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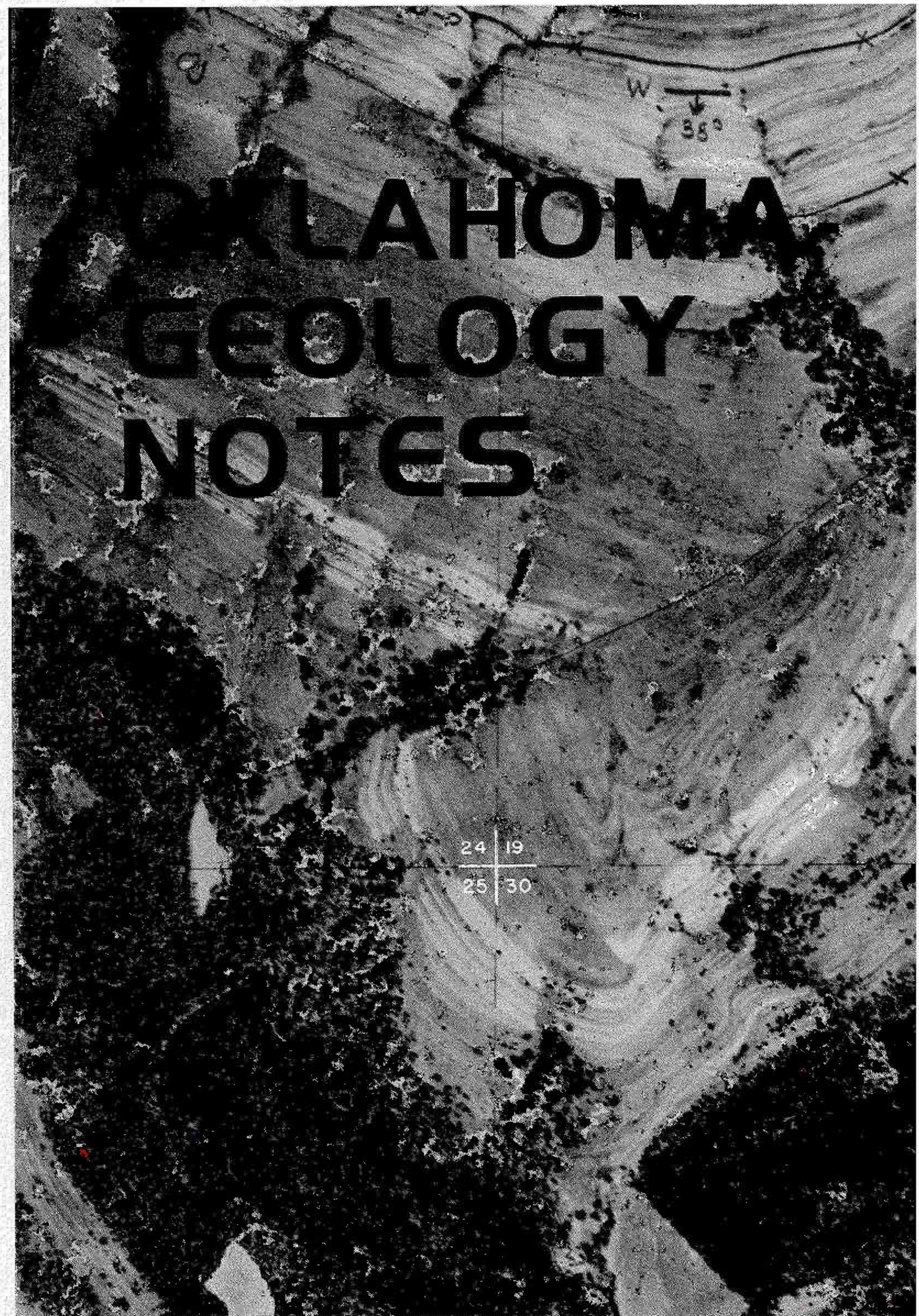
OKLAHOMA GEOLOGY NOTES



Cover Picture

FAULTED STRATA ON SOUTH FLANK OF ARBUCKLE MOUNTAINS

The cover photograph for this issue shows folded and faulted Ordovician strata on the south flank of the Arbuckle anticline. Light-colored strata exposed in the northern (top) part of the photograph are uppermost Arbuckle Group limestones, whereas the remainder of the photograph shows limestones, sandstones, and shales of the Simpson Group (Middle Ordovician Joins, Oil Creek, McLish, Tulip Creek, and Bromide Formations).

Strata dip toward the south, in general, at angles of 30 to 40 degrees. The principal fault, which extends northeastward across the center of the photograph, is easily identified by the offset of the thin, light-gray layers of limestone at the top of the Oil Creek Formation. Other small-scale faults and complex folds are seen in the central part of the photograph.

Parts of secs. 19 and 30, T. 2 S., R. 1 E., and secs. 24 and 25, T. 2 S., R. 1 W., are shown (Carter County, about 3 miles northeast of Woodford, Oklahoma). The long axis of the picture is 1 mile. The photograph was taken by the U.S. Department of Agriculture, Agricultural Stabilization and Conservation Service.

—*Kenneth S. Johnson*

Editorial staff: William D. Rose, Rosemary L. Hardage, Elizabeth A. Ham

Oklahoma Geology Notes is published bimonthly by the Oklahoma Geological Survey. It contains short technical articles, mineral-industry and petroleum news and statistics, an annual bibliography of Oklahoma geology, reviews, and announcements of general pertinence to Oklahoma geology. Single copies, seventy-five cents; yearly subscription, $4.00. All subscription orders should be sent to the address on the front cover.

Short articles on aspects of Oklahoma geology are welcome from contributors. A set of guidelines will be forwarded on request.

This publication, printed by The University of Oklahoma Printing Services, Norman, Oklahoma, is issued by the Oklahoma Geological Survey as authorized by Title 70, Oklahoma Statutes 1971, Section 3310, and Title 74, Oklahoma Statutes 1971, Sections 231-238. 1,500 copies have been prepared for distribution at a cost to the taxpayers of the State of Oklahoma of $1,990.00.

OKLAHOMA PALEOICHTHYOLOGY
ADDENDUM TO PART V

Jiri Zidek[1]

New information concerning a number of interesting specimens of Pennsylvanian chondrichthyans in a private collection owned by Mr. E. L. Gilmore of Tulsa, Oklahoma, makes it necessary to add a brief supplement to Part V of the series on Oklahoma paleoichthyology published in the October 1976 issue of *Oklahoma Geology Notes* (Zidek, 1976). These specimens, brought to my attention by Mr. Roger Burkhalter, former student at The University of Oklahoma, include a nodule from the Oologah Formation (Desmoinesian) in the Dewey Cement Company quarry in Tulsa that contains a small *Listracanthus*-type spine associated with a *Petrodus*-type denticle; a *Ctenacanthus* spine from the Seminole Formation (Missourian) at Glenpool near Tulsa; and a second *Ctenacanthus* spine and a *Physonemus* spine, both from the Coffeyville Formation (Missourian) in NE¼ sec. 22, T. 19 N., R. 12 E., Tulsa County.

I am grateful to Mr. Gilmore for his kindness in lending the specimens from his collection and for permission to record them. I would like to thank Mr. Burkhalter also for bringing them to my attention, and Mr. R. A. Mollison, formerly of The University of Oklahoma, for preparing the photographs.

Family Ctenacanthidae
Genus **Ctenacanthus** Agassiz, 1837
Fig. 1

The *Ctenacanthus* spine from the Seminole Formation (fig. 1A) is 200 mm long, although a section that must have been about 30 mm long is missing from the tip and another part, also about 30 mm long, is lacking from the basal end. The total length of the spine if completely preserved would have been approximately 260 mm. The inserted portion is 100 mm long at the posterior margin but only 50 mm long at the anterior margin, indicating that the spine was inserted obliquely, at an angle of approximately 30°. The pulp cavity is wide open along more than half (140 mm) the length of the posterior face. The cross section is obliquely triangular, forming an equilateral triangle near the base and an isosceles triangle at the distal end. The anterior margin is straight in the proximal half of the exserted part and curves gently posteriorly in the distal

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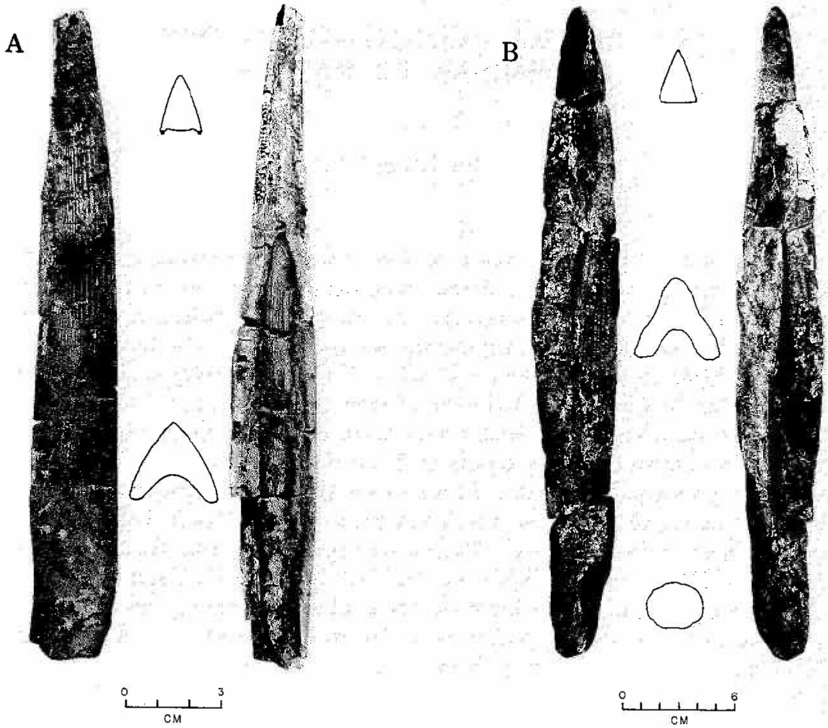

Figure 1. **Ctenacanthus** sp. spines from Seminole **(A)** and Coffeyville **(B)** Formations in Tulsa County, Oklahoma. Lateral views to left, posterior views to right.

half. The anterior median ridge is low, of oblique profile. The lateral walls contain 20 ridges proximally and 11 ridges at the distal end, all narrowing distad as well as posteriorly. A number of the more posteriorly situated ridges issue from the posterior margin rather than from the insertion level, and higher up (distad) they anastomose with the more anterior ridges. All the ridges are ornamented with closely spaced transverse costae. In the distal third of the spine the most posterior (and narrowest) ridges are fragmented into separate tubercles that grade into postero-lateral denticle rows. The posterior face is straight to a point 10 mm above the distal end of the opening of the pulp cavity, whereas more distad this face is slightly concave in lateral view and bears rows of minute denticles set on elevated postero-lateral margins. The denticles are dome shaped and show no evidence of preferential bending. The more proximal denticles are set in double rows, with the elements alternating, but toward the tip they merge into a single row on each margin.

The spine from the Coffeyville Formation (fig. 1B) is 335 mm long, with only the extreme tip lacking; total length was about 360 mm. The inserted part is 105 mm long anteriorly, but its posterior length is indeterminate, making it impossible to establish the angle of insertion of the spine. The pulp cavity opens posteriorly 110 mm below the distal end, with the opening extending to a point 70 mm above the basal end, and a substantial part of the base is therefore not excavated. The cross section is ovoid at the base, becoming obliquely triangular in the exserted part, where it ranges from equilateral proximally to isosceles at the distal end. There is no prominent anterior ridge. Except for arching very gently posteriorly in the distal third, the anterior margin is straight. The posterior parts of the lateral walls are heavily encrusted, so that the posterior extent of the ornamentation cannot be determined, nor can any postero-lateral denticulation be seen. The lateral walls are ornamented with longitudinal tubercle rows. The tubercles show no preferential orientation, and they decrease gradually in size posteriorly.

The Seminole Formation spine is reminiscent of *C. buttersi* (St. John and Worthen, 1883, p. 240, pl. 22, fig. 2a–e), although the ornamentation in *C. buttersi* does not reach the posterior margin. In certain respects the Coffeyville spine resembles the spine of *C. harrisoni* (St. John and Worthen, 1883, p. 236, pl. 23, fig. 1a–f), but ornamentation in the Coffeyville specimen is coarser and more extensive and the opening of the pulp cavity is narrower basally than in *C. harrisoni*. Although the Seminole spine and the Coffeyville spine show affinities to *C. buttersi* and *C. harrisoni*, respectively, it is not probable that they belong to those species, and without comparative material at hand I cannot venture to state whether they do or do not represent new species. Because of the element of uncertainty involved, and because in my opinion naming them would serve no useful purpose, they are identified only generically in this paper.

Chondrichthyes Incertae Sedis

Listracanthus Newberry and Worthen, 1870, and **Petrodus** M'Coy, 1848

Fig. 2A

Although the nodule from the Oologah Formation (fig. 2A) contains only a single specimen of each of these genera, the occurrence is of interest because (a) *Listracanthus* has not been reported previously in Oklahoma and (b) because the two organ genera are found associated. Although this particular association may not have much significance, it is worth mentioning because of the close association of the two reported from other localities (Chorn and Reavis, in press).

The *Listracanthus* spine lacks the tip and the convex (presumably anterior) margin. The part preserved is 15 mm long, and the total length of the spine probably did not exceed 20 mm. The lateral wall exposed contains 10 ridges proximally and 5 ridges at the distal end. The ridges do not anastomose, and the distad decrease in their number is accomplished by fingering out at the concave (presumably posterior) margin. The fingering out results in the formation of thin, distad-pointing projections at the concave margin. The specimen can be identified only generically. The term spine is used loosely for *Listra-*

canthus; the morphology of the base leaves no doubt that the spines are in fact prolonged dermal denticles.

The organ genus *Petrodus* has already been reviewed (Zidek, 1973, p. 97–100). It is included here only to enlarge the Oklahoma occurrence list and because of the association with *Listracanthus*. Zangerl (1973, p. 9) referred to Moy-Thomas' (1935) partially articulated specimen of *Petrodus patelliformis* as "a shark of phalacanthous design." This strengthens my belief in a *sensu lato* hybodontoid derivation of the *Petrodus*-type denticles.

Physonemus M'Coy, 1848

Fig. 2B

The spine of *Physonemus* from the Coffeyville Formation (fig. 2B) matches most closely the one described and figured by St. John and Worthen (1875, p.

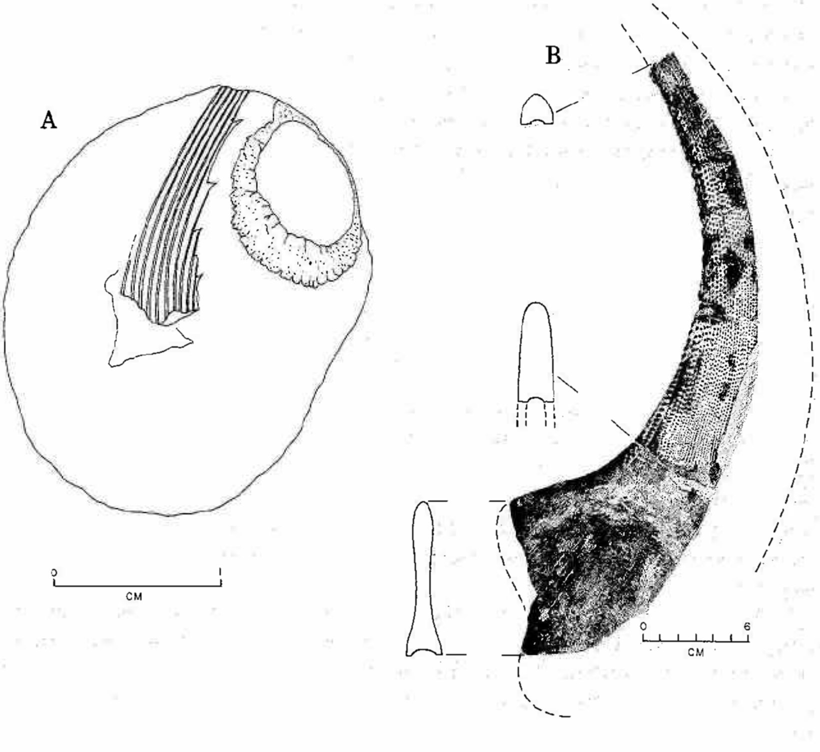

Figure 2. **Listracanthus** spine and **Petrodus** denticle **(A)** from Oologah Formation, and **Physonemus mirabilis (B)** from Coffeyville Formation in Tulsa County, Oklahoma.

458, fig. 1a–1) under the name *Xystracanthus mirabilis*. The morphology of the individual tubercles, their size distribution in the longitudinal tubercle rows of the ornament, and the shape of the cross section are identical in the two. In addition to figure 2B of this paper, the reader is referred to the illustrations in St. John and Worthen's paper for more information on these characteristics. Although the Coffeyville specimen is deficient in preservation of the antero-posterior thickness, it is much more complete lengthwise than the holotype, as the Oklahoma specimen has both the inserted part (the base) and much of the exserted, ornamented part preserved.

The spine tapers evenly and is bent anteriorly in an arc amounting to approximately 55° for the exserted part. The preserved length is 355 mm, and, estimating the length of the missing tip, the total would exceed 400 mm. The base makes up over one-fourth of the estimated total length (125 mm) and is almost twice as thick antero-posteriorly as the proximal end of the exserted part. Perhaps as much as 40 percent of the posterior portion is lacking, and consequently only the very top of the pulp cavity is preserved, forming a shallow groove that runs throughout the length of the specimen. The pulp cavity occupied much of the posterior half of the spine; with its full extent added, the Oklahoma spine becomes almost identical in size to the type specimen of St. John and Worthen. The similarity in total size is also apparent from comparing the size of elements in the ornamentation in the two spines.

The lateral walls are parallel to each other through much of their antero-posterior extent and begin arching toward the midline only near the anterior margin. The lateral tubercles are set in longitudinal rows that decrease in number distad. No merging of rows is apparent in the distad direction, and there is no decrease in tubercle size in any of the rows (i.e., narrowing of the rows). Therefore, the decrease in number of the rows toward the tip of the spine can be accounted for only by their fingering out at the posterior margin. Thirty-two lateral tubercle rows are preserved in the Oklahoma specimen, and a comparison with the holotype allows for at least 20 more rows in the missing posterior part. The tubercles increase gradually in size anteriorly. The oblique anterior margin bears a paired row of tubercles that increase in height in the distal third of the spine and become hook shaped, proximad-pointing denticles. The left and right denticles stand in an alternating order, but more proximad, where they grade into oblique tubercles, there is some variation in this arrangement, so that the tubercles may be set in pairs opposite each other, rather than alternating. In the proximal third of the exserted length the tubercles of the paired row broaden antero-posteriorly, and the row diverges and is intercalated by another, inner, paired row. Finally, a short distance above the base the inner paired row also diverges and is intercalated by a median orthodentinous ridge of low relief.

In the holotype a median denticle row, rather than a continuous ridge, is intercalated near the base (St. John and Worthen, 1875, pl. 20, fig. 1b; Baird, 1957, p. 1014). The ridge in the Coffeyville Formation specimen, however, can be interpreted either as simply an undifferentiated row or, more likely, as a row of fused denticles. This difference between the holotype and the Oklahoma specimen is but a minor, intraspecific variation, and the Oklahoma spine can be assigned safely to *Physonemus mirabilis* (St. John and Worthen).

According to Roger Burkhalter (personal communication), the Oklahoma spine comes from the basal foot and a half of the Coffeyville Formation, making it Stephanian A in age. The holotype, from the upper part of the Carbondale Formation of Illinois, is Westphalian D in age. Baird (1957, p. 1013–1015) also included in the *Physonemus mirabilis* group: *Xystracanthus grandis* Moore, 1929, from the Wayland Shale (late Stephanian) of Texas; "*Parahelicoprion*" of Karpinsky (1925) from the Artinskian (Lower Permian) of the Ural Mountains, U.S.S.R.; and *Xystracanthus giganteus* Waagen, 1880, *X. major* Waagen, 1879, and *X. gracilis* Waagen, 1879, all from the Upper Permian of the Salt Range, Pakistan. Of these species, *X. major* and *X. gracilis* are *Physonemus* sp. indet.; *X. giganteus* may be retained as a separate species, i.e., *Physonemus giganteus* (although closely allied to *P. mirabilis*); and Karpinsky's "*Parahelicoprion*" and *X. grandis* may both be placed in synonomy with *Physonemus mirabilis.*

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OGS Releases Bulletin on Muskogee County

A publication released this week marks another milestone in the long-term goal of the Oklahoma Geological Survey to provide information on the geology and mineral resources of each of the State's 77 counties.

The report, *Geology and Mineral Resources (Exclusive of Petroleum) of Muskogee County, Oklahoma*, has been issued as OGS Bulletin 122. It is a posthumous work, its author, Malcolm C. Oakes, having died July 3 of this year.

A native of Oklahoma who put in more than an ordinary lifetime working in the State, Oakes was known to many for his broad knowledge of Oklahoma geology, particularly that of the eastern counties. He was author or coauthor of 7 bulletins, a circular, and 2 mineral reports for the Oklahoma Geological Survey, in addition to numerous papers for national journals.

Bulletin 122 describes the structure, economic geology (except for petroleum), and geography of Muskogee County, but the major contribution of Oakes' 78-page report is the detailed information it contains on the stratigraphy of the Paleozoic sedimentary rocks of Ordovician, Devonian, Mississippian, and Pennsylvanian age that are exposed. The bulletin's appendix contains 102 descriptive measured stratigraphic sections.

One of the most important components of the bulletin is the accompanying areal geologic map, which should be of value to all investigators in the area. Marion Clark of the OGS staff did the principal cartographic preparation of the full-color map, which is at a scale of 1:63,360, or 1 inch = 1 mile.

In his report, Oakes states that although shales are most abundant throughout the stratigraphic section in Muskogee County, it is sandstone that is most in evidence, "conspicuous out of all proportion to its amount." Sandstone is featured on the cover and title page of the bulletin in an ink drawing by Roy D. Davis, chief cartographer of the OGS, showing ledges of the Bluejacket Sandstone Member of the Boggy Formation of Pennsylvanian age. These sandstones were used as building stone for many of the older structures in the area.

In addition to building stone, the economic mineral resources described for the county include limestone for aggregate, clay shales for brick and tile, and several coal beds. The Stigler coal is presently being mined in the county.

Malcolm Oakes was born near Hugo, southeastern Oklahoma, in 1890. He joined the OGS staff as a field geologist in 1921. He served in that capacity until 1923, when he went to work as a petroleum geologist with Shell Petroleum Corp. He was later an independent consulting geologist to various companies, rejoining the Survey staff as geologist in 1937. He retired in 1960 but had remained on the staff as a part-time special consultant.

Oakes was assisted in the preparation of the bulletin by Walton Bell, David G. Campbell, Walter F. Coleman, William Gregware, Jimmy T. Lontos, Robert A. Meek, Francis Stewart, Jr., and Joseph G. Stine, all former graduate students in geology at The University of Oklahoma who wrote master's theses covering parts of Muskogee County.

Robert O. Fay, OGS geologist, contributed current geologic information and, with Oakes' agreement, assisted in editing both the text and the geologic map.

Bulletin 122 is available at the Oklahoma Geological Survey, 830 Van Vleet Oval, Norman, Oklahoma 73019. The price is $9.00 paperback and $11.00 clothbound.

Two New Publications Issued by GSA

The Geological Society of America has released two publications that should be of interest to biostratigraphers working in Oklahoma.

The first has been issued as Memoir 149 and is entitled *Stratigraphic, Paleontologic, and Paleoenvironmental Analysis of the Upper Cretaceous Rocks of Cimarron County, Northwestern Oklahoma.* Authors are Erle G. Kauffman, Donald E. Hattin, and J. Dan Powell. The 150-page publication is in two parts: the first part deals primarily with the stratigraphy and paleoenvironments of the Upper Cretaceous units, and the second with the systematic paleontology. The cost of the volume is $19.00.

The second publication, *Bibliography and Index of Paleozoic Crinoids, 1969–1973,* has been issued as Microform Publication 8. With this work, which consists of 235 pages on three 24× microfiche, author G. D. Webster has continued and updated his *Bibliography and Index of Paleozoic Crinoids, 1942–1968,* issued as GSA Memoir 137. Thus the format of the present volume, which lists 279 new titles, follows that of the earlier work. Microform Publication 8 sells for $4.50.

Both of these publications can be ordered from The Geological Society of America, Publication Sales Department, 3300 Penrose Place, Boulder, Colorado 80301.

Environmental Geology Emphasized in Colorado Publication

The proceedings of a conference on environmental geology held in Aspen, Colorado, were issued recently by the Colorado Geological Survey as Special Publication 8. Topics of the papers include specific geologic hazards, mineral resources, mined-land reclamation, county case histories, and legal problems related to geologic factors in land-use planning.

The special publication, *Geologic Factors in Land-Use Planning—Proceedings, Governor's Third Conference on Environmental Geology,* can be ordered from the Colorado Geological Survey, 1313 Sherman Street, Room 715, Denver, Colorado 80203, for $4.00 a copy. Prepayment is requested.

NEW WATER RESOURCES FOR CHOCTAW AND ATOKA COUNTIES, OKLAHOMA

George G. Huffman[1]

Introduction

Construction of several large dams and reservoirs has been approved by Congress for southeastern Oklahoma. Included in this authorization are the Broken Bow, Lukfata, and Pine Creek reservoirs in McCurtain County and the Hugo and Boswell reservoirs in Choctaw County. The Broken Bow, Pine Creek, and Hugo projects have been completed, and the Lukfata and Boswell reservoirs await final approval and funding. These projects are part of Phase 1 of the Oklahoma Comprehensive Water Plan, developed by the Oklahoma Water Resources Board in cooperation with other State agencies, plus various federal and local agencies. The Hugo and Boswell reservoirs have been included in the Southern Oklahoma Interconnected System, designed to furnish water to arid parts of western Oklahoma (Oklahoma Water Resources Board, 1975, fig. 1-1).

Hugo Dam and Lake

Hugo Dam, authorized by the Flood Control Act of 1946, is on the Kiamichi River about 7 miles east of Hugo, Oklahoma, near the village of Sawyer. The dam is constructed of rolled earthen material. The dam and spillway have a combined length of 10,200 feet and rise 100 feet above the river bed. The spillway has a concrete ogee weir 290 feet wide and is surmounted by six 40- by 50-foot gates with a maximum discharge of 369,999 cfs (cubic feet per second). The elevation of the top of the dam is 452.5 feet msl (mean sea level), the flood-pool level is 437.5 feet, and the conservation-pool level is 404.5 feet. According to data released by the U.S. Army Corp of Engineers in 1967, the flood-control pool covers 34,490 acres and has a storage capacity of 988,500 acre-feet; the conservation pool covers 13,250 acres and has a storage capacity of 157,300 acre-feet (written communication). Revised figures (Oklahoma Water Resources Board, 1975) indicate that Hugo Lake will provide 809,200 acre-feet of flood-control storage, 121,500 acre-feet of water-supply storage, and a water-supply yield of 375,000 acre-feet per year. The reservoir is multipurpose, designed for water supply, flood control, recreation, and wildlife. Water quality for the Kiamichi River and for Hugo Lake has been rated as good (Oklahoma Water Resources Board, 1975, sec. 2, p. 4-5). The lake is approximately 11 miles long and has a maximum width of 3 miles. The shoreline totals 110 miles, providing easy access for

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water sports such as fishing, boating, swimming, and water skiing. Six public-use areas are being developed, and plans call for a system of hiking trails. The Antlers Sandstone and terrace deposits border the lake on the east side; extensive terrace sands and gravels are along the west side. These deposits should furnish abundant material for sandy beaches when the shoreline becomes stabilized.

The Kiamichi River originates in the Ouachita Mountains east of Big Cedar in T. 2 N., R. 26 E. It follows a curved pathway westward and southward for a distance of about 80 miles, paralleling Ouachita-Mountains structures to the vicinity of Moyers (Pushmataha County), where it bends abruptly to follow a southeast-trending course across coastal-plain sediments of Cretaceous age. It empties into the Red River in T. 7 S., R. 20 E., after flowing an additional 33 miles below Moyers. Principal tributaries of the Kiamichi River in Pushmataha County include Buffalo Creek, Jackfork Creek, Buck Creek, Tenmile Creek, Cedar Creek, and Beaver Creek. In Choctaw County, important tributaries are Salt Creek and Long Creek, which empty into Hugo Lake, and Gates Creek, which joins the Kiamichi River about 5 miles below Fort Towson and 13 miles below the Hugo dam. The Hugo-Lake drainage basin includes approximately 1,709 square miles. Average annual rainfall in the drainage basin is about 47 inches per year; the average annual temperature ranges from 62 to 64; the average annual runoff is 15 inches; and the average annual lake evaporation in the area is 51 inches (Oklahoma Water Resources Board, 1975, section 2, p. 1–3).

The geology of the area surrounding the Hugo reservoir is shown in figure 1, taken from *Geologic Map of Choctaw County, Oklahoma*, by Huffman and others (1975, pl. 1). The oldest outcrop near the Hugo reservoir is the Wildhorse Mountain Formation, which consists of a sequence of massive, quartzitic sandstones that form a series of prominent ridges projecting as inliers above the surface on the Antlers Sandstone of Cretaceous age. The formation's surface distribution is limited to a few isolated masses in T. 5 S., Rs. 18 and 19 E. The largest and most prominent of these is Spencerville Mountain, an east-west trending ridge in secs. 13 and 14, T. 5 S., R. 18 E., and secs. 17 and 18, T. 5 S., R. 19 E. The Wildhorse Mountain Formation is part of the Jackfork Group, currently assigned to the Early Pennsylvanian.

Lower Cretaceous strata rest unconformably on eroded Paleozoic rocks. Units represented include the Antlers Sandstone (200 feet±), the Goodland Limestone (26–55 feet), Kiamichi Formation (28–33 feet, which has the *Texigryphaea navia* (Hall) shell beds at the top), the Caddo Formation (150 feet; the Oklahoma equivalent of the Duck Creek and Fort Worth Formations of Texas), the Bokchito Formation (average thickness 140 feet; which contains, in ascending order, the Denton Clay, Soper Limestone, Weno Clay, McNutt Limestone, and Pawpaw Sandstone Members), and the Bennington Limestone. The Upper Cretaceous Woodbine Formation crops out in the southwest corner of the area mapped in figure 1.

Extensive alluvium and terrace deposits characterize the Hugo Lake area. Most of the alluvium will be covered by water when the lake level rises above the conservation pool (404.5 feet). Two distinct terrace levels are present;

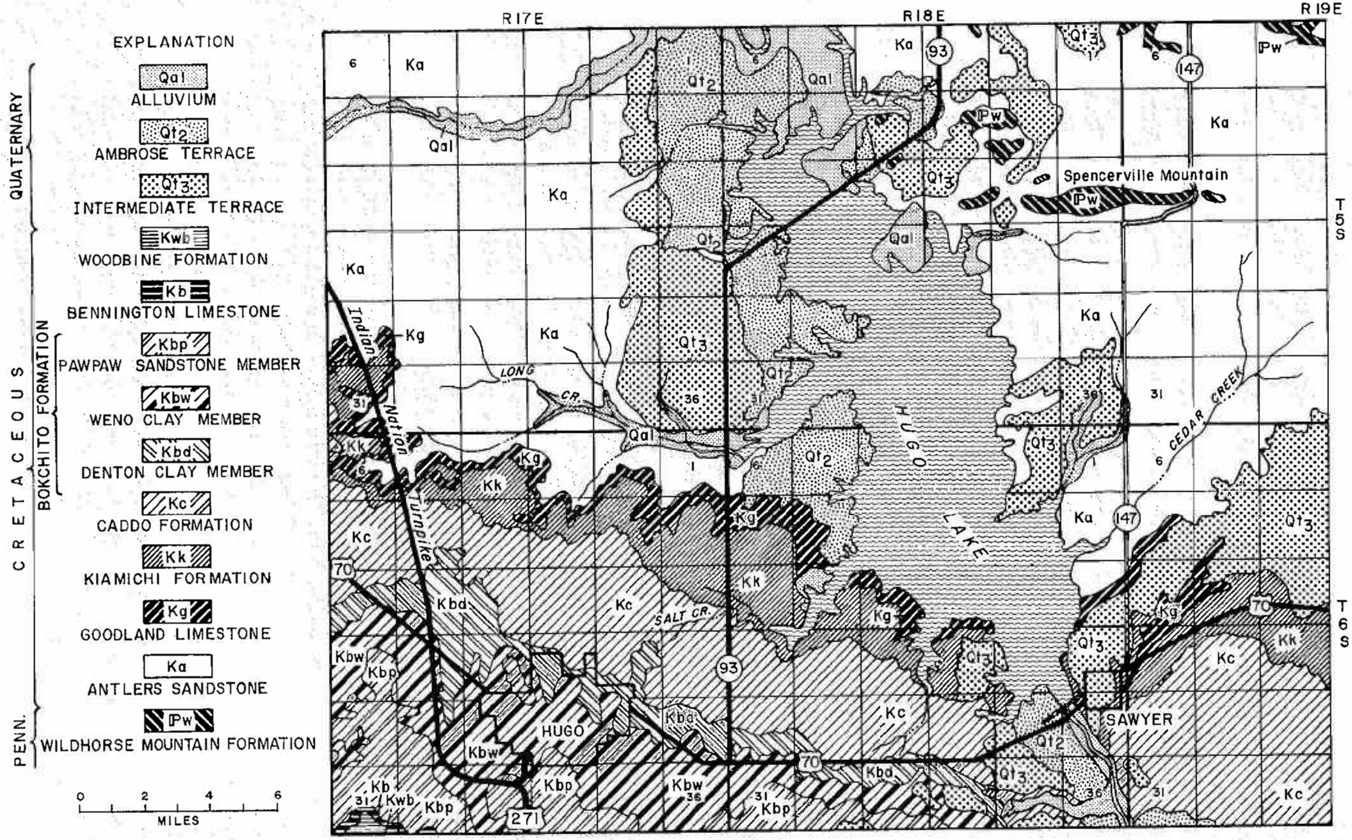

Figure 1. Geologic map of Hugo Lake, Choctaw County, Oklahoma (see index map, figure 2).

these have been assigned to the Ambrose (Qt_2) and intermediate (Qt_3) levels. The Ot_3 level is extensively developed on both sides of the lake and will remain above water level even when the flood-control pool is filled. Much of the area occupied by the Qt_2 deposit will be covered with water when the conservation level is exceeded.

Access to Hugo Lake is via U.S. Highway 70, which crosses southern Oklahoma from west to east, passing through Hugo and Sawyer. The Indian Nation Turnpike enters the area from the northwest and connects with U.S. Highway 271, which continues southward across the Red River into Texas. State Highway 93 extends northward from U.S. Highway 70, 2 miles east of Hugo, runs along the west side of the lake through the village of Messer, then turns northeastward across the lake and enters Pushmataha County, intersecting State Highway 3 at Rattan. State Highway 147 extends northward from Sawyer along the east side of the lake, entering Pushmataha County 3 miles south of Oleta, where it too joins State Highway 3.

Boswell Dam and Lake

The Boswell Reservoir was authorized by Congress in the Flood Control Act of 1946. The dam is to be located on Boggy Creek about 4.75 miles below the confluence of Clear Boggy Creek and Muddy Boggy Creek in northwestern Choctaw County. The location is 80 miles east of Ardmore, 36 miles east of Durant, and 3 miles west of Soper, Oklahoma. The name is taken from the town of Boswell, located 7 miles west of the proposed site.

The dam and reservoir will constitute a multipurpose project designed to provide water supplies, flood control, recreation, and fish and wildlife preservation. The dam will be constructed of rolled, earth-fill material. Alignment of the dam conforms to the natural topography of the valley. The dam and spillway will have an overall length of 19,950 feet and will rise 111 feet above the stream bed (written communication, U.S. Army Corps of Engineers, 1968). The spillway will be a gated, concrete, ogee-weir type 320 feet wide. Eight 40- by 36-foot spillway gates will release 362,500 cfs during maximum flow. Low flow will be regulated by two 24″ pipes and four 5′ 8″ × 10′ sluices.

The drainage area embraces 2,273 square miles. Average rainfall in the drainage basin ranges from 40 to 45 inches per year. Mean annual temperature is 63°F., average runoff ranges from 7.5 to 10 inches, and average annual lake evaporation is 55 inches (Oklahoma Water Resources Board, 1975, sec. 2, p. 1–3).

According to figures prepared by the U.S. Army Corps of Engineers in 1968 (written communication), the top of the dam will have an elevation of 516.5 feet, top of the conservation pool will be 482.5 feet, and top of the flood-control pool will be 500.0 feet. Reserve capacity at flood-control level will be 2,402,000 acre-feet and at conservation level will be 1,306,000 acre-feet. Conservation-pool storage for water supplies will be 1,243,800 acre-feet; flood-control storage is 1,096,000 acre-feet; and 62,200 acre-feet are for sediment reserve. The proposed reservoir at conservation-pool level will cover 52,740 acres of land in northwestern Choctaw County, southern Atoka County, and the northeast corner of Bryan County. At flood-control level, 72,480 acres will be inundated.

Clear Boggy Creek and Muddy Boggy Creek originate near Ada in Pontotoc County, Oklahoma, and flow southeastward for 75 miles and 90 miles, respectively, to their confluence in northwestern Choctaw County in sec. 1, T. 6 S., R. 14 E., a point 4.75 miles above the proposed dam site. Clear Boggy Creek flows southeastward across the eastern Arbuckle Mountains and Cretaceous sediments of the Gulf Coastal Plain. Muddy Boggy flows southeastward across the western end of the Arkoma basin, then southeastward across the southwestern end of the Ouachita Mountains, then southward across Cretaceous sands, gravels, and clays of the Gulf Coastal Plain. Major tributaries whose waters enter Clear Boggy Creek are Delaware Creek, Sandy Creek, and Salt Creek. Tributaries whose water enters Muddy Boggy Creek include Caney-Boggy Creek, Caney Creek, North Boggy Creek, Chickasaw Creek, and McGee Creek. These streams will play a major role in development of Phase I of the Southern Interconnected Water System (Oklahoma Water Resources Board, 1975, fig. 1–1). Boggy Creek continues its southeastward flow across Choctaw County from the proposed dam site to a point near the village of Gay in T. 7 S., R. 16 E., where it enters the Red River.

Tributary streams that will flow directly into the lake, when completed, include Mayhew Creek, Shawnee Creek, Bois d'Arc Creek, Pine Creek, Caney Creek, Delaware Creek, Sandy Creek, Potubbi Creek, Tanyard Creek, Beaverdam Creek, and Sugar Creek. Their locations are shown in figure 2.

The oldest outcrop known in the Boswell-Reservoir area is the Antlers Sandstone, a basal, transgressive marine deposit of Early Cretaceous age. North of the mapped area, the Antlers overlaps some eroded late Paleozoic rocks (of the Stanley and Jackfork Groups and the Atoka Formation). The Antlers covers the northern one-half of the mapped area and is the principal bedrock unit exposed in southern Atoka and northern Choctaw Counties. The Antlers is succeeded by the Goodland Limestone (30 feet), which is exposed around the margin of the lake in much of northwestern Choctaw and northeastern Bryan Counties. The Goodland is succeeded by the Kiamichi Formation (33 feet), the Caddo Formation (150 feet), the Bokchito Formation (140 feet—including the Denton Clay, Soper Limestone, Weno Clay, McNutt Limestone, and Pawpaw Sandstone Members) and the Bennington Limestone (10 feet), all assigned to the Lower Cretaceous. The Upper Cretaceous is represented by a few feet of the Dexter Member of the Woodbine Formation, whose distribution is limited to the southernmost part of the mapped area (fig. 2).

Extensive deposits of alluvium form the flood plain of Clear Boggy Creek, Muddy Boggy Creek, and the lower parts of their tributaries. Most of the alluvium will be covered by the waters of Boswell Lake after its completion. A few small areas are covered with terrace deposits of the Ambrose level (Qt_2) and the intermediate level (Qt_3). Most of the Qt_2 will be covered by water on completion of the lake, and the Qt_3 will be restricted to an island in sec. 35, T. 5 S., R. 14 E., and a large peninsula in secs. 5 and 6, T. 6 S., R. 15 E., and sec. 31, T. 5 S., R. 15 E. Two additional areas of Qt_3 have been inferred from

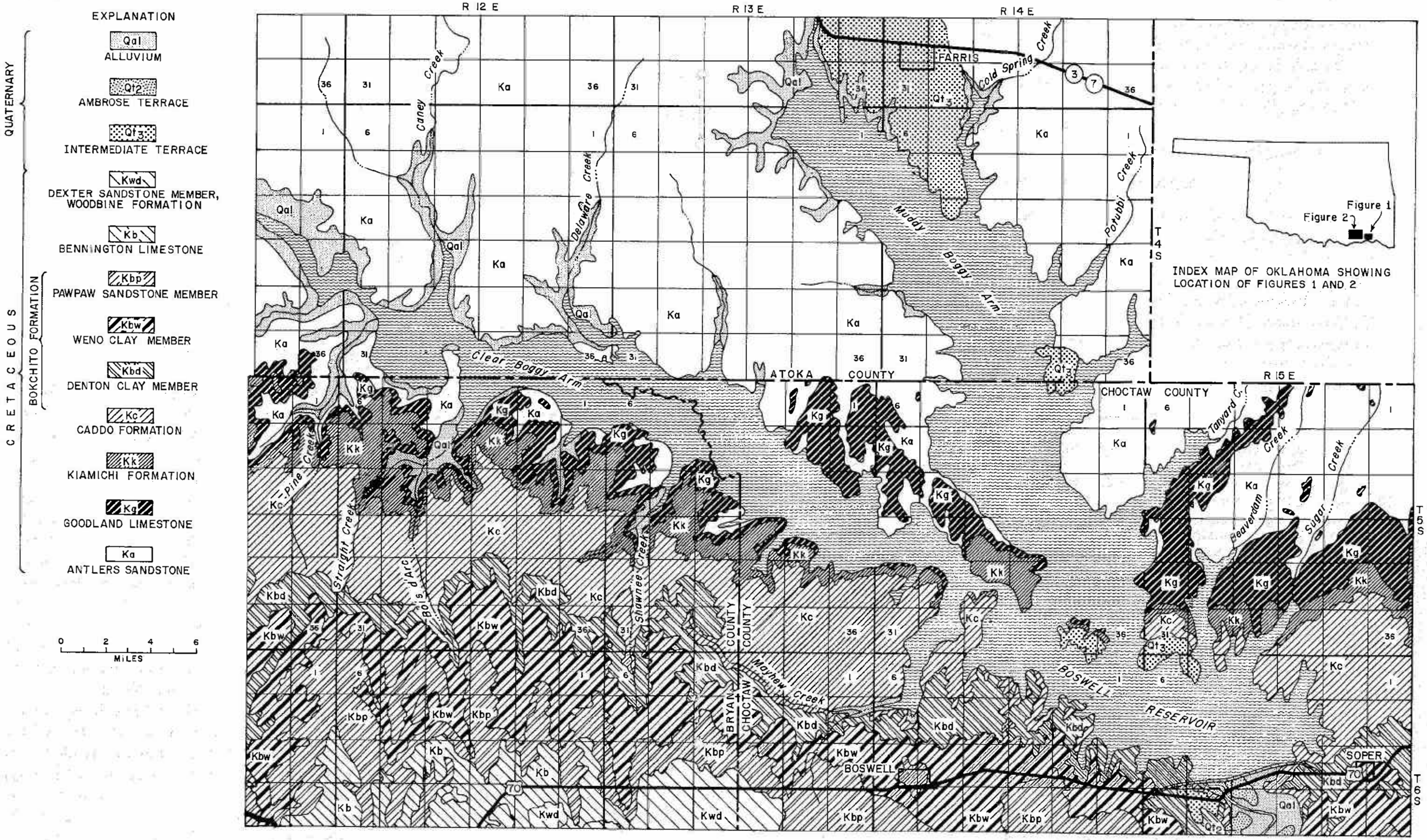

Figure 2. Geologic map of Boswell Reservoir, Atoka, Bryan, and Choctaw Counties, Oklahoma.

topographic maps. One of these areas covers a peninsula in secs. 34 and 35, T. 4 S., R. 14 E., and the second is in the vicinity of Farris, where there is about 7 square miles of terrace (see Miser and others, 1954, *Geologic Map of Oklahoma*, which indicates terrace deposits in this area).

Access to the Boswell Lake will be by means of U.S. Highway 70, which extends east-west across Bryan and Choctaw Counties, passing through the villages of Boswell and Soper near the southeastern end of the reservoir. Access to the Muddy-Boggy arm will be via State Highways 3 and 7, which pass through the village of Farris on the route from Atoka to Antlers, Oklahoma. U.S. Highways 69 and 75 cross Clear Boggy Creek about 5 miles upstream from the end of the conservation pool. Several county roads will be improved and relocated at places to provide adequate access to the lake shore.

Summary and Conclusions

Completion of the Boswell Dam and Reservoir will create a large, Y-shaped lake covering 52,740 acres at conservation pool level and 72,480 acres at flood-control level. Conservation storage will be 1,306,000 acre-feet and flood-control storage will be an additional 1,096,000 acre-feet. The Muddy-Boggy arm will extend northwestward from the dam for 19.6 miles, and the Clear-Boggy arm will extend about 19 miles from its junction with the Muddy-Boggy arm and 26 miles above the dam. This lake will furnish abundant supplies of fair- to good-quality water for the Southern Interconnected Water System as currently visualized by the Oklahoma Water Resources Board (1975, fig. 1–1).

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Alternate Energy Resources Detailed in New Book

Geology of Alternate Energy Resources in the South-Central United States is the title of a 400-page text recently published by the Houston Geological Society. Edited by Michael D. Campbell, the book is billed as a state-of-the-art analysis as well as a current reference source for research and applied use.

Five chapters have been devoted to uranium, 5 to lignite, and 5 to geopressured-geothermal energy. The volume focuses on frontier and trend exploration, development-utilization, and environmental considerations.

The book can be ordered from the Houston Geological Society, 806 Main Street, Suite B-1, Houston, Texas 77002. The price is $15.00, payable in advance.

Ardmore Society Issues Fossil Guide

A publication released recently by the Ardmore Geological Society should prove helpful to paleontology buffs interested in doing some collecting in and around the Arbuckle Mountains. The 20-page paperback book, *Fossil Collecting in the Ardmore Area*, authored by Bronston W. (Bronc) James, contains numerous clearly reproduced pencil drawings by the author, showing species of brachiopods, corals, crinoids, pelecypods, bryozoans, graptolites, a fusulinid, and a trilobite.

Detailed directions explain the best routes to reach localities designated on an index map included with the book. The map, marked off into sections and showing roads and highways, covers an area about 20 miles wide extending from Turner Falls in the north, where the Ordovician Sylvan Shale is exposed, to the Cretaceous outcrops on U.S. Highway 77 south of Lake Murray.

Bronc James is a graduate of The University of Oklahoma (B.S. geol. '31) who has done about everything there is to do in the oil fields, from roughnecking to administration, and he is known as an authority on the geology of southern Oklahoma. He has always had an interest in paleontology and has chosen one of the best collecting areas of the State to write about.

Fossil Collecting in the Ardmore Area can be ordered from The Bookseller, 614 West Main Street, Ardmore, Oklahoma 73401. The price is $4.50 plus postage. Copies are available for inspection and consultation at the Oklahoma Geological Survey offices and in the Geology and Geophysics Library at OU.

Oklahoma's Geological Societies Announce New Officers

New officers and executive committees for the 1977–78 year have been announced by the following geological and geophysical societies in Oklahoma:

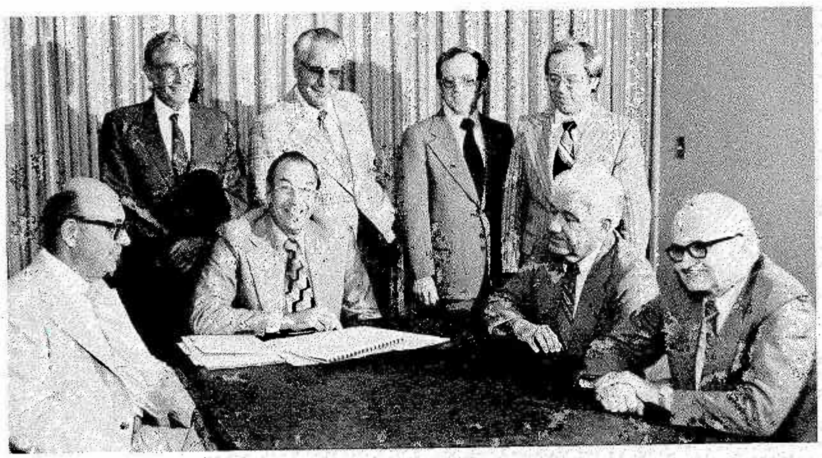
Ardmore Geological Society
President, **Harry Spring**, Kingery Drilling Co.
Vice-President, **B. W. (Bronc) James**, independent
Secretary-Treasurer, **George Ramsey**, consultant
Past President, **Lawrence S. Morrison**, Westheimer-Neustadt Corp.

Geophysical Society of Oklahoma City
President, **R. R. Foster**, Dawson Geophysical Co.
First Vice-President, **Michael G. Cook**, Cities Service Gas Co.
Second Vice-President, **Ronald E. Zdyb**, Phillips Petroleum Co.

Secretary, **Clint Hutter**, Texas Pacific Oil Co.
Treasurer, **Kenneth R. Ainsworth**, Union Oil Co. of California
Editor, **Richard E. Schneider**, Continental Oil Co.
Past President, **Jeffrey M. Collar**, Forest Oil Corp.

Geophysical Society of Tulsa
President, **M. R. Hewitt**, Amoco Production Co.
First Vice-President, **E. W. Johnson**, Cities Service Oil Co.
Second Vice-President, **S. W. Fruehling**, consultant
Secretary, **R. W. Saubert**, Seismograph Service Corp.
Treasurer, **N. K. Moody**, consultant
Editor, **R. M. Borcherding**, Texaco, Inc.
Editor-Elect, **W. S. French**, Amoco Production Co.
Past President, **R. W. Mossman**, Seismograph Service Corp.

Oklahoma City Geological Society
President, **Sherrill D. Howery**, Union Oil Co. of California
First Vice-President, **Don F. Weber**, independent
Second Vice-President, **Gary W. Hart**, independent
Secretary, **W. P. (Andy) Anderson, Jr.**, independent

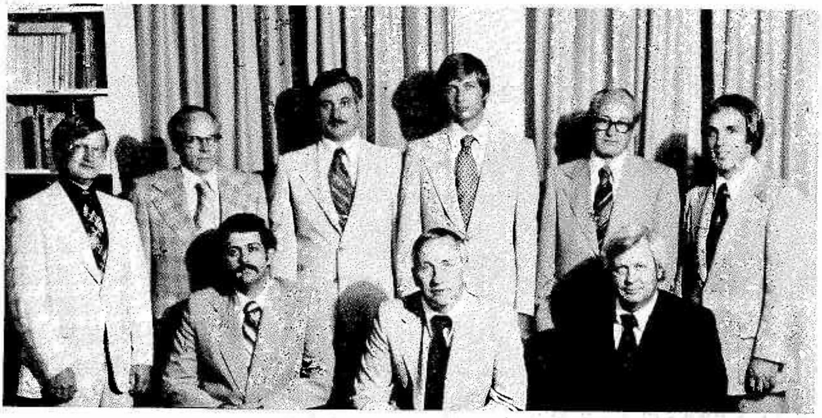


Geophysical Society of Tulsa executive committee for 1977–78. Seated, left to right: S. W. Fruehling, second vice-president; M. R. Hewitt, president; E. W. Johnson, first vice-president; R. W. Mossman, past president. Standing, left to right: N. K. Moody, treasurer; R. W. Saubert, secretary; R. M. Borcherding, editor; W. S. French, editor-elect.

Treasurer, **Jerry E. Upp**, Tenneco Oil Co.
Shale Shaker Editor, **W. T. (Tom) Gans**, Continental Oil Co.
Library Director, **J. W. (Jim) McHugh**, consultant
Social Chairman, **Hubert G. (Bert) Wessman**, Union Oil Co. of California
Public Relations Chairman, **Paul B. Pipes**, Samedan Oil Co.
Past President, **Thomas C. Cronin**, Hoover and Bracken Oil Properties, Inc.

Tulsa Geological Society

President, **Frederick V. Ballard**, consultant
First Vice-President, **George W. Krumme**, Krumme Oil Co.
Second Vice-President, **J. Glenn Cole**, Williams Exploration Co.
Secretary, **Edward D. Pittman**, Amoco Production Co.
Treasurer, **Alvin A. Chinn**, Texaco, Inc.
Editor, **Dale W. Peterson**, GeoData Corp.
Newsletter Editor, **Paul B. Basan**, Amoco Production Co.
Past President, **George R. Bole**, Amoco Production Co.
Councilors: **Bailey Rascoe, Jr.**, Phillips Petroleum Co.; **Norman S. Morrisey**, consultant; **Robert W. Scott**, Amoco Production Co.



Oklahoma City Geological Society executive committee for 1977–78. Seated, left to right: Gary W. Hart, second vice-president; Sherrill D. Howery, president; Don F. Weber, first vice-president. Standing, left to right: W. T. Gans, **Shale Shaker** editor; Hubert G. Wessman, social chairman; Jerry E. Upp, treasurer; W. P. Anderson, Jr., secretary; Kenneth G. Redman, representative-at-large to AAPG Mid-Continent Section; Thomas C. Cronin, past president. Not pictured: J. W. McHugh, library director; Paul B. Pipes, public relations chairman.

USGS Launches Coal-Map Series

The U.S. Geological Survey has initiated a new series of coal maps designed to portray the occurrence and development potential of coal deposits owned by the federal government within designated areas of known recoverable resources. A principal objective of the project is evaluation of areas for inclusion in future coal-lease sales.

The maps in the new series are being prepared on 1:24,000-scale quadrangles, compatible with the 7.5-minute USGS topographic series. During the next 4 years, maps are planned for more than 800 quadrangles covering about 15 million acres in the major coal basins in Oklahoma, New Mexico, Colorado, Utah, Wyoming, Montana, North Dakota, and Alabama.

A map for a given quadrangle consists of multiple sheets showing federally owned coal lands, surface and subsurface coal data, depth and thickness of coal seams, reserve information, overburden data, and mining ratios. A brief report accompanies each map set.

The first map and report in the series have recently been published and cover the Little Thunder Reservoir quadrangle, Campbell County, Wyoming. They are designated open-file reports 77-57 and 77-58, respectively.

For availability of this map set and for further information on the program, check with the USGS Public Inquiries Office, 1012 Federal Building, 1961 Stout Street, Denver, Colorado.

USBM Issues Circular on Mine-Reclamation Costs

A recent publication by the U.S. Bureau of Mines deals with reclamation costs of western land that has been surface mined for coal. Issued as Information Circular 8737, the report summarizes surface mining and reclamation practices in four regions of the Western United States, including Oklahoma. In addition to reclamation costs, topics covered are costs for backfilling and grading, revegetation, permit and bond fees, and expenses for design, engineering, and overhead.

Authors Franklin Persse, Alec Lindquist, and David Lockard report that average reclamation costs varied widely in the four coal regions—from $1,105 to $5,050 per acre. Average reclamation costs per ton of coal ranged from 7 cents to 60 cents, and the average per million Btu's of heating value in the coal mined ranged from 0.45 cents to 2.67 cents. These estimates were based on observations at 13 large surface mines in 9 states during 1974 and 1975, plus interviews with mining officials.

Copies of the circular, *Coal Surface Mining Reclamation Costs in the Western United States*, can be ordered for $1.50 each from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. Orders should specify the complete title plus GPO stock number 024-004-01906-9.

POSSIBLE COMMENSAL RELATIONSHIP BETWEEN *EDRIOCRINUS* AND THE BULBOUS FLOAT OF *SCYPHOCRINITES* (CRINOIDEA: ECHINODERMATA)

Harrell L. Strimple[1]

Modern crinoids go through several developmental stages, and it is assumed that fossil crinoids were more or less analagous in their ontogeny. In the doliolaria stage, many modern crinoids are pelagic, but at the end of the stage, the larva contacts a hard surface for attachment (Hyman, 1955). Many specimens of *Edriocrinus* have been found attached to brachiopod or pelecypod shells, and some apparently attain a free state in maturity (for example, *E. sacculus* Hall). *Edriocrinus adnascens* Dunbar has been found attached to the bulbous floats of *Scyphocrinites*, and the present report is primarily concerned with this relationship.

Bulbous floats ("*Camarocrinus*") of *Scyphocrinites* are prolific in the Haragan Formation, Hunton Group, Devonian, of southeastern Oklahoma. This writer has found them literally packed-in at 2 localities in NW¼ sec. 12, T. 1 N., R. 7 E., Pontotoc County, Oklahoma. Christina Strimple, the author's wife, has collected specimens from yet another locality in the same area. Out of 40 random specimens from Oklahoma, 4 have 1 or more specimens of *Edriocrinus adnascens* attached to the lateral sides of bulbs or to the abcolumnal surface. The two specimens shown in figure 1 are from the abcolumnal surface of a single, slightly crushed bulb. They are representative of the attached basal circlets of *Edriocrinus*. The radials have been lost in preservation. The larger of the two specimens has taller side walls, and the attachment surface of the smaller is overgrowing it at one point. The smaller specimen is probably younger.

A comprehensive study of "*Camarocrinus*," the bulb-like float of *Scyphocrinites* was made by Charles Schuchert (1904, p. 253–272), who gathered all of the information known up to that time concerning the bulbs. In passing, Schuchert (1904, p. 261) noted that the basal portion of *Edriocrinus* was often found attached to "*Camarocrinus*" *ulrichi* in Oklahoma. Schuchert examined many occurrences of "*Camarocrinus*" in situ and found that almost all of them had the stem downward or, conversely, the nonstalked end upward. He also noted the paucity of other echinoderm material—or of almost any other fossils—in association. This observation is confirmed by my findings.

The "*Camarocrinus*" bed in the Haragan Formation of Oklahoma was traced by E. O. Ulrich for 100 miles while he was engaged in stratigraphic

[1] Curator and research investigator, Department of Geology, The University of Iowa, Iowa City, Iowa.

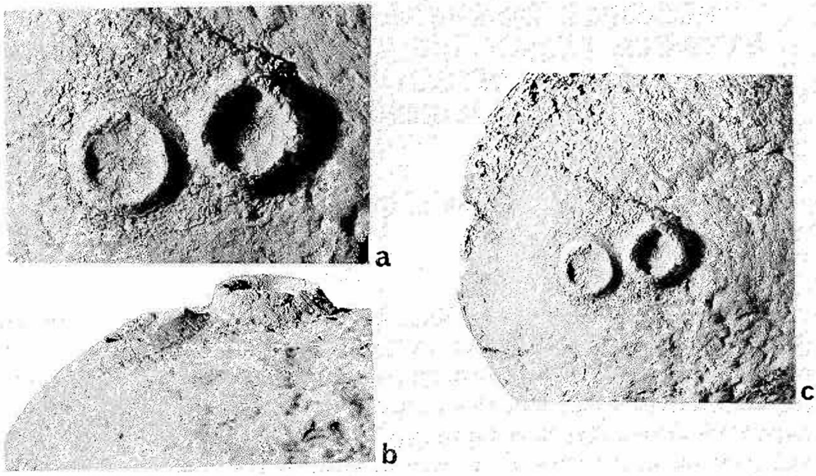


Figure 1. **Edriocrinus adnascens** Dunbar, attached to bulbous float of **Scyphocrinites ulrichi**? (Shumard) from the Haragan Formation of southeastern Oklahoma. Hypotype basal discs (SUI 42770): (**a**)—summit view, ×2; (**b**)—side view, ×2; (**c**)—summit view, ×1.

work in Indian Territory (Oklahoma) in 1901. During the same year (1901) Schuchert collected a larger number of the bulbs in Maryland, and by his own account (1904, p. 258), he considered them to be cystoids at the time he was gathering them. This was contrary to the views of Hall (1879), who considered the bulbous structure to be a float. After more exhaustive investigation, Schuchert reached this same conclusion, and most modern investigators consider the bulbs to be floats.

Strimple (1963, p. 125, pl. 10, fig. 6) reported a specimen of *E. dispansus* Kirk (from the Haragan Formation) in which the attachment scar was almost obliterated and occupied less than one-fourth the diameter of the base. Yet another specimen reported by the author (1963, p. 17) had outgrown the pelecypod shell to which it was attached in youth, and both specimens were considered to exhibit a vagrant habitus.

Prokop (1976) reported the first known occurrence of *Edriocrinus* in Europe, and he commented that they apparently had escaped the notice of most collectors because of their inconspicuous nature. Where only the basal circlets are preserved, they are easily overlooked. LeMaitre (1958a, b) has reported *Edriocrinus* cf. *pocilliformis* Hall from the Middle Devonian of North Africa. The material from Bohemia has been described as *E. ata* Prokop, from the Lower Devonian, and *E. tara* Prokop and *E. cylindricus* Prokop, from the Middle Devonian. Specimens of *E. tara* are reported to be attached to orthocone nautiloids or to be free. *E. cylindricus* is reported to have irregular bases; this indicates attachment to objects having variable topography.

I believe that a more intensive search for the attached bases of *Edriocrinus* will reveal a prolific, world-wide distribution in Lower and Middle Devonian strata because of the apparent capability of the larval stage to attach to epiplanktonic hosts (as well as to other available hard surfaces). *Scyphocrinites* has world-wide distribution.

Material studied.—Five fused basal circlets of *Edriocrinus* sp. attached to 4 bulbous floats of *Scyphocrinites ulrichi*? (Schuchert), deposited in Geology Department Repository, The University of Iowa, Iowa City, Iowa, catalogue numbers SUI 42770-42773. The specimens were collected by my wife, Christina Cleburn Strimple, from the Haragan Formation, Lower Devonian, south of Fittstown, (NW¼, sec. 12, T. 1 N., R. 7 E.), Pontotoc County, Oklahoma.

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Recent U.S. Geological Survey Publications

Water Resources, Oklahoma

Oklahoma water publications continue to pour forth from our good colleagues with the U.S. Geological Survey.

Of general interest is a folder entitled *Water Resources Investigations in Oklahoma, 1976.* In addition to listing current water programs and cooperators (such as the Oklahoma Geological Survey), the folder also explains how to obtain completed research reports and lists a moderately comprehensive series of USGS publications and those of other agencies dealing with the water resources of Oklahoma, beginning with 1939. Several index maps show geographic coverage. Limited copies of the folder are available free from the District

Chief, U.S. Geological Survey, Water Resources Division, 201 NW 3d Street, Room 621, Oklahoma City, Oklahoma 73102.

Single copies of the following open-file reports are available without charge from the same address:

No. 77-73: *Selected Water-Level Records for Western Oklahoma, 1950-1975*, by R. L. Goemaat, 94 p. 1 fig., 1 table.

No. 77-204: *Index of Published Surface-Water-Quality Data for Oklahoma, 1946-1975*, by J. D. Stoner, 218 p., 3 figs., 4 tables.

No. 77-238: *Ground-Water Levels in Observation Wells in Oklahoma, 1975*, by R. L. Goemaat, 94 p., 1 fig., 1 table.

No. 77-239: *Selected Water-Level Records for Western Oklahoma, 1975-76*, by R. L. Goemaat, 54 p., 1 fig., 1 table.

No. 77-278: *A Preliminary Appraisal of the Garber-Wellington Aquifer, Southern Logan and Northern Oklahoma Counties, Oklahoma*, by J. E. Carr and M. V. Marcher, 49 p., 5 pls., 6 figs., 2 tables.

Ground Water, Arkansas–White–Red River Region

All of Oklahoma and parts of Colorado, New Mexico, Kansas, Texas, Missouri, Arkansas, and Louisiana are covered in a report on the ground-water resources of the Arkansas–White–Red River region. One of the conclusions of the 31-page publication is that the amount of fresh ground water stored in the region is about 60,000 times larger than total water use but that only part of this amount is recoverable. The report is the 7th in a series of 21 such reports covering the ground-water resources of the United States. Professional Paper 813-H, *Summary Appraisals of the Nation's Ground-Water Resources—Arkansas–White–Red Region*, by M. S. Bedinger and R. T. Sniegocki, can be ordered for 85 cents from the Branch of Distribution, U.S. Geological Survey, 1200 South Eads Street, Arlington, Virginia 22202.

Coal Bibliography

Circular 742, *Bibliography and Index of U.S. Geological Survey Publications Relating to Coal, 1971-1975*, by F. K. Walker, supersedes USGS Circular 709 and supplements Bulletin 1377. The 32-page bibliography is available without charge from the address given in the preceding paragraph.

Precambrian Geology

Published as Professional Paper 902 is *Precambrian Geology of the United States; An Explanatory Text to Accompany the Geologic Map of the United States*, by P. B. King. The 85-page text reviews the Precambrian rocks that are exposed in the Lake Superior region, the Appalachian Mountains, the Central Interior region, and the Western Cordilleran region. The report sells for $2.00 and is available from the Branch of Distribution, same address as given previously.

Uranium-Thorium

Circular 753 is a set of 41 expanded abstracts of technical papers presented at a 1977 conference held at Golden, Colorado, April 27-28, 1977. The 75-page circular, *Short Papers of the U.S. Geological Survey Uranium-Thorium Symposium, 1977*, edited by J. A. Campbell, is available without charge from the Branch of Distribution, same address as given previously.

Stratigraphic Nomenclature

Stratigraphic names adopted, revised, reinstated, or abandoned in 1975 are detailed in Bulletin 1422-A by G. V. Cohee and W. B. Wright. The 84-page report, *Changes in Stratigraphic Nomenclature by the U.S. Geological Survey, 1975*, can be ordered for $1.15 from the Branch of Distribution at the same address given previously.

OKLAHOMA ABSTRACTS

AAPG–SEPM Annual Meetings
Washington, D.C., June 12–16, 1977

The following abstracts are reprinted from the May 1977 issue, v. 61, of the *Bulletin* of The American Association of Petroleum Geologists. Page numbers are given in brackets below each abstract. Permission of the authors and of Gary Howell, AAPG publications manager, to reproduce the abstracts is gratefully acknowledged.

Middle Paleozoic History of Anadarko and Arkoma Basins, Oklahoma

THOMAS W. AMSDEN, Oklahoma Geological Survey, Norman, Oklahoma

The Anadarko and Arkoma basins are Paleozoic sedimentary-structural basins in the western third and eastern third of Oklahoma, respectively. These basins are separated in the south by the Arbuckle Mountains–Criner Hills and in the north by the structural complex that includes the Hunton arch and the central Oklahoma fault zone (Nemaha ridge). These basins are similar in many respects, but each has a different middle Paleozoic (Sylvan-Hunton-Woodford) history.

In the southern, deeper, part of the Anadarko basin, just north of the Wichita fault zone, Sylvan-Hunton-Woodford strata thicken progressively with increased depth, suggesting continuous deposition from Late Ordovician into Mississippian time. In the northern, shallower, parts of this basin, Hunton and

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OKLAHOMA ABSTRACTS is intended to present abstracts of recent unpublished papers relating to the geology of Oklahoma and adjacent areas of interest. The editors are therefore interested in obtaining abstracts of formally presented or approved documents, such as dissertations, theses, and papers presented at professional meetings, that have not yet been published.

Sylvan strata are truncated by pre-Woodford erosion, pointing to differential uplift in post-Early Devonian time, with the southern part continuing to subside and receive sediments while the northern half was uplifted and subjected to subaerial erosion.

In contrast, Sylvan-Hunton strata in the Arkoma basin are truncated along the southern, deeper, part as well as along the northern, shallower, part and now form an east-west-trending lens of sedimentary deposits quite unlike the wedge-shaped Anadarko sedimentary rocks. This suggests that following deposition of Lower Devonian strata the Arkoma basin was uplifted and eroded, probably by streams flowing in an easterly direction, followed in turn by renewed subsidence in Late Devonian (Woodford) time. [760-761]

Coking-Coal Reserves of Oklahoma

S. A. FRIEDMAN, Oklahoma Geological Survey, Norman, Oklahoma

Six bituminous coal beds in Oklahoma contain 3,427 million MT of remaining resources of coking coal, a vital carbonizing fuel in steel manufacture. This quantity is 53% of the state's remaining coal resources as of January 1, 1974.The net recoverable reserves of coking coal are 965 million MT (28% of the remaining coking-coal resources); 111 million MT is recoverable by surface mining. At present, approximately 0.9 million MT is shipped annually from 7 surface mines to 4 out-of-state steel manufacturers.

Oklahoma's coking-coal resources are broken down as follows, by bed, metric tonnage, and sulfur percentage: Hartshorne coal, 1,071 million, 1.6%; Lower Hartshorne coal, 1,048 million, 1.0%; Upper Hartshorne coal, 405 million, 1.5%; McAlester coal, 468 million, 1.0%; Stigler coal, 302 million, 1.4%; and Croweburg coal, 133 million, 0.8%.

Plans are developing for the production of 0.9 MT from 3 underground mines and 1 surface mine within the next three years. The capital investment for a new mine is estimated at $1 to $5 million (1976 dollars) for planned annual production of 100,000 to 1,000,000 MT. Coal-preparation plants will cost $½ to $3 million each. Annual operating costs of coking-coal production in Oklahoma have more than doubled since 1973; high-volatile bituminous coking-coal prices (f.o.b.) have doubled, and medium to low-volatile coking-coal prices have tripled.

Thus, considering the present and planned production of coking coal in Oklahoma, the state's 900 million MT of net-recoverable reserves of this coal should last 500 to 1,000 years. [787]

Review and Application of Petroleum Finding-Rate Methodologies to Appraisal of Undiscovered Oil and Gas Resources in United States

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Some concept of "finding rate" or "discovery rate" has been used almost universally to assess and project the availability of future oil and gas resources. However, many finding-rate definitions have evolved because the terms and units of measurement vary from method to method. Regardless of the definition used, the ultimate purpose is to permit statistically valid projections of resource availability based on historical data, commonly within a set of given geologic and economic conditions, and measured by some unit of exploratory effort.

In 1976 the Federal Energy Administration (FEA) asked the Resource Appraisal Group, of the U.S. Geological Survey, to review and analyze all known methodologies used to determine finding rates and determine the data requirements for each. The group also was asked to investigate the feasibility of developing a "better" methodology for determining the finding rate for crude oil and natural gas compatible with the resource appraisal procedures established by the Resource Appraisal Group for oil and gas in basins and provinces.

The results of the study are: (1) a comprehensive review, analysis, and data requirements of the basic procedures for determining finding rates; (2) testing and application of various known methods of determining the finding rate to the exploration statistics in three petroleum provinces, and (3) the development of a series of methods for projecting finding rates for petroleum provinces in one of three stages of exploration and drilling—maturely and semi-maturely drilled, immaturely drilled, and frontier.

The units of exploratory effort used in the proposed methods are total oil-and/or gas-in-place found per unit of exploratory footage drilled, as determined by field size categories and the related depth of occurrence of fields within a basin. Depth estimates provided can be used in finding-cost studies being conducted independently by consulting groups for the FEA.

All of the methodologies are computerized and new data input can be readily added. The finding rates are projected as minimum, maximum, and mean values, based on projections of the historical trends. [813-814]

Favorable Hydrocarbon Potential Predicted for Ouachita Mountains

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The Ouachita Mountains of Oklahoma have considerable potential for hydrocarbons, particularly dry gas. The exploration key will be the utilization of a deep-sea fan model for E-log and outcrop data of Stanley-Jackfork clastic rocks. Dark shales from many zones have been brought to stages of diagenesis adequate to generate oil and gas. Sandstones have undergone reduction in porosity and permeability by pressure solution as well as development of quartz overgrowths yet many still have adequate textures when compared with producing zones in the Arkoma basin. The more favorable sandstones were sandy debris flows within distributary channels and proximal turbidites forming suprafan depositional lobes of deep-marine fans. Blanket distal turbidites of the active outer fan are unfavorable. Thick, favorable sandstones are present at many stratigraphic horizons in both the Stanley and Jackfork but shift laterally as well as up or down the fan axis. Anticlinal axes are crushed, shattered, and faulted with substantial decrease in favorable sandstone textures whereas broad synclines are altered least by tectonism. Ideal exploration "fairways" will combine effective sand development, minimal sandstone diagenesis, and best structural position, probably intermediate between anticlinal and synclinal axes. Surface mapping and photogeology will be a more effective tool than seismic reflection surveys because of lack of reflections under surface anticlines. Search for gas in fractured cherts of older zones will require a thorough understanding of the development of multiple, transcurrent thrust faults and folds from compressional overburden tectonics. [816]

Flow Patterns and Bar Morphology in Braided-to-Meandering Transition Zone—Red River, Texas and Oklahoma

DANIEL E. SCHWARTZ, The University of Texas at Dallas, Richardson, Texas

Among fluvial sedimentary systems, the transition between the braided and meandering pattern has had limited coverage in the literature. This reorganization of major patterns involves a complex association between regional (climate, discharge, vegetation, etc.) and local (sediment size, flow velocity, permeability, etc.) parameters. The Red River in Texas and Oklahoma changes from a braided to a meandering pattern within a fluctuating transition zone. A 100-km segment of this zone is the subject of this study.

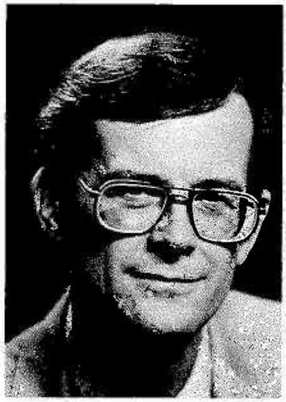
Medium sand- through pebble-sized sediments are abundant in the upper and middle parts of the transition zone, with fine-sand through coarse-grained sand-sized sediments dominating the lower reach. Clasts, ranging from 2 to 13.5 cm, are common in the upper and middle reaches, less so in the lower.

Large scale channel bed forms are predominantly linguoid and transverse bars. Lateral, braid, and longitudinal bars are present in channels with straight, large-radius meander bend, or point-bar crossover segments. Channel-bar slip faces rarely exceed 1 m in height and chord length ranges between 10 and 200 m. Point bars are present throughout the zone, with height increasing and width decreasing downstream. Point-bar formation results from three distinct processes: (1) bar-toward-channel deposition, in which sand waves and linguoid, transverse, and chute bars migrate over the point-bar surface toward the channel; (2) apparent upstream bar migration resulting from the erosion of the downstream end with deposition on the upstream end of the next successive point bar; and (3) channel-toward-bar (normal "helical") deposition. Four types of small-scale ripples are present in close lateral proximity on many bar surfaces. These are: linguoid, sinuous, straight, and lunate. Straight and sinuous small-scale ripples of eolian origin cover subaerially exposed bars.

Stratification in the transition zone is variable, with no major trends in size or type of bedding feature. The most readily preserved structures result from flood deposition that represents less than 2% of the average annual discharge. Channel deposits are characterized by basal lag, graded large- and small-scale trough and tabular cross-stratification. Point bars contain large-scale trough, tabular, and small-scale trough cross-stratification as well as parallel lamination. Overbank deposits of the river flood plain are characterized by small-scale trough cross- and climbing-ripple stratification.

The transition zone is a preservable fluvial pattern. The structural and formational associations on the Red River differ greatly from previous descriptions of braided and meandering and braided-meandering rivers. Because of these differences, further examination of other "transfluvial" rivers is needed to understand the complexity and variability of modern and ancient fluvial systems. [827-828]

Welcome Back, Charlie Gilbert!



M. Charles Gilbert has joined the Oklahoma Geological Survey as a visiting geologist for the term of September 1, 1977, through June 30, 1978. A native of Lawton, he comes here from Virginia Polytechnic Institute and State University (VPI&SU), where he served most recently as chairman of the Department of Geological Sciences.

Charlie has been appointed to the OGS staff specifically to prepare a detailed areal geologic map of the Wichita Mountain region of southwestern Oklahoma, something that has never been done before. His work will concentrate on the petrology of the intrusive and extrusive igneous rocks of the region. Mapping will be done at a scale of 1:24,000, using 7½-minute topographic quadrangles as bases.

The program will be implemented by coordinating and augmenting work done by earlier investigators in the Wichita Mountains and by filling in gaps by mapping localities not covered previously. Charlie hopes to define and delineate consistent units throughout the Wichita Mountains that can be used as basic references for future geologic investigations. To avoid duplication of effort, particular geochemical, petrologic, and petrographic analyses will be selected to complement similar work being conducted at other institutions.

In accepting this temporary assignment, Charlie Gilbert is returning to his alma mater, having earned both the B.S. and M.S. degrees in geology from The University of Oklahoma. The subject of his master's thesis was the geology of the western Glen Mountains, a study of the layered basic intrusive rocks of a line of mountains trending west-northwest from the west boundary of the Wichita Mountains Wildlife Refuge in Kiowa County, Oklahoma. He received his Ph.D., also in geology, from UCLA in 1965; the topic of his dissertation was an experimental study of hornblende.

Charlie was employed by UCLA as an assistant research geologist in the spring and summer of 1965, conducting field studies in the Sanbagawa metamorphic terrane of Japan and in the Franciscan terrane of California. For the following 3 years, he was a postdoctoral fellow at the Geophysical Laboratory of the Carnegie Institution in Washington, D.C., working in experimental mineralogy and petrology. Since September 1968, he has been a member of the faculty of VPI&SU, and he became chairman in January 1975.

He is a fellow of the Mineralogical Society of America and a member of the Mineralogical Society of Great Britain, the American Geophysical Union, The Geological Society of America, The Society of the Sigma Xi, and Phi Beta Kappa. He has served on the External Awards Committee of the Mineralogical Society of America; as secretary of the section on Volcanology, Geochemistry, and Petrology of the American Geophysical Union; and as an associate editor of the *Bulletin* of The Geological Society of America.

Charlie Gilbert has more than 55 publications to his credit as an author or coauthor. He is preparing a monograph on the synthesis and stability of the aluminum silicate minerals for publication by Springer-Verlag. He has been the recipient of several grants from the National Science Foundation, the National Aeronautics and Space Administration, and the North Atlantic Treaty Organization.

Charlie is married to the former Mary Carol Leonard of Sulphur, Oklahoma. They have 3 children: Karen, 15, Sara, 13, and David, 9.

We extend a warm welcome to all the Gilberts!

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