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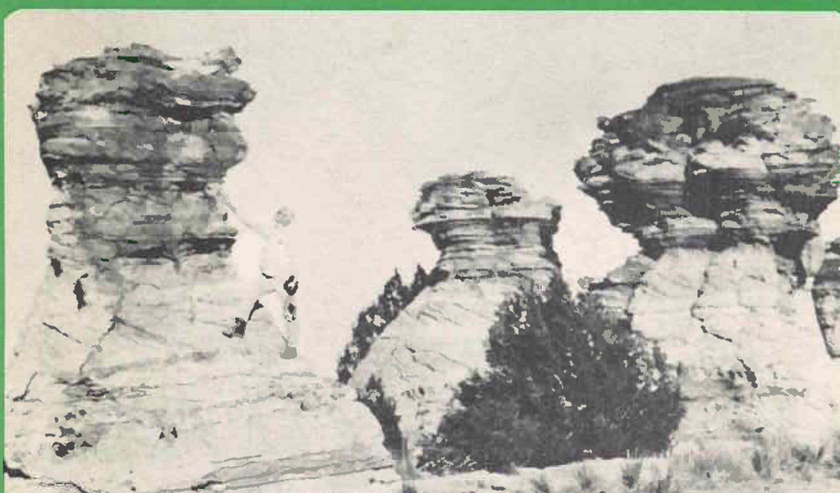

OKLAHOMA GEOLOGICAL SURVEY / THE UNIVERSITY OF OKLAHOMA / NORMAN, OKLAHOMA 73069

Cover Picture

Three Sisters of Cimarron County, Oklahoma

The conspicuous cross-bedded rock unit that caps many buttes in Cimarron County, Oklahoma, and forms the rim rock of the Cimarron River valley and tributary canyons is the lowest member of the Dakota Sandstone of Cretaceous age. This sandstone unit weathers into fantastic forms such as the "Three Sisters" shown on the cover. These erosional remnants are in sec. 18, T. 5 N., R. 2 E,. approximately 5 miles east of the village of Kenton, and they can be seen if one walks about 100 yards south of the main road. The "Sisters" have been landmarks for many years, and if the inscriptions on Castle Rock (sec. 10, T. 5 N., R. 2 E.), several miles northeast, are truly those of Coronado's expedition in 1541 to find the Seven Cities of Cibola and Quivira, then he, too, may have observed these striking sandstone buttes.

—*L. R. Wilson*

Oklahoma Paleoichthyology

Part I: A Review and Commentary

Jiri Zidek[1]

Abstract—This initial report of a proposed series comprises a résumé of the recorded discoveries of fossil fish in Oklahoma. It includes also a partial revision of the stratigraphic time placement and paleontological classification of the remains described.

The first occurrence of a Lower Devonian fish, **Machaeracanthus** sp., is noted. **Stethacanthus**, **Coccosteus**-like plates, and **Cladodus** have been labeled as occurring in the Caney Shale (Delaware Creek Formation) of Mississippian age, but the first two are more likely to be of Late Devonian age and the **Cladodus** specimens of Morrowan (Early Pennsylvanian) age. A number of minute, isolated fragments of fossil fish of Pennsylvanian age have been described as conodonts, and a listing and discussion of these remains are presented. Some of the fish-bearing localities previously regarded as Permian (Waurika no. 1 and the East Taylor and Southwest Taylor sites of Olson, 1967) are referred to the Pennsylvanian to conform with the recent upward shift of the Pennsylvanian-Permian boundary. Permian occurrences are listed, and the taxa are discussed. New finds of xenacanth, acanthodian, platysomoid, dipnoan, and tetrapod remains at the East Manitou site (lower Hennessey Formation, Permian) permit environmental reinterpretation. In addition, it appears from examination of the type specimens of Oklahoma pycnodontid holosteans of the Kiowa Shale (Lower Cretaceous) that **Uranoplosus flectidens** Cope is an unidentifiable vomerine dentition, whereas **U. arctatus** Cope clearly is a **Coelodus** (cf. **C. gyrodoides** Egerton). Extensive studies of the fossil fish of the Pleistocene (Illinoian) and Pliocene (Laverne and Ogallala Formations) have been published, and a list of the taxa is included as well as numerous references for these periods.

Future work will be based upon field investigations with the purpose of studying occurrences of all fossil fish groups represented in Oklahoma.

INTRODUCTION

Fossil fish remains in Oklahoma are known to occur in deposits of Devonian, Mississippian, Pennsylvanian, Permian, Cretaceous, Pliocene, and Pleistocene age. Up to now, however, only the Pliocene and Pleistocene occurrences have been described and discussed comprehensively (C. L. Smith, 1954, 1958, 1962; G. R. Smith, 1963; Hibbard and Taylor, 1960; Stovall and McAnulty, 1939; Hubbs, 1942). During the last ten years a foundation for study of the Permian fish faunas has been established (Olson, 1965, 1967), but only the lungfish *Gnathorhiza* has been studied in detail (Carlson, 1968). Nothing comparable to the above reports exists for the Cretaceous, Pennsylvanian, or Mississippian fossils, and the existence of fish in the Devonian has remained completely unnoticed. It is not an overstatement to say that,

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on the whole, fish have been the most neglected group of fossil vertebrates in this state. To remedy this situation, a long-range task involving extensive field work by several students will be required. Since little is known of Oklahoma fossil fish, a survey of the literature and type specimens should first be made as a basis for more thorough studies. Such a survey will be carried out in *Oklahoma Geology Notes* in the form of a series of short articles. The present article offers a general review of published occurrences, plus a commentary, whereas the following ones will be devoted to systematic paleontology.

I would like to express sincere gratitude to Dr. Horace G. Richards of the Academy of Natural Sciences of Philadelphia and to Dr. Marlyn Mangus of the American Museum of Natural History, New York, for their assistance with the type specimens of Oklahoma pycnodontids and of *Platysomus palmaris,* respectively, and to Dr. Robert O. Fay of the Oklahoma Geological Survey, who kindly agreed to review the manuscript and has contributed to its stratigraphic accuracy.

DEVONIAN AND MISSISSIPPIAN

In 1969 a fragment of an acanthodian spine was collected by R. O. Fay from the Bois d'Arc Limestone of Early Devonian age, about 10 feet below the base of the Woodford Shale, in Murray County. The locality given by Fay is 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. The specimen is deposited in Stovall Museum, The University of Oklahoma (OUSM 00139). Although it is abraded and poorly preserved, the presence of two longitudinal winglike crests and the large size are enough to indicate that the fragment belongs to the genus *Machaeracanthus* Newberry.

According to the records, the spine referred to above is the first fish fossil of Devonian age to be found in Oklahoma, but this designation may not be valid. Two figured specimens among the fish described and (or) illustrated by Eastman (1917, pl. 10, figs. 5, 6) are identified as "*Coccosteus*-like antero-ventro-lateral plates" from the Caney Shale[2] (Mississippian) of Oklahoma, and although there can be no doubt that these fossils are placoderms, their stratigraphic placement is questionable. This group is almost entirely restricted to the Devonian Period, notwithstanding some fragmentary evidence of placoderms in the Upper Silurian (Gemuendinida: Karatajute-Talimaa, 1968; cf. also Mark-Kurik, 1969) and in the Lower Mississippian (Ptyctodontida: Branson and Mehl, 1938; cf. also Andrews and others,

[2]Because the name "Caney" had been commonly used, Elias and Branson (1959) found its retention desirable in spite of the fact that the name is derived from an area (Ouachita Mountains) different from that of the actual interpretation of the unit (Arbuckle Mountains). However, this is not in accord with the rules of stratigraphic nomenclature, and for that reason "Caney" has been replaced by "Delaware Creek" by Fay (1969, 1970).

1967, and Moy-Thomas and Miles, 1971). Moreover, the Mississippian evidence is based on *Ptyctodus* teeth that are so badly abraded that E. B. Branson (1914) considered them probable erosion remnants from Devonian deposits.

I find it much more reasonable to regard the specimens as erroneously labeled. The placoderms, as well as all of the other fish reported from the "Caney," were collected by G. H. Girty (1909, p. 13), who made no attempt to describe them. It was only after his collection was deposited in the U.S. National Museum that Eastman (1913, 1917) described some of the fish specimens and figured the others. To date, the locality is known for two cladodont teeth from the "Caney"; all the other fish in Girty's collection can only be said to come from the Arbuckle Mountains or from the western-northwestern margin of the Ouachita Mountains. It is not unlikely that the placoderm remains were actually collected from an older unit, possibly from the Woodford Shale of Late Devonian age.

In addition to the placoderms, Eastman described *Cladodus aculeatus* n. sp.[3] (1917, p. 255, pl. 10, fig. 4; pl. 18, fig. 1) and briefly commented on the ichthyodorulite *Stethacanthus* (p. 255, 266) and on two palaeoniscoid specimens that he tentatively assigned to the genus *Rhadinichthys* (p. 255, 273; cf. also Eastman, 1913). The description of *C. aculeatus* is based on two teeth that come from Girty's location 3987, in the SW¼ sec. 2, T. 2 S., R. 13 E., Atoka County. Girty (1909, register) believed the exposure to be middle to lower Caney, but Elias and Branson (1959, fig. 1) assigned no stratigraphic symbol to that locality. According to R. O. Fay (oral comm., 1972), the shale belongs not to the Caney but to the Johns Valley Formation (Morrowan, Lower Pennsylvanian). The *Stethacanthus* specimen comes, according to Eastman, from Girty's location 6079. However, no such number has been listed by Girty. It could belong to location 2079 in the NE¼ sec. 20, T. 3 N., R. 16 E., Pittsburg County, which Elias and Branson (1959) described as middle Caney (Delaware Creek); it is equally possible that *Stethacanthus* was collected from an older unit, because this ichthyodorulite is known to occur in Late Devonian deposits. *Rhadinichthys* is confined to the Mississippian, and these specimens may be more or less safely regarded as being from the Caney Shale.

Croneis (1927) described *Cladodus ozarkensis* n. sp. and *Deltodus cingulatus* Newberry and Worthen from the Fayetteville Formation (Upper Mississippian) of northeastern Oklahoma. The specimens could not be examined before publication of this part of the investigation but will be commented upon in the second part.

Shortly before the manuscript of this article was submitted for publication, Drs. M. K. Elias and C. C. Branson informed me that in 1966 a slab of the Caney Shale containing the remains of an acanthodian had been donated to the American Museum of Natural His-

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[3]**Phoebodus** of Eastman (1913); **Cladodus aculeatus,** nom. praeocc.=**Cladodus eboreus,** nom. nov. (Hay, 1929, p. 532).

tory, New York. The specimen (AMNH 425) was found near Arbuckle, Oklahoma, in an area now covered by the Lake of the Arbuckles. Unfortunately, the slab is too big to be requested for loan, and therefore the generic assignment cannot be decided here. The museum identified it as *Acanthodes;* however, with respect to its age, this identification has to be regarded as doubtful.

PENNSYLVANIAN

Fish remains from Oklahoma's Pennsylvanian formations have been reported from the McAlester, Boggy, and Francis Formations in Pontotoc County (*Cladodus, Petrodus,* and *Petalodus* in Morgan, 1924, p. 73, 83, 118, pl. 53, figs. 12-14; *Petalodus* in Giles, 1963); from the Boggy and Wewoka Formations in Hughes County (*Petrodus* and *Petalodus* in Weaver, 1954, p. 29, 62); from the Wewoka in Okfuskee County (*Petrodus* in Ries, 1954, p. 40); and from the Vamoosa, Wood Siding, Vanoss (Red Eagle Limestone and Roca Shale Members), and Oscar (Neva Limestone Member) Formations in Pawnee County (*Petalodus* and *Deltodus* in Greig, 1959, p. 37, 48, 65, 71, 87, 94, 99). However, the principal interest of the above authors in regional geology and mineral resources resulted, quite naturally, in a nominal treatment of the fossils. Heretofore, only *Petrodus* has received close attention, this from Stovall (1945) and C. C. Branson (1965), who listed its occurrences and commented on its nature.

In addition to the above genera (including the "Mississippian" species, *Cladodus eboreus*), a portion of the symphyseal tooth-row of *Edestus* from the lower part of the Deese Formation in Carter County (C. C. Branson, 1964) has been described, and a few indeterminate remains of cladoselachian, bradyodont, and xenacanth sharks, acanthodians, and palaeoniscoids from the coal balls of the Secor coal, Boggy Formation, in Pittsburg County (Mamay and Yochelson, 1962, p. 196, 209, pl. 34, figs. 52-57), have been observed.

The latter authors found all the fish remains in coal balls, which they termed homogeneous-mixed type (containing both plant and animal remains and, in contradistinction to the heterogeneous-mixed type, showing no distinguishable segregation) and concluded that this type, as well as the exclusively faunal coal balls, should—in contrast to the concretionary floral coal balls—be interpreted as clastic allochthonous material. However, they seem to regard all the fish as marine, which in my opinion is not so; the xenacanth remains, unquestionably, and the acanthodian and palaeoniscoid remains, very likely, are freshwater elements. Therefore, it would appear to me more appropriate to consider the homogeneous-mixed and the faunal coal balls also as being of a combined, i.e., both detrital and concretionary, origin.

Fay (1968, 1971a, 1971b, 1972) considered the base of the Ryan Sandstone at the base of the Wellington Formation to be the base of the Permian. In accord with this upward shift of the Pennsylvanian-Permian boundary, some of the localities previously regarded as Permian have to be included in the Pennsylvanian. Of the fish-bearing localities, this stratigraphic relocation applies to the site referred to as Taylor by Case (1915), Jefferson County by Smith (1927), Waurika no. 1 by Olson (1967), and to the East and Southwest Taylor sites of Olson (1967), all of which are in the Oscar Formation, Gearyan Series, Pennsylvanian, about 50, 20, and 75 feet, respectively, below the base of the Ryan (R. O. Fay, oral comm., 1972). Isolated teeth and spines of the xenacanth sharks have been found in all of these localities and are particularly abundant at the Waurika site. Also, heteropolar spiral coprolites, suggestive of the xenacanths (cf. Williams, 1972) occur, but they are common only at the Southwest Taylor site. In addition to the above-cited occurrences, Wegemann (1915, p. 25, 26) recorded xenacanth teeth, platysomoid scales, and some indeterminate fish bones from the Waurika site, and xenacanth teeth from Cotton County in the NE¼NW¼ sec. 3, T. 5 S., R. 11 W., i.e., within the range of the Southwest Taylor site of Olson.

Although as yet incomplete, the record of Oklahoma's fish of Pennsylvanian age is actually richer than indicated above. In the paleontological collection of The University of Oklahoma's Stovall Museum are a number of unpublished specimens, collected chiefly by A. A. Graffham (Geological Enterprises, Ardmore) from Morrowan, Desmoinesian, and Gearyan formations of Carter, Pontotoc, Johnston, and Jefferson Counties and by M. G. Lockwood and myself from Missourian formations of Pontotoc County. These collections include a number of elasmobranch teeth, spines, and ganoid scales that are new discoveries for Oklahoma. Also, many of the minute isolated elements that actually belong to fish have been published in conodont literature and, consequently, have often been overlooked by paleoichthyologists. A search for fossil fish therefore requires reevaluation of conodont studies. Specifically, reexamination must be made of the work on the Johns Valley Shale by Harlton (1933), on new Pennsylvanian conodonts by Harris and Hollingsworth (1933), of a Master's thesis on micropaleontology of the Boggy Formation by Cooksey (1933), and of one on the Francis Formation by Perkinson (1934). Genera and species described in the cited papers that are of special interest to the present study are listed in table 1.

The specimens described by Harlton are probably not from the Johns Valley Shale but from the lower part of the Wapanucka Limestone or, possibly, from the upper part of the Goddard Shale.

The names *Vesiculodus conica* and *Idiacanthus corrugata* are found in unpublished theses and are therefore invalid. From Cooksey's description and illustration (1933, p. 53, pl. 3, fig. 11a-b) it appears that *Vesiculodus* actually is a single cusped tooth of a cladoselachian shark. No closer identification can presently be made, because, according to Dr. R. W. Harris (oral comm., 1972), the specimen is in Cooksey's possession, and my attempts to contact the author have failed. The generic name *Idiacanthus* Gunnell, 1933, is preoccupied by *Idiacanthus* Peters, 1876 (Monats. Ber. Akad. Wiss. Berlin, p. 846). A new name, *Gunnellodus,* was erected for *Idiacanthus* Gunnell by Wilimovsky (1954, p. 693). Also, this genus is a cladoselachian.

The specimens identified as *Scolopodus* by Harlton (1933, p. 12, pl. 3, figs. 1, 6), Harris and Hollingsworth (1933, p. 194, pl. 1,

TABLE 1.—FOSSIL-FISH FRAGMENTS FROM THE PENNSYLVANIAN OF OKLAHOMA THAT HAVE BEEN DESCRIBED AS CONODONTS

Harlton (1933)	Harris and Hollingsworth (1933)
Scolopodus striatum n. sp.	**Scolopodus sigmoidalis** n. sp. (Wapanucka Ls.)
oklahomensis n. sp.	**Holmesella quadrata Gunnell** (Wapanucka Ls.)
Multidentodus johnsvalleyensis n.g., n. sp.	**Icthyodus gunneli** n. g., n. sp. (Boggy Fm.)
wapanuckensis n. sp.	Cooksey (1933)
typicus n. sp.	**Scolopodus striatus** Harlton
gracilis n. sp.	**Icthyodus gunneli** Harris and Hollingsworth
brevis n. sp.	**Vesiculodus conica** n. g., n. sp.
irregularis n. sp.	Perkinson (1934)
Bransonella tridentata n. g., n. sp.	**Holmesella equilaterata** Gunnell
Holmesella triangularis n. sp.	**Icthyodus gunneli** Harris and Hollingsworth
wapanuckensis n. sp.	**Idiacanthus corrugata** n. sp.
"Cusp belonging to Distacodidae"	

figs. 4a, b, 5) and, for that matter, also by Gunnell (1931, p. 248, pl. 29, fig. 10—*S. ellipticus*, Fort Scott Limestone of Missouri) do not belong to that genus. The name *Scolopodus* was erected by Pander (1856) for a Lower Ordovician simple lamellar conodont, whereas the Pennsylvanian *Scolopodus sigmoidalis* is a bony fish and *S. striatus*, *S. oklahomensis*, and *S. ellipticus* all are elasmobranch teeth.

In regard to the "cusp belonging to Distacodidae," Harlton (1933, p. 11) noticed the presence of such cusps at numerous localities and stated that "specimens from the Deese formation in the Ardmore basin show these cusps attached to a plate, similar to that in *Bransonella*." However, his *Bransonella tridentata* (p. 14, pl. 3, fig. 9a-c) undoubtedly is an elasmobranch, whereas the cusps of Distacodidae (pl. 4, figs. 3, 4) are similar to those described by Harris and Hollingsworth (1933, p. 195, pl. 1, fig. 1a-c) as *Icthyodus gunneli* and commented upon by the authors as being "very similar in structure to teeth of the living channel cat-fish, *Ictalurus punctatus* (Rafinesque)." However erroneous this comparison may be, the most basic point is correct; *Icthyodus* is not an elasmobranch.

Holmesella is the only organ genus in the above list that has received the close attention of paleoichthyologists. This genus was erected by Gunnell (1931, p. 252, pl. 29, figs. 31, 32—*H. quadratae*, type species), who later (1933, p. 288) referred it to the acanthodians. In both works Gunnell seems to regard the elements as teeth rather than scales. Wells (1944, p. 21, 28) compared *Holmesella* to the scales of the genus *Acanthodes* and even went so far as to synonymize the two. A detailed description and discussion of *Holmesella* scales and elements that may be regarded as teeth were given for the first time by Ørvig (1966), and the treatment of the scales was later confirmed by Zangerl (1968). The presence of prismatic calcified cartilage that encrusts some of the endoskeletal elements (not described) and properties of the teeth led Ørvig (1966) to believe that *Holmesella* should not be regarded as an acanthodian but as an elasmobranch (this type of calcification is known to exist only in the elasmobranchs and holocephalians).

It should be emphasized that the seemingly confused conodont-fish content of the papers published by Gunnell, Harlton, and others in the 1930's was not due, at least in a great majority of cases, to any lack of ability to distinguish between the fish remains and conodonts. The authors were aware of the nature of the remains; one needs only to read the introductions to the papers of Gunnell and others to be aware of this. The reason for describing the conodonts and fish as representatives of the same group of organisms is to be seen in the fish hypothesis of the nature of conodonts that was especially popular in the 1930's. In spite of criticism, modified versions of this theory are still advocated by some scientists (cf. Matveev, 1970). For a complete bibliography see Fay (1952); Lindström (1964, p. 117, 118) offers a fine review and commentary on the fish hypothesis.

PERMIAN

Perhaps the first article on the paleontology of the Permian System of Oklahoma was written by Cope (1891), who described a chondrostean fish, *Platysomus palmaris* n. sp., based on specimens collected by W. F. Cummins from one of the Deep Red Run sites in Cotton County. In 1902 Case mentioned two other fish genera, *Sagenodus* and *Diacranodus (Pleuracanthus)*, from the Orlando site in Noble County, and in 1915 (p. 96) he listed *Pleuracanthus quadriseriatus*, *Diacranodus texensis*, *Platysomus palmaris*, and *Gnathorhiza pusilla* from the Pond Creek site, Grant County; *D. texensis* from the Taylor site (Oscar Formation, Gearyan Series, Pennsylvanian), Jefferson County; and *Sagenodus dialophus* from the Orlando site.

Smith (1927), in his Master's thesis, attempted a collation of the Permian vertebrates of Oklahoma, did additional collecting at the Pond Creek, Orlando, and Taylor sites, and reported on two new sites yielding vertebrate remains—Lucien (=Lucien 1 site of Olson, 1967) and Morrison, both in Noble County. He recorded and discussed *Pleuracanthus gracilis*, *P. compressus*, *Sagenodus vinslovi*, *Gnathorhiza pusilla*, and *Sphaerolepis arctata* from the Pond Creek; *P. gracilis* and *P. compressus* from the Lucien; *P. compressus* and *G. pusilla* from the Orlando; and *P. compressus* from Jefferson County (Oscar Formation, Gearyan Series, Pennsylvanian).

In the thirties and forties an extensive collection of Permian vertebrates was made by J. W. Stovall. However, Stovall collected mainly from the nonmarine Hennessey Formation in the vicinity of Norman, Oklahoma, where the fauna is primarily terrestrial. Accordingly, the collection offers no fish.

The most important paleontological work on the Oklahoma Permian has been done by Olson, who reviewed and revised the local geology, examined all the old sites, discovered numerous new ones, and provided faunal lists for all of them. Olson's results are contained in three publications, one on the vertebrates from the Flowerpot Formation (Olson and Barghusen, 1962), another on the Chickasha Formation (Olson, 1965), and the third on the early Permian vertebrates (Olson, 1967). No fish remains have been found in the Flowerpot Formation of the El Reno Group of western Oklahoma, but its partial time equivalent in central Oklahoma, the Chickasha Formation, has yielded a xenacanth tooth plus spine and ganoid scales. Olson (1965, p. 29) says the tooth is "most suggestive of *Xenacanthus platypternus* as defined and described by Hotton (1952)." The scales have been identified as palaeoniscoid, but the family remains uncertain. All the specimens were collected from the lower part of the Chickasha and are believed to be middle Flowerpot age.

The Leonardian Series contains more abundant fish remains. Although extensive collecting in 1965-67 by Olson and party revealed few new forms, hundreds of specimens were collected and the documentation of distribution and habitats was significantly improved. Furthermore, new specimens of the lungfish *Gnathorhiza* from the Perry sites, Noble County, allowed a paleoecological study of the estivating habits and a revision of the skull morphology (Carlson, 1968). Since the data on fish occurrences are scattered throughout Olson's (1967) work, in faunal lists and comments on various sites, it may be helpful to show them in a single table (table 2).

TABLE 2.—PERMIAN FISH AS LISTED BY OLSON (1967)

Stratigraphic unit		Site	*Xenacanthus*	*Orodus*	*Platysomus*	*Sphaerolepis*	Ganoids	*Sagenodus*	*Gnathorhiza*	Crossopterygii
Lower Hennessey Fm.		Norman[1]							X	
		E. Manitou		X						
Garber Fm.	Upper	N. Manitou	X, C?							
		W. Grandfield	X							
	Middle	Pond Creek	X		X	?		X	X	X
		Deep Red Run[2]	X							
	Lower	Bean Farm	X							
		Lucien #1-4	X(1-4)							
Upper Wellington Fm.		Lucien #5	X							
		Orlando	X			X		?	X	
		McCann quarry	X			X	X			
(Partly middle Wellington)		Perry #1-6	X(3 4, 6)				X(4, 6)		X(1,2,4,5)	?(6)

Stratigraphic succession of the sites after R. O. Fay, Oklahoma Geological Survey (oral comm., 1972).
C= coprolites
?= doubtful
(1-6)= site nos.
[1]SW¼NW¼ sec. 13, T. 8 N., R. 2 W., Cleveland Co.
[2]In sec. 21, T. 4 S., R. 12 W., Cotton Co.

Olson did not find xenacanth remains at the East Maniotu site, but recently L. C. Simpson, a student in the School of Geology and Geophysics at The University of Oklahoma, collected xenacanth remains from that locality. In addition to those listed above, the Richards Spur (Fort Sill, Oklahoma) and Hayward sites have produced xenacanth teeth. Although no fish remains from the Hayward site were included in Olson's (1967) report, there is a xenacanth tooth deposited in the Stovall Museum that is labeled as having been collected 6 miles southeast of Covington, in the NE¼NE¼ sec. 13, T. 20 N., R. 4 W., Garfield County, which is the location of the above site. The vertebrates (presumably including the xenacanth specimen) came from a single pocket in the Hayward Sandstone Member of the Garber Formation, about 100 feet below the base of the Hennessey. At Richards Spur the fossils occur in fissure fillings that have been suggested by various authors to be of an Arroyo age. However, there is little evidence to support this belief; the fillings could be from any Permian deposit older than the upper Hennessey Formation.

In addition to the isolated teeth and spines, calcified cartilage of the xenacanth sharks is fairly common, but specimens usually come in fragments too small to reveal the morphology. Of all the Oklahoma localities, only the Bean Farm site has produced a specimen that comprises the chondrocranium and visceral arches. In identifying the xenacanth remains, Olson was consistent with his previous works (cf. Olson, 1946). Consequently, the Oklahoma specimens that have been identified as *Pleuracanthus quadriseriatus, P. gracilis, P. compressus,* and *Diacranodus texensis* by the older authors are all regarded as *Xenacanthus* sp. by Olson. However, this does not express the true situation if the group as a whole is considered, and it should therefore be viewed as a temporary scheme suitable to one working with only the American xenacanth sharks. There are known articulated specimens from Europe and Australia that demonstrate effectively the existence of two genera, *Xenacanthus* and *Orthacanthus,* that are distinctive in both the endoskeleton and the dermal skeleton (cf. Zidek, 1965). Knowledge of these articulated specimens makes it possible to distinguish between the two genera even when only the cephalic spines and teeth are available. Lund (1970) arrived at a similar conclusion through study of isolated teeth and spines from formations of Pennsylvanian age in Pennsylvania. In my opinion, such a distinction is clearer than one based on endoskeletal remains would be, mainly because of the difficulties arising from differences in preservation—usually three-dimensional in the American specimens but two-dimensional in the European ones.

The term "Ganoids" in table 2 includes all the scales identified as palaeoniscoid or ganoid by Olson, the platysomoid scales and body segments from Perry no. 6 site that, in his opinion, are not identifiable generically, and the abundant but badly macerated remains of palaeoniscoid fish found at Perry no. 4 site (cf. Olson, 1967, p. 42). The Palaeonisciformes labeled as *Platysomus* (Pond Creek site) and *Sphaerolepis* (Pond Creek and McCann quarry sites) are shown separately. Olson (1967, p. 69) has made only a general statement about *Platysomus*. He states that scales that appear to pertain to this genus are in the collections but that species assignments are not possible. Since the evidence consists only of isolated scales, the generic assignment should be regarded as highly tentative, or, preferably, the scales should be labeled only as platysomoid. The type material of *Platysomus palmaris* Cope, 1891, was collected in 1884 by Cummins from one of the Deep Red Run sites in Cotton County. The exact location remains unknown (cf. Olson, 1967, p. 22), and the material is exceedingly fragmentary, consisting of about 200 body fragments deposited in the American Museum of Natural History (AMNH 7281 and 9160), few of which show traces of the shoulder girdle and none of which show the fins. I have been unable to identify the specimens illustrated by Cope (1891, pl. 33) in this material. Hussakof (1911, p. 174, fig. 56) figured one of the fragments representing the type specimen (AMNH 7281) and also an imperfect fish in a nodule, with the caudal and anal fins preserved (AMNH 7935). The latter specimen probably does not belong to the type material. The shape, ornamentation, and—most importantly—the arrangement of the scales support the generic assignment, but I would not assign a species name to this material.

Sphaerolepis is not a form genus known only from isolated dentigerous plates described by Cope (1877), as Olson (1967, p. 49) implies. Cope called the plates *Peplorhina,* an insufficiently defined genus that he established earlier, and it was pointed out later by Hussakof (1911, p. 170) that "these elements agree quite well with the type of teeth figured by Professor Fritsch in his genus *Trissolepis* (Fauna der Gaskohle, III, pl. 109, fig. 1; pl. 110, figs. 1 and 2)—a form he had previously named *Sphaerolepis* and which name should be retained, because of priority." I have had an opportunity to examine the type specimens of Fritsch in the National Museum, Prague, and fully agree with Hussakof's observation. Since *Sphaerolepis* is based on a number of articulated specimens (cf. also redescription of this genus by Gardiner, 1967), it can hardly be regarded as a form genus. The specific name *arctata* used for the American specimens is of dubious value. At most, this could be used to indicate the difference in age between the *Sphaerolepis kounoviensis* Fritsch specimens of the Upper Pennsylvanian and those of the Lower Permian. However, even in this restricted sense the name is not very meaningful, because Cope (1877) based the species on a Pennsylvanian specimen.

With regard to *Gnathorhiza,* the reader is referred to Carlson (1968), who studied this genus in detail. The other lungfish genus, *Sagenodus,* was listed from the Orlando site by Case (1902, 1915—*S. dialophus*), but was not found by Olson at that locality. The listing of *S. periprion* from the Pond Creek site (Olson, 1967, p. 69) is erroneous. These data were evidently taken from Smith (1927), who copied, not quite correctly, the faunal list from Case (1915, p. 96); Case did not list lungfish from Pond Creek. Olson collected only a single tooth fragment from the Pond Creek site, and it was too imperfectly preserved to allow species identification.

Orodus and the crossopterygians were first recorded by Olson. From the Perry no. 6 site he collected remains of large carnivorous fish identified as "crossopterygians?" and from the Pond Creek site the rhipidistian *Megalichthys* (=*Ectosteorhachis*). The Perry site remains are deposited in the Chicago Natural History Museum and, as far as I know, have not yet been studied. The Pond Creek specimen consists of a single scale (Stovall Museum, 1-34-S2, OUSM 00141), and its generic assignment is dubious. Also, the record of *Orodus* consists of a single element—a tooth from the East Manitou site. According to Olson (1967, p. 99), the specimen is deposited in the Stovall Museum (unnumbered), but my search for it has been in vain. Based on the presence of this shark, Olson (1967, p. 25) suggested nearshore marine deposition for the East Manitou site. However, a more recent work by L. C. Simpson (oral comm., 1972) does not support this interpretation. Simpson has collected xenacanth and platysomoid remains, *Acanthodes, Sagenodus, Eryops, Trimerorhachis,* and *Dimetrodon* from the site. The sedimentation pattern seems to fit the model of a deltaic, distributary channel type of environment.

CRETACEOUS

The record of Cretaceous fish of Oklahoma consists of only a few specimens collected in 1893 by Professor A. P. Brown of the University of Pennsylvania during E. D. Cope's collecting expedition for the Academy of Natural Sciences of Philadelphia. The specimens were collected from "a marine bed of Lower Cretaceous age about 6 miles N. W. of Fort Supply" (Cope, 1894b, p. 446), i.e., from one of the isolated outliers of the Kiowa Shale (Comanche Series) in T. 25 N., R. 23 W., Harper County. (For an account of the Kiowa Shale in Harper County, cf. Myers, 1959, p. 43-45.) Two of the specimens are shark teeth (*Lamna* nos. 1, 2 of Cope, 1894a), and three belong to pycnodontid holosteans. The pycnodontids have been described as *Coelodus brownii* n. sp., *Uranoplosus arctatus* n. sp., and *Uranoplosus flectidens* n. sp. by Cope (1894b). *Coelodus brownii* is based on a left splenial (Cope, 1894b, p. 447, pl. 20, fig. 10, 10a). However, I have examined only an isolated tooth (Acad. Nat. Sci. Phila. 7) that was found near the type specimen and regarded by Cope as possibly belonging to the same species. The type specimen may have been lost. The generic name *Uranoplosus* Sauvage was invalidated by Woodward (1895, p. 283), who regarded all its species as generically indeterminable vomerine dentitions. The status of the genus cannot be discussed here, for it would require revision of *U. cotteaui,* the type species. Of the Oklahoma species, I do not believe that the specimen of *U. flectidens* (Acad. Nat. Sci. Phila. 8) is identifiable, but *U. arctatus* (Acad. Nat. Sci. Phila. 6 or 8971) clearly is a *Coelodus* specifically comparable to a vomerine dentition, locality and age unknown, in the collection of The University of Oklahoma Stovall Museum (OUSM 00140). These two specimens appear similar to *Coelodus gyrodoides* Egerton from the Upper Cretaceous of England (cf. Grey-Egerton, 1877, p. 52, pl. 4, fig. 3; Woodward, 1895, p. 255, fig. 31).

PLIOCENE AND PLEISTOCENE

Stovall and McAnulty (1939) reported on fish remains from south of Cheyenne, Oklahoma, Roger Mills County, and found them similar to *Plancterus kansae*—a living cyprinodont abundant in western Oklahoma. However, Hubbs (1942) found the assignment to the family Cyprinodontidae unacceptable and referred the specimens to the family Atherinidae, tentatively to the genus *Menidia*. The location and geological situation as given by Stovall and McAnulty both point to the Ogallala Formation (middle Pliocene). The closest vertebrate localities described in the Ogallala are west of Arnett, Ellis County, Oklahoma, and at Higgins, Lipscomb County, Texas. Both are believed to be of late Clarendonian or early Hemphillian age (Hesse, 1939; Kitts, 1957), but, since only mammals have been collected from them, they provide no means for correlation with the site near Cheyenne.

More recently, fish remains have been collected also from the Laverne Formation, lower Pliocene, in Beaver County. These are part of the local fauna from the Laverne (Hibbard, 1951), and they were described and their significance discussed by C. L. Smith (1962).

The Pleistocene fish remains in Oklahoma belong to two local faunas, both of Illinoian age, that are described in the literature as the Berends fauna and the Doby Springs fauna. The former occurs in exposures near the Gate Ash pit in the vicinity of Gate, Beaver County; the latter is found between Buffalo and Rosston in Harper County. The fish remains of both these faunas were described by C. L. Smith (1954, 1958), and they were included also in G. R. Smith's (1963) work. A detailed comparison of the late Pleistocene faunas of northwestern Oklahoma and southwestern Kansas was made by Hibbard and Taylor (1960), who discussed the stratigraphy, environments, consequent differences in assemblages, and correlation of the faunas and compared them to the modern faunas.

The thorough treatment of the Pliocene and Pleistocene fish occurrences outlined above makes it possible to refer the reader to the works cited for additional information. Here, only a list of the taxa hitherto described and their localities is presented. Except for the atherinid *Menidia* sp. (OUSM 1-0-S34 through 71), all the specimens are deposited at the University of Michigan Museum of Paleontology.

TABLE 3.—TAXA AND LOCALITIES OF FOSSIL FISH FROM THE PLIOCENE AND PLEISTOCENE OF OKLAHOMA

Infraclass Holostei
Order Semionotiformes
Suborder Lepisosteidei
Family Lepisosteidae

Lepisosteus cf. **L. spatula** (Lacépède); lower Pliocene (Laverne Fm.); Beaver Co., NE¼ sec. 4 & NW¼SE¼ sec. 5, T. 3 N., R. 28 ECM, C. L. Smith (1962).

Lepisosteus sp.; Pleistocene (Illinoian); Beaver Co., SE cor. sec. 6, T. 5 N., R. 28 ECM, C. L. Smith (1954; 1958).

Infraclass Teleostei
Superorder Protacanthopterygii
Order Salmoniformes
Suborder Esocoidei (Haplomi)

TABLE 3.—*Continued*

Family Esocidae

Esox masquinongy Mitchill; Pleistocene (Illinoian); Beaver Co., SE cor. sec. 6, T. 5 N., R. 28 ECM, C. L. Smith (1954), G. R. Smith (1963).

?**Esox** sp.; lower Pliocene (Laverne Fm.); Beaver Co.; C. L. Smith (1962, p. 509).

Superorder Ostariophysi

Order Cypriniformes

Suborder Cyprinoidei

Family Cyprinidae

Notemigonus crysoleucas (Mitchill); Pleistocene (Illinoian); Beaver Co., SE cor. sec. 6, T. 5 N., R. 28 ECM, C. L. Smith (1954).

Semotilus atromaculatus (Mitchill); Pleistocene (Illinoian); Beaver Co., SE cor. sec. 6, T. 5 N., R. 28 ECM, Harper Co., N½SW¼ sec. 10, T. 27 N., R. 24 W.; C. L. Smith (1954; 1958), G. R. Smith (1963).

Pimephales promelas Rafinesque; Pleistocene (Illinoian); Harper Co., N½SW¼ sec. 10, T. 27 N., R. 24 W.; C. L. Smith (1958).

Hybopsis cf. **H. gracilis** (Richardson); Pleistocene (Illinoian); Harper Co., N½SW¼ sec. 10, T. 27 N., R. 24 W.; C. L. Smith (1958).

?**Semotilus** sp.; Pleistocene (Illinoian); Beaver Co., SE cor. sec. 6, T. 5 N., R. 28 ECM, C. L. Smith (1954).

Cyprinidae Indet.; Pleistocene (Illinoian); Beaver Co., SE cor. sec. 6, T. 5 N., R. 28 ECM, C. L. Smith (1954).

Family Catostomidae

Catostomus commersoni (Lacépède); Pleistocene Illinoian); Beaver Co., SE cor. sec. 6, T. 5 N., R. 28 ECM, Harper Co., N½SW¼ sec. 10, T. 27 N., R. 24 W.; C. L. Smith (1954; 1958), G. R. Smith (1963).

Ictiobus cf. **I. bubalus** (Rafinesque); lower Pliocene (Laverne Fm.); Beaver Co.; C. L. Smith (1962, p. 509).

Order Siluriformes

Family Ictaluridae

Ictalurus punctatus (Rafinesque); Pleistocene (Illinoian); Beaver Co., SE cor. sec. 6, T. 5 N., R. 28 ECM, C. L. Smith (1954).

Ictalurus melas (Rafinesque); Pleistocene (Illinoian); Beaver Co., SE cor. sec. 6, T. 5 N., R. 28 ECM, Harper Co., N½SW¼ sec. 10, T. 27 N., R. 24 W.; C. L. Smith (1954; 1958).

Ictalurus sp.; lower Pliocene (Laverne Fm.); Beaver Co., NW¼SE¼ sec. 5 & C sec. 5, T. 3 N., R. 28 ECM, C. L. Smith (1962).

Superorder Atherinomorpha

Order Atheriniformes

Suborder Atherinoidei

Family Atherinidae

Menidia sp. (=cyprinodont "**Plancterus kansae?**" of Stovall and McAnulty, 1939); middle Pliocene (Ogallala Fm.); Roger Mills Co., NE¼NE¼ sec. 8, T. 12 N., R. 23 W.; Hubbs (1942).

Superorder Acanthopterygii

Order Perciformes

Suborder Percoidei

Family Percidae

Perca flavescens (Mitchill); Pleistocene (Illinoian); Beaver Co., SE cor. sec. 6, T. 5 N., R. 28 ECM, Harper Co., N½SW¼ sec. 10, T. 27 N., R. 24 W.; C. L. Smith (1954; 1958), G. R. Smith (1963).

TABLE 3.—*Continued*

Family Centrarchidae

Lepomis cf. **L. cyanellus** Rafinesque; Pleistocene (Illinoian); Beaver Co., SE cor. sec. 6, T. 5 N., R. 28 ECM, Harper Co., N½SW¼ sec. 10, T. 27 N., R. 24 W.; C. L. Smith (1954; 1958), G. R. Smith (1963).

Micropterus sp.; lower Pliocene (Laverne Fm.); Beaver Co. NE¼ sec. 4, T. 3 N., R. 28 ECM, C. L. Smith (1962).

Centrarchidae Indet.; lower Pliocene (Laverne Fm.); Beaver Co., NE¼ sec. 4, T. 3 N., R. 28 ECM, C. L. Smith (1962).

Family Sciaenidae

Aplodinotus grunniens Rafinesque; Pleistocene (Illinoian); Beaver Co., SE cor. sec. 6, T. 5 N., R. 28 ECM, C. L. Smith (1954).

?**Aplodinotus** sp.; lower Pliocene (Laverne Fm.); Beaver Co., NW¼-SE¼ sec. 5, T. 3 N., R. 28 ECM, C. L. Smith (1962).

References Cited

Andrews, S. M., Gardiner, B. G., Miles, R. S., and **Patterson, C.,** 1967, Pisces, chap. 26 of Harland, W. B. (prin. ed.), The fossil record; a symposium: London Geol. Soc., Paleont. Assoc., p. 637-683.

Branson, C. C., 1964, Record of **Edestus** in Oklahoma: Oklahoma Geology Notes, v. 24, p. 210.

_____1965, **Petrodus** in Oklahoma: Oklahoma Geology Notes, v. 25, p. 274-275.

Branson, E. B., 1914, The Devonian fishes of Missouri: Missouri Univ. Bull. 15, Sci. Ser., v. 2, no. 4, p. 59-74.

Branson, E. B., and **Mehl, M. G.,** 1938, Pisces from the Lower Mississippian of Missouri, in Stratigraphy and paleontology of the Lower Mississippian of Missouri, part 2: Missouri Univ. Studies, v. 13, no. 4, p. 109-127.

Carlson, K. J., 1968, The skull morphology and estivation burrows of the Permian lungfish, **Gnathorhiza serrata:** Jour. Geology, v. 76, p. 641-663.

Case, E. C., 1902, On some vertebrate fossils from the Permian beds of Oklahoma: Territory of Oklahoma, Dept. Geology and Nat. History Bienn. Rept. 2, p. 62-68.

_____1915, The Permo-Carboniferous red beds of North America and their vertebrate fauna: Carnegie Inst. Washington Pub. 207, 176 p.

Cooksey, C. L., 1933, The micropaleontology of the Boggy formation of Oklahoma: Oklahoma Univ. unpub. M.S. thesis, 60 p.

Cope, E. D., 1877, Descriptions of extinct Vertebrata from the Permian and Triassic formations of the United States: Am. Philos. Soc. Proc., v. 17, p. 182-193.

_____1891, On new species of Platysomidae, pt. 7 of On the characters of some Paleozoic fishes: U.S. Nat. Mus. Proc., v. 14, no. 866, p. 460-462.

_____1894a [1895], Observations on the geology of adjacent parts of Oklahoma and northwest Texas: Philadelphia Acad. Nat. Sci. Proc., p. 63-68.

_____1894b, New and little known Paleozoic and Mesozoic fishes: Philadelphia Acad. Nat. Sci. Jour., ser. 2, v. 9, p. 427-448.

Croneis, C. G., 1927, Sharks from Fayetteville formation: Pan-Am. Geologist, v. 47, p. 41-46.

Eastman, C. R., 1913, Brain structures of fossil fishes from the Caney shales [abs.]: Geol. Soc. America Bull., v. 24, p. 119-120.

_____1917, Fossil fishes in the collection of the United States National Museum: U.S. Natl. Mus. Proc., v. 52, no. 2177, p. 235-304.

Elias, M. K., and **Branson, C. C.,** 1959, Type section of the Caney shale: Oklahoma Geol. Survey Circ. 52, 24 p.

Fay, R. O., 1952, Catalogue of conodonts: Kansas Univ. Paleont. Contr., Vertebrata Art. 3, 206 p.

______1968, Geology of Region III, **in** Appraisal of the water and related land resources of Oklahoma—Region Three: Oklahoma Water Resources Board Pub. 23, p. 13-18.

______1969a, Geology of Region V, **in** Appraisal of the water and related land resources of Oklahoma—Regions Five and Six: Oklahoma Water Resources Board Pub. 27, p. 18-25.

______1969b, Geology of Region VI, **in** Appraisal of the water and related land resources of Oklahoma—Regions Five and Six: Oklahoma Water Resources Board Pub. 27, p. 26-31.

______1970, Geology, **in** Appraisal of the water and related land resources of Oklahoma—Region Seven: Oklahoma Water Resources Board Pub. 29, p. 18-29.

______1971a, Geology, **in** Appraisal of the water and related land resources of Oklahoma—Region Eight: Oklahoma Water Resources Board Pub. 34, p. 17-25.

______1971b, Geology, **in** Appraisal of the water and related land resources of Oklahoma—Region Nine: Oklahoma Water Resources Board Pub. 36, p. 17-32.

______1972, Geology, **in** Appraisal of the water and related land resources of Oklahoma—Region X: Oklahoma Water Resources Board Pub. 40, p. 19-29.

Gardiner, B. G., 1967, Further notes on palaeoniscoid fishes with a classification of the Chondrostei: British Mus. (Nat. History) Bull., Geology, v. 14, no. 5, p. 143-206.

Giles, A. H., 1963, Physical paleoecology of the Francis Formation (Pennsylvanian) near Ada, Oklahoma: Oklahoma Univ. unpub. M.S. thesis, 127 p.

Girty, G. H., 1909, Fauna of the Caney shale of Oklahoma: U.S. Geol. Survey Bull. 377, 106 p.

Greig, P. B., 1959, Geology of Pawnee County, Oklahoma: Oklahoma Geol. Survey Bull. 83, 188 p.

Grey-Egerton, Sir Philip, 1877, On some new pycnodonts: Geol. Mag., ser. 2, v. 4 (i.e., v. 14), no. 2, p. 49-55.

Gunnell, F. H., 1931, Conodonts from the Fort Scott Limestone of Missouri: Jour. Paleontology, v. 5, p. 244-252.

______1933, Conodonts and fish remains from the Cherokee, Kansas City, and Wabaunsee groups of Missouri and Kansas: Jour. Paleontology, v. 7, p. 261-297.

Harlton, B. H., 1933, Micropaleontology of the Pennsylvanian Johns Valley shale of the Ouachita Mountains, Oklahoma, and its relationship to the Mississippian Caney shale: Jour. Paleontology, v. 7, p. 3-29.

Harris, R. W., and Hollingsworth, R. V., 1933, New Pennsylvanian conodonts from Oklahoma: Am. Jour. Sci., ser. 5, v. 25, no. 147, p. 193-204.

Hay, O. P., 1929, Second bibliography and catalogue of the fossil Vertebrata of North America, volume 1: Carnegie Inst. Washington Pub. 390, 916 p.

Hesse, C. J., 1939, A Pliocene vertebrate fauna from Higgins, Lipscomb County, Texas: Texas Univ. Pub. 3945, p. 671-698.

Hibbard, C. W., 1951, An antilocaprid from the lower Pliocene of Beaver County, Oklahoma: Kansas Acad. Sci. Trans., v. 54, no. 3, p. 387-390.

Hibbard, C. W., and Taylor, D. W., 1960, Two late Pleistocene faunas from southwestern Kansas: Michigan Univ. Mus. Paleontology Contr., v. 16, no. 1, 223 p.

Hotton, N., 1952, Jaws and teeth of American xenacanth sharks: Jour. Paleontology, v. 26, p. 489-500.

Hubbs, C. L., 1942, An atherinid fish from the Pliocene of Oklahoma: Jour. Paleontology, v. 16, p. 399-400.

Hussakof, L., 1911, The Permian fishes of North America, **in** Case, E. C., Revision of the Amphibia and Pisces of the Permian of North America: Carnegie Inst. Washington Pub. 146, p. 155-175.

Karatajūte-Talimaa, V., 1968, On the stratigraphic position and correlation of Downtonian deposits (Minija and Jura beds) of the Baltic area, **in** Stratigraphy of the Baltic Lower Paleozoic and its correlation with other areas, p. 273-285. (In Russian.)

Kitts, D. B., 1957, A Pliocene vertebrate fauna from Ellis County, Oklahoma: Oklahoma Geol. Survey Circ. 45, 27 p.

Lindström, Maurits, 1964, Conodonts: Amsterdam, Elsevier, 196 p.

Lund, R., 1970, Fishes from the Duquesne Limestone (Conemaugh, Pennsylvanian), **pt. 1 of** Fossil fishes from southwestern Pennsylvania: Carnegie Mus. Annals, v. 41, p. 231-261.

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

Mark-Kurik, Elga, 1969, Distribution of vertebrates in the Silurian of Estonia: Lethaia, v. 2, no. 2, p. 145-152.

Matveev, B. S., 1970, On the origin of conodonts as shown by evolutionary morphology data: Voprosy Ichtiologii, v. 10, no. 1 (60), p. 3-14. (In Russian.)

Morgan, G. D., 1924, Geology of the Stonewall quadrangle: Norman, Okla., [Oklahoma] Bur. Geology Bull. 2, 248 p.

Moy-Thomas, J. A., and **Miles, R. S.,** 1971, Palaeozoic fishes (2d ed., revised by R. S. Miles): Philadelphia, W. B. Saunders Co., 259 p.

Myers, A. J., 1959, Geology of Harper County, Oklahoma: Oklahoma Geol. Survey Bull. 80, 108 p.

Olson, E. C., 1946, Fresh- and brackish-water vertebrate-bearing deposits of the Pennsylvanian of Illinois: Jour. Geology, v. 54, p. 281-305.

——1965, New Permian vertebrates from the Chickasha Formation in Oklahoma: Oklahoma Geol. Survey Circ. 70, 70 p.

——1967, Early Permian vertebrates of Oklahoma: Oklahoma Geol. Survey Circ. 74, 111 p.

Olson, E. C., and **Barghusen, H. R.,** 1962, Vertebrates from the Flowerpot Formation of Oklahoma, **in** Permian vertebrates from Oklahoma and Texas: Oklahoma Geol. Survey Circ. 59, p. 5-48.

Ørvig, Tor, 1966, Histologic studies of ostracoderms, placoderms, and fossil elasmobranchs, **pt. 2 of** On the dermal skeleton of two late Palaeozoic elasmobranchs: Arkiv Zoologi, v. 19, no. 1, 39 p.

Pander, C. H., 1856, Monographie der fossilen Fische des silurischen Systems der russisch-baltischen Gouvernements: Königl. Akad. Wiss., 91 p.

Perkinson, Floyd, 1934, The microfauna of the Francis formation in the vicinity of Ada, Oklahoma: Oklahoma Univ. unpub. M.S. thesis, 79 p.

Ries, E. R., 1954, Geology and mineral resources of Okfuskee County, Oklahoma: Oklahoma Geol. Survey Bull. 71, 120 p.

Smith, C. L., 1954, Pleistocene fishes of the Berends fauna of Beaver County, Oklahoma: Copeia, no. 4, p. 282-289.

——1958, Additional Pleistocene fishes from Kansas and Oklahoma: Copeia, no. 3, p. 176-180.

——1962, Some Pliocene fishes from Kansas, Oklahoma, and Nebraska: Copeia, no. 3, p. 505-520.

Smith, G. N., 1927, The Permian vertebrates of Oklahoma: Oklahoma Univ. unpub. M.S. thesis, 46 p.

Smith, G. R., 1963, A late Illinoian fish fauna from southwestern Kansas and its climatic significance: Copeia, no. 2, p. 278-285.

Stovall, J. W., 1945, The occurrence of **Petrodus** in Oklahoma: Am. Midland Naturalist, v. 34, no. 3, p. 720-722.

Stovall, J. W., and **McAnulty, W. N.**, 1939, Cyprinodontidae from the Pliocene in Roger Mills County, Oklahoma: Am. Midland Naturalist, v. 22, no. 3, p. 749-752.

Weaver, O. D., Jr., 1954, Geology and mineral resources of Hughes County, Oklahoma: Oklahoma Geol. Survey Bull. 70, 150 p.

Wegemann, C. H., 1915, Anticlinal structure in parts of Cotton and Jefferson counties, Oklahoma: U.S. Geol. Survey Bull. 602, 108 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.

Wilimovsky, N. J., 1954, **Gunnellodus**, a new name for **Idiacanthus** Gunnell: Jour. Paleontology, v. 28, p. 693.

Williams, M. E., 1972, The origin of "spiral coprolites": Kansas Univ. Paleont. Contr. Paper 59, 19 p.

Woodward, A. S., 1895, Catalogue of the fossil fishes in the British Museum (Natural History), part 3: London, 544 p.

Zangerl, R., 1968, The morphology and the developmental history of the scales of the Paleozoic sharks **Holmesella**? sp. and **Orodus**, in Ørvig, Tor (ed.), Nobel Symposium 4 Proceedings: Stockholm, Almqvist and Wiksell, p. 399-412.

Zidek, Jiri, 1965, Notes on the vertical range and the benthonic adaptation of the xenacanth sharks: Prague, Natl. Mus. Mag., Nat. Sci. Sec., v. 134, no. 2, p. 65-68. (English title only.)

New Water Resources Administrative Regions Announced

The Water Resources Division of the U.S. Geological Survey has established four new administrative regions: Northeastern, Southeastern, Central, and Western. This restructuring of the nation's largest water resources investigating agency conforms with the ten administrative districts recently developed in President Nixon's Federal Assistance Review Program.

Regional headquarters will be located in Arlington, Virginia; Atlanta, Georgia; Denver, Colorado; and Menlo Park, California, coinciding with recently established field centers of the U.S. Geological Survey.

Oklahoma is in the Central Region, and the federal portions of our cooperative water-resources programs will be administered through the Denver office under the direction of Edward A. Moulder, the new regional hydrologist. A graduate of Michigan State University, Mr. Moulder joined the USGS in 1946 and from 1967 to 1972 was chief of the Colorado district.

Other regional hydrologists are Joseph T. Callahan (Northeastern), Rolland W. Carter (Southeastern), and Elwood R. Leeson (Western).

Victor Elvert Monnett

1889-1972

During the 31 years (1924-1955) that Dr. Victor Elvert Monnett was director of the Department and School of Geology and Geological Engineering at The University of Oklahoma, 2,218 students earned a Bachelor of Science degree in geology or geological engineering. It is believed that this far exceeds the number of like degrees earned under any other individual as head of these departments at a university. Advanced degrees awarded during these years were 252.

Victor Elvert Monnett was born December 1, 1889, in Hale, Missouri. He died at Oklahoma City, September 18, 1972, 12 hours following a heart attack. There had been no previous record of heart trouble. At Laclede, Missouri, and Purcell, Oklahoma, he received his high school education. He attended The University of Oklahoma from 190[illegible] to 1912, where he was awarded a Bachelor of Arts degree in geology. Cornell University granted him a fellowship for graduate study in geology. There, from 1913 to 1916, he served as an instructor in that subject.

In 1914 Victor and Kathryn Brown from Laclede, Missouri, were married. They have one son, Dr. Victor Brown Monnett, who has been head of the Department of Geology and associate dean of the College of Arts and Sciences at Oklahoma State University.

In 1916 Victor Elvert Monnett was appointed an assistant professor of geology at The University of Oklahoma. In 1922 a Doctor of Philosophy degree was received from Cornell University with the major field of study in geology and the minor field in soil technology. In 1924 he became chairman of the Department of Geology and Geography of Oklahoma University and director of the School of Geological Engineering. The School of Geology was established in 1927, and Dr. Monnett assumed that directorship. He retired from all of these administrative duties in 1955 but continued to teach geology, particularly structural geology, until full retirement in 1959 at the age of 70. In addition to his departmental supervision and his teaching he had served in numerous other positions of responsibility for the University, notably dean of the Graduate School and director of the Research Institute. His course on petroleum geology was one of the earliest courses organized on that subject.

A permanent and lasting improvement in the Geology Department was brought about principally through the several years of planning and negotiations by Dr. Monnett for a badly needed geology building, Gould Hall. The appropriation did not include equipping the building. His appeal to alumni and industry brought the necessary contributions for that purpose.

We, who were classmates of "Vic," knew him as a friendly, warm-hearted individual with a ready laugh, a kindly sense of humor, and a serious mind, characteristics which remained with him throughout his life. They grew as he grew in stature to enable him to take so much of a personal interest in each student that usually, at gatherings, such as conventions of The American Association of Petroleum Geologists, he could call any former student by name. Approximately half of the 2,218 graduates are members of the OU Alumni Association.

He was a founder and honorary member of The American Association of Petroleum Geologists. In 1965 the association made him a Sidney Powers medalist, the highest award which they bestow. He was Sigma Xi, Phi Beta Kappa, Sigma Gamma Epsilon, Gamma Alpha, and Sigma Chi.

In 1953 he was selected as a David Ross Boyd Distinguished Professor in recognition of his excellent counseling and teaching, one of the greatest honors awarded to a member of The University of Oklahoma faculty.

He was an honorary member of the Oklahoma City Geological Society.

Personal comments of two of his former students follow. From W. Dow Hamm (Atlantic Refining):

> The thing that characterized Dr. Monnett's teaching of petroleum geology was his intense interest in the subject, especially in regard to structural geology. It was his great enthusiasm for geology and his special interest in each of his students that will long be remembered by all who had the good fortune to pass his way. . . . We considered "Vic" not only as our professor but our close personal friend. This relationship has endured throughout the years. Vic Monnett will be missed by all of us.

From A. L. Solliday (Stanolind Oil and Gas):

> Victor Elvert Monnett, or "Vic," as he was known to thousands of his students, as well as to countless others, was one of those rare individuals; that, once having met him, would be remembered for life. His personality made you feel close to him, but still to respect him as you would a much older person. There was only 9 years' difference in our ages, but he was so mature in ability and experience that you would readily go to him for advice. His enthusiasm for geology was contagious. He was a demanding instructor, but you received what you deserved and no more.

The effect of Dr. Monnett's qualities and high standards has been reflected through his former students most significantly in the petroleum industry, many of whom have attained excellent success as company executives or independent operators, also some as teachers. They have applied the profession of petroleum geology both in this country and widely over the free world. Through them, the large measure of good which this gentle man has done will live on and on.

—*Jerry B. Newby*

(Appreciation is expressed to Jerry B. Newby, to the editor of the **Shale Shaker**, and to the executive committee of the Oklahoma City Geological Society for permission to reprint this memorial.)

Scholarship Fund Established in Memory of Dr. Monnett

The family of Dr. Victor Monnett has established the Victor E. Monnett Memorial Scholarship Fund in Geology to benefit students in the School of Geology and Geophysics at The University of Oklahoma. Contributions, which are tax deductible, may be sent to the fund, 830 Van Vleet Oval, Room 107, Norman, Oklahoma 73069.

An additional memorial to Dr. Monnett is under consideration by the Alumni Advisory Council of the OU Foundation of Geology and Geophysics and is expected to be shaped in final form at the council's next meeting.

AIPG Holds National and State Meetings

The ninth annual meeting of the American Institute of Professional Geologists was held October 11-14 in Pittsburgh, Pennsylvania. The theme of the meeting was "The Professional Geologist, His Community Impact and Concern." The meeting program was formulated to establish the role of geology in solving various community problems and geology's relation to the formal (governmental restraints) and informal (business community, press, local government) impacts on existing social and economic structure and attitudes.

New institute officers for 1973 were announced at the meeting: president, Adolf U. Honkala, consultant, Richmond, Virginia; vice-president, Jack A. Simon, Illinois State Geological Survey, Urbana, Illinois; secretary-treasurer, Vito A. Gotautas, consultant, Lafayette, Louisiana; and editor, Allen F. Agnew, Washington State University, Pullman, Washington. Neilson Rudd, retiring president, will continue to serve on the executive committee of the institute for the coming year.

One of the meeting's highlights took place at the annual banquet, when the institute presented awards to the crew of Apollo 15 for their outstanding contributions to geology. Col. David Scott, commander of the mission, was present to accept the awards. The three major television networks, ABC, CBS, and NBC, received awards for publicizing the role of geology in the lunar program and for accurate coverage of the missions. An award was also given to NASA for its support of the missions and for lunar geological studies.

In September the Oklahoma Section of AIPG met in delightful surroundings at Arrowhead State Lodge, after which the following section officers began their terms: president, Edward L. Johnson, U.S. Geological Survey, Tulsa; first vice-president, William D. Rose, Oklahoma Geological Survey, Norman; second vice-president, John F. Harris, consultant, Tulsa; and secretary-treasurer, D. Craig Wright, consultant, Oklahoma City. District representatives are John J. Rupnik (Tulsa), Gerald D. Neff (Oklahoma City), and Warren B. Weeks of Bartlesville, representative at large. Named as delegates to the 1973 national advisory board were retiring president Suzanne Takken, Oklahoma City, and incoming president Johnson.

Interstate Mining Compact Commission Adopts Bylaws

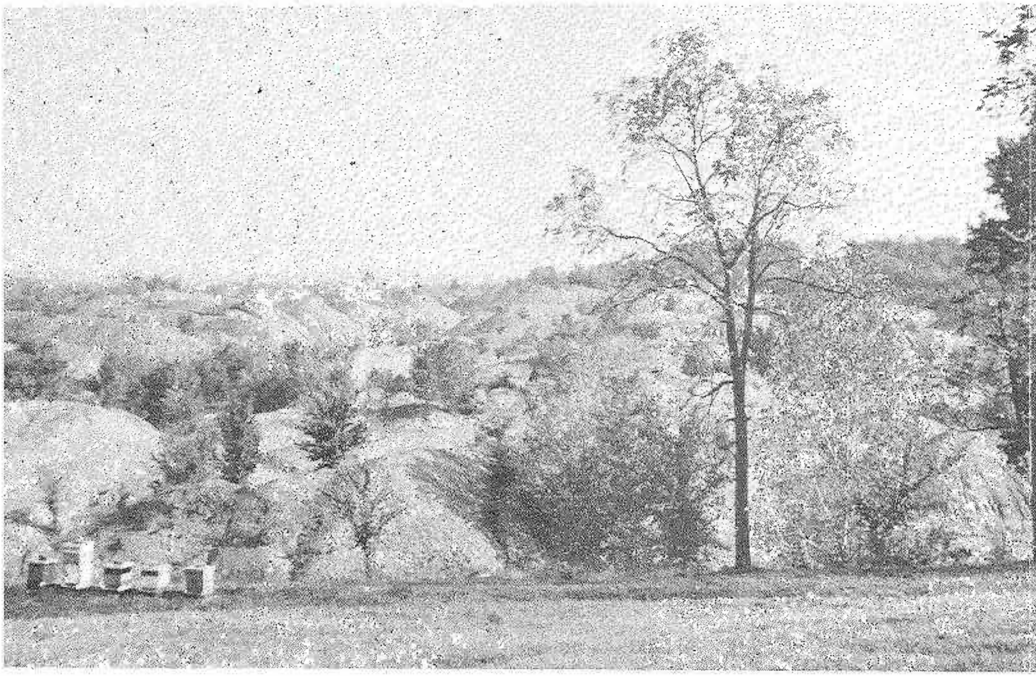
Representatives from 20 states were in Tulsa October 11-13 to attend the fall meeting of the 18-month-old Interstate Mining Compact Commission. The first day's activities included a field trip to the Tulsa Port of Catoosa and to three surface-mining operations in an effort to relate Oklahoma practices to those of other states. A banquet was held that evening, at which Oklahoma Governor David Hall stressed the important position of Oklahoma as an energy producer and indicated that oil, gas, and coal production can be increased under incentives derived from favorable federal legislation and regulations. He also presented a plaque to Frank McNabb for restoring land to conditions that exceeded State requirements. Technical sessions were conducted the following day.

Bylaws approved in executive session by the commission's six member states (Pennsylvania, Kentucky, North Carolina, Oklahoma, West Virginia, and South Carolina) reinforced the role of the group as an advisory and information-oriented body concerned with assisting mining companies to increase efficiency and to develop programs aimed at making the land surface more useful after it has been mined. Five or six other states have expressed interest in joining the compact and can assume membership after their state legislatures pass enabling acts.

The 83 registrants constituted the most diverse group ever assembled at a commission meeting. Government officials—including representatives from the U.S. Geological Survey and the U.S. Bureau of Mines, state legislators, state geologists and mine inspectors, and conservation and environmental officials—were joined by lawyers, engineers, and personnel of mining, trucking, and equipment companies.

Participants agreed that the field trip was especially beneficial because of the interplay between mine operators, legislators who pass reclamation laws, and inspectors who enforce them. On the field trip, an ad hoc committee, composed of Ward Padgett, chief mine inspector, Oklahoma Department of Mines; S. A. Friedman and Kenneth S. Johnson, geologists, Oklahoma Geological Survey; Frank McNabb and Bill Patch, coal-mine operators; Frank Farnsworth, area engineer, Curtis Dement, and Otis English, mine superintendents, and Scott Brundage, in charge of reclamation for Arkansas, Oklahoma, and Missouri—all of Peabody Coal Company; and Robert Arndt, liaison officer, U.S. Bureau of Mines, provided background information and answered questions.

The Oklahoma Geological Survey was well represented in the technical part of the meeting—fittingly, since this agency is charged with the responsibility of providing for the orderly and progressive development of the State's mineral resources. Charles J. Mankin, director, outlined the Survey's relations with the mining industry and introduced S. A. Friedman, who spoke on "Coal Resources and Mining in Oklahoma," and Kenneth S. Johnson, whose topic was "Oklahoma's Mineral Resources and Mining Activities."



The f·eld-trip part of the Interstate Mining Compact Commission's Tulsa meeti·g included a stop in southwestern Rogers County (top photo), where land mined 30 years ag awaits r clamation. By contrast, mined land less than ile from the first site (b ttom photo) has been leveled and seeded for grass. In fact, catt·e ha·e been grazing on it for over a year.

Walter Heine, associate deputy secretary for mines and land protection, Pennsylvania Department of Environmental Resources, was moderator for the technical session. Others on the program were Leonard A. Solomon, director of the Oklahoma State Conservation Commission; Ronald Hill, chief of mine drainage pollution control activities, U.S. Environmental Protection Agency; Ed Westphal, quarry superintendent, U.S. Gypsum Company; Robert H. Arndt, liaison officer, U.S. Bureau of Mines; and Thomas O. Harris, commissioner, Kentucky Department of Natural Resources.

Ward Padgett, Oklahoma's chief mine inspector, deserves credit for coordinating activities of this Interstate Mining Compact Commission meeting.

—S. A. Friedman

Two Kerr-McGee Operations to Close

The Choctaw Mining Facility of the Kerr-McGee Corporation was placed on a standby basis effective August 19. The plant, located near Stigler in Haskell County, began operation in June 1969 and was still in the development phase when the decision was made to close it for evaluation of solutions to a number of personnel and engineering problems. The company plans to maintain the mine in operating condition with the hope of resuming production at a later date.

Kerr-McGee's naphtha plant in Cleveland, Oklahoma, is in the process of shutting down, with final termination of operations scheduled for December 31, 1972. "Rising costs and unsuccessful attempts to obtain a satisfactory charge stock" are listed by the company as causes leading to a decision to close the plant. Naphtha and solvents will continue to be supplied by Kerr-McGee through refineries at Wynnewood, Oklahoma, and Cotton Valley, Louisiana.

1972 Officers of Oklahoma Mineralogical Societies Listed

The Rocky Mountain Federation of Mineralogical Societies has listed the following 1972 officers for the 12 clubs in Oklahoma:

Arbuckle Rock and Fossil Club of Ada
President, Wayne Sanders
Secretary, Gordon Harrel
Federation Activities Member, Conner Logsdon
Editor, Phyllis Kreis
Southwest Oklahoma Rock and Mineral Society of Altus
President, Mrs. Harold Jones
Secretary, Ralph Samuelson

Federation Activities Member, Elmer Craft, Jr.
Editor, Herbert Roach

Osage Hills Gem and Mineral Society of Bartlesville
President, John C. Hillyer
Acting secretary, Mrs. B. L. Munro
Editor, Mrs. Jackie Bush

Western Oklahoma Gem, Rock and Mineral Society of Elk City
President, Bob Harness
Secretary, Jack Humphrey
Federation Activities Member, Bob Harness
Editor, Marie Dobson

Enid Gem and Mineral Society of Enid
President, Frank Ryan
Secretary, Mrs. O. R. Dalke
Federation Activities Member, Mrs. O. R. Dalke
Editor, Mrs. E. A. Franke

Tri-State Rock Club of Guymon
President, DeWitt Harris
Secretary, Carl L. Barnes
Federation Activities Member, Jim Howell
Editor, Mrs. Jim Howell

Wichita Mountains Rock Club of Hobart
President, Linn Boles
Secretary, Mrs. Helen Boles
Federation Activities Member, Elmer Pickering
Editor, Mrs. Helen Boles

Northeastern Oklahoma Gem and Mineral Society of Miami
President, Robert L. Rice
Secretary, Mrs. Cliff Sloan
Federation Activities Member, Cliff Sloan
Editor, Mrs. Jerry Jones

Oklahoma Mineral and Gem Society of Oklahoma City
President, Garland Holmes
Secretary, Mrs. Juanita Hamilton
Federation Activities Members, Dan and Lucy McLennan
Editor, Mrs. Minnie Lee Morgan

Northern Oklahoma Gem and Mineral Society of Ponca City
President, LeRoy Slocum
Secretary, Shirley Petersen
Federation Activities Member, Edith Slocum
Editor, Mrs. Alton Horne

Stillwater Gem and Mineral Society of Stillwater
President, Guy Rising
Secretary, Mrs. Daniel Lingelbach
Federation Activities Member, Opal Blasingame
Editor, Opal Blasingame

Tulsa Rock and Mineral Society of Tulsa
President, John Kent
Secretary, Flora M. Oxford
Federation Activities Member, C. T. West
Editor, Mrs. K. R. Buchanan

Geomorphology of Tesesquite Creek Valley Cimarron County, Oklahoma

L. R. Wilson[1]

INTRODUCTION

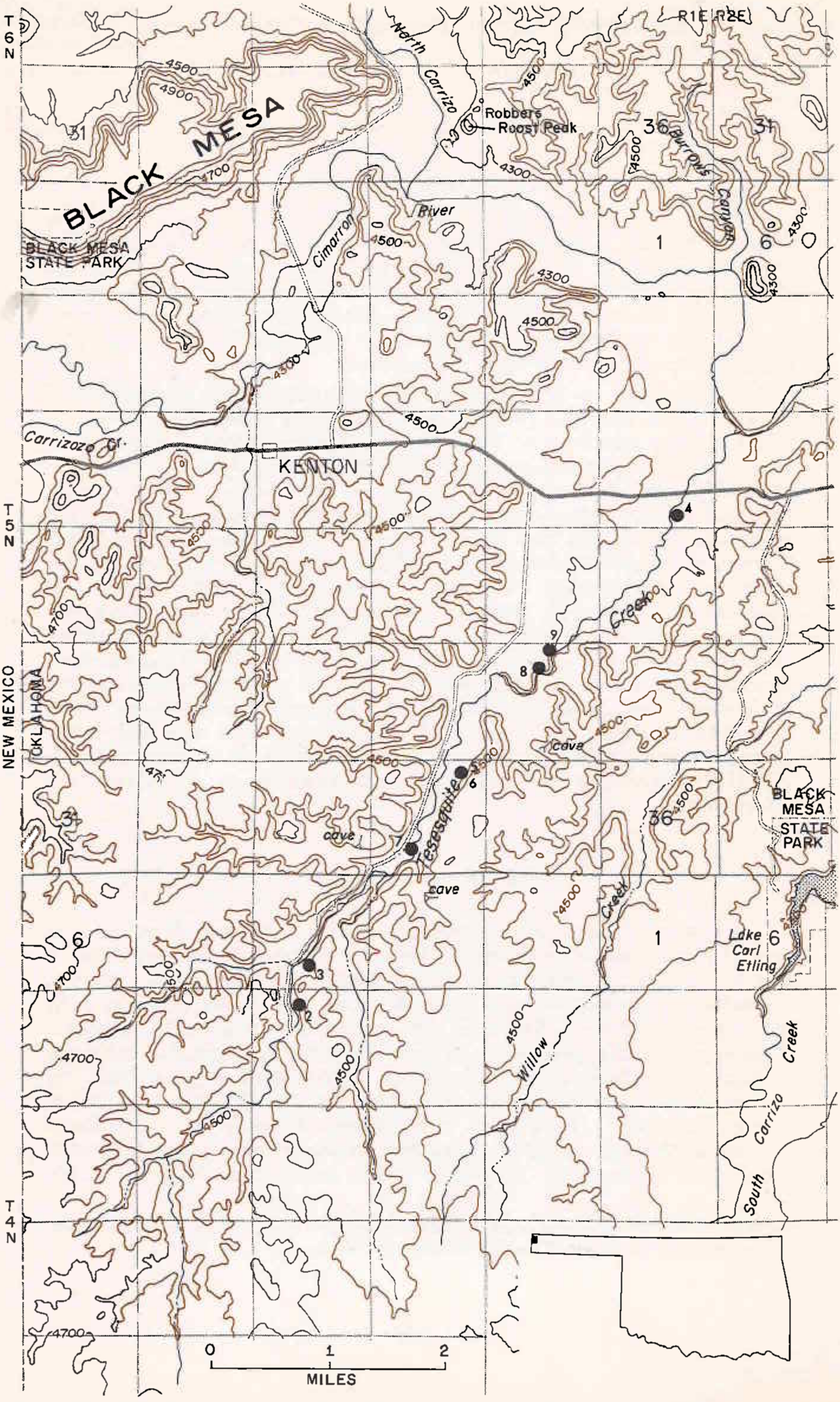
The valley of Tesesquite Creek in Cimarron County, Oklahoma (fig. 1), has had a complicated history of excavation and filling similar to many others in the Great Plains province. Observations over the past 8 years have made it possible to determine, from newly eroded portions of the valley, major stages of late and post-Pleistocene development and to determine approximately the time of some events by carbon-14 measurements from buried wood.

Although an early description of Tesesquite Creek was published by Schoff and Stovall (1943, p. 128), the valley's complicated history was noted by members of the Ponca City Archaeology Society when they conducted reconnaissance studies in the area during 1964. Samples of blue-black clay were collected by Mr. Stephen Hall for palynological study by the writer, and Hall reported the presence of buried wood associated with this clay. Subsequent field work over the past 8 years in company with members of the Ponca City Archaeology Society, and particularly with field assistance from Mr. Charles L. Slovacek, Mr. Stephen Hall, Mr. Delbert E. Potter of Sinclair Oil Company, and Dr. Carl C. Branson of The University of Oklahoma and Oklahoma Geological Survey, has revealed instructive sedimentary deposits in this rapidly eroding valley, as well as numerous exposures of a forest bed in an old channel of Tesesquite Creek. Wood from buried *in situ* trees has been analyzed for carbon-14 age determinations, and appreciation is here expressed to Mobil Oil Corporation and the U.S. Department of Agriculture for kindness in supplying this information.

DESCRIPTION OF VALLEY

Tesesquite Creek is a tributary of the Cimarron River and is several miles east of Kenton; it flows northeastward through Tps. 4 and 5 N. in Rs. 1 and 2 E. in Cimarron County, Oklahoma (fig. 1). Its valley is approximately 11½ miles long, and at its junction with the Cimarron River valley it is approximately 1 mile wide, although it narrows rapidly headward as shown by the topographic contours in figure 1. Tesesquite Creek is an intermittent stream from its source at approximately 4,650 to 4,515 feet altitude, where it leaves Cretaceous rocks (Purgatoire and Dakota Formations) and flows 9½ miles through a valley developed in sandstone of the Morrison Formation (Jurassic?). Tesesquite Creek enters the Cimarron River

[1]Geologist, Oklahoma Geological Survey, and George Lynn Cross Research Professor of Geology, The University of Oklahoma.



T 6 N
R1E R2E
BLACK MESA
BLACK MESA STATE PARK
North Carrizo
Robbers Roost Peak
Burrows Canyon
Cimarron River
Carrizozo Cr.
KENTON
T 5 N
NEW MEXICO
OKLAHOMA
Creek
Tesesquite
cave
Willow Creek
BLACK MESA STATE PARK
Lake Carl Etling
South Carrizo Creek
T 4 N
0 1 2
MILES

Figure 1. Topographic map of northwestern corner of Oklahoma Panhandle showing drainage of Tesesquite Creek and locations of photographs in this report. Base and topographic contours from U.S. Geological Survey 7½-minute series, scale 1:24,000. Contour interval, 100 feet.

at 4,200 feet. Thus it has a total drop of 440 feet and an average gradient of approximately 38.26 feet per mile. From the point where the stream has permanent flowage (fig. 3) the gradient is 33.15 feet per mile through unconsolidated sediments.

The narrow channel of Tesesquite Creek above the point of permanent flowage extends headward into sec. 29, T. 4 N., R. 1 E., where it occupies a wide valley developed in the Cretaceous rocks. Much of the wide valley is floored with an alluvial fill, and the channel of Tesesquite Creek is little more than a dry sandy ditch a few feet wide. This condition persists northward down its drainage course into sec. 4, becoming only slightly more entrenched. Figure 2 illustrates the physiographic condition of most of the upper portion of the area of Tesesquite Creek where it is an intermittent stream. Downstream from the point illustrated in figure 2 there is additional stream-channel entrenchment where several tributary valleys join that of Tesesquite Creek. The channel in sec. 4 (fig. 3) is approximately 10 feet deep

Figure 2. View looking southward from near the north line of sec. 9, T. 4 N., R. 1 E., of the youngest erosional portion of the present Tesesquite Creek.

and floors on an erosionally resistant blue silty clay. This competent clay has retarded the erosion cycle headward from this point, but the blocky nature of the clay has been responsible for the development of an intermittent waterfall. During torrential rainstorms, which are characteristic of this area, undercutting of the blocky clay results in headward development of the channel. A plunge pool several feet deep is a permanent feature here, and downstream from this point Tesesquite Creek is a permanent stream except at low-water stages, when it becomes an interrupted stream choked with sand in parts of its course. At these times numerous quicksand areas develop where water is seeping through the choked channel.

North-northeastward from the waterfall, the stream channel widens to approximately 50 feet and is cut to approximately 15 feet in alluvium. The channel direction is relatively straight until it encounters an outcrop of Morrison sandstone in sec. 27; from there it veers eastward for approximately half a mile, forming several meanders, and then encounters the Morrison sandstone on the east side of the rock-cut valley. From this point the stream flows northward approximately a quarter of a mile, makes a sharp turn at a resistant caliche bed, flows 100 yards eastward to an outcrop of sandstone, and again flows in a general north-northeastward direction for about $3\frac{1}{2}$

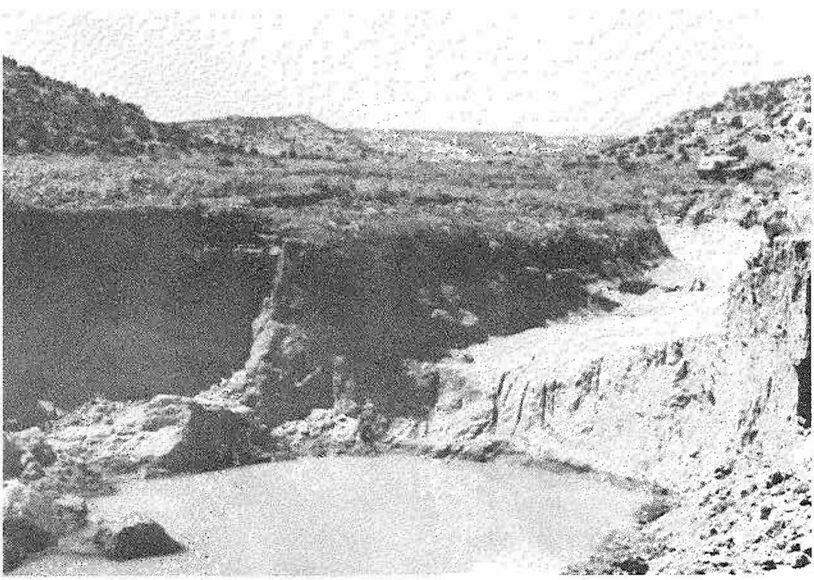


Figure 3. Tesesquite Creek valley approximately $\frac{1}{4}$ mile from point in figure 2, in sec. 4, T. 4 N., R. 1 E., looking southward. Here the intermittent creek has incised the terrace soils to a depth of 10 feet down to an erosionally resistant blue silty clay. A waterfall operates during periods of wet-weather runoff.

miles across alluvium to the Cimarron River. The channel in that area varies from 100 to more than 300 feet wide, as shown in figure 4. It is within the area just described that much of the historical record of Tesesquite Creek is exposed.

Two continuous terraces are evident in most of the valley (fig. 5), but may not represent correlative levels throughout their extent because section exposures in the upper terrace are few and the deposits of the lower terrace appear to represent complicated events of scour and fill, local channel deposits, caliche beds, and torrential rainstorm deposits. During flash floods, the entire channel valley may fill with water and overflow for a short period. At these times the channel is eroded considerably, and extensive flood deposits may be laid down on top of the low terrace and on the channel floor. A well-developed intermediate and discontinuous terrace occurs in the SW$\frac{1}{4}$ sec. 34, T. 5 N., R. 1 E. Here, many Indian artifacts have been found, suggesting occupancy. Also, in 1970, fire-pit sections were observed in the low terrace of the opposite bank of the creek. These pits are at the paleosoil level shown in figure 6 and were covered by approximately 1 foot of flood deposits. Remnants of other discontinuous terraces are recognizable in the valley, but no serious attempt has been made to map or interpret them other than to recognize their presence.

An important detail in the history of Tesesquite Creek valley is

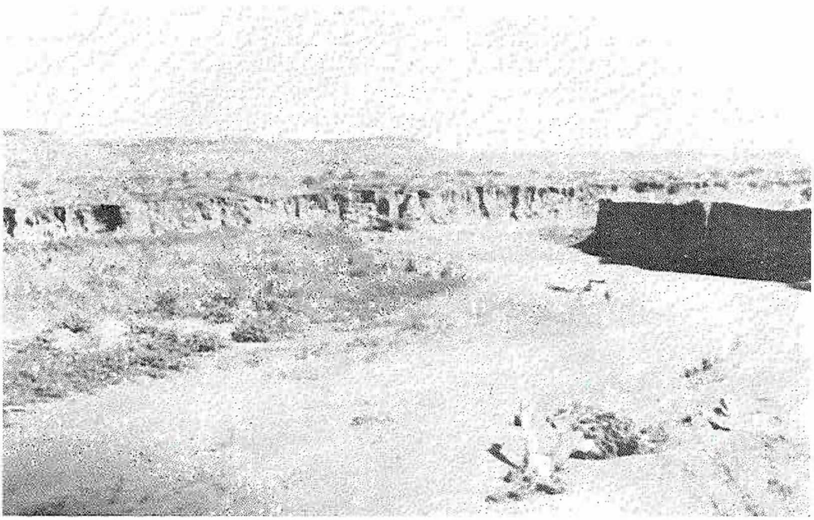


Figure 4. View of Tesesquite Creek and its valley approximately 1 mile from its mouth in sec. 13, T. 5 N., R. 1 E., looking southward. Here the valley is 300 feet or more wide and is incised approximately 18 feet into the lowest terrace. The creek was at a low stage when photographed and shows temporary interruption from the left foreground to the base of the terrace at right.

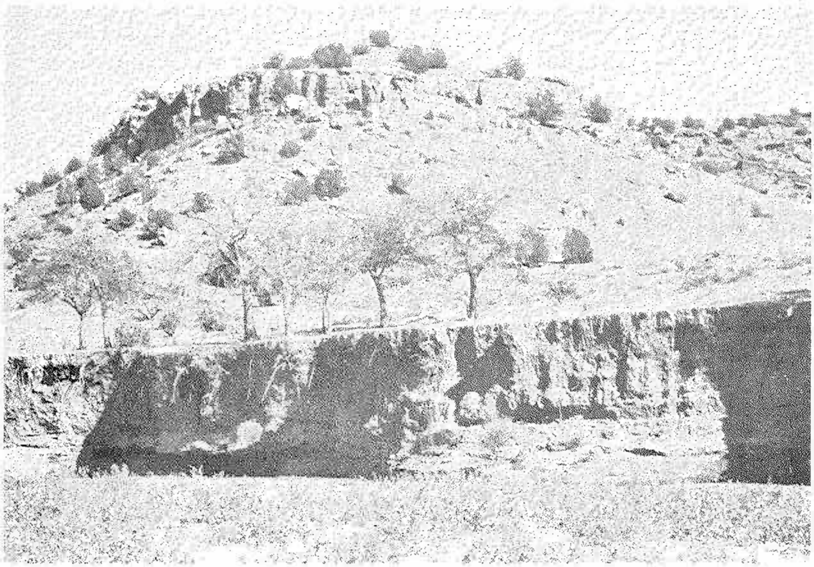


Figure 5. East bank of Tesesquite Creek in NE¼ sec. 34, T. 5 N., R. 1 E., showing lower terrace and remnant of upper terrace at bottom of Morrison sandstone slope.

the occurrence of buried stumps (fig. 7) on the blue clay and their cover by sediments of the channel fill that formed the low terrace. During the time of the buried forest growth, and possibly at other periods, caliche deposits developed in a swampy environment of, or adjacent to, the stream (fig. 9). The discovery of many details of the valley's sedimentary history will require an intensive drilling program and laboratory analysis of alluvial samples.

The wide valley of the present channel in the vicinity of the intermittent waterfall (fig. 3) and below was begun in 1914, according to local residents. At that time the channel must have been similar to that shown in figure 2. Schoff and Stovall (1943, p. 128) stated: "In historical times this creek had no channel, but flowed over a well-sodded valley bottom. In 1914 and 1924 excessive floods cut the present channel, which is from 4 to 15 feet deep, and exposed the older stream deposits." At present the channel is more than 15 feet deep in the vicinity of the area shown in figure 8, and in 1969 it had reached a width of approximately 300 feet in the vicinity of the area shown in figure 4. Residents of the area have expressed the opinion that the initial 1914 erosion was caused by overgrazing as well as by several severe floods.

DEPOSITS

A generalized stratigraphic section of the sedimentary deposits exposed in Tesesquite Creek valley is shown in figure 10. The rock

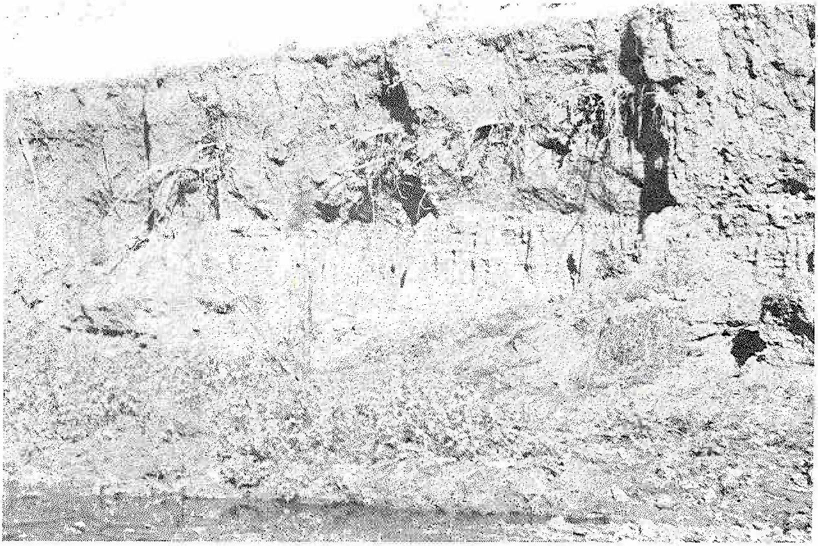


Figure 6. Detail of east bank of Tesesquite Creek in NE¼ sec. 34, T. 5 N., R. 1 E., showing exposed section in lower terrace. Basal sediments are blue clay, above which are 5 feet of laminated sand, silt, and clay of stage C (fig. 11) and 4 feet of laminated sand, silt, and clay of stage E (fig. 11); approximately 1 foot below the top of the terrace is a weakly developed paleosoil horizon. Flash-flood deposits overlie the paleosoil.

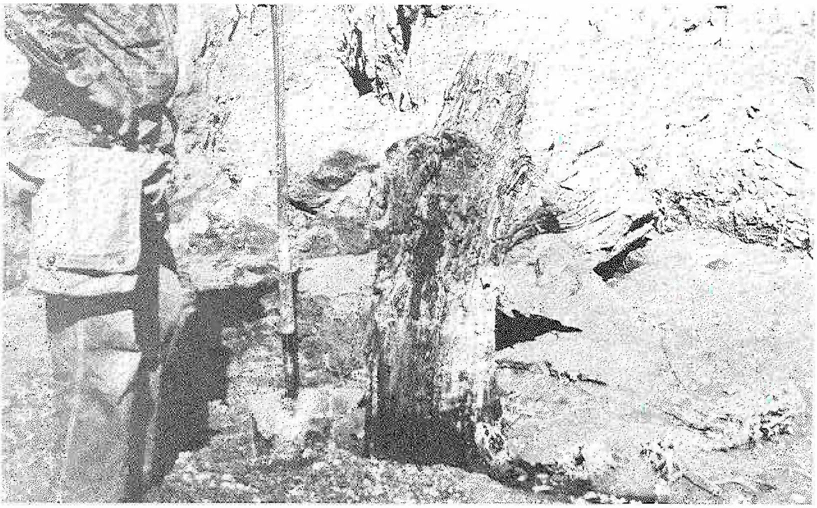


Figure 7. Fossil stump of cottonwood (Populus sp.) rooted in blue clay on north side of creek in SW¼ sec. 34, T. 5 N., R. 1 E. This and other stumps are remnants of trees living during stage D (fig. 11). The carbon-14 age of this stump was reported to be 625 ± 100 years B.P.

valley containing these deposits is mostly developed in sandstone of the Morrison Formation (Jurassic?). Only the upper portion and the rimrock of the valley are composed of sandstone and shale of the Dakota Formation (Cretaceous). Weathering of these rocks has produced most of the sand, silt, and clay found in the valley alluvium. In addition, some calcareous material in solution may have been derived from the Tertiary mantle of the High Plains and would have been the source of calcium for the caliche beds.

The rock valley was probably formed in late Tertiary or early Pleistocene time, based on an apparent absence of Tertiary sediments in the valley or igneous rocks from the nearby Black Mesa vulcanism.

The basal alluvium deposit in contact with bedrock is a blue to black blocky clay of lacustrine or slack-water fluvial origin. In numerous exposures it contains abundant snail and clam shells, and in several, a few caliche pebbles. The pebbles appear to have been transported. Elephant and bison bones also have been recovered from these clays. The greatest thickness of the basal clay observed was a 4-foot section near the location of figure 6 and another of the same thickness at the falls shown in figure 3. Undoubtedly the deposit was much thicker, especially in the lower part of the course, and was eroded before the laminated sediments overlying the clay were deposited. In several places the contact is undulating, which suggests an unconformity, but other exposures seem to indicate a transition from clay to silty sand.

The laminated sediments are generally buff colored and comprise a mixture of sand, silt, and clay; they are commonly well bedded, as the upper 3-4 feet show in figure 6. It is presumed that these sediments

Figure 8. Profile of filled tributary channel in NW¼ sec. 26, T. 5 N., R. 1 E., of stage D and illustrated as channel sections in stage F (fig. 11). The filled channel illustrated here appears to have extended in a direction away from the viewer and into a channel now filled but cropping out as a caliche bed, approximately 200 feet to the west; it is similar to a deposit in the west bank of the creek approximately 200 yards north (see fig. 9).

formed the high terrace illustrated in the stratigraphic section (fig. 10) and the remnant at the foot of the rock slope shown in figure 5. At no place was it possible to measure the total thickness of the high-terrace deposit, but an estimate of 36 feet was obtained by a hand-level traverse up a tributary valley in sec. 34, T. 5 N., R. 1 E. In the lower levels of the high terrace, in laminated silt and clay, snails are present in considerable quantity.

High-terrace laminated sediments are not exposed in some places because they have been eroded to the basal clay, as shown in figure 10, and subsequent valley fill has obscured them. Stumps were exposed in several places (fig. 7) but were partially covered with the more recent sand and clay shown in the figure 10 section. Only by searching a nearby tributary valley was it possible to observe the complete erosional relationship between deposits of the high and low terraces. Figure 8 illustrates a channel developed in the high terrace and filled by low-terrace sediments. In figure 6 the erosional contact between the well-bedded high-terrace sediments (below) and the poorly laminated low-terrace sediments (above) is shown. The contact represents a portion of the erosional surface upon which the trees grew and which is now represented by buried stumps in the channel.

The low-terrace deposits are also buff colored but are generally more silty and contain more clay than the high-terrace sediments. However, in some exposures small gravel deposits and lenses of coarse sand indicate floods or torrential events. Large bison-bone fragments are common, and one complete skull was collected from these beds.

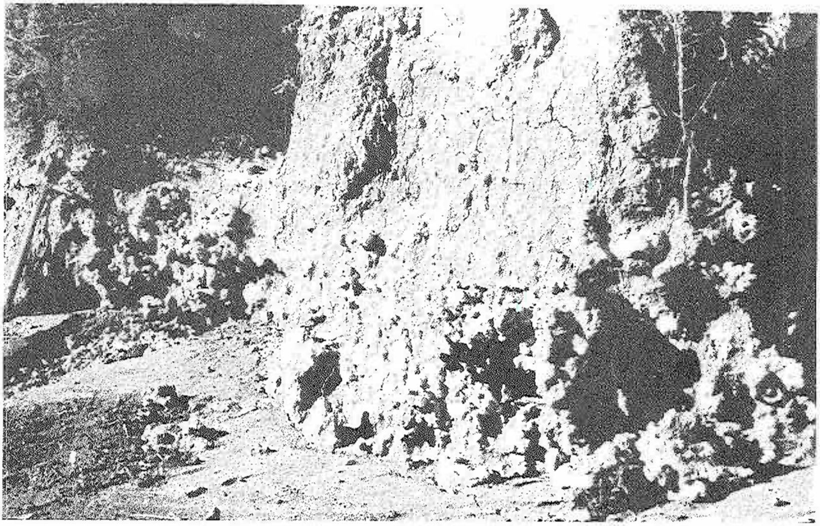


Figure 9. Caliche mortar bed cropping out at base of west bank of Tesesquite Creek in NC., sec. 26, T. 5 N., R. 1 E. The formation of this deposit is related to stage D and is covered by sediments of stage E (fig. 11).

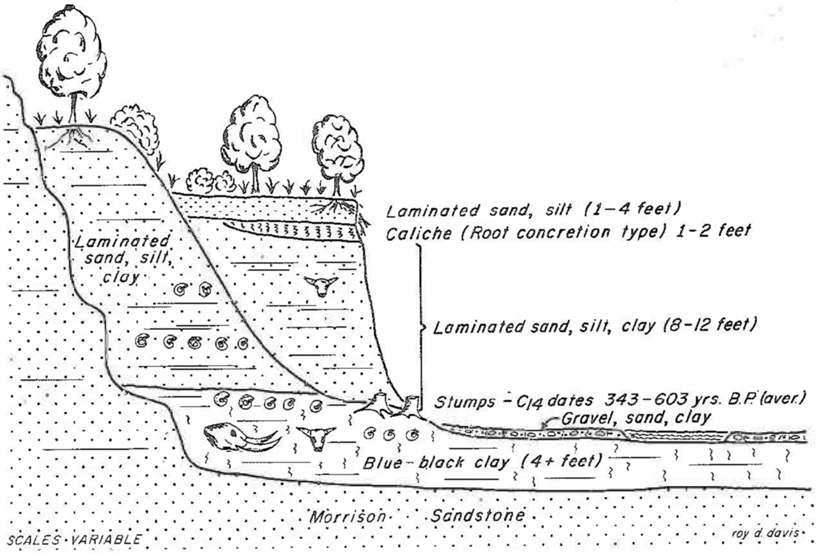


Figure 10. Stratigraphic section of Tesesquite Creek valley.

The low-terrace deposits contain several extensive caliche deposits, one of which is illustrated in figure 9. All caliche deposits of the type shown in this illustration appear to have been formed from root concretions of stream-inhabiting sedges, but the caliche outline of the sediment-filled channel shown in figure 8 appears to have another explanation. No evidence of megascopic plant relationship is evident, but the duff of the forest soil in the channel and on the then-exposed surface may have been responsible for the later precipitation of calcium carbonate as shown at this exposure.

The low terrace is capped erratically by laminated sand and silt deposits that do not appear to have uniform or wide distribution but which cover a weakly developed soil profile in many places. These deposits, illustrated in figures 6, 7, and 10, have not yet received enough study to offer a conclusive explanation. On one occasion in 1968, a torrential rainstorm that occurred during research on Tesesquite Creek offered evidence that suggests that such storms might have a bearing on the problem.

About 1 hour transpired from the beginning of the torrential rain through the rise of the water (slightly above the brim of the 15-foot vertical walls and 50-foot-wide channel) to a drop in flow near its normal state. An extensive sheet of sand, as much as 2½ feet thick, was deposited over parts of the channel course by this storm. From local ranchers, information has been obtained concerning other flash floods in which Tesesquite Creek overflowed its banks and deposited soils on the low terrace. The topmost sediments on the low terrace are problematic, as some were probably deposited before the present erosion cycle and others continue to accumulate during floods.

The sedimentary deposits exposed in Tesesquite Creek valley are the evidence for the following interpreted geomorphic history. Figure 11 illustrates 6 recognized stages in the valley development.

The rocks in which Tesesquite valley developed are Jurassic(?) and Cretaceous sandstones. Overlying these were Tertiary High Plains deposits; several miles to the west are the Black Mesa late Tertiary volcanic rocks. A cycle of erosion in the area apparently began after the Black Mesa volcanics were laid down. The Tertiary rocks, including much of the area about Black Mesa, were eroded and transported out of the region. The present rock valleys, including that of Tesesquite Creek, were apparently formed during late Tertiary or very early Pleistocene time (fig. 11A). The stream valley had reached geomorphic maturity before the exposed sediments were deposited, because the valley is much wider than it is deep and had a well-developed meander belt in its lower course.

The effects of the Pleistocene, or Glacial Period, in Oklahoma are mostly an unknown chapter, except that we know that the glaciers, which never reached the state, did overload some rivers when the ice was melting in the Rocky Mountains and draining to the sea. The Arkansas and Cimarron Rivers both were larger rivers at that time, as evidenced today by their wide valleys and high terraces. When the Cimarron River was functioning as a drainage channel during Pleistocene glaciation, the tributary valleys must have been impounded to the height of the water in the Cimarron River. Impounded water appears to have been the medium of deposition of the blue-black clay that floors much of the channel of Tesesquite Creek. The sediments may have originated locally as well as from the backwater of the Cimarron River. In the vicinity of sec. 26, T. 5 N., R. 1 E., the clay resembles a lacustrine deposit in many exposures, whereas higher up the channel there is evidence of less slack-water deposition. Abundant beds of snail and clam shells in the clay indicate aquatic deposition. Other fossils occurring in the clay are elephant bones and teeth and bison bones; they do not necessarily indicate a Pleistocene age for the deposit, because these fossils were transported to the depositional sites. No carbon-14 date has been secured from the basal clay deposit, but lithologically similar blue-black clays are widespread in Oklahoma channels associated with Pleistocene drainage. Two of these clays have been dated, on the basis of included organic materials, as 21,360 ± 1,250 years B.P. (Myers, 1965) and 11,200 ± 500 years B.P. (Leonhardy and Anderson, 1966). If the Tesesquite Creek deposit is of similar age, then it was associated with a late Wisconsin stage of glaciation as suggested in figure 11B.

The laminated sediments that formed at least a large portion of the high terrace appear to have been locally derived and deposited by a braided stream, as shown in figure 11C. There appears to have been little or no time break between the formation of the two deposits, but the sediment differences suggest that a shift in climatic conditions occurred.

Following deposition of the high-terrace sediments, an erosion cycle occurred that excavated a portion of the valley to the level of the blue-black clay and exposed bedrock in several areas along the sides. This cycle of erosion appears to have reached a stage of stability with a valley approximately 100 feet wide. In this valley a forest growth of willow (*Salix* sp.), cottonwood (*Populus* sp.), hackberry (*Celtis* sp.), juniper (*Juniperus* sp.), and possibly pine (*Pinus* sp.) established itself (fig. 11D). Tree stumps as much as 3 feet in dia-

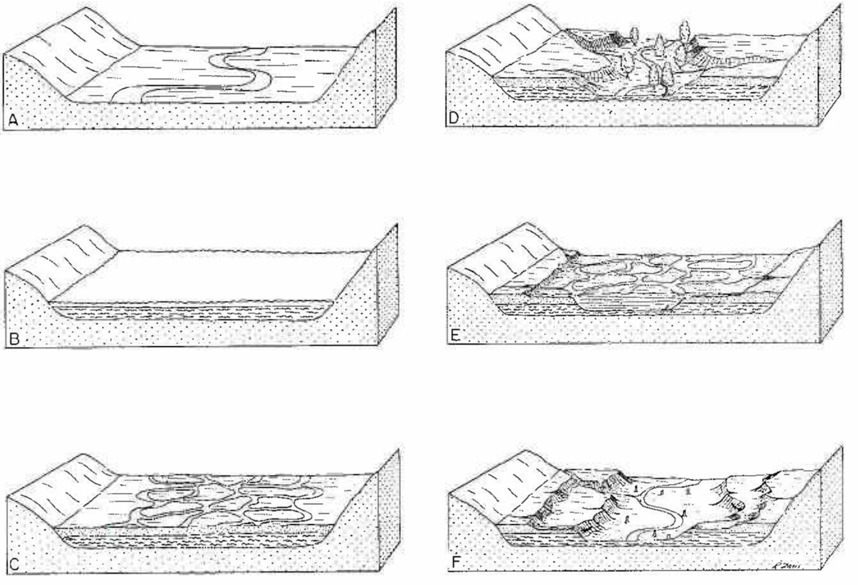


Figure 11. Geomorphic development of Tesesquite Creek valley.

- **A. Initial erosion of Tesesquite Creek valley in Jurassic(?) and Cretaceous sandstones, possibly in pre-Pleistocene time.**
- **B. Deposition of fluvial and lacustrine blue clays over valley floor, possibly in Wisconsin glacial time when Cimarron River was in flood stage and tributaries were impounded.**
- **C. Deposition of laminated sand, silt, and clay from upland subsequent to drainage of impounded valley.**
- **D. Erosion of valley deposits and establishment of a forest cover on blue clay. The average C^{14} age of buried wood from these trees is 474 ± 147 years B.P.**
- **E. Flooding of valley, cutting into high terrace, and deposition of sand, silt, clay, and caliche in channel and to foot of high terrace.**
- **F. Erosion of present channel since 1914 and exposure of blue clay, buried wood (stumps), laminated sediments, caliche beds, and tributary channel sections.**

meter have been excavated from the sediments that subsequently buried the forest. An attempt has been made to count the growth rings of the preserved wood, but a maximum of only 26 rings could be found. Most of the larger stumps are partially decayed, and growth rings are obscured. Carbon-14 determinations of the buried wood gave the following values: sample 1 (271 ± 180 and 526 ± 174 years B.P.), sample 2 (303 ± 150 and 467 ± 178 years B.P.), sample 3 (655 ± 100 years B.P.), and sample 4 (625 ± 100 years B.P.). The averages of extreme values are 327-621 years B.P. The low values of each of samples 1 and 2 may be due to some unknown factor; the later values of each appear to be more consistent. These carbon-14 dates indicate the time of valley flooding and extinction of the forest. They do not give an indication of the time of valley or forest duration. An estimate of several centuries may be made for the development of the valley forest, based on the size and distribution of the trees and on the thickness of a forest litter that was found on the blue clay near the area shown in figure 5. Enough time elapsed during the valley stage to permit tributary valleys to develop as portrayed in figure 11D.

In Tesesquite Creek or in adjacent marshy areas, caliche beds have formed around roots and stems of plants, as shown in figure 9. The caliche beds are numerous and are not all of the same age.

The valley stage came to a sudden end, as indicated by gravel and cobble deposits which overlie small prostrated trees (mostly juniper) in sec. 3, T. 5 N., R. 1 E. The valley-filling stage appears to have required a number of years because the sediments are not uniform and the flooding stream has cut into parts of the high terrace, as suggested in figure 11E. Caliche deposits also occur in these sediments, indicating some temporal stability of the channel necessary for their formation.

Although the present condition of Tesesquite Creek and its channel has been described, there is need to emphasize the rapid erosion that has occurred since 1964, when this study was begun. At that time most of the channel above the Kenton road was less than 100 feet wide. Today the channel has widened to 300 feet or more in several places, and in most other areas it has widened markedly. The channel has not been deepened, except locally, and some of those areas have been subsequently filled. Figure 11F is a representation of the present channel.

Considering the history of Tesesquite Creek in relation to other streams of the area, one can note a great similarity; but as yet no buried forest has been seen in any of the eroded channels of these other streams. The cause for a history such as this paper has outlined has been the subject of many published studies. Most of these studies describe older erosion cycles than that noted here but also discuss the present cycle and causes for the phenomena. The cyclic-erosion problem has been summarized by Miller and Wendorf (1958), who conclude that although the present accelerated erosion of the arid and semiarid portions of the western United States may be due to misuse of the land, these erosion features have exposed earlier erosion cycles such as those illustrated for Tesesquite Valley. Therefore, we must also look to causes other than man for their explanation.

Literature Cited

Leonhardy, F. C., and **Anderson, A. D.,** 1966, The archaeology of the Domebo site, *in* Domebo—A Paleo-Indian mammoth kill in the Prairie Plains: Lawton, Okla., Mus. Great Plains Contr., no. 1, p. 14-26.

Miller, J. P., and **Wendorf, Fred,** 1958, Alluvial chronology of the Tesuque Valley, New Mexico: Jour. Geology, v. 66, p. 177-194.

Myers, A. J., 1965, Late Wisconsinan date for the Bar M local fauna: Oklahoma Geology Notes, v. 25, p. 168-170.

Schoff, S. L., and **Stovall, J. W.,** 1943, Geology and ground water resources of Cimarron County, Oklahoma, with a section on Mesozoic stratigraphy: Oklahoma Geol. Survey Bull. 64, 317 p.

AESE Departure from Boulder Precedes Gridiron Defeat

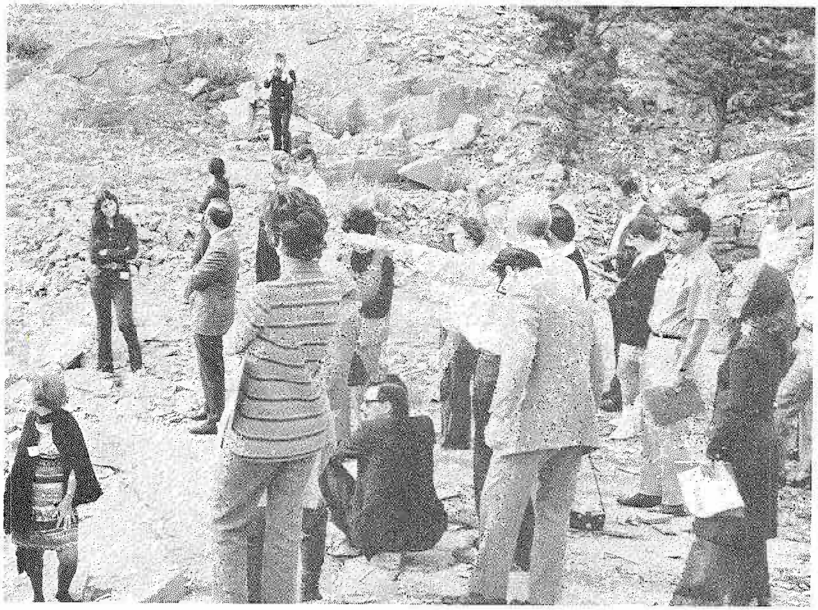
Earth science editors met in Boulder, Colorado, October 15-17 for their sixth annual conference, the first since the association became a member society of the American Geological Institute. Panel discussions on style manuals; new production techniques; format, design, and illustrations for producers and users; and microforms were all the more enjoyable for being held in The Geological Society of America's magnificent new home, overlooking the Rocky Mountains. But the close of the meeting preceded by just a few days an unexpected blow to OU's championship hopes in the form of a 20-14 defeat by the Colorado Buffaloes.

Breaks between sessions were spent admiring mineral and rock specimens that were donated to the GSA headquarters building and served to decorate the interior handsomely. Oklahomans were proud of the sand-barite roses contributed by the Oklahoma Geological Survey.

Program Chairman John Heller, chief of the Denver editorial section for the U.S. Geological Survey, did everything to make participants happy—short of guaranteeing Sooners in attendance that the football game scheduled the following weekend would be decided in their favor. OGS staff members seen prematurely sporting "OU #1" stickers at the meeting were William D. Rose, editor; Rosemary Kellner and Elizabeth Ham, associate and assistant editors, respectively; and Marion Clark, Dave Deering, and Sondra Underwood from the Survey's cartography section.

New AESE officers introduced at the Boulder meeting included Richard V. Dietrich, dean of the School of Arts and Sciences, Central Michigan University, chairman, and Mary R. Hill, geologic data officer for the California Division of Mines and Geology, vice-chairman. Fred Spilhaus, executive director of the American Geophysical Union, was selected to serve on the association's executive committee; Patricia Wood Dickerson (former OGS associate editor) continues to serve as secretary. OGS editors Bill Rose and Rosemary Kellner agreed to serve as editors this year for the association's newsletter.

After the close of the AESE conference, the Norman contingent spent a day touring USGS offices in Denver and discussing cooperative projects currently in progress between the USGS and the OGS.



This photo proves that editors don't spend all their time behind desks thinking up new ways to confound authors. On a field trip, Wally Hansen of the USGS, editor of the Bulletin of the Association of Engineering Geologists, **points out to AESE sixth conference participants salient features of the large-scale sets of cross-strata that characterize the Lyons Sandstone of Permian age in its classic exposures at the Sterling quarry near Lyons, Colorado.**

New Directory of Information on Biological Sciences Issued

A new, computer-based directory listing over 2,200 information resources in the biological sciences has been published by the Library of Congress. The volume, compiled by the National Referral Center of the library's Science and Technology Division with support from the National Science Foundation, completes the revision of the center's earlier directory. A separate volume issued last year updated the coverage of the physical sciences and engineering. Other directories in this series cover social sciences, water, the federal government, and general toxicology. The center also operates a free phone and mail referral service for information sources.

The new 577-page directory, entitled *A Directory of Information Resources in the United States: Biological Sciences,* may be purchased in paperback for $5.00 from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

Federal Studies of Earth Resources and Environment

Recent issues of the *AGI Report* (the weekly *Geotimes* newsletter) have included reports on the following studies made by federal agencies:

Publication of a series of digests of state water-quality standards by the Environmental Protection Agency. These will include water-quality criteria, stream-use designations, and a general overview of the states' water-quality implementation plan. Digests are now available for several states, and the one covering Oklahoma may be ordered from EPA, 1600 Patterson Street, Dallas, Texas 75201.
Revised state-by-state compilations of water-quality criteria approved under the national program for water-quality standards are also available. The address for ordering these is EPA, Public Inquiries Branch, Washington, D.C. 20460.

A joint study of the environmental effects of oil-shale development, to be administered by the Bureau of Land Management of the Interior Department and by Colorado's Department of Natural Resources, should be completed by the spring of 1974.

A staff review of 35 recent studies of energy demand has been released by the Committee on Interior and Insular Affairs of the U.S. House of Representatives. It concludes that the studies are of limited use because of incomplete information on future growth rates and consumption. This committee has also published a transcript of April hearings on fuel and energy resources: *Energy 'Demand' Studies: An Analysis and Appraisal* and *Fuel and Energy Resources, 1972*. Both are available from House Interior Committee, Washington, D.C. 20515.

Bureau of Mines Energy Program, 1971 (IC 8551) is a report of U.S. Bureau of Mines research on coal, oil, natural gas, and oil shale. It may be obtained from Bureau of Mines Publications Distribution Section, 4800 Forbes Avenue, Pittsburgh, Pennsylvania 15213.

Elements of a National Materials Policy (NMAB-294) is a report prepared by the National Academy of Sciences for the National Commission on Materials Policy. This study of resources concludes that what is needed is a new, viable materials policy that recognizes the need for control of per-capita consumption and population growth and predicts increasing regulation of the allocation and use of mineral resources. It may be ordered from National Materials Advisory Board, NAS, 2101 Constitution Avenue NW, Washington, D.C. 20418.

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Help Asked for Pennsylvania Geological Survey

John C. McCaslin, writing in the November 20 issue of the *Oil & Gas Journal,* has issued a timely reminder to the geological community that the Pennsylvania Geological Survey still needs publications to replace those lost in the flood that struck the survey's offices back in June and destroyed some 40,000 volumes and 200,000 maps.

Arthur A. Socolow, state geologist and director of the survey, has called for help in rebuilding the survey's library. He would appreciate donations of all types of geological publications and asks that prospective donors first send lists from which the publications needed can be chosen. Provision has been made for paying collect express charges on publications approved for shipment, and acknowledgments can be made for possible tax deductions.

Those wishing to contribute publications may send their lists to: Pennsylvania Geological Survey, Harrisburg, Pennsylvania 17120.

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