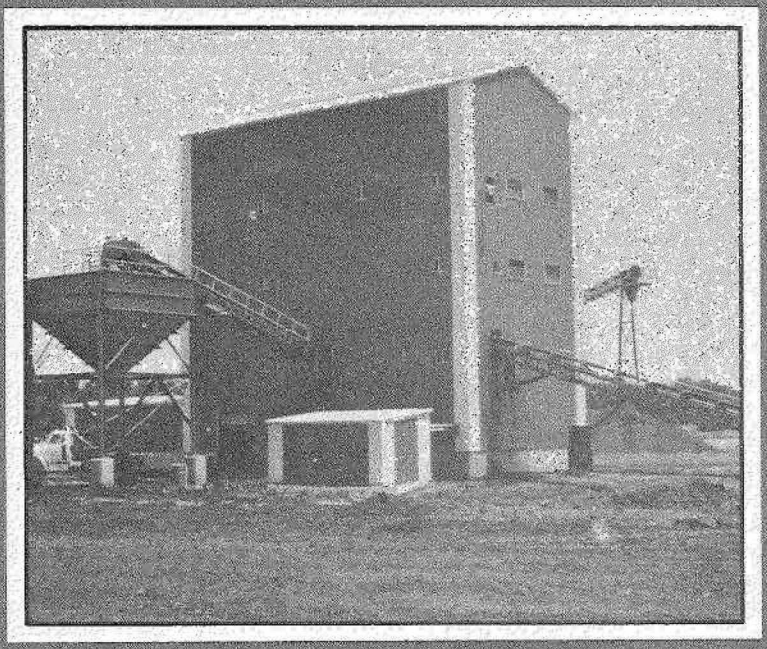


OKLAHOMA GEOLOGICAL SURVEY
THE UNIVERSITY OF OKLAHOMA
NORMAN, OKLAHOMA 73069
VOLUME 35 / NUMBER 4 / AUGUST 1975

OKLAHOMA GEOLOGY NOTES

Cover Picture

NEW COAL-PREPARATION PLANT OPENS IN LE FLORE COUNTY

In May, Oklahoma's first new coal-preparation plant in 8 years began washing coal 2 miles south of Bokoshe in northwestern Le Flore County, Oklahoma. The Garland Coal and Mining Company facility uses low-volatile, low-sulfur bituminous coal from Upper and Lower Hartshorne beds that are mined by surface operations at the company's No. 10 mine in nearby Fort Smith, Arkansas. Metallurgical coking coal was first produced at this mine in January 1975, and planned production is believed to be about 200,000 short tons annually.

After being crushed to a maximum size of 2 inches by a primary and a secondary crusher adjacent to the preparation plant, coal is fed by means of a front-end loader. The plant (whose value is estimated at $750,000) washes the coal by means of a water bath and vibrating tables, screens, and heavy media (magnetite) separation. Pyritic sulfur and shale partings are removed from the coal to make it suitable for use as high-grade coking coal. An electronic control panel in the plant permits one man to monitor the complex cleaning process while simultaneously controlling the loading of the cleaned coal into railroad hopper cars waiting on a spur of the Missouri Pacific Railroad.

In 2 to 3 years, when the coal beds have been mined to a depth of 90 feet on this federal lease, a new underground mine will be developed at the base of the highwall to produce from the Lower Hartshorne Coal, thus providing a continuous supply of coal for the new preparation plant.

—S. A. Friedman

Editorial staff: William D. Rose, Rosemary Croy, 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. All articles are reviewed by members of the Survey staff or by outside specialists as deemed appropriate by the editor. Single copies, seventy-five cents; yearly subscription, $3.00. 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 American Color Press, Oklahoma City, 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 $1,842.62.

OKLAHOMA PALEOICHTHYOLOGY
PART IV: ACANTHODII

JIRI ZIDEK[1]

INTRODUCTION

There are few records prior to 1972 of acanthodians recovered from Oklahoma deposits. Some indeterminate remains of this class of fishes were reported from coal balls of the Secor coal in the Boggy Formation (Desmoinesian) of Pittsburg County in 1962 (Mamay and Yochelson). In 1966, a large acanthodian, discussed in this paper, was collected in Murray County by Mr. Frank Bunch of Sulphur and Mr. Allen A. Graffham of Ardmore from the Delaware Creek Formation (middle Mississippian), but the specimen remained undescribed until now. In 1969, Dr. Robert O. Fay of the Oklahoma Geological Survey collected a fragment of a *Machaeracanthus* spine, described herein (from the Bois d'Arc Limestone [Lower Devonian] in Murray County), which is, except for the recently reported Middle Ordovician Heterostraci (Ossian, 1975), the oldest vertebrate fossil known from the State.

In 1972, Mr. Larry C. Simpson, at that time a graduate student in the School of Geology and Geophysics of The University of Oklahoma, collected *Acanthodes* from the lower part of the Hennessey Group (Lower Permian) in Tillman County (Simpson, 1973). Only a few occurrences of *Acanthodes* had previously been reported from the Permian of the Western Hemisphere, and in none of them is the age firmly established (Simpson, 1973; Zidek, 1973). It may well be that Simpson's specimens represent the first Permian occurrences recorded for the entire hemisphere.

AMNH = American Museum of Natural History, OUSM = Stovall Museum of Science and History, The University of Oklahoma.

ACKNOWLEDGMENTS

I would like to thank Bobb Schaeffer and Marlyn Mangus of the American Museum of Natural History for loaning the Delaware Creek specimen described herein and Max V. Brown of the School of Geology and Geophysics of The University of Oklahoma for his expert photography.

[1] Assistant professor of geology and curator of vertebrate paleontology for the Stovall Museum, The University of Oklahoma, Norman. Parts I, II, and III of this study were published in *Oklahoma Geology Notes* (v. 32, p. 171-187, v. 33, p. 87-103, and v. 33, p. 155-159, respectively).

SYSTEMATIC PALEONTOLOGY

Acanthodii Indet.
Figs. 1, 2

Material.—AMNH 425, an incomplete specimen in concretion.

Horizon.—Delaware Creek Formation, middle Mississippian.

Locality.—NE¼SE¼ sec. 32, T. 1 S., R. 3 E., Murray County, south-central Oklahoma (now covered by the Lake of the Arbuckles).

Description and discussion.—Before examining the specimen, I followed the preliminary identification assigned by the American Museum of Natural History and listed it as *Acanthodes* (Zidek, 1972, p. 173-174). On examination,

Figure 1. Acanthodii Indet., AMNH 425, from the Delaware Creek Formation (middle Mississippian) of Murray County, south-central Oklahoma. An anterior portion of the flank, showing squamation (see fig. 2 for detail) and a few neural arches (na).

however, I could see that this specimen is indeterminate, and it is included in this report only for the sake of completeness.

In splitting the concretion containing the specimen, the specimen was broken into numerous pieces, some of which are missing. From the available fragments, it is apparent that even when complete the concretion contained only parts of the head and segments of the branchial skeleton and of the anterior portion of the flank of a large acanthodian, not an entire fish. No appendicular skeleton is preserved, and the head and branchial parts are so badly crushed and obscured that they offer no clue to even a general classification of the remain. The anterior portion of the flank exhibits the squamation and a few neural arches (fig. 1). Unfortunately, nowhere in the specimen are the crowns of the scales preserved; only the bases of the scales can be observed, and little can be inferred from them. In relation to the large size of the fish, the scales are minute, barely exceeding the size range expected for *Acanthodes*, and this may be why the specimen was tentatively assigned to that genus. However, it appears from the scale bases that the scales were not rhombic as in *Acanthodes* but isodiametric, perhaps not far removed in shape from those described for *Homalacanthus* by Miles (1966, fig. 16).

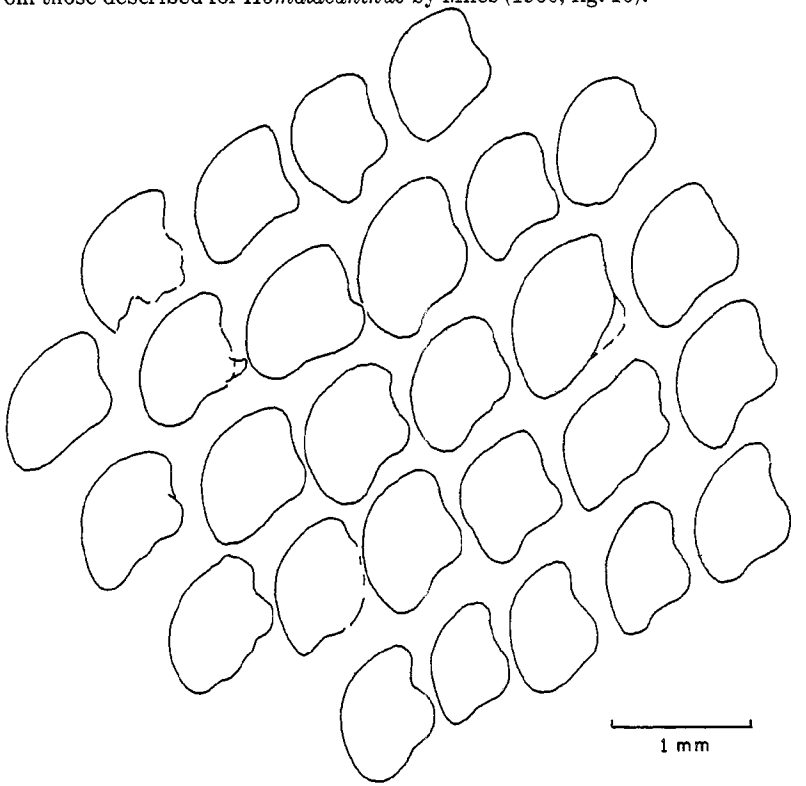


Figure 2. Acanthodii Indet., AMNH 425, from the Delaware Creek Formation (middle Mississippian) of Murray County, south-central Oklahoma. Detail of squamation; only the scale bases are preserved.

Order ?ISCHNACANTHIFORMES

Family ?ISCHNACANTHIDAE

Genus **Machaeracanthus** Newberry

Machaeracanthus cf. **M. major** Newberry, 1857

Fig. 3

Material.—A single specimen, OUSM 00139, collected by R. O. Fay of the Oklahoma Geological Survey (*Machaeracanthus* in Zidek, 1972, p. 172).

Horizon.—Bois d'Arc Limestone, about 10 feet below the base of the Woodford Shale, Lower Devonian.

Locality.—East side of State Highway 77D, on a curve half a mile east of U.S. Highway 77, in the SE¼SE¼NE¼ sec. 30, T. 1 S., R. 2 E., Murray County, south-central Oklahoma.

Description and discussion.—An abraded fragment of spine, 34 mm long and 23 mm wide. Width was measured between the longitudinal wing-like carinae, although most of their structure is missing. Extrapolating the estimated width of the carinae, the total width would be about 40 mm. Projecting from this, the total length of the spine may be estimated at about 200 mm. Although little of the form is preserved, the evidence of the prominent carinae, the cross section (even though incomplete), and the large size support the above identification.

Machaeracanthus is an organ genus known predominantly from its heavy sabre-shaped spines (fig. 3B), the curvature and asymmetrical cross section of which identify them as paired fin structures. The spines are usually found isolated, although in the National Museum of Czechoslovakia in Prague there is a slab of limestone (unnumbered) that exhibits a pair of pectoral spines of *Machaeracanthus bohemicus* (Barrande) apparently preserved *in situ*, with associated fragments of the pectoral girdle, cranial elements, and dentition. A tooth-cusp detached from that specimen (fig. 3C) appears to be an apically rounded osteodentinous cone 7 mm high and 5.5 mm in diameter, roughly circular in cross section, and faintly but densely striated except for the apex. This is a type of cusp that corresponds closely to the teeth found in some representatives of the family Ischnacanthidae (cf. Gross, 1957, pl. 4, figs. 8, 9, text-fig. 3J; Ørvig, 1967, pl. 2, text-fig. 4).

Machaeracanthus scales have been reported from the Lochkovian (Lower Devonian) of Bohemia (Fritsch, 1893, p. 73, fig. 272, 273; Ørvig, 1969, p. 310) and have been described in detail from the Hunsrückschiefer (Lower Devonian) of Germany (Gross, 1965). Gross did not suggest any particular relationship for the scales, but it appears from his illustrations that they do not differ much from ischnacanthid scales such as those described by Spjeldnaes (1967) as *Ischnacanthus*(?) *scheii*. For the above reasons the genus *Machaeracanthus* is here tentatively assigned to the family Ischnacanthidae. This assignment is further supported by the overall similarity of the *Machaeracanthus* pectoral girdle (Barrande, 1872, pl. 34, fig. 29; cf. also Fritsch, 1893, fig. 274A) with that of *Ischnacanthus gracilis* (Miles, 1973, text-fig. 24).

Machaeracanthus is common in certain other Lower Paleozoic sections, where it is regarded as an index fossil by some authors. The lithology of Lower Devonian deposits in the Arbuckle Mountains of south-central Oklahoma does not differ significantly from that found, for instance, in the Barrandian section, Bohemia, Czechoslovakia. In Bohemia, however, *Machaeracanthus* is common,

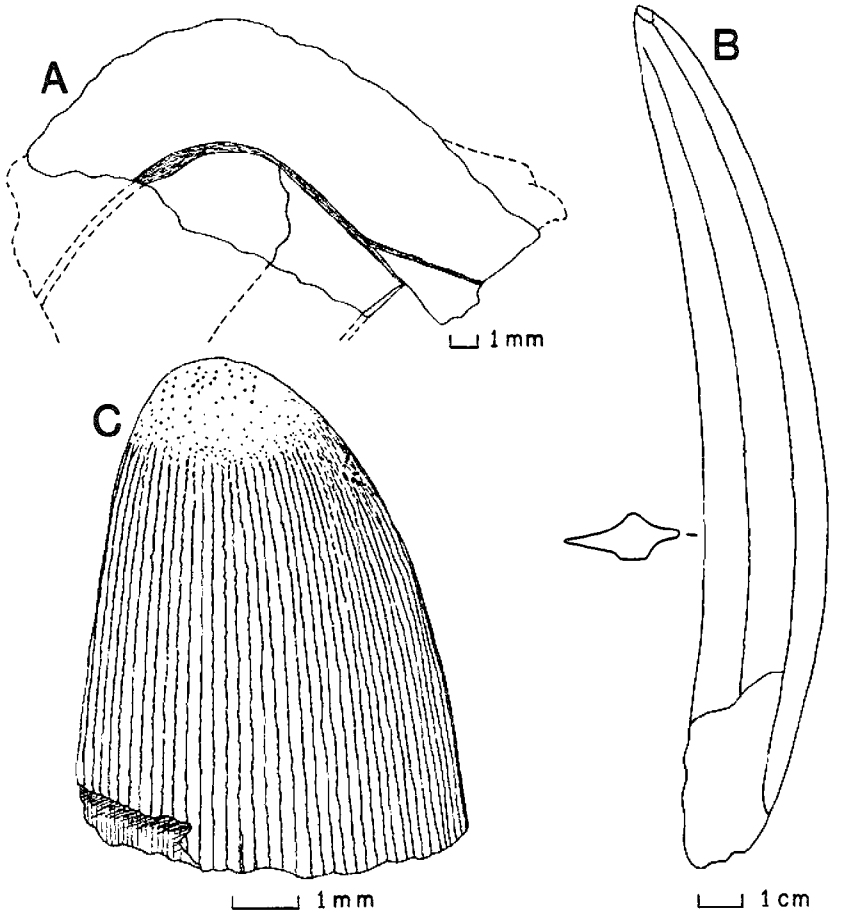


Figure 3.
A—*Machaeracanthus* cf. *M. major* Newberry, schematic cross section of OUSM 00139, fragment of spine from Bois d'Arc Limestone, Lower Devonian, of south-central Oklahoma. Parts shown by dashed line are present only beyond the cross-sectional plane.
B—*Machaeracanthus major* Newberry, pectoral spine (from Newberry, 1889, pl. 29, figs. 4, 4a; schematized).
C—*Machaeracanthus bohemicus* (Barrande), a tooth-cusp from the Lower Devonian (Lochkovian) of Bohemia.

whereas in Oklahoma the genus appears to be rare. Both areas have been intensively collected for many years, and it is difficult to find a feasible explanation for this discrepancy.

M. bohemicus, *M. polonicus* Gürich from the Devonian of Poland, and a *Machaeracanthus* sp. specimen from the lower Emsian of Sahara (Lehman, 1964, fig. 2; Pageau, 1969, fig. 17k) are very close to *M. major* in morphology and size. The spines of *M. major* appear to be more compressed, i.e., the height : width ratio of their cross-sections is greater than in the other species named (cf. Barrande, 1872, pls. 28, 30, 34; Newberry, 1873, pl. 25, fig. 2a; 1889, pl. 29, fig. 4a; Gürich, 1901, fig. 8b). This ratio should prove useful in studying the variability of *Machaeracanthus* spines, but such a statistical work remains to be carried out. An interesting observation was made by Ørvig (1951, fig. 2A-B and footnote, p. 347), who noted that the interosteonal tissue in *M. bohemicus* spines was completely devoid of cell spaces, whereas in *M. major* the cell spaces were present (cf. also Wells, 1944, p. 31, pl. 7, fig. 1, for a photomicrograph of *M. major*). Similar results obtained from the thin sections I have examined indicate that the two species can be distinguished on the grounds of both morphology and histology. If *M. polonicus* proves also to lack cell spaces, the height : width ratio will have to be used to determine whether the Polish specimens are separable from *M. bohemicus* on other than geographic grounds.

ORDER ACANTHODIFORMES

FAMILY ACANTHODIDAE

Genus **Acanthodes** Agassiz

Figs. 4-6

Material.—Specimens OUSM 00402, 00404-00414, 00500-00514A

Horizon.—Basal part of the Purcell Sandstone, at the base of the Hennessey Group, Lower Permian.

Locality.—East Manitou site, NW¼ sec. 5, T. 1 S., R. 16 W. (roadcut), Tillman County, southwestern Oklahoma.

Remarks.—The East Manitou site was described by Olson (1967, p. 24-25) and has been studied recently by Simpson (1973; 1974a). Among other fossils indicative of fresh-water depositional environment, Simpson (1973; 1974a; 1974b) reported the presence of *Acanthodes* at the site (cf. also Zidek, 1972, p. 181); however, no description of the specimens has been presented so far.

Almost all the fish remains were found in a highly fossiliferous shale-sandstone-conglomerate lens that is restricted to a few square yards at the southwestern end of the roadcut (cf. "bone bed," Simpson, 1973, p. 191; 1974a, p. 21). This lens is a part of the bed designated unit 3 by Simpson (1974a, fig. 2). Platysomid fish and *Acanthodes* prevail in this deposit, with some of the platysomid specimens articulated, whereas the *Acanthodes* remains are invariably disarticulated. Unfortunately, the preservation provides no evidence of autochthonity or allochthonity of any of the fish in the deposit. No

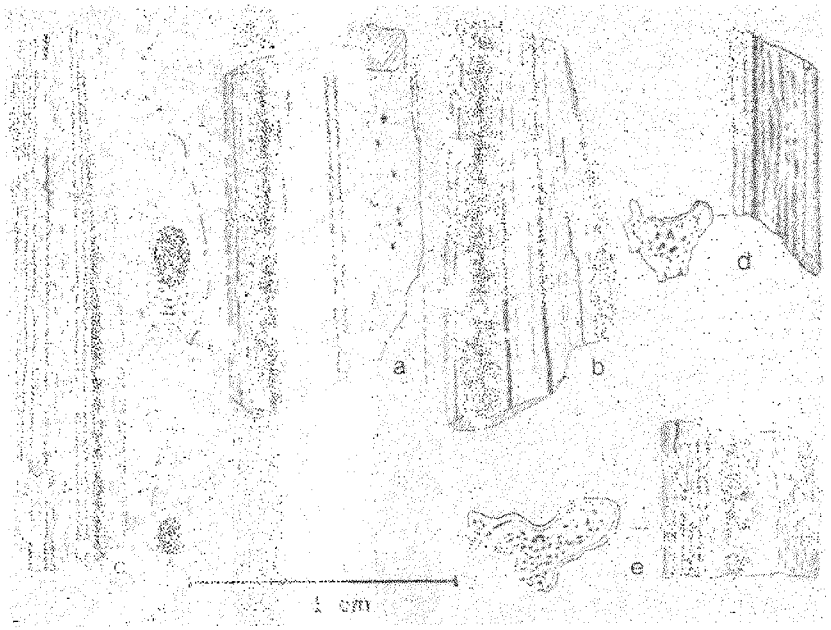


Figure 4. *Acanthodes* sp. indet., spines OUSM 00405 (a) through 00409 (e), East Manitou site, Tillman County, Oklahoma. Cross sections show that spines labeled *a-c* belong to the median fins, and those labeled *d* and *e* belong to the paired fins.

more can be said on this point than that the imbricating platysomid scales connected with pegs are likely to retain articulation of the body better than the nonimbricating acanthodian scales.

Description and discussion.—The East Manitou *Acanthodes* material consists of a large number of detached and mostly broken spines, some scattered scales, and three incomplete pectoral girdles. In only two instances (OUSM 00512 and 00514A) are the pectoral spines plus the girdle, one of the median fin spines (dorsal or anal), and scattered scales, all belonging to the same individual, preserved together. Specimen 00514A (fig. 6B) is somewhat better preserved than 00512, and judging from the dimensions of the spines, the two specimens were of similar size.

The pectoral spines of OUSM 00514A are 40 mm long and a maximum of 2.6 mm high; the median spine is 30 mm long and a maximum of 2 mm high. These dimensions indicate a fish 250-280 mm in total length. The spines are typically acanthodid in their morphology: gently arcuate and laterally compressed rods with a deep main longitudinal groove that divides the spine into an anterior keel and a higher and broader posterior part, with additional shallow posterior grooves that spread distally and interrupt (cf. Zidek, 1975). Spines similar in appearance to those of the East Manitou specimens have been described previously in *Acanthodes* by several authors. Unfortunately, with rare exceptions (e.g., Fritsch, 1893) the descriptions lack detail, and the

question of whether of not the spine morphology alone can be considered diagnostic of the genus cannot be answered as yet. Under these circumstances the distribution and the size of the spines relative to each other are especially important. In the 00512 and 00514A specimens the distribution cannot be studied, but the pectoral : dorsal (anal) spine size ratio, as well as the pectoral girdle morphology (see below), clearly are indicative of the genus *Acanthodes*.

The acanthodian spines are asymmetrical in cross section in the paired fins (figs. 4d, 4e) and bilaterally symmetrical in the median fins (figs. 4a-c). In the East Manitou material the cross sections could be studied only in some of the detached and broken spines, because it has proved virtually impossible to prepare specimens such that they are separated from the firmly cemented matrix. Since in *Acanthodes* the pectoral spines are by far the largest, it has been a considerable surprise to find that some of the largest spines in the collection, up to 7.5 mm in height, are bilaterally symmetrical, i.e., they belong to either the dorsal or the anal fin (e.g., OUSM 00450, fig. 4a) The spine OUSM 00511 (fig. 6A) equals in height the 00405 specimen, but in this case the cross section could not be studied, and the spine may have belonged to the pectoral fin. Such a spine height is indeed unusual even for pectoral spines and indicates a fish whose total size exceeds that of any specimen of *Acanthodes* known to me. The morphology of these large spines agrees with that of the spines in the OUSM 00512 and 00514A specimens. However, this fact alone is insufficient to determine whether we are dealing with the remains of mature and immature individuals that belong to the same species or whether more than one species may be involved.

The pectoral girdle is preserved in only three instances, most completely in the OUSM 00514A specimen (fig. 5). In OUSM 00509 almost all the scapular blade is missing, but otherwise the scapulocoracoid is a mirror image of, and identical with, 00514A. In OUSM 00512 the girdle is represented only by the scapular blade. In no instance are the suprascapular or procoracoid ossifications preserved. All three specimens have their surfaces marked with short longitudinal rugae and pits. Because of the similarity of the OUSM 00509 and 00514A girdles, the following description is that of the more complete 00514A specimen.

The scapular blade (bsc) is circular in cross section and gradually narrows distally before expanding again into the scapulocoracoid plate. The proximal termination of the scapular blade is somewhat higher posteriorly, lacks perichondral cover (endochondral lining, end. l), and was apparently connected to the suprascapular (spsc) by cartilage. Distally, a substantial part of the coracoid plate is missing, making interpretation of the remainder of the girdle difficult. Anterolaterally, the scapulocoracoid bears a procoracoid process (pr. proco), and posterolaterally the base of the scapular blade extends into a surface for the dorsal adductor muscles of the fin (m. add). The surface for articulation of the pectoral fin skeleton (margo radialis) is not preserved. There is an additional posteromesial wing-like extension (ext. pm) of this surface that appears to end slightly below the level of the procoracoid process. Should this extension be present only in the 00514A specimen, it might easily be regarded as resulting from deformation during fossilization. However, it is

well developed also in the 00509 specimen, and as both girdles have undergone little compression, it appears to be a true part of the girdle's morphology. Between the procoracoid process and the posterolateral surface for attachment of the adductor muscles, there is a lateral extension of the surface of the scapulocoracoid that has the appearance of a partially preserved process, and distally and somewhat posteriorly there is a sweep of bone that is an inflected anterolateral continuation of the posterolateral surface. This interpretation is based on the description of a pectoral girdle of *Acanthodes bronni* by Miles (1973), according to which there can be only one feasible explanation for the two features just noted: that they are parts of a groove that housed the

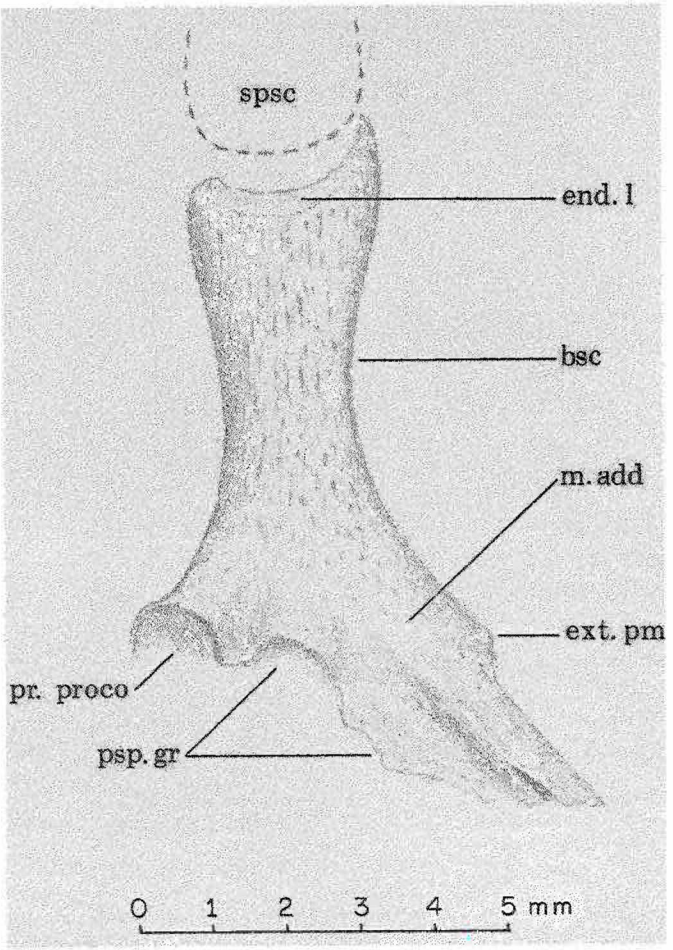


Figure 5. *Acanthodes* sp. indet., pectoral girdle OUSM 00514A, East Manitou site, Tillman County, Oklahoma. Abbreviations included in text.

pectoral spine (psp. gr). More precisely, what appears to be a partially preserved process must be only a somewhat laterally extended surface of the scapulocoracoid capping the pectoral spine. If so, the pectoral spine groove of the specimens in question was more enclosed in the scapulocoracoid than it was in *A. bronni*. Since the pectoral fossa (cf. Miles, 1973, text-fig. 19A, fo. p) in the case of the East Manitou *Acanthodes* appears to be formed chiefly by the anterior margin of the scapulocoracoid, the procoracoid should be expected to have its dorsal and ventral (coracoid) articulation surfaces closely spaced, with only a minor indentation between them.

I emphasize that the above interpretation is only tentative. If a better preserved specimen shows the laterally extended surface of the scapulocora-

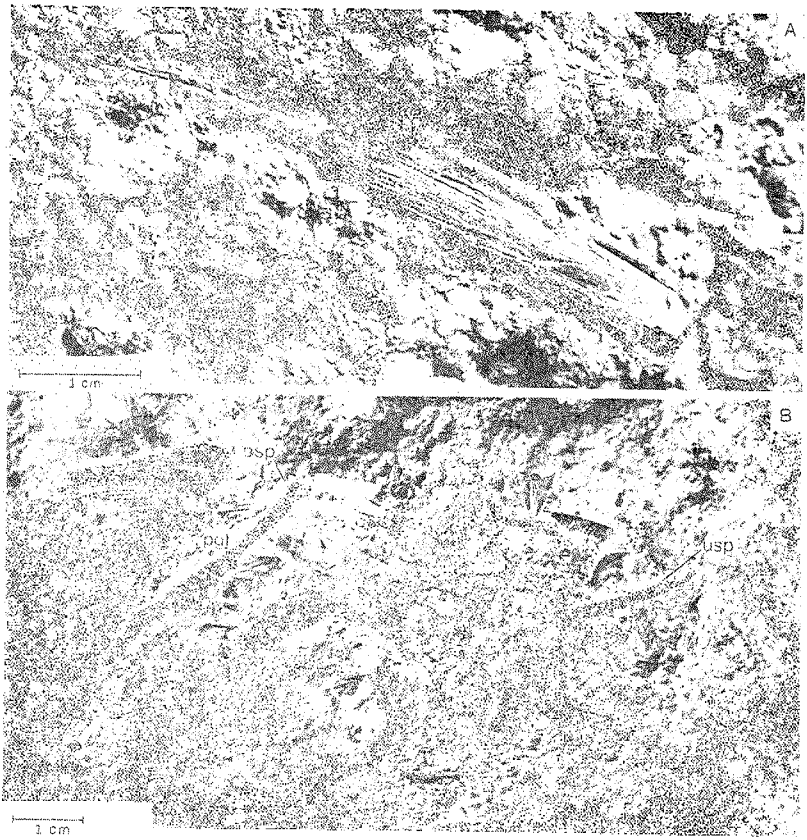


Figure 6. *Acanthodes* sp. indet., East Manitou site, Tillman County, Oklahoma.
A — OUSM 00511, an exceptionally large spine
B — OUSM 00514A, pectoral girdle (pgl), pectoral spines (psp), an unidentified median spine (usp), and scattered scales. The pectoral girdle is illustrated in detail in figure 5. All unlabeled parts belong to a platysomid.

coid to be a real process, it would have to be concluded that there was a transversely expanded or double dorsal articulation of the procoracoid.

The squamation is best preserved in the OUSM 00508 and 00509 specimens, although even in these specimens it consists only of scattered scales, or at best of small patches of scales that are of the size range and morphology usual for *Acanthodes* (cf. Simpson, 1973, fig. 3). Consequently, these specimens can add nothing of substance to the above description of the East Manitou material.

References

Barrande, Joachim, 1872, Système silurien du centre de la Bohême, supplement au v. I, planches: Prague and Paris, 35 pls.

Fritsch, Anton, 1893, Fauna der Gaskohle und der Kalksteine der Permformation Böhmens, v. 3, no. 2: Prague, F. Řivnač, p. 49-80.

Gross, Walter, 1957, Mundzähne und Hautzähne der Acanthodier und Arthrodiren: Palaeontographica, Abteilung A, v. 109, no. 1-2, 40 p.

_____1965, Uber einen neuen Schädelrest von *Stensiöella heintzi* und Schuppen von *Machaeracanthus* sp. indet. aus dem Hunsrückschiefer: Notizblatt der hessischen Landesamtes für Bodenforschung zu Wiesbaden, v. 93, p. 7-18.

Gürich, Georg, 1901, Nachträge zum Palaeozoicum des Polnischen Mittelgebirges: Stuttgart, Neues Jahrbuch für Mineralogie, Geologie und Palaeontologie, Beilage-Band 13 (1899-1901), p. 331-388.

Lehman, J. P., 1964, A propos du quelques arthrodires et ichthyodorulites sahariens: Mélanges Ichthyologiques, v. 68. (Not seen, cf. Pageau, 1969.)

Mamay, S. H., and **Yochelson, E. L.,** 1962, Occurrence and significance of marine animal remains in American coal balls: U.S. Geological Survey Professional Paper 354-I, p. 193-224.

Miles, R. S., 1966, The acanthodian fishes of the Devonian Plattenkalk of the Paffrath trough in the Rhineland: Arkiv för Zoologi, ser. 2, v. 18, no. 9, p. 147-194.

_____1973, Articulated acanthodian fishes from the Old Red Sandstone of England, with a review of the structure and evolution of the acanthodian shoulder-girdle: British Museum (Natural History) Bulletin, Geology, v. 24, no. 2, p. 111-213.

Newberry, J. S., 1857, Fossil fishes from the Devonian of Ohio: Washington, D.C., Proceedings of the National Institute, n. s., v. 1, p. 119-126.

_____1873, Descriptions of Fossil fishes, *in* Palaeontology, *part 2 of* Geology and Palaeontology, Report of the Geological Survey of Ohio: v. 1, p. 247-355.

_____1889, The Paleozoic fishes of North America: U.S. Geological Survey, Monograph 16, 340 p.

Olson, E. C., 1967, Early Permian vertebrates of Oklahoma: Oklahoma Geological Survey Circular 74, 111 p.

Ørvig, Tor, 1951, Histologic studies of placoderms and fossil elasmobranchs, 1, the endoskeleton, with remarks on the hard tissues of lower vertebrates in general: Arkiv för Zoologi, ser. 2, v. 2, no. 2, p. 321-454.

_____1967, Some new acanthodian material from the Lower Devonian of Europe: The Journal of the Linnean Society of London (Zoology), v. 47, no. 311, p. 131-153.

_____1969, Vertebrates from the Wood Bay Group and the position of the Emsian-Eifelian boundary in the Devonian of Vestspitsbergen: Lethaia, v. 2, p. 273-328.

Ossian, C. R., 1975, Ordovician vertebrate remains from the Arbuckle Mountains of southern Oklahoma [abstract]: Geological Society of America Abstracts with Programs, v. 7, p. 222-223.

Pageau, Yvon, 1969, Nouvelle faune ichthyologique du dévonien moyen dans les grès de Gaspé (Québec), pt. II, morphologie et systématique, sect. I, eurypterides, ostracodermes, acanthodiens et élasmobranches: Le Naturaliste Canadien, v. 96, no. 3, p. 399-478.

Simpson, L. C., 1973, Occurrence of *Acanthodes* in the Lower Permian of Oklahoma: Oklahoma Geology Notes, v. 33, p. 191-196.

———1974a, Paleoecology of the East Manitou site, southwestern Oklahoma: Oklahoma Geology Notes, v. 34, p. 15-27.

———1974b, *Acanthodes* and *Hybodus* in the Permian of Texas and Oklahoma: Journal of Paleontology, v. 48, p. 1291-1293.

Spjeldnaes, Nils, 1967, Acanthodians from the Silurian-Devonian of Ellesmere Island, *in* Oswald, D. H. (ed.), International Symposium on the Devonian System, Proceedings, v. 2, p. 807-813: Calgary, Alberta Society of Petroleum Geologists, 1377 p.

Wells, J. W., 1944, Fish remains from the Middle Devonian bone beds of the Cincinnati arch region: Palaeontographica Americana, v. 3, no. 16, 46 p.

Zidek, Jiri, 1972, Oklahoma paleoichthyology, pt. 1, a review and commentary: Oklahoma Geology Notes, v. 32, no. 6, p. 171-187.

———1973, Remarks on an acanthodian specimen from Texas: Oklahoma Geology Notes, v. 33, no. 5, p. 201-202.

———1975, Some fishes of the Wild Cow Formation (Pennsylvanian) in the Manzanita Mountains, New Mexico: Socorro, New Mexico Bureau of Mines and Mineral Resources, Circular 135. (In press.)

Oklahoma City Quadrangle Hydrologic Atlas Issued

Reconnaissance of the Water Resources of the Oklahoma City Quadrangle, Central Oklahoma has been released by the Oklahoma Geological Survey and the U.S. Geological survey as Hydrologic Atlas 4. Authored by Roy H. Bingham and Robert L. Moore of the USGS Water Resources Division, with cartography by Sondra Underwood of the OGS staff, HA-4 is the 4th of a proposed series of 9 water atlases to be completed under a cooperative agreement made in 1965 between the two agencies.

HA-4 covers approximately 8,000 square miles in the central, most populous section of Oklahoma, and its completion had been eagerly awaited by many. Its revised information should prove of value not only to hydrologists but also to land-use planners, environmentalists, and those interested in basic geology. The atlas includes 4 large sheets, one of which is an updated areal geologic map with primary input by OGS geologist Robert O. Fay. A second map is a ground-water map of major aquifers, with the yields of each given in gallons per minute. This sheet has insets showing graphic data of wells and monthly precipitation figures. The third map contains information on water quality, with the geologic units that are the source of deposits, and it also carries a smaller inset map indicating depths to fresh water in the quadrangle. Mapping is at a scale of 1:250,000 on each sheet. The fourth sheet, the largest of the set, contains graphs, tables, and two small maps (1:500,000 and 1:750,000) giving information on water sampling, streamflow and lakes, runoff, water-quality analyses, and sources of rural and municipal supplies.

Surface waters, including numerous man-made lakes and ponds, are the major source of supply in this area, providing 66 percent (33.3 billion gallons) of

the water used in 1970, some of it good, some of it mineralized. Both quality and quantity improve during wet seasons, receding during dry periods. Water districts have been set up in some localities in order to obtain good-quality water in sufficient amounts.

The quality of ground water varies, being hard or very hard in most parts of the quadrangle with excessive quantities of various dissolved solids, some of which are indicative of pollution. The terrace deposits carry water of good quality; water from alluvium along the larger streams is of fair to poor quality.

Sets previously published in the hydrologic series are HA-1, on the Oklahoma portion of the Fort Smith quadrangle; HA-2, covering the Oklahoma portion of the Tulsa quadrangle; and HA-3, on the Ardmore quadrangle and the Oklahoma portion of the Sherman quadrangle. Each set of four maps comes folded in a manila envelope. They can be obtained from the Oklahoma Geological Survey for $3.00 each for HA-1 and HA-2 and for $5.00 each for HA-3 and HA-4.

Tertiary Recovery to Be Tried in Burbank Field

A 51-month field demonstration of recovery of tertiary oil from a Pennsylvanian-age reservoir by chemical injection will be initiated by Phillips Petroleum Company in May 1976 in Tract 97 of the North Burbank Unit of Osage County, Oklahoma. The company, through the Bartlesville Energy Research Center of the U.S. Energy Research and Development Administration (ERDA), has done extensive laboratory work on tertiary recovery by chemical flooding, and an in-depth study plus encouraging previous tests on two other tracts in the unit indicates that a water-miscible, micellar-polymer process should show good results in this area.

The micellar flooding agent to be used contains surfactants, cosurfactants, and brine and will be injected into the Burbank sandstone reservoir as a slug, with the purpose of releasing residual oil left after waterflooding. The micellar fluid injection is followed by an injection of thickened water, a polymer, which has the effect of controlling mobility and causing a pistonlike oil and water displacement. Based on laboratory tests, a high percentage of recovery is predicted.

With reservoir recovery now averaging less than 40 percent nationwide, tertiary methods are highly significant, especially at a time when petroleum and natural gas are in greater demand than ever before. It is believed that 400 million barrels of good-quality oil remain in the Burbank reservoir.

Such methods do not come cheap, however. This field-testing demonstration of 9 injection wells is funded at $9,764,514, with funding shared by Phillips and ERDA. Mineral rights in the North Burbank Unit are owned by the Osage Indians, and improvement in production will be of benefit to the entire tribe.

September and October Meetings Scheduled

Environmental Geology

The Third Governor's Conference on Environmental Geology will meet September 24-26, 1975, at the Gant in Aspen, Colorado, under co-sponsorship of the American Institute of Professional Geologists, the Colorado Geological Survey, and the Association of Engineering Geologists. Many phases of environmental geology, ranging from regulation of the use of land and its resources to inherent geologic hazards of the earth's surface, will be studied. The conference is offered to provide information useful to land-use planners and governmental administrators as well as engineering and other professional geologists.

Further information can be obtained from the Governor's 3d Conference on Environmental Geology, c/o Colorado Geological Survey, 1845 Sherman Street, Denver, Colorado 80203.

Rocks, Reservoirs, and Reserves in the Midcontinent

The next biennial meeting of the Mid-Continent Section of The American Association of Petroleum Geologists will be October 1-3 in Wichita, Kansas, with Robert L. Dilts serving as general chairman. The meeting will be preceded by a field trip led by Phillip Heckel over Upper Pennsylvanian limestones in the vicinity of Neodesha, southeastern Kansas. In addition to the geology of the area, a feature of interest near Neodesha is a replica of the first oil well drilled west of the Mississippi River.

Kenneth S. Johnson, Oklahoma Geological Survey geologist, will present a paper on the geology of the Blaine Formation and associated strata, and papers on petroleum developments and technology in Oklahoma will be given by Donald Bloustine, Gene Collins, Larman J. Heath, William V. Knight, Lawrence S. Morrison, Norton Perry, Bailey Rascoe, Jr., Suzanne Takken, and John A. Taylor.

For information and registration materials, write Robert L. Dilts, Kansas Geological Survey, 4150 Monroe, Wichita, Kansas 67209.

Viburnum Trend Lead-Zinc Deposits

A second conference scheduled for October is a "Symposium on the Geology and Ore Deposits of the Viburnum Trend, Missouri," to be held at Rolla, Missouri, October 17-18. The symposium is sponsored by the Missouri Geological Survey, the Society of Economic Geologists, and several mining companies.

The southeastern Missouri Viburnum trend area is a highly interesting region—geologically, historically, scenically, and culturally. Lead has been mined almost continuously in the district since 1720, but the industry was dying out in 1955 when it was reactivated by the discovery of deposits on the

Viburnum trend. Information on exploration geology has been withheld for competitive economic reasons, and this year's symposium will offer a rare opportunity to share knowledge of geology, ore deposits, and technology. Papers will be offered on structure and stratigraphy, petrography, environmental geology, ore genesis and sequence of deposits, and geochemistry; several presentations on mine geology will be made by industry personnel. Escorted underground tours to four mines are available on a limited basis.

For information, contact Jerry D. Vineyard, Viburnum Trend Symposium, P.O. Box 250, Rolla, Missouri 65401.

Pecora Memorial Symposium

Of interest to geologists involved in remote sensing by satellite should be the announcement of the 1st Annual William T. Pecora Memorial Symposium on the applications of LANDSAT (ERTS) data to mineral and mineral-fuel exploration. The symposium, offered in honor of the man who was the 8th director of the U.S. Geological Survey and later undersecretary of the Department of the Interior, will be held October 28-31 at Sioux Falls, South Dakota, under the sponsorship of the American Mining Congress and 5 other national organizations.

Highlights will include tours of the Earth Resources Observation Systems (EROS) Data Center and three days of technical sessions on the uses of LANDSAT data in exploration, monitoring, cartographic control, hydrology, and environmental geology.

Information is available from the American Mining Congress, 1100 Ring Building, Washington, D.C. 20036.

Ground-Water Conference

The 20th Annual Midwest Ground-Water Conference will be held October 29-31 at Overland Park, Kansas, in suburban Kansas City. Sponsorship is by the Kansas Geological Survey, the Water Resources Division of the U.S. Geological Survey, and the Division of Continuing Education of The University of Kansas. Frank C. Foley of the Kansas Geological Survey is program-selection coordinator.

The boundaries of the region designated as "Midwest" are flexible; as many as 15 and as few as 4 states have participated in the past. The conference is equally unstructured, in the strict sense. It is a gathering by invitation of a host organization for the purpose of exchange of information. This year's meeting has as its theme "Feasibility," which encompasses in particular the economic feasibility of models, water management, and water augmentation, with the third category including importation of water, artificial recharge, and weather modification.

Address inquiries to R. F. Treece, Continuing Education Building, The University of Kansas, Lawrence, Kansas 66045.

Federal Uranium-Resource Grants Announced

Both the U.S. Geological Survey and the U.S. Energy and Development Administration (ERDA) recently released information on grants and contracts awarded for exploration, evaluation, and development of uranium deposits.

The USGS awarded nine 1-year grants totaling $240,000 to agencies and universities in 7 states. The grants will support field and laboratory studies in areas that have not been intensively investigated but show possibilities of containing uranium ores. In this region, a grant went to The University of Texas to investigate the uranium potential of the red beds of the Texas Panhandle. It is also hoped that results of this study will help in locating deposits in other red-bed localities. Other states involved in investigations under the USGS program are Alabama, Arizona, Colorado, New Jersey, Pennsylvania, Utah, and Wyoming.

ERDA has contracted with 21 universities, private companies, and state agencies throughout the United States to conduct uranium-resource evaluations, including geological exploration and related analytical studies, airborne radiometric surveys, and geophysical technology. Oklahoma State University has contracted to complete a study on the "delineation of fluvial systems favorable for the occurrence of uranium in Permo-Pennsylvanian sedimentary rocks of Oklahoma and adjacent parts of Texas, Kansas, and Missouri."

Both programs were initiated with the goal of assisting private industry in the development of uranium and thorium to fill increasing energy demands throughout the world. According to E. N. Harshman, deputy chief of the USGS Branch of Uranium and Thorium Resources, "The anticipated increase in the use of nuclear energy for power generation during the rest of this century will create a demand for uranium far in excess of domestic reserves." Known reserves are stated by ERDA as 315,000 tons, but estimated high-grade recoverable deposits may contain as much as 1,250,000 tons. Their recovery will entail extensive geological exploration, both on the ground and by the use of remote sensing, and intensive application of new techniques of computerization, logging, and assaying.

Uranium Purchases Decline in United States

Survey of United States Uranium Marketing Activity (ERDA-24), the annual report of the U.S. Energy Research and Development Administration (ERDA) on commercial marketing of supplies of uranium fuel to nuclear power plants, indicates a marked decrease of buying activity in the United States during 1974. Contracts with foreign suppliers during 1974 are approximately double the increase in new domestic commitments, a reflection of the former Atomic Energy Commission's decision in October 1974 to remove restrictions on enrichment of foreign uranium for domestic use beginning in 1977.

The report offers data as of January 1, 1975, and was compiled from information furnished by 70 utilities, 5 reactor manufacturers, and 25 firms producing uranium or with definite plans for future production. Data on 218 civilian nuclear-power reactors are included, as is information on buyer inventories and unfilled needs for the period 1975-82.

A copy of the report can be obtained from Elmo G. Knutson, Supply Evaluation Branch, Division of Production and Materials Management, Energy Research and Development Administration, Washington, D.C. 20545, or from J. C. Westbrook, Grand Junction Office, Energy Research and Development Administration, P.O. Box 2567, Grand Junction, Colorado 81501.

A Possible Origin for Copper in Oklahoma

Robert O. Fay[1]

A brief investigation of copper mineralization in Oklahoma and adjacent states indicates the presence of only two common copper minerals in this region. Chalcopyrite ($CuFeS_2$) occurs in veins associated with galena and sphalerite and is found in older rocks, i.e., those older than the Ada Formation of Virgilian (Late Pennsylvanian) age. Chalcocite (Cu_2S), on the other hand, occurs in pods and layers in sedimentary rocks and has not been found in rocks older than the Ada.

Some 65 prospects, mines, and districts are known in the area under discussion (fig. 1; table 1), but of these only two are useful in dating the times of copper mineralization (localities 19, 45).

At locality 19, on the Butterly Ranch in the western Arbuckle Mountains, mineralization is associated with faults in the Butterly Dolomite of Late Cambrian age, and since these faults occurred before the deposition of the Collings Ranch (or Ada) Formation, they are dated as Virgilian. This indicates strongly that chalcopyrite mineralization occurred at that time.

Chalcocite, at locality 45 in Okfuskee County, occurs in pods and layers in the Ada Formation and possibly in some subsurface stringers as deep as the underlying Lecompton Limestone.

The vein chalcopyrite occurs mostly in the Wichita, Arbuckle, Boston, and Ouachita Mountains and in the Joplin-Miami-Picher area of the Tri-State mineral district, with deposits found in rocks ranging in age from Cambrian through Middle Pennsylvanian. It is my opinion that these areas were uplifted, faulted, and mineralized in Late Pennsylvanian (Virgilian) time. The copper ions could have originated from the basement granitic rocks, with heat being

[1] Geologist, Oklahoma Geological Survey.

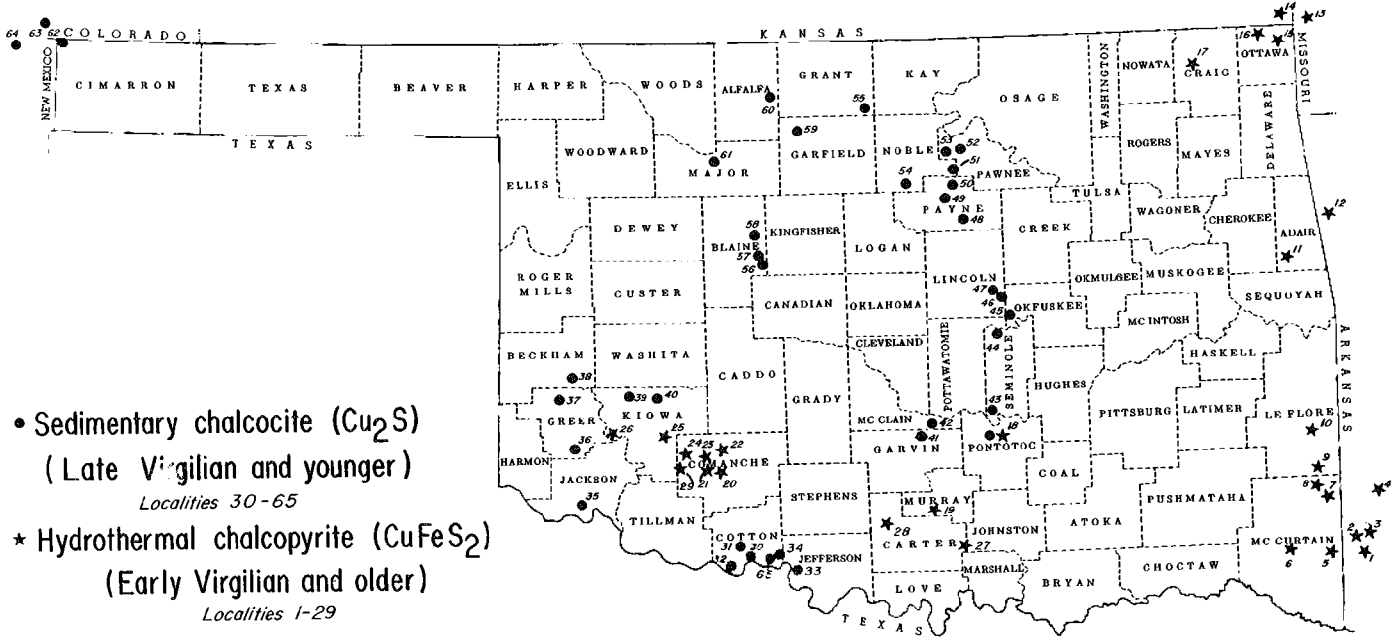


Figure 1. Map showing locations of copper prospects, mines, and districts in Oklahoma and adjacent areas. Numbers refer to listing in table 1.

TABLE 1.—LIST OF PROSPECTS, MINES, AND DISTRICTS IN OKLAHOMA AND ADJACENT AREAS

1. Bellah, Arkansas
2. Copper King, Arkansas
3. Davis, Arkansas
4. Brock, Arkansas
5. Meade Johnson
6. Kit Carson
7. Buffalo
8. Watson
9. Octavia
10. North Big Cedar
11. North Bunch
12. Morrow, Arkansas
13. Joplin, Missouri
14. Galena, Kansas
15. Miami-Picher
16. Quapaw
17. Southeast Centralia
18. Ada
19. Butterly Ranch
20. Copper Eagle
21. Parker
22. Buckhorn
23. Clark & Bennett
24. Hale Copper Mine
25. Kiowa Copper Company
26. Flattop Mountain
27. Mannsville
28. Graham
29. Northwest Indiahoma
30. Taylor
31. Neel
32. South Randlett
33. Waurika
34. Whiskey Creek
35. Creta district
36. Mangum district
37. Plainview district
38. Moravia district
39. Sentinel district
40. Gotebo district
41. Paoli district
42. Byars
43. Konawa
44. Turkey Creek
45. Southwest Paden
46. East Arlington
47. Max B. Martin
48. Ripley
49. Northeast Stillwater
50. Southwest Glencoe
51. North Glencoe
52. Lee D. Uto
53. North Lela
54. South Perry
55. Northwest Billings
56. Southwest Altona
57. Kingfisher Creek
58. Bucher
59. Hillsdale
60. Great Salt Plains
61. Glass Mountains
62. North Black Mesa
63. Baca County, Colorado
64. Northeast Union County, New Mexico
65. Cache Creek

applied from the mantle and with solutions in the granitic and overlying rocks carrying the copper ions upward.

Carrying this concept further, erosion and weathering of the chalcopyrite must have occurred after emplacement of the minerals, and the copper ions must have been carried in solution under oxidizing conditions, with chalcocite deposition taking place under reducing conditions from Ada time onward. Also, it is possible that Llanoria, rather than the present mineralized areas, could have been the main source area for the copper ions for the chalcocite and that Llanoria was itself mineralized in Virgilian time.

Following the solution-front or roll-front hypothesis of Shockey and others (1974), it is possible that after initial emplacement of the chalcocite, secondary movement of copper ions was effected by the movement of ground water.

Thus we may conclude that most sedimentary chalcocite occurs in a depositional environment beyond the delta margin, along the basin edge, near the breakover of the delta with the deep basin and shallow platform. Evidently, the intermingling of fresh water from land with near-shore-marine water was favorable for the deposition of copper ions, whereas conditions in the deep basins and shallow platforms were not.

Reference Cited

Shockey, P. N., Renfro, A. R., and **Peterson, R. J.,** 1974, Copper-silver solution fronts at Paoli, Oklahoma: Economic Geology, v. 69, p. 266-268.

A Lot In a Little
or
The Printed Page is Great, but—

"Publication" in microfiche saves time and labor, and therefore money, and saves measureless shelf space; also, it provides a medium for reproduction of data worth publishing but without an outlet for publication.

The Geological Society of America, with the above considerations in mind, is initiating a new series, Microform Publications. Material to be issued in the new series will supplement present publications, the *Bulletin*, Special Papers, and Memoirs, and will include data the society considers significant enough for dissemination that might otherwise not reach publication.

Symposia volumes will no longer be released in book form; the GSA hopes rather to provide microfiched proceedings of symposia and other special sessions at the time of the meetings. For this to be possible, reviewed texts will have to be submitted two months prior to such meetings. In addition to this service, the society foresees in microfiche the prerelease of some Special Papers and Memoirs; reprints of selected subjects, both current and out-of-print; annual issuance of material from the GSA depository of supplemental data for published articles; and reprinting of material not easily accessible and of guidebooks and other material issued in limited copies. *Abstracts with Programs* may become available in microfiche as well as in printed form.

The society is asking for suggestions for Microform Publications and would welcome material to be considered. The microfiche are prepared from ordinary 8½- by 11-inch typewritten copy, which is photographed and reduced to accommodate standard 98-frame fiche. Projection is on 24× readers. Manuscripts should be submitted as usual for peer review and revision. When the author returns the manuscript in clear typescript, it is ready for processing.

Microform Publication 1

With the preceding information as prelude, The Geological Society of America has announced the release of *Environmental Geology: A Selected Bibliography*, by Vivian S. Hall, geology librarian at the University of Kentucky, which was issued as Microform Publication 1.

Hall's bibliography contains over 4,200 entries with 8 subdivisions, an author index, and 2 appendixes; one appendix lists major reference titles, and the other contains names and addresses of agencies or publishers of titles included in the bibliography. Works listed range from elementary introductory publications to highly technical studies.

Dederick C. Ward of the University of Colorado is quoted in the foreword of this bibliography as being convinced that the "explosion" of the rapidly growing interest in environmental geology represents the "geological revolution" of the past decade. In geology, as in other sciences, the foci have

changed or regrouped markedly over recent years. These changes are easily noted by the perusal of recent bibliographies.

The rather sudden increase in emphasis on environmental geology in this state alone can be seen by examining the bibliographies and indexes of Oklahoma geology for the past three years (see *Oklahoma Geology Notes*, v. 33, p. 31-65; v. 34, p. 47-93; v. 35, p. 83-121). Whether or not this development is radical enough to be termed revolutionary, it is a good example of the growth of interrelated disciplines and, in geology, of the increased concern over the relation of the earth to its chief inhabitant.

What *is* revolutionary is the development of "remote sensing" in the publishing field, as exemplified by the GSA's new series, Microform Publications.

Standing orders for Microform Publications can be placed with Publication Sales Department, The Geological Society of America, 3300 Penrose Place, Boulder, Colorado 80301. *Environmental Geology: A Selected Bibliography* can be obtained from the same address for $6.00.

John Shelton Named AAPG Editor

John W. Shelton, Oklahoma State University professor of geology, was elected to a 2-year term as editor of The American Association of Petroleum Geologists. Dr. Shelton, a native Texan, did his undergraduate work at Baylor University and earned his Ph.D. degree from the University of Illinois. He worked as a geologist for Shell Oil Company for 10 years before joining the faculty at OSU. He continues to serve also as a director of ERICO, Inc., a geological-consulting firm headquartered in England. He is author of the recently reprinted OGS Bulletin 118, *Models of Sand and Sandstone Deposits: A Methodology for Determining Sand Genesis and Trend* (see p. 164).

The AAPG, which now numbers 17,000 members from all 50 states and 80 foreign countries, will be led during the 1975-76 term by John E. Kilkenny, who moved up from his year as president-elect. John D. Moody, New York City consultant and retired Mobil senior vice-president, will serve as president-elect, and Frank C. Crawford, independent and consulting geologist of New Orleans, is the new vice-president. Robey C. Clark, vice-president of Diamond Shamrock for exploration and production, will undertake a 2-year term as secretary, and George C. Grow, consultant of Newark, New Jersey, will carry over as treasurer. Robert N. Hacker, consultant of Santa Monica, California, will serve on the executive committee as the newly elected chairman of the association's House of Delegates.

The new executive committee of AAPG assumed office on July 1.

Office of Land Information Established by USGS

Dr. James R. Balsey has been named chief of a new division set up by the U.S. Geological Survey to coordinate seven previously separated but interrelated programs in environmental and land-resource considerations.

The largest unit to be incorporated in the Office of Land Information and Analysis (LIA) is the Earth Resources Observation Systems program (EROS), which since 1966 has been experimenting in the application of information gained from LANDSAT satellites (formerly ERTS), from Skylab, and from high-altitude aircraft. Other programs consolidated under the new office include Urban Areas Studies (UAS), Land Resources and Analysis (LRA), Geographic Applications Program (GAP), Land Use Data and Analysis (LUDA), Resource and Land Investigations (RALI), and Environmental Impact Analysis (EIA).

Dr. V. E. McKelvey, USGS director, defines the function of LIA as "preventive earth science" and describes its initiation as a "natural step in the Survey's administrative and operational evolution shaped to be responsive to real National needs."

It is believed that the new interdisciplinary office will be able to make assembled data on environment, land use, and resources available to the user in less complex, more readily applicable form than has been possible heretofore.

New Officers Announced By Oklahoma's Geological Societies

New officers and executive boards for the 1975-76 year have been announced by the following geological and geophysical societies in Oklahoma:

Ardmore Geological Society

President, **Robert W. Allen**, consulting geologist
Vice-President, **R. P. Wilkinson**, consulting geologist
Secretary-Treasurer, **Lawrence S. Morrison**, Westheimer-Neustadt Corporation
Past-President, **James M. Coffman**, independent geologist
Executive Committee: **Joe P. Gill**, Jake L. Hamon; **J. N. King, Jr.**, consulting geologist
AAPG Mid-Continent Section council representatives, **Robert W. Allen** and **James M. Coffman**

Geophysical Society of Oklahoma City

President, **Richard E. Schneider**, Continental Oil Company
First Vice-President, **Jeffrey M. Collar**, Cities Service Oil Company
Second Vice-President, **R. Rod Foster**, Dawson Geophysical Company
Secretary, **D. D. Ferrell**, Data Finders
Treasurer, **Michael G. Cook**, Cities Service Gas Company
Past President, **C. Wayne Carter**, Union Oil Company of California

Geophysical Society of Tulsa

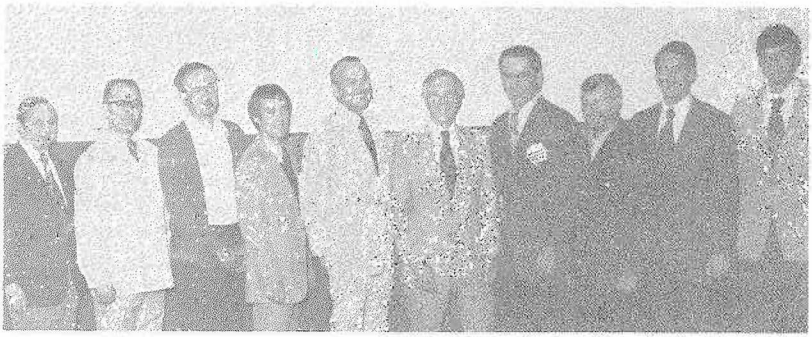
President, **E. L. Current,** Cities Service Oil Company
First Vice-President, **O. J. Nunez,** Skelly Oil Company
Second Vice-President, **T. A. Halbrook,** consultant
Secretary, **W. G. Clement,** Amoco Production Company
Treasurer, **S. W. Fruehling,** consultant
Editor, **P. M. Ferguson,** consultant
Editor-Elect, **D. G. Stone,** Seismograph Service Corporation
Past-President, **F. W. Lau, Jr.,** Skelly Oil Company

Oklahoma City Geological Society

President, **William E. Jackson,** Eason Oil Company
First Vice-President, **Harold A. Brown,** Texas Oil & Gas Corporation
Second Vice-President, **Thomas C. Cronin,** Beard Oil Company
Secretary, **Don F. Weber,** independent geologist
Treasurer, **W. P. [Andy] Anderson,** Tenneco Oil Company
Shale Shaker Editor, **Cary L. McConnell,** Gulf Oil Company, U.S.
Library Director, **Philip K. Webb,** Ratliff Drilling Company
Public Relations Chairman, **Arthur W. Sundholm,** Coquina Oil Corporation
Social Chairman, **Robert W. Waring,** Equitable Royalty Corporation
Past-President, **Wilbur E. McMurtry,** consulting geologist

Tulsa Geological Society

President, **Roderick W. Tillman,** Cities Service Oil Company
First Vice-President, **W. F. Ammentorp,** Northern Natural Gas Company
Second Vice-President, **George Bole,** Amoco Production Company
Secretary, **Laura Wilpitz,** American Association of Petroleum Geologists
Treasurer, **Terry Miller Beck,** Cities Service Oil Company
Editor, **Charles Seiler,** Oklahoma Natural Gas Company
Past-President, **Theodore E. Stanzel,** Skelly Oil Company
Councilmen: J. **Glenn Cole,** Amoco Production Company; **Edward L. Johnson,** U.S. Geological Survey; **John Huh,** Texaco, Inc.



Oklahoma City Geological Society executive committee for 1975-76. Left to right: Philip K. Webb, library director; Arthur W. Sundholm, public relations chairman; Robert W. Waring, social chairman; Thomas C. Cronin, second vice-president; Wilbur E. McMurtry, past-president; William E. Jackson, president; Harold A. Brown, first vice-president; Don F. Weber, secretary; Cary L. McConnell, *Shale Shaker* editor; W.P. (Andy) Anderson, treasurer.

GIANT COAL-SLURRY PIPELINE PLANNED FOR MIDCONTINENT

Energy Transportation Systems, Inc., is planning construction in 1976-77 of a 1,036-mile coal-slurry pipeline from a surface coal mine just south of Gillette, Campbell County, Wyoming, to an electricity-generating power plant at White Bluff, Arkansas, near Pine Bluff (fig. 1). These plans were outlined by Mr. E. J. Wasp, executive engineer, Bechtel Incorporated, San Francisco, California, at a meeting June 29, 1975, at The University of Kansas in Lawrence, sponsored by the Kansas Geological Survey.

Mr. Wasp stated that the planned pipeline will be 38 inches in diameter, will be buried to a depth of 30 inches, and will have a capacity large enough to deliver 25 million short tons of coal annually, not only for use in the plant at White Bluff but for other industrial customers who might be interested in obtaining coal. In Oklahoma, the pipeline will pass near the southern part of Tulsa and then proceed through the coal fields of the State eastward to a point south of Fort Smith, Arkansas.

Coal of subbituminous rank will be crushed to 14-mesh size at the proposed preparation plant in Wyoming. This crushed coal, of a size between granulated sugar and talcum powder, will be ground in a large rod mill. The slurry will be composed of approximately a 50-50 mixture of coal and water, and it will move about 100 miles a day, pumped by 10 electricity-powered stations about 100 miles apart.

Some 40 wells have been planned in southeastern Wyoming to provide an annual average of 15,000 acre-feet of water for the slurry from the Madison Limestone of Mississippian age. They are projected to depths of at least 2,500 feet. A dewatering facility in Arkansas will yield all the water to the power plant's cooling towers to satisfy part of their water requirement.

The system is scheduled to begin operation in 1979 and will require a technical staff of 335 persons. The total system is projected to cost $750 million. Based on a national inflation rate of 4 percent a year, the average cost of delivered coal over a 30-year period would be $7.90 a ton. In comparison, railroad-delivered coal from Wyoming to Arkansas would cost $28.50 a ton.

The nation's first successful coal-slurry pipeline operated for 6 years, beginning in 1957. It is 104 miles long and extends from Cadiz, Ohio, northward to Cleveland. This 10-inch-diameter pipeline moved coal mined from the Pittsburgh coal bed for use in an electricity-generating plant. The Black Mesa pipeline in Arizona has been moving coal since August 1970 from surface mines in the Black Mesa 273 miles westward to an electricity-generating plant on the Colorado River near the Arizona-Nevada-California border. Thus coal slurry has been transported successfully and economically in pipelines, and it is increasingly likely that more coal will be transported in pipelines in the next few years.

—*S. A. Friedman*

Editor's Note—A local wag reported that plans were afoot to install a series of flanges at regular intervals atop the large-diameter pipeline mentioned in the preceding note. He understands that the Oklahoma portion of the line will be known as "the slurry with the flange on top."

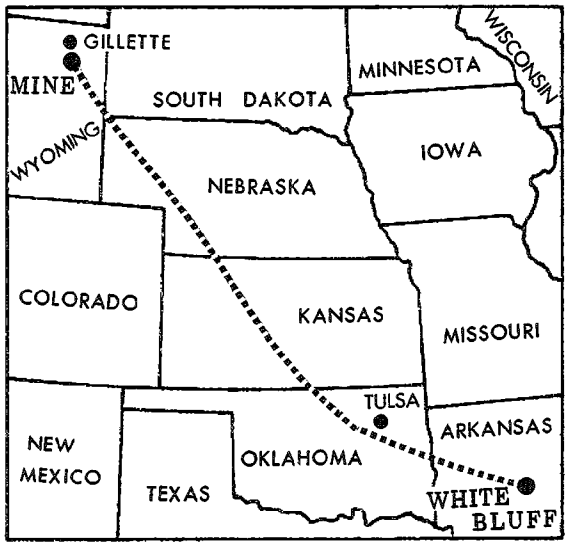


Figure 1. Map of Midcontinent showing proposed route of large-diameter coal-slurry pipeline.

USGS Funds Oklahoma Coal-Quality Research

A program to provide analytical data on the quality of Oklahoma's coal reserves has been undertaken by S. A. Friedman, coal geologist for the Oklahoma Geological Survey, under a $7,050 grant awarded by the U.S. Geological Survey to Charles J. Mankin, OGS director, and Friedman, principal investigator.

The program, which involves collecting and studying 60 coal samples, will extend through December of this year. Trace elements in the samples will be analyzed by the USGS in its Denver laboratories, and proximate and ultimate analyses will be done by the U.S. Bureau of Mines in Pittsburgh. Kurt Hollocher, geology major at Antioch College, Yellow Springs, Ohio, who is at OU on a work-study program, has assisted Friedman in the project.

Information obtained through this project will be highly valuable in determining the potential uses of the various coals, whether for electric-power generation, coke manufacture for use by iron and steel industries, fuel for cement manufacture, or gasification and liquefaction. Oklahoma has coal resources suitable for all these uses.

USGS Aerial and Space Photography Available

The U.S. Geological Survey has expanded its computer network to provide greater accessibility to aerial and space photography available through the National Cartographic Information Center (NCIC). Computer terminals have been installed at USGS mapping centers in Denver, Colorado; Rolla, Missouri; and Menlo Park, California. Terminals were already operational at NCIC headquarters at the USGS National Center in Reston, Virginia, and at the EROS (Earth Resources Observation Systems) Applications Assistance Facility at the National Space Technology Laboratories in Bay St. Louis, Mississippi.

The terminals are connected to a computer at the EROS Data Center in Sioux Falls, South Dakota, where over five million frames of pictures of the Earth, taken from airplanes or from Apollo, Gemini, Skylab, and LANDSAT (known as ERTS prior to January 1975) satellites, are on file. The terminals can be used to ask the computer what aerial and space pictures are available for specific areas on the Earth. The computer's replies, identifying the pictures available, are printed out by electronic typewriters at the terminals. Photographs can then be ordered from the Sioux Falls facility at a wide range of prices, depending on size and form, or microfilm copies on file at the computer terminal sites can be viewed.

Oklahoma residents interested in obtaining more information about USGS aerial and space photographs should contact the Mid-Continent Mapping Center, Topographic Division, U.S. Geological Survey, 9th and Pine Streets, P.O. Box 133, Rolla, Missouri 65401 (telephone 314/364-3680) or the Rocky Mountain Mapping Center, Topographic Division, U.S. Geological Survey, Building 25, Denver Federal Center, Denver, Colorado 80225 (303/234-2326).

New USGS Open-File Report Includes Oklahoma Stratigraphic Units

Analytical Data for Geologic Units in Missouri and parts of Kansas, Oklahoma, and Arkansas has been issued by the U.S. Geological Survey as Open-File Report 75-137. The 276-page report was authored by J. G. Boerngen, George Van Trump, Jr., and R. J. Ebens.

USGS open-file reports are available for inspection at USGS libraries and public-inquiry offices throughout the United States and may be copied at private expense. Information on this service can be obtained from these sources. The repository closest to Oklahoma is the Public Inquiries Office, Room 1C45, Federal Building, 1100 Commerce Street, Dallas, Texas 75202.

One copy of Open-File Report 75-137 has been deposited in the Geology and Geophysics Library at The University of Oklahoma.

State AIPG Section to Meet in September

The Oklahoma Section of the American Institute of Professional Geologists is planning a 1½-day annual meeting at Arrowhead Lodge on Lake Eufaula Saturday and Sunday, September 27 and 28.

W. B. Creath, meeting chairman, has formulated a program for Saturday that he feels will be of interest to all geological scientists, including students. Saturday's session will begin at 9:00 a.m. and will conclude at 5:00 p.m. It will begin with a special 3-hour course on prospect analysis and presentation by John A. Taylor, well-known consultant from Oklahoma City, who is a past vice-president of The American Association of Petroleum Geologists as well as a past president of the Oklahoma Section of AIPG.

The regular business meeting of the Oklahoma Section will be called to order at 9:30 Sunday morning by president Thomas L. Thompson. The meeting will include committee reports, a review of section activities, special recognition awards, introduction of new officers, and a progress report on reorganization of AIPG as the Association of Professional Geological Scientists through affiliation with the American Geological Institute. Nonmembers are invited to stay over and attend.

Preceding the meeting, at 6:00 on Friday evening, there will be an ice-breaker to welcome early arrivals.

The speaker for the banquet Saturday noon will be Rep. James R. Jones (Dem., Tulsa), who represents Oklahoma's First Congressional District and who is Assistant Majority Whip in the House of Representatives as well as a member of the Committee on Ways and Means. Mr. Jones' talk will center on ways in which current and pending legislation might affect Oklahoma. After his talk, Mr. Jones will be available for informal discussion.

The complete program outline for Saturday's session follows.

9:00 a.m.—"Prospect Analysis and Presentation": John A. Taylor, consulting petroleum geologist and engineer, Oklahoma City
12:00 noon—Banquet; Rep. James R. Jones, speaker
2:00 p.m.—"Securities-Law Considerations for Independent Geologists": Peter G. Pierce III, Carson and Trattner, Attorneys, Oklahoma City
3:00 p.m.—"Outlook for Students in Geology—the Next Generation": Gary F. Stewart, associate professor of geology, Oklahoma State University, Stillwater
4:00 p.m.—"Natural Land-Use Policy": R. D. Flanagan, consultant on urban planning and land use, Tulsa

The registration fee of $15.00 covers all meeting sessions Saturday and Sunday as well as the banquet. This fee has been reduced to $5.00 for students. In addition, spouses and other non-participating guests may attend the banquet for $5.00.

Arrowhead Lodge should be an ideal setting for a family outing in addition to providing excellent meeting facilities. The lodge's recreation program includes fishing, golf, horseback riding, swimming, tennis, and table tennis.

For further information about the meeting, contact W. B. Creath, 626 Mayo Building, Tulsa, Oklahoma 74103; phone (918) 584-7281. For overnight accommodations, call Arrowhead Lodge direct: (918) 339-2711.

OKLAHOMA ABSTRACTS

THE UNIVERSITY OF OKLAHOMA

Palynology of the Middle and Upper Seminole Coals (Pennsylvanian) of Tulsa County, Oklahoma

DANIEL LYNN PEARSON, The University of Oklahoma, M.S. thesis, 1975

A palynological investigation of the Middle and Upper Seminole coals (Pennsylvanian, Lower Missourian) including limited sections of the enclosing shales was undertaken. Statistical and qualitative results show that these two coals can be distinguished palynologically even though they are in stratigraphic proximity, were deposited under similar environmental conditions, and are in the same geographic area. Biological succession is evident in the Dawson, Middle Seminole, and Upper Seminole coals. A significant break in the palynomorphic succession exists between the Dawson coal and the Middle Seminole coal with the disappearance of *Lycospora* and *Thymospora pseudothiessenii*, which have been used to establish the boundary between Desmoinesian and Missourian rocks. This boundary, a subject of controversy in Tulsa County, is here defined as the base of the Middle Seminole Sandstone (Upper Cleveland Sand in subsurface).

Geophysical and Geological Investigation of the Southern Oklahoma Aulacogen

MARTIN A. PRUATT, The University of Oklahoma, M.S. thesis, 1975

The southern Oklahoma aulacogen (a transverse, marginal, intracratonic trough extending from the buried Amarillo uplift in Texas, southeastward to the Ouachita foldbelt of southeastern Oklahoma) is an area that produces anomalous gravity, magnetic and seismic data. The gravity data, after removal of the regional background, has maximum values of over 100 milligals in western Oklahoma, 90 milligals over the Wichita Mountains, and 75 milligals over the Marietta Basin. This data is consistent with a model of a lopolith-shaped mafic body emplaced along the axis of

---

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.

the aulacogen. To fit the observed gravity, a highly differentiated intrusion, which appears likely from petrologic criteria, will be approximately 5,000 meters thick in places and emplaced in the upper crust. These mafic bodies were emplaced in the rifting stage of the aulacogen during Early and Middle Cambrian time with the extrusion of cogeneric spilites and later silicic igneous rocks. Gravity and magnetic data indicate that the only complete section of the rift valley likely preserved is in the Marietta Basin, whereas elsewhere it has been partially or completely eroded away by later uplift. Crustal thinning under the aulacogen may have occurred during the rifting stage as indicated by earlier seismic arrival times and by gravity models. This is consistent with thinning found in similar features such as the Russian aulacogens and the Oslo graben.

From Late Cambrian to Devonian time the aulacogen underwent subsidence or downwarp in which carbonate sedimentation dominated. The Devonian through Early Permian was a time of deformation by dominantly vertical and some transcurrent movements which resulted in the present Amarillo-Wichita, Criner and Arbuckle uplifts, and the Anadarko, Ardmore and Marietta basins. These later Paleozoic uplifts and basins, though formed along the same crustal zones of weakness as the aulacogen, are not genetically related to processes forming the aulacogen.

Stratigraphic Pamphlet Printed by GSA

Stratigraphic Nomenclature in Reports of the U.S. Geological Survey, by George V. Cohee, a pamphlet issued in 1974 by the USGS for internal use in the federal survey, has been reprinted by The Geological Society of America for general usage. The 45-page booklet, developed by Cohee, the chairman of the Geologic Names Committee of the USGS, is filled with detailed information on the policies, rules, and definitions developed by that body and contains numerous examples of the applications of such rules. It is not only a useful tool for the geological writer but a handy and virtually indispensable reference-in-hand to editors and cartographers as well.

Copies of the pamphlet can be obtained by sending full payment of $2.00 to Publication Sales, The Geological Society of America, 3300 Penrose Place, Boulder, Colorado 80301. Discounts are available for large quantities.

A companion article, *Code of Stratigraphic Nomenclature*, is available for $1.00 from The American Association of Petroleum Geologists, P.O. Box 979, Tulsa, Oklahoma 74101.

OGS Bulletin 118 and Guidebook 15 Reissued

John W. Shelton's *Models of Sand and Sandstone Deposits: A Methodology for Determining Sand Genesis and Trend*, issued as Oklahoma Geological Survey Bulletin 118 in 1973, sold out its first printing of 2,500 copies in 18 months, and 2,000 additional copies have been printed by the Survey. The bulletin, comprising a general discussion of basic depositional concepts followed by detailed, illustrated examples of numerous specific models, has proved to be of value to the oil industry and to academic departments.

Guidebook 15, *Guide to Alabaster Cavern and Woodward County, Oklahoma*, by Arthur J. Myers, A. M. Gibson, Bryan P. Glass, and Carol R. Patrick, first released in 1969 and reprinted in 1972, is now in its third printing. The guidebook, in addition to a discussion of the geology of the area, contains articles on recreation areas, the history of the county, and the bats inhabiting the cavern, plus many illustrations, and has attracted popular interest from the general public as well as appealing to geologists.

Both publications are available at the Oklahoma Geological Survey. The cost of Bulletin 118 is $3.00; Guidebook 15 is $1.00. The guidebook is sold at Alabaster Caverns State Park for the same price.

OKLAHOMA GEOLOGY NOTES

Volume 35 August 1975 Number 4