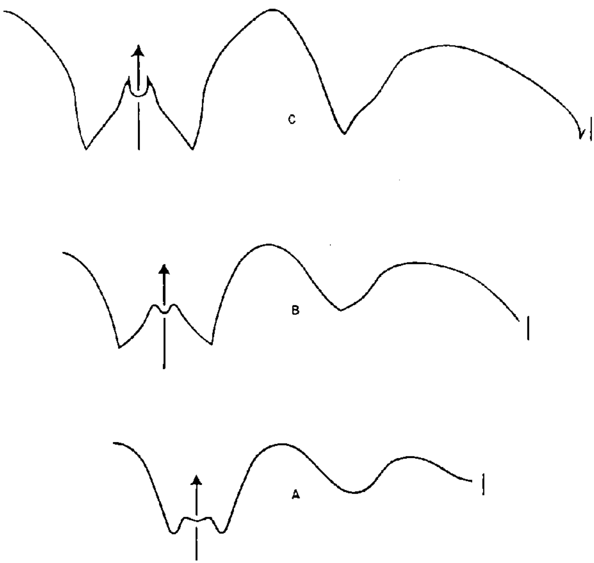
Figures D, E. Side and front views of holotype, UA 154-1, x2.

Figure F. Side view of topotype, UA 154-4, showing depressed area around umbilicus, x6.

Suture drawings made by use of camera lucida; photographs are unretouched. Specimen shown as figure F was lightly smudged with smoke from burning lighter fluid before photographing.

Plate I





larger than that of either *E. atratum* or *E. asiaticum*, and the W/D ratio is larger than that of *E. asiaticum*, but generally smaller than that of *E. atratum*. The test ornamentation of *E. atratum* and *E. asiaticum* is more complex than that of the new species, the deep sinuous constrictions present on the test of *E. atratum* being absent on *E. furnishi.*

The new species is named in honor of Dr. W. M. Furnish, State University of Iowa, who was the first to recognize the occurrence of *Eogonioloboceras* in North America.

Occurrence.—The type locality of *E. furnishi* is on the westernmost tributary of Town Branch, 1.2 miles west of Fayetteville on State Highway 62, NW¼ sec. 20, T. 16 N., R. 30 W., Washington County, Arkansas, in the middle portion of the Fayetteville Formation, of late Mississippian age. The specimens were collected from shale beds on the banks and in the bed of the stream. Additional specimens were collected elsewhere along Town Branch, and on the weathered Fayetteville shale banks of a stock pond northeast of Drakes Creek, on the north side of State Highway 74, S½ sec. 29, T. 16 N., R. 27 W., Madison County, Arkansas.

Other representatives of the genus *Eogonioloboceras* have been collected from the Mississippian Cienguita Formation near Shafter, in central Texas, and from the Mississippian Pitkin-Fayetteville limestone on the north side of Braggs Mountain along State Highway 10, Muskogee County, Oklahoma. The Braggs Mountain specimen is about 60 mm in diameter and seems referable to *Eogonioloboceras furnishi* upon the basis of comparisons permitted by its state of preservation.

Three ammonoids from the upper Mississippian Perdido Formation of Inyo County, California, were described as *Anthracoceras macallisteri* (Gordon, 1964, p. A18). These specimens belong in the genus *Eogonioloboceras*; however specific designation was not possible upon the basis of the published material.

Types.—The holotype of *Eogonioloboceras furnishi* (UA 154-1) is in the State University of Iowa repository, as is the Braggs Mountain specimen (SUI 11840).

Acknowledgments.—Most of the specimens upon which the new species is based were collected by students of the University of Arkansas Geology Department, in particular Charles H. Vyles and Royal H. Mapes. The Coordinator of Research, University of Arkansas, provided microscope equipment to facilitate study and illustration of specimens. The helpful criticism and advice of Professor James H. Quinn were invaluable in the preparation of this paper.

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Irazú, an Active Volcano

Carl C. Branson

Irazú is an active volcano in Costa Rica about 20 miles east of the city of San José. The highest point is 11,560 feet above sea level. The mountain is a caldera in which are a main crater and four volcanic cones. In 1723, an earthquake cracked the wall of the caldera and water in the crater flooded the town of Cartago. The eruption lasted from February 1723 to December 1726 (Sapper, 1927, p. 349). The volcano was then dormant for 191 years.

A major eruption occurred in 1917 and continued intermittently in-

Figure 1. Eruption of Irazú in 1920.
(Photograph by E. B. Branson)

to 1920 (fig. 1). At that time the volcano emitted vapor. Minor activity occurred until 1943, and the volcano was then dormant for 20 years. On March 13, 1963, Irazú began ejecting solid material, and ash has continued to fall until now (May 1964). Much rich land is ruined for years to come, and the city of San José is covered with ash which ruins machinery, causes respiratory disorders, clogs drains, and builds up a big demand for sweeping equipment.

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Basement Tests in Areas of Recent Aeromagnetic Mapping, Payne and Osage Counties, Oklahoma

Louise Jordan

The U. S. Geological Survey recently issued two aeromagnetic maps of areas in northeastern Oklahoma, compiled by G. E. Andreasen, R. W. Bromery, and F. P. Gilbert. The maps are at a scale of 1:62,500 and contour interval of 10 gammas. Twenty-three holes have been drilled to basement within the mapped areas.

Geophysical Investigations Map GP-469, *Aeromagnetic map of the Glencoe-Ripley area, Payne County, Oklahoma,* is of Tps. 18, 19, 20 N., Rs. 3, 4 E. The only closed maximum anomaly shown on the map trends northeastward and is in the area of the Ingalls field in secs. 27, 28, 33, 34, T. 19 N., R. 4 E. A basement test, Magnolia Petroleum Company 10 Main, drilled in 1937 in SW¼ NW¼ NW¼ sec. 34, encountered the top of the basement at 4,146 feet (3,206 subsea) and penetrated only 3 feet of Arbuckle rocks.

Map GP-470, *Aeromagnetic map of the Hominy area, Osage County, Oklahoma,* is of Tps. 23, 24 N., Rs. 7, 8, 9 E., and one to two miles surrounding these townships. Several anomalies of high intensity and one of low intensity are shown by closed contours. Three of the high-intensity anomalies are closely related to known basement peaks which have been drilled. However, the basement peak in the Tidal-Osage field (secs. 15, 16, T. 24 N., R. 8 E.), where Arbuckle did not cover the basement is not shown as a closed maximum. Interpreters of aeromagnetic data probably can explain this condition.

Basement tests in the Hominy area are listed in table I. Unfortunately, of the 22 wells, the Survey was able to locate samples from only 6 wells. Of these, two wells encountered rhyolite and four granite. Strangely enough, the Survey has as much difficulty in obtaining samples from newly drilled wells as from those drilled 30 to 40 years ago. Samples have not been saved from many recent wells, and if samples were saved from old wells, they have since been thrown away.

Maps GP-469 and GP-470 may be obtained from the U. S. Geological Survey in Denver or Washington.

TABLE I.—BASEMENT TESTS IN THE HOMINY AREA

Operator Lease	Location	Top of Basement: Depth (Feet)	Top of Basement: Subsea Elevation (Feet)	Thickness of Arbuckle (Feet)
Jernigan & Morgan 1 Osage (Degen)	10-22N-8E NE SE SW	2850	—1919	271
Texaco Inc. 13-SWD Bennett	12-23N-7E SW SE NW	3468*	—2464	554
Pure Oil Co. 190 Osage-Hominy	8-23N-8E SW NE SE	2536**	—1590	0
Pure Oil Co. 192 Osage-Hominy	8-23N-8E SE SE NW SE	2572**	—1612	0
Pure Oil Co. 191 Osage-Hominy	9-23N-8E C SW	2602	—1614	19
Sinclair-Pure 16 Osage	9-23N-8E NE SW SW	2611	—1640	0
Sinclair-Pure 171 Osage	9-23N-8E NW SE SW	2646	—1676	46
Producers Oil Co. 16 Osage	20-23N-8E C SW SE	3064	—2024	294
Prairie O. & G. 12 Osage	25-23N-8E C SW NE SE	2545	—1688	0
J. G. Buell 14 Osage	25-23N-8E SE NE SW SE	2383**	—1523	0
J. R. Higgins 16 Osage	25-23N-8E NW NE SW SE	2475	—1632	0
Fred DeMier 1-A Osage	29-23N-8E NW NE NW	2913	—1711	148
Cox & Hamon 42 Osage	19-23N-9E C W/2 W/2 SE	2914	—2109	388
J. M. Boyd 2-A Osage	30-23N-9E SW SW NW SW	?2549	—1723	?3
Texas Co. et al. 1-WS, Tr. 1	16-24N-7E SW NE NW	4291	—3238	1155
Texaco Inc. 17-WS, Tr. 17	21-24N-7E NW NE	4216	—3164	1080
Texas Co. 1-S, Tr. A-26	28-24N-7E NW NE SE	3757*	—2677	677
F. M. Pinney 36, Tr. 296	15-24N-8E SW SW NW	2504	—1490	0
F. M. Pinney 41, Tr. 296	15-24N-8E NW SW NW	2505	—1488	0
Marland-Gled 2 Kohpay	16-24N-8E SE SE NE	2480**	—1451	0
Marland-Gled 3 Kohpay	16-24N-8E NL SE NE NE	2708	—1707	28
Sunray D-X S-1 Osage	24-24N-9E NE SW NW	3276	—2296	742

* Basement rock is rhyolite.
** Basement rock is granite.
No samples from other wells.

Composition of Conodonts

Carl C. Branson and Charles J. Mankin

Conodonts (Conodontophorida) as now known are discrete toothlike and jawlike elements found among microscopic fossils in Cambrian to Triassic rocks. The organisms were marine and were free swimming. Some workers have found assemblages which are presumed to be natural associations of apparatus in the body of an unknown animal. Suggested affinities to annelids, gastropods, and arthropods are rejected as being refuted by incontrovertible evidence. Conodonts appear to be hard parts of some type of extinct fish, probably members of the Chondrichthyes.

Conodonts have pulp cavities and have the specific gravity and appearance of such chondrichthyan parts as teeth and shagreen granules. Animal groups with the geologic range of conodonts are not known. Fish groups of similar ranges to that of conodonts are not recorded; no fish is older than Middle Ordovician; none became extinct in the Triassic. It is possible that conodonts belonged to more than one chondrichthyan group.

The collections here selected for anlysis of composition were picked to embrace "Neurodontiformes," the fibrous conodonts, and "Conodontiformes," the laminar conodonts. Specimens analyzed represent Ordovician, Devonian, Pennsylvanian, and Permian occurrences.

Composition of the conodonts is such that their affinities must be sought among the vertebrates. Worm jaws (scolecondonts) are chitinous.

The literature contains several papers concerned, at least in part, with the crystalline structure of conodonts. Even a brief survey of this literature will reveal a large range of reported crystalline compositions.

Duncan McConnell (in Stauffer, 1938, p. 414) examined conodonts from the Decorah Shale (Ordovician) of Faribault, Minnesota, and from the Olentangy Shale (Devonian) of Arkona, Ontario, by means of X-ray diffraction. Although no X-ray data are presented in the paper, the observation is made that the diffraction patterns are essentially similar and the substance is classified as collophane. (At that time collophane was considered to have a distinctive mineral composition, whereas the name is now commonly used to denote a cryptocrystalline variety of apatite.)

Ellison (1944) published a paper describing the physical, optical, wet-chemical, X-ray-diffraction, and emission-spectrographic data on conodonts. The samples analyzed by X-ray diffraction were obtained from the Quivira Shale (Pennsylvanian) of Jackson County, Missouri. The X-ray data were compared with previously published information on the minerals fluorapatite, chlorapatite, francolite, dahllite, dehrnite, and hydroxyapatite. Crystallographic *d* spacings for fossil bone, tooth enamel, and recent bone were also compared. The data presented by Ellison confirm the earlier observations that conodonts are composed of one or more mineral species of the apatite group. Although he did not assign the conodonts to one or more specific mineral species, Ellison presented a personal communication from McConnell, who stated that they are probably composed of dahllite, francolite, lewistonite, or dehrnite.

An examination of the X-ray data presented by Ellison reveals that some of the crystallographic *d* spacings listed for conodonts are β reflections. Elimination of those lines permits the indexing of the *khl* values by analogy to a dahllite structure.

Hass and Lindberg (1946) reported some detailed petrographic and emission-spectrographic observations on conodont mineralogy. The spectrographic analyses were run on four samples of conodonts, from the Plattin Limestone (Ordovician) near St. Louis, Missouri; the Welden Limestone (Mississippian), Pontotoc County, Oklahoma; the Chappel Formation (Mississippian), Burnet County, Texas; and the Des Moines Group (Pennsylvanian), St. Louis outlier, St. Louis County, Missouri. All four analyses showed about 1 percent fluorine. This information, in addition to the reported indices of refraction on the conodonts, led Hass and Lindberg to the conclusion that conodonts were composed of a fluorine-bearing dahllite. Although based upon only four samples, the observation of the consistency of fluorine content in Ordovician, Mississippian, and Pennsylvanian conodonts is probably significant. It is probable that maximum fluoridation has been achieved for all specimens; therefore the idea that the fluorine content of carbonate apatites increases with geologic age may not be significant for rocks older than Cenozoic or, at most, Mesozoic in age.

TABLE I.—SAMPLES OF CONODONTS

Sample 1.	Specimens of **Idiognathodus.** Eudora Shale Member of Stanton Limestone Formation, Lansing Group, Missouri Series, Upper Pennsylvanian. Bonner Springs, Wyandotte County, Kansas.
Sample 2.	Specimens of **Idiognathodus.** Hughes Creek Shale Member of Foraker Limestone Formation, Council Grove Group, Geary Series, Permian(?). Manhattan, Riley County, Kansas.
Sample 3.	Specimens of **Polygnathellus.** Upper Devonian shale fillings in solution openings in Niagaran dolomite. Elmhurst quarry, Elmhurst, Cook County, Illinois.
Sample 4.	Specimens of **Chirognathus.** Harding Sandstone, Trentonian, Ordovician. Harding quarry, S½ NW¼ sec. 31, T. 18 S., R. 70 W., Fremont County, Colorado.
Sample 5.	Specimens of **Idiognathodus.** Base of Higginsville Limestone Member of Ft. Scott Formation, Marmaton Group, Des Moines Series, Middle Pennsylvanian. SE¼ sec. 28, T. 26 N., R. 17 E., Nowata County, Oklahoma.
Sample 6.	Specimens of **Idiognathodus.** Soldier Creek Shale Member of Bern Limestone Formation, Wabaunsee Group, Virgil Series. 10 miles west of Topeka, Shawnee County, Kansas.
Sample 7.	Specimens of **Distacodus.** "Glauconite sand," Volkhov (Wolchova) Formation, Lower Ordovician, Esthonia.

TABLE II.—CRYSTALLOGRAPHIC *d* SPACINGS* AND RELATIVE-INTENSITY DATA

Sample 1		Sample 2		Sample 3		Sample 4		Sample 5		Sample 6		Sample 7	
d	I/I_o	d	I/I_o	d	I/I_o	d	I/I_o	d	I/I_o	d	I/I_o	d	I/I_o
4.04	11	4.03	12	4.04	17	4.03	19	4.04	12	4.04	8	4.14	15
3.42	46	3.40	39	3.42	47	3.42	46	3.43	50	3.42	43	3.43	48
3.15	15	3.14	10	3.16	38	3.15	19	3.16	35	3.16	29	3.17	31
3.05	19	3.05	14	3.05	41	3.05	38	3.05	36	3.06	27	3.06	36
2.79	100	2.79	100	2.79	100	2.80	100	2.79	100	2.79	100	2.80	100
2.70	81	2.70	70	2.70	90	2.70	87	2.70	91	2.70	83	2.70	89
2.61	31	2.61	27	2.62	63	2.62	32	2.62	48	2.62	46	2.62	42
2.51	8	2.51	8	2.51	21	2.51	10	2.51	11	2.51	10	2.52	13
2.25	39	2.26	29	2.25	69	2.25	46	2.25	50	2.25	44	2.24	43
2.13	12	2.13	9	2.14	28	2.14	11	2.14	16	2.14	16	2.16	14
2.06	8	2.06	6	2.06	18	2.06	10	2.06	16	2.06	13	2.07	8
1.93	44	1.93	37	1.93	82	1.93	39	1.94	56	1.94	48	1.94	55
1.88	30	1.88	22	1.88	63	1.88	32	1.86	34	1.88	34	1.88	34
1.84	58	1.83	46	1.83	100	1.84	48	1.84	72	1.83	68	1.84	64
1.79	39	1.79	26	1.79	76	1.79	42	1.80	38	1.80	41	1.80	41
1.77	35	1.77	25	1.77	68	1.77	43	1.77	39	1.77	39	1.77	38
1.75	29	1.74	21	1.75	66	1.75	27	1.75	34	1.75	32	1.75	34
1.72	26	1.72	22	1.72	60	1.72	21	1.72	38	1.72	33	1.72	28
1.64	16	1.65	16	1.64	27	1.64	15	1.64	22	1.63	20	1.64	15
1.53	13	1.53	15	1.54	28	1.53	18	1.54	14	1.54	20	1.53	15
1.50	9	1.50	12	1.50	24	1.50	13	1.50	15	1.50	18	1.50	10
1.47	30	1.47	28	1.47	67	1.47	30	1.47	34	1.47	35	1.47	31
1.45	22	1.45	26	1.45	59	1.45	24	1.45	31	1.45	34	1.45	24
1.43	15	1.43	15	1.43	37	1.43	26	1.43	27	1.43	23	1.43	23
1.31	14	1.31	16	1.31	24	1.31	21	1.31	18	1.31	21	1.31	16
1.28	13	1.28	16	1.28	39	1.28	23	1.28	20	1.28	21	1.28	17
1.26	14	1.26	17	1.26	36	1.26	22	1.26	29	1.26	22	1.26	20
1.23	21	1.23	27	1.23	51	1.24	30	1.24	36	1.24	34	1.24	29
1.22	12	1.22	17	1.22	37	1.22	26	1.22	26	1.22	19	1.22	18
1.16	16	1.16	23	1.16	37	1.16	21	1.16	21	1.16	22	1.16	22

*Given in angstroms.

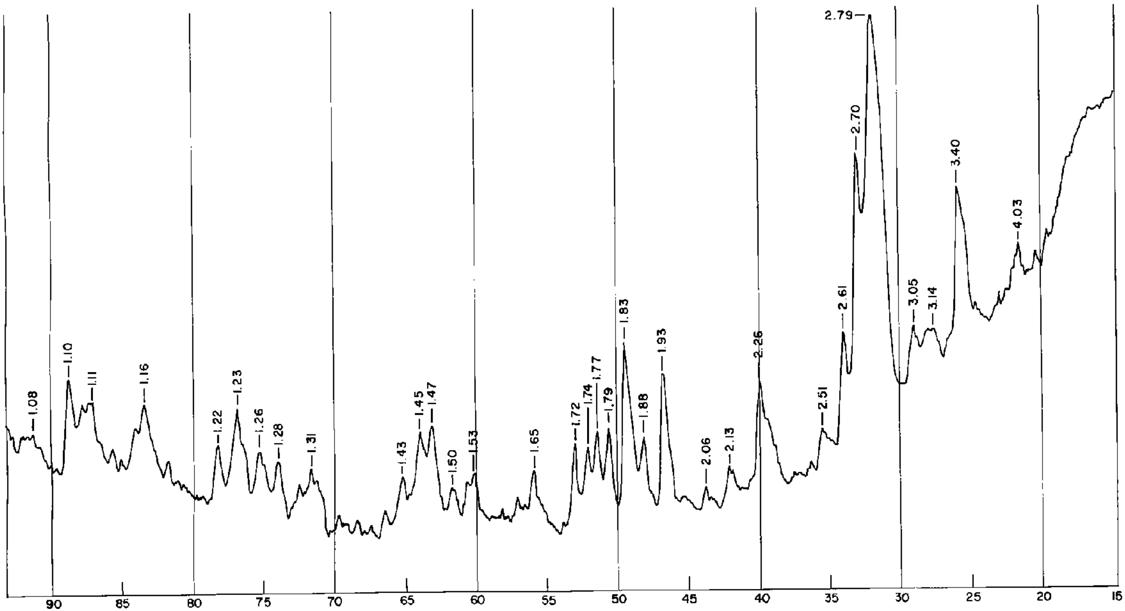

Figure 1. Densitometer recording of the powder photograph of sample 2.

TABLE III.—UNIT-CELL DIMENSIONS AND c/a RATIOS FOR MINERAL COMPOSITION OF CONODONT SAMPLES

(Values for a and c obtained by indexing lines by analogy to the reported dahllite structure)

Sample no.	a	c	c/a
1.	8.085	6.888	0.852
2.	8.073	6.876	0.852
3.	8.085	6.888	0.852
4.	8.085	6.884	0.851
5.	8.097	6.888	0.851
6.	8.094	6.896	0.852
7.	8.097	6.896	0.852

Phillips (in Rhodes, 1954, p. 428-430) examined five samples of conodonts by means of X-ray diffraction, using a 9-cm-diameter powder camera. In all, seven film strips were obtained from the five conodont samples. No data were presented on the crystallographic *d* spacings obtained from the film strips, but the statement was made that the data are virtually identical with those of Ellison's conodonts. Phillips applied no specific mineral name to the determined conodont mineralogy, preferring instead to use the general description of hydroxy-carbonate-fluor apatite. His reason for this is as follows (Rhodes, 1954, p. 429):

> Attempts which have been made to apply the names of individual apatite species, such as dahllite and francolite, to the mineral content of conodonts are obviously doomed to failure, and indeed it is doubtful if some of these names should ever have been considered as true mineral species.

The argument proposed by Phillips for the rejection of specific names for apatite minerals in conodonts could be expanded to include many other minerals and mineral groups for which detailed crystallographic studies have been accomplished. In these instances the argument is reduced to the degree of sophistication of the observations. Accordingly, we have attempted to apply specific names to the conodont mineralogy, realizing full well the limitations imposed.

Seven samples of conodonts were selected from the collections of Carl C. Branson, T. W. Amsden, and E. B. Branson (table I). The samples were selected in order to provide as wide a stratigraphic and geographic distribution as possible. From each sample three to five individual specimens were selected. The specimens selected from each sample represented as near identities as possible.

Each sample was ground to —230 mesh and the resulting powder was loaded into Lindemann glass capillary tubes. Each tube was in turn placed into a 2-radian Debye-Scherrer X-ray camera and a powder-photograph film strip was obtained on Kodak No-Screen Medical X-ray film, using nickel-filtered copper radiation. Exposure times of 3.5 hours were necessary to obtain a linear-intensity ratio for all lines observed on the film strips. William H. Bellis prepared the samples and made the X-ray powder photographs.

The resulting seven film strips were analyzed with a Siemens recording film-strip densitometer in order to obtain accurate line-intensity data (fig. 1). The crystallographic *d* spacings and the relative-intensity data are shown in table II. No measurable variation in either crystallographic *d* spacings or relative intensities can be seen for the seven analyzed conodont samples. The observed structural identity for these conodonts, despite their wide stratigraphic and geographic distribution, leads to the ultimate conclusion that conodonts have a mineral composition defined within relatively narrow limits.

Studies by Brasseur (1950, p. 521-524), Périnet (1959, p. 31-34), and others have provided X-ray-diffraction techniques which permit the rapid distinction of minerals within the apatite group. These techniques, when applied with sufficient rigor, permit the recognition of small compositional variations. An analysis of the c/a ratios for the seven X-rayed conodont samples gives the results shown in table III. It can be seen that the c/a ratios for all seven samples are essentially the same and that these ratios closely correspond to that given for carbonate-fluorapatite of fossil vertebrates by Osmond and Sawin (1959, p. 1653). Such a correlation should not be construed to imply a zoological affinity of conodonts with fossil vertebrates as it is our feeling that a mineralogical correlation is not sufficient basis for the establishment of such an affinity.

We believe the observations presented in this paper permit us to conclude that conodonts are composed of an apatite-group mineral with a limited compositional range. The observed correlation of conodonts with the carbonate-fluorapatite structure confirms the work of Hass and Lindberg (1946), which indicated that conodonts are composed of a portion of the isomorphous series dahllite-francolite. However, following the definition of francolite by McConnell (1938), we conclude that conodonts have a mineral composition with closer affinity to that end member of the series.

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*Reference is to first page of article containing indexed item.

ERRATA

Oklahoma Geology Notes, November 1964, Volume 24, Number 11

Page 247, figure 1, distance between points C and G: For 299.60 read 299.64.

Page 256, figure 5: Bar scale is for 1 mile. Boundary line in Poteau River south of junction with Mill Creek should be deleted.

Page 259, last line under "Computation of an east-west distance": For 2,464,489.46 feet read 2,464,469.46 feet.

Publication Dates, **Oklahoma Geology Notes,** Volume 24

The twelve numbers of this volume of the Notes were issued on the following dates during 1964:

NUMBER	MONTH	DATE	NUMBER	MONTH	DATE
1	January	2	7	July	1
2	February	3	8	August	1
3	March	4	9	September	1
4	April	2	10	October	5
5	May	6	11	November	2
6	June	1	12	December	1

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