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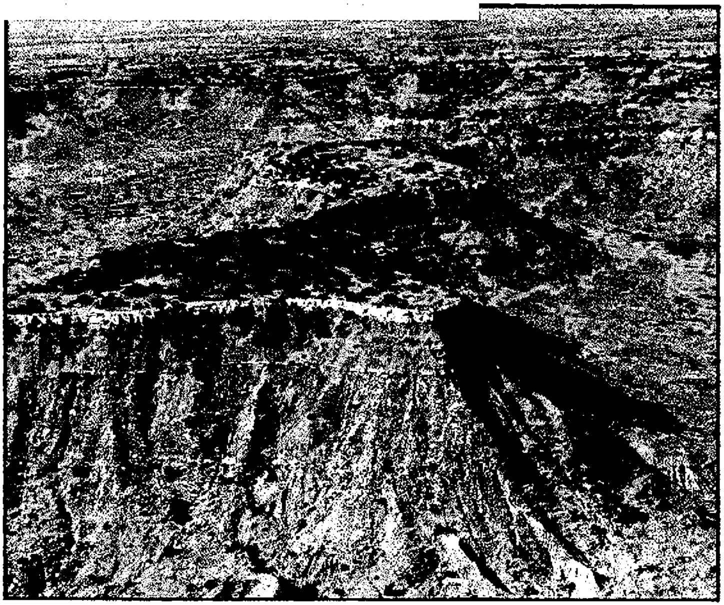

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Cover Picture

GYPSUM-CAPPED MESA IN SOUTHWESTERN OKLAHOMA

This aerial photograph shows flat-lying Permian gypsum and shale near Mangum, in southwestern Oklahoma. Twenty feet of massive white gypsum at the base of the Blaine Formation caps the escarpment, below which is 200 feet of underlying Flowerpot Shale. The caprock is named the Haystack Gypsum Bed, and it is the basal evaporite unit of the Blaine throughout western Oklahoma, western Kansas, and the Texas Panhandle. The Flowerpot here also contains several thin layers of gypsum or gypsiferous shale interbedded in a thick sequence of reddish-brown shales.

The Haystack Bed and other thick gypsum units of the Blaine Formation crop out extensively in western Oklahoma. Although gypsum is a soluble rock, the low average rainfall in the area (about 24 inches per year) enables the gypsum to stand out as resistant rock in comparison to the overlying and underlying shale formations.

The view is looking southwest in SE¼ sec. 10, T. 7 N., R. 23 W., Greer County.

—Kenneth S. Johnson

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

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THE TYPE SPECIES OF *Mortoniceras* AND THE HOLOTYPE SPECIMENS OF LOWER CRETACEOUS *Texigryphaea* OF THE SOUTHWESTERN UNITED STATES

ROBERT O. FAY[1]

Abstract—Three type specimens of fossils were collected in Choctaw County, Oklahoma, in the early 19th century. These are *Mortoniceras vespertinum* (Morton), *Gryphaea corrugata* Say, and *Texigryphaea pitcheri* (Morton). A search was made for the original specimens and for the original collecting localities. The name *Gryphaea corrugata* is here suppressed.

A key to species of Lower Cretaceous *Texigryphaea* is presented, with illustrations of each type specimen of each species.

HISTORICAL PERSPECTIVE

Of historical interest, three type specimens of fossils were collected from Lower Cretaceous rocks along the plains of the Kiamichi River in Choctaw County, southeastern Oklahoma. These fossils were named *Ammonites vespertinus* Morton, 1834, *Gryphaea corrugata* Say, 1823, and *Gryphaea pitcheri* Morton, 1834.

The type specimen of *Ammonites vespertinus* Morton was collected by a Dr. Zina Pitcher in 1833, from the "plains of Kiamesha," through which a road was being cleared from Fort Towson (now in Choctaw County) to Fort Smith, Arkansas Territory. Morton (1834, p. 40-41; pl. 17, fig. 1) described and figured the specimen. Meek (1876, p. 448) designated this species as the type species for *Mortoniceras*. Branson (1965) summarized the knowledge about this type specimen, concluding that the specimen was collected from the middle part of the Caddo Formation (=upper Duck Creek-lower Fort Worth Formations). The type specimen is on deposit at the museum of the Academy of Natural Sciences of Philadelphia, no. 4783, being designated as the holotype specimen of the type species of *Mortoniceras vespertinum* (Morton).

Thwaites (1906, p. 147) states that "Dr. Zina Pitcher (1797-1872) was a graduate (1822) of Middlebury College, Vermont. He entered the army (1822) as assistant surgeon, becoming surgeon with rank of major in 1832. In 1836 he resigned from the army, and began practice in Detroit, where he became a prominent citizen. In 1842 and 1844-47 he was mayor of the city, held the office of county (1843) and city physician (1848-1851), and served upon the board of health. Dr. Pitcher was interested in education and was one of the first regents of the University of Michigan (1837-1851), giving much time and thought to the establishment of that institution, especially its medical school."

[1]Geologist, Oklahoma Geological Survey.

The exact collecting locality for Pitcher's ammonite is not known, but the position of the Fort Smith-Fort Towson military road is known (see map of Choctaw County, fig. 1). The Fort Smith-Horse Prairie road was built in 1832 under direction of Captain John Stuart (Foreman, 1927). The position of the road is shown on an anonymous map of 1833 (now in the National Archives, Group 94). The road entered northern Choctaw County about 2 miles north of Nelson in sec. 1, T. 5 S., R. 15 E., following the ridge southeastward toward Hugo. The road branched several miles northwest of Hugo, with a south branch extending to Horse Prairie at the mouth of Horse Creek. An east branch extended to Fort Towson, crossing the Kiamichi River at Rock Chimney. This east branch was marked out in 1831 (Morrison, 1926, p. 333). On the 1833 map, this east branch is shown as a road east of the Kiamichi River and as a trail west of the river. Thus, it is probable that the soldiers were building the western section of this branch west of the river in 1833. The ammonite zone would have been crossed in two places: sec. 27, T. 5 S., R. 16 E., and sec. 14, T. 6 S., R. 17 E. The former location is along the road built in 1832, but the latter is along the part built in 1833, and it is here assumed that the latter location is the collecting locality for the ammonite. A well-used road extended south of Fort Towson to Towson Landing on the Red River, near the site of old Doaksville (spelled "Dokesville" on the 1833 map) and the site of old Fort Towson of 1824-29 (Morrison, 1930, p. 226-231; Wright, 1928, p. 108). This road also crossed the ammonite zone, but Pitcher did not mention this road; thus it is doubtful that this is Pitcher's collecting locality.

A second type specimen collected by Dr. Pitcher was an oyster named *Gryphaea pitcheri* Morton, 1834 (p. 55; pl. 15, fig. 9). Dr. Pitcher mentions the collecting locality in a letter of October 12, 1859, written to Capt. A. W. Whipple and quoted by Marcou (1889, p. 189-190):

> "The Kiamechia" is a small stream which empties into the Red river a few miles above [actually below] Fort Towson. My little fossil which has acquired so much consequence from the discussions into which it has been drawn by scientific names, was picked up on the plains drained by this little rivulet, through which our troops were marking out a road from Fort Smith to Fort Towson, in 1833. . . . I write this history to show that I have been a geological observer for a long series of years and to furnish a reason for my sending the fossils obtained on the march from Fort Gibson, *via* Fort Smith to Fort Towson, to my particular friend Dr. Morton.

As previously mentioned, the collecting locality of this specimen is probably the same as that of the type for *Mortoniceras* from sec. 14, T. 6 S., R. 17 E., Choctaw County. The type is on deposit at the museum of the Academy of Natural Sciences of Philadelphia, no. 14351, being designated as the holotype of the species *Texigryphaea pitcheri* (Morton). Stenzel (1959, p. 22) proposed the name *Texigryphaea* for a new subgenus of *Gryphaea,* raising the subgeneric rank to genus in 1971 (p. 1113) for species of *Gryphaea*-like oysters in the Cretaceous beds of southwestern North America.

A third type specimen is that of *Gryphaea corrugata* Say, 1823, collected by Thomas Nuttall in 1819. In Nuttall's published account (1821, p. 146-165), it is not clear where or from what formation the specimen was collected. On

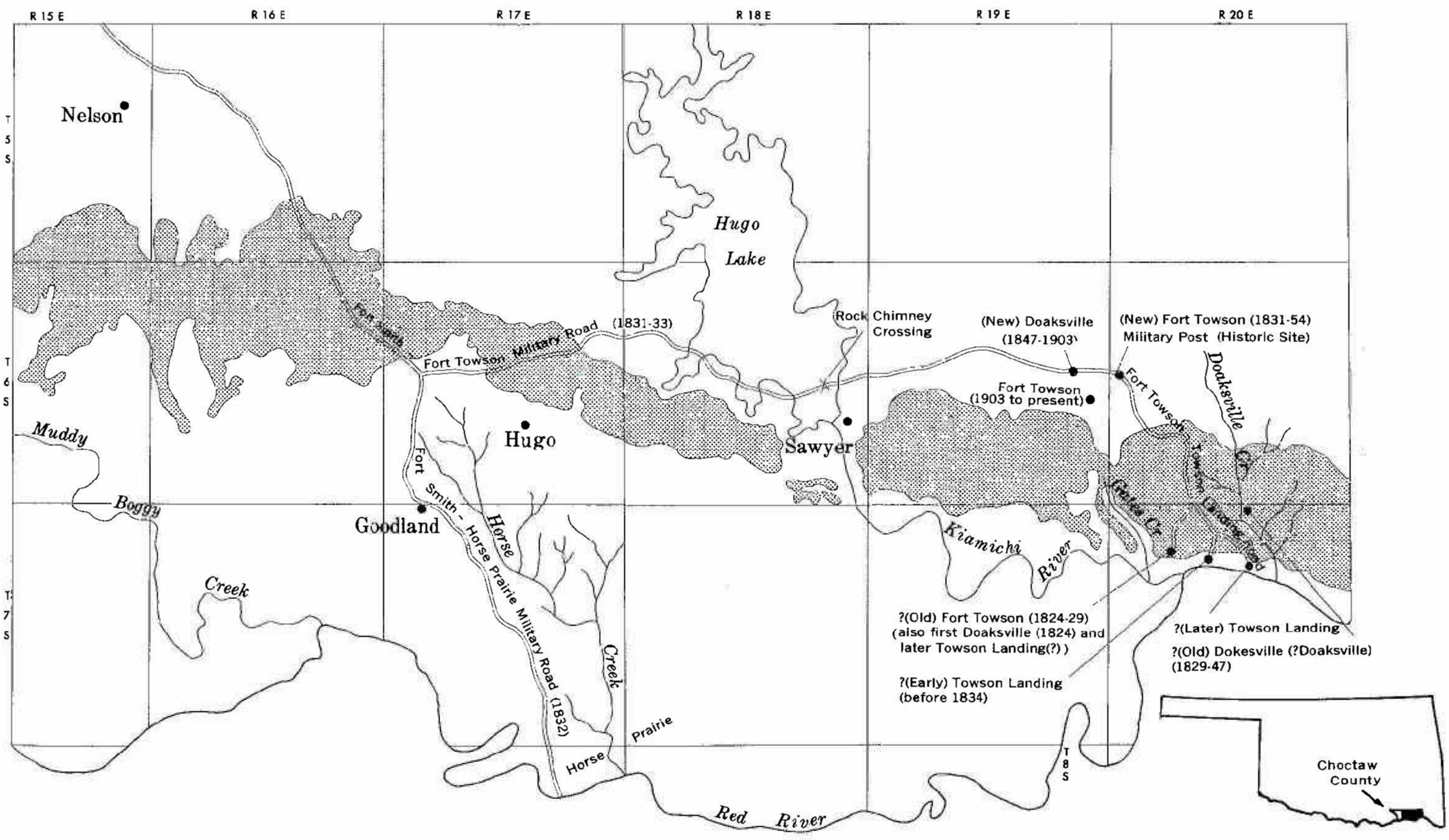

Figure 1. Outline map of the eastern two-thirds of Choctaw County, Oklahoma, showing early overland routes and settlements. Outcrop of Caddo Formation (= Duck Creek-Fort Worth Formations) of Early Cretaceous age shown by shaded pattern; generalized from Huffman and others (1975,

May 22, 1819, Nuttall arrived from the north at the house of a Mr. Styles, on the margin of the prairie just out of the timber, west of Gates Creek and about 6 miles north of the Red River, which would be near or just west of present-day Fort Towson. Nuttall stated (p. 152):

After breakfast we continued our route, parallel with Red river, over an extensive prairie to the confluence of the Kiamesha. . . .

[P. 154:] The change of soil in the great Prairie of Red river now appeared obvious. It was here that I saw the first calcareous rock charged with shells. . . . After passing through a swamp, we crossed the Kiamesha in boats, and swam our horses. Five or six miles from Styles's we, at length, obtained sight of Red river. . . .

[May 24.] To day we continued to the Horse-prairie [present-day mouth of Horse Creek in sec. 1, T. 8 S., R. 17 E.] 15 miles above the mouth of the Kiamesha. In our way we proceeded for about three miles through the fertile alluvion of Red river to Mr. Varner's, where we breakfasted, and at length arriving at our destination on the banks of Red river, we remained there the whole of the following day. . . .

[P. 155:] [May 26.] To-day we prepared to return by the route which we had come. . . . I delayed about two hours behind the party [referring to Major Bradford] . . . no less than seven miles below Mr. Styles's. . . . By pursuing a new path which now opened, I had the good fortune to arrive at the [p. 156:] house of Mr. Davis, contiguous to Gates's creek, which I had crossed. Here I was kindly requested to remain for the night. . . .

[May 27.] I offered one of Mr. Styles's sons two dollars to accompany me for a few hours . . . to overtake them. . . .

[P. 157:] The soil appears to be universally calcareous, with the limestone nearly white and full of shells, among which there was abundance of a small species of gryphite, and in the more compact beds some species of terebratulites [commenting on the general features of the region toward Little Rock]. This calcareous rock, different from the mountain limestone, often contains uncemented or loose shells immersed in beds of friable clay. . . . Along the further edge of the prairie, relative to Red river, there were, in the distance of 10 miles, five or six families settled. . . .

[June 1-5.] I still remained at the house of Mr. Styles, without any very obvious prospect of regaining fort Smith. On the 4th I walked over the adjoining prairie to a more considerable hill than any which I had yet visited, near Red river. Its northwestern declivity was thinly wooded; here I found the limestone more compact than usual, containing also smaller shells, but still presenting scarcely any perceptible dip. The summit was scattered with coarse quartzy and petrosiliceous pebbles, originating from the disintegration of a ferruginous conglomerate, of which large masses still lay on the surface compact. . . .

[P. 159:] On the 8th I went down to the Red river settlement. . . . In our way to this settlement we crossed Gates's and Lemon's [now Doaksville] creek and another smaller brook. . . . Along the borders of this part of Red river a chain of low hills appears, on which I observed large dislocated masses of a ferruginous conglomerate, inclined towards the river, and incumbent on the usual calcareous rock. . . .

[P. 162:] [June 16.] All the rock we saw since our departure from Mr. Styles', consisted of a fine-grained sandstone, with no inconsiderable dip, and, as far as visible, destitute of organic remains.

The type specimen was given to Thomas Say for description in 1823 (p. 410-411). The description is inadequate, the specimen was not figured, and the type has been lost. Hill and Vaughan (1898, p. 33-34, 57) collected many specimens from the Kiamichi Shale north of Goodland, thinking that this was Nuttall's collecting locality, in an attempt to erect new type specimens. Clearly, Nuttall was not near this locality, and thus the name *Gryphaea corrugata* Say is here suppressed, being a *nomen nudum*.

KEY TO SPECIES OF *Texigryphaea*

In order to understand the valid names for the various species of *Texigryphaea* from the Lower Cretaceous beds, each type for each species was studied. New collections were made from the Kiowa, Goodland, Kiamichi, Duck Creek, Fort Worth, Denton, and Grayson formations of Oklahoma and from the Tucumcari Shale on Mount Tucumcari, New Mexico. The following brief key to species, with illustrations, is presented as a result of this study.

Phylum Mollusca (Aristotle)
 Class Bivalvia Linné, 1758
  Subclass Pteriomorphia Beurlen, 1944
   Order Pterioida Newell, 1965
    Suborder Ostreina Férussac, 1822
     Superfamily Ostreacea Rafinesque, 1815
      Family Gryphaeidae Vyalov, 1936
       Subfamily Pycnodonteinae Stenzel, 1959, p. 16
        Genus *Texigryphaea* Stenzel, 1959, p. 22

Stenzel (1959, p. 19-29; 1971, p. 1113-1114) discusses the various characteristics of gryphaeas, showing how *Texigryphaea* differs from true *Gryphaea*. Figure 2 illustrates the terminology used for descriptions of species of *Texigryphaea*. Essentially, specimens of *Texigryphaea* have a vesicular shell structure, straight anachomata or tubercles on the periphery of the inner surface of the right valve, a deep radial posterior sulcus, a well-detached posterior flange, a well-defined commissural shelf, and an umbonal region inclined posteriorly with the beak mostly opisthogyral. The growth curvature of the left valve of gryphaeas is that of a logarithmic spiral. The range of *Texigryphaea* is Lower Cretaceous to Upper Cretaceous, from Mexico to the southwestern United States. The type species of *Texigryphaea* is *T. roemeri* (Marcou, 1862, footnote on p. 95). Some confusion existed until 1959 regarding the correct name for this species.

Dr. H. B. Stenzel (Louisiana State University, written communication, 1975) recently provided the information contained in the following two paragraphs.

"Hill and Vaughan had thought that *Texigryphaea mucronata* (Gabb, 1869) was the same as the *Texigryphaea* species that is prolifically abundant in the Del Rio Clay (or Grayson Clay) of Texas. Gabb's original material, however, was collected near Arivechi, northern Mexico, in beds that contain a Fredericksburg fauna, including ammonites. Thus it is impossible that the *T. mucronata* corresponds to the Del Rio *Texigryphaea* of Texas, because the respective strata differ so much in age. The late W. S. Adkins (of Austin, Texas) was the first to recognize this fact. After Stanton's death, the manuscript he left behind was turned over to Ralph W. Imlay (U.S. Geological Survey, Washington, D.C.) to improve and to make ready for publication (Stanton, 1947). Imlay came to Austin to inspect the collections of Cretaceous fossils which were at the Bureau of Economic Geology under the care of H. B.

Stenzel and to consult with Stenzel himself. Stenzel told Imlay about Adkins' conclusion, and Imlay made the necessary changes in Stanton's manuscript, inserting the new name *graysonana* for the *Texigryphaea* from the Del Rio Clay.

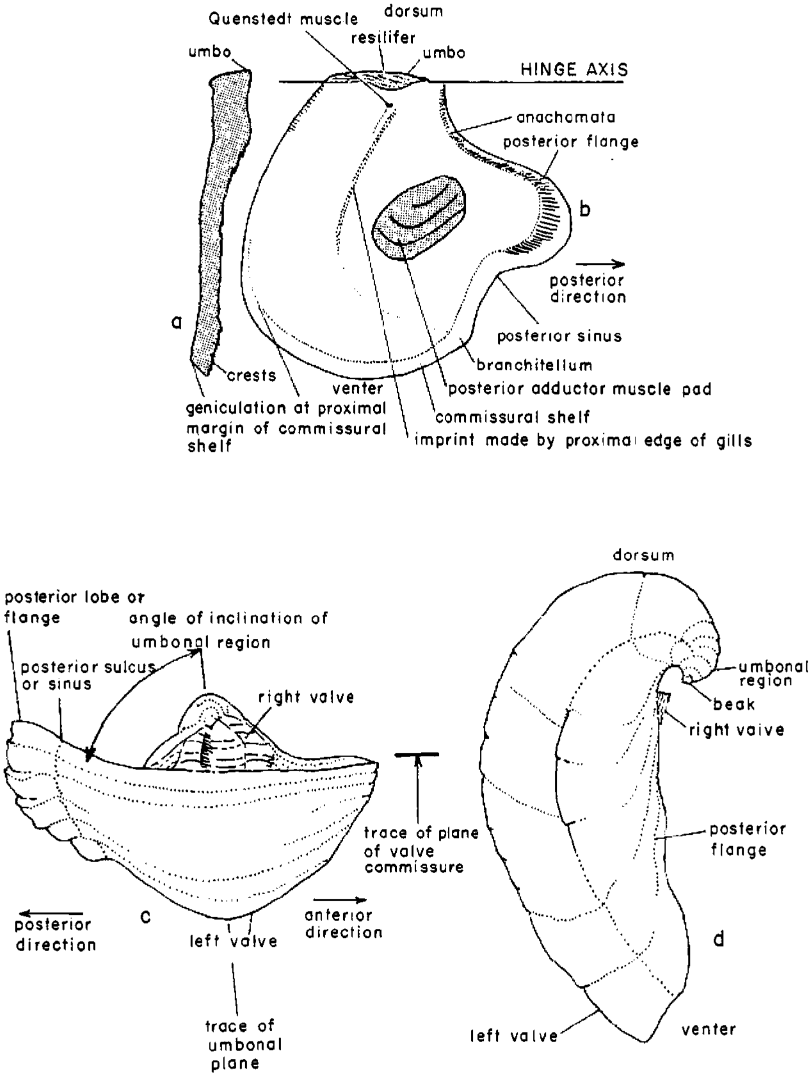

Figure 2. Terminology of *Texigryphaea* (after Stenzel, 1959, p. 23, 25, 27; 1971, p. 965, 1113): *a*, cross section of right valve; *b*, interior view of right valve; *c*, ventral view; *d*, posterior view.

"However, Adkins through his enormously detailed knowledge of the literature pertaining to the Cretaceous of Texas was familiar with the obscure footnote in which Marcou (1862) had proposed a new name for a *Texigryphaea* which Roemer had collected from the Del Rio Clay near the Waco Indian camp near Waco Springs and which Roemer had misidentified and figured. This name (*Gryphaea roemeri* Marcou, 1862) had escaped notice by Imlay. However, this was pointed out to Stenzel by Adkins, and Stenzel adopted the name for the Del Rio species because the name had valid priority of publication. In short, Adkins deserves credit for furnishing all data necessary to straighten out the name of the species, misunderstood by so many scientists."

Key to Lower Cretaceous species of ***Texigryphaea:***

A. Anterior flange well developed:

T. washitaensis (Hill and Vaughan, 1898). Duck Creek Formation to Denton Clay; Tucumcari Shale (figs. 3-4).

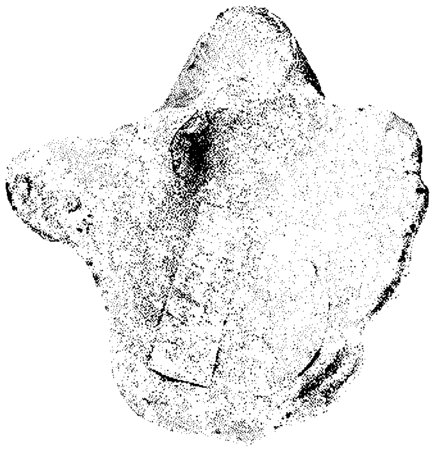

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Figure 3. *Texigryphaea washitaensis* (Hill and Vaughan, 1898). Lectotype, 209983 U.S. National Museum, from Duck Creek Formation, 2 miles north of Denison, Texas (same as Hill and Vaughan, 1898, pl. 19, fig. 4). Inner view of left valve, ×1.5.

Figure 4. Same as figure 3. Outer view of left valve, ×1.44.

B. Anterior flange not well developed.
1. Beak of left valve prominently raised above right valve.
a. Posterior flange more toward center, if well developed, and more sharply defined:
T. mucronata (Gabb, 1869)[=*T. marcoui* (Hill and Vaughan, 1898)]. Potrero Formation, Walnut Clay, Goodland Limestone (figs. 5-8).

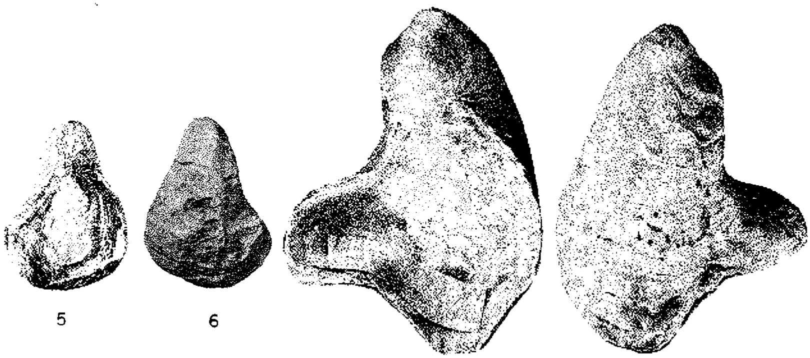

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Figure 5. *Texigryphaea mucronata* (Gabb, 1869). Lectotype, one of four old syntypes, 4773-A Academy of Natural Sciences of Philadelphia, from Potrero Formation, Sierra de las Conchas, near Arivechi, Sonora, Mexico (from Stanton, 1947, pl. 18, fig. 2). Inner view of left valve, ×0.75.

Figure 6. Same as figure 5. Outer view of left valve, ×0.75 (from Stanton, 1947, pl. 18, fig. 1).

Figure 7. *Texigryphaea mucronata* (Gabb, 1869). Lectotype of *Texigryphaea marcoui* (Hill and Vaughan, 1898), 209984 U.S. National Museum, from ?Walnut Clay, on Bee Caves Road, 9 miles west of Austin, Texas (same as Hill and Vaughan, 1898, pl. 4, fig. 1). Inner view of left valve, ×1.2.

Figure 8. Same as figure 7. Outer view of left valve, ×1.13.

b. Posterior flange more toward ventral margin, if well developed, and rounded:
T. roemeri (Marcou, 1862)[=*T. graysonana* (Stanton, 1947)]. Grayson Clay or Del Rio Clay to lower Buda Limestone (figs. 9-12).

2. Beak of left valve not prominently raised above right valve.
a. Beak prominently curved laterally.
a'. Posterior margin extended laterally, giving a subtriangular outline to shell:
T. navia (Hall, 1856)[=*T. forniculata* (White, 1880)]. Kiowa Formation, Kiamichi Formation, lower Duck Creek Formation (figs. 13-14).

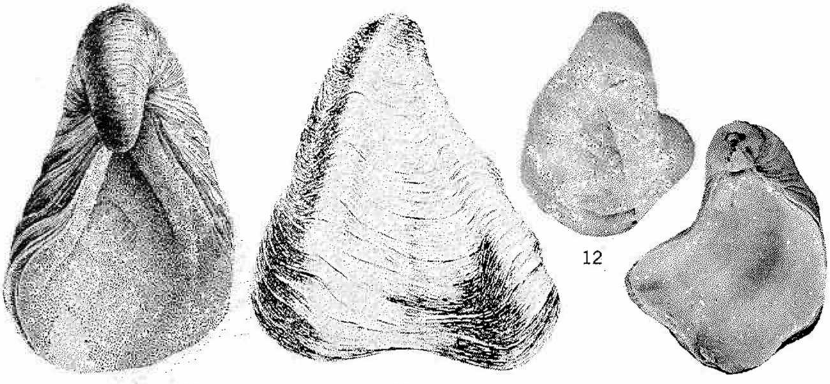

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Figure 9. *Texigryphaea roemeri* (Marcou, 1862). Syntype, 135a Geologisch-Palaeontologische Institut der Universität Bonn, from Grayson Clay or Del Rio Clay, 6 miles NNW. of New Braunfels, Texas, below Hueco (Waco) Springs along or near Guadalupe River (same as Roemer, 1852, pl. 9, fig. 1b). Inner view of left valve, ×0.75.

Figure 10. Same as figure 9, only a different specimen. Syntype, 135b (same as Roemer, 1852, pl. 9, fig. 1c). Outer view of left valve, ×0.75.

Figure 11. *Texigryphaea roemeri* (Marcou, 1862). One of the syntypes (now new lectotype) of *Texigryphaea graysonana* (Stanton, 1947), 209985 U.S. National Museum, from Del Rio Clay, Shoal Creek, near Linders Spring, Travis County, Texas (same as Stanton, 1947, pl. 25, fig. 4). Inner view of left valve, ×1.28.

Figure 12. Same as figure 11. Outer view of left valve, ×1.2.

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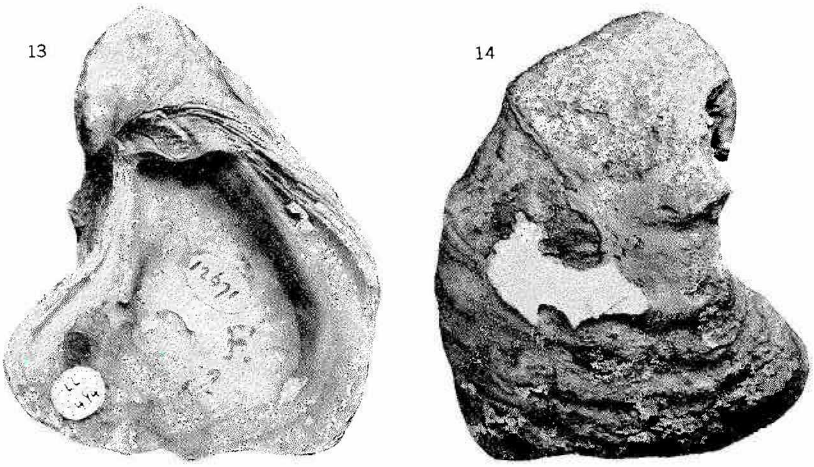

Figure 13. *Texigryphaea navia* (Hall, 1856). Syntype, LL1494 (previously 12671) British Museum of Natural History, London, from Kiowa Formation, SE¼ sec. 34, T. 13 N., R. 18 W., Custer County, Oklahoma (same as Hall, 1856, pl. 1, fig. 7). Inner view of left valve, ×0.91.

Figure 14. Same as figure 13. Outer view of left valve, ×0.91.

b′. Posterior margin more rounded:
T. belviderensis (Hill and Vaughan, 1898). Upper Kiowa Formation (figs. 15-16).

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Figure 15. *Texigryphaea belviderensis* (Hill and Vaughan, 1898). One of the syntypes (now new lectotype), 209986 U.S. National Museum, from upper part of Kiowa Formation, Hell's Half Acre area of Black Hills, about 6 miles west of Sun City, northeastern Comanche County, Kansas (same as Hill and Vaughan, 1898, pl. 9, fig. 2). Inner view of left valve, ×0.9.

Figure 16. Same as figure 15. Outer view of left valve, ×0.9.

c′. Posterior lobe prominent:
T. hilli (Cragin, 1891). Lower Kiowa Formation (figs. 17-18).

b. Beak not prominently curved laterally.
a′. Posterior lobe prominent:
T. pitcheri (Morton, 1834)[=*T. gibberosa* (Cragin, 1893)].
Duck Creek to Fort Worth Formations (figs. 19-22).

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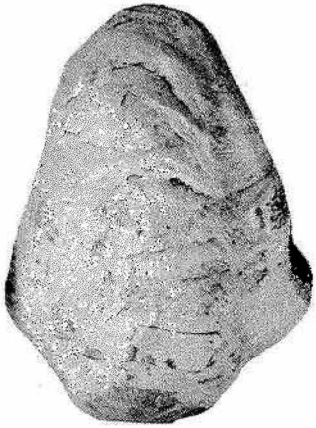

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Figure 17. *Texigryphaea hilli* (Cragin, 1891). Neotype (one of the plesiotypes of old no. 103187c), 209987 U.S. National Museum, from Champion Shell Bed at base of Kiowa Formation, about 1 mile south of Belvidere, south side of Medicine Lodge River, Kiowa County, Kansas (same as Stanton, 1947, pl. 17, figs. 6, 8, 9). Upper view of left valve, with right valve in place, ×1.6.

Figure 18. Same as figure 17. Outer view of left valve, ×1.5.

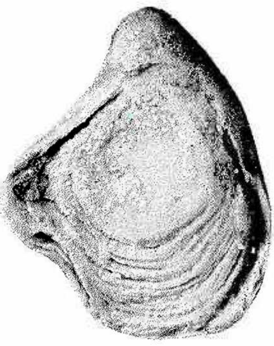

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Figure 19. *Texigryphaea pitcheri* (Morton, 1834). Holotype, 14351 Academy of Natural Sciences of Philadelphia, from middle part of Caddo Formation, sec. 14, T. 6 S., R. 17 E., Choctaw County, Oklahoma (same as Morton, 1834, pl. 15, fig. 9). Upper view of left valve, with right valve in place, ×1.8.

Figure 20. Same as figure 19. Outer view of left valve, ×1.8.

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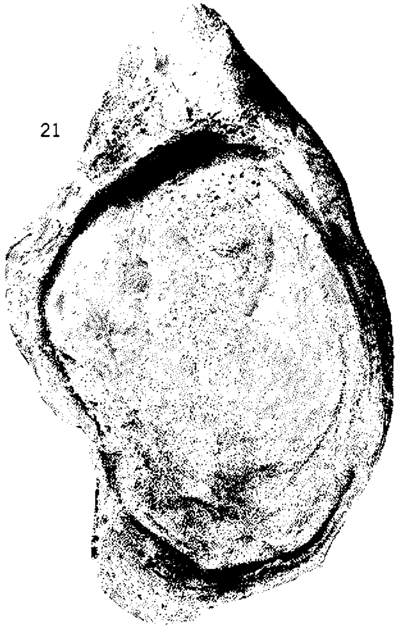

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Figure 21. *Texigryphaea pitcheri* (Morton, 1834). Lectotype of *Texigryphaea gibberosa* (Cragin, 1893), old no. 17256 The University of Texas, from base of Georgetown Limestone (lower Duck Creek), Round Rock, Williamson County, about 15 miles north of Austin, Texas (same as Cragin, 1893, pl. 33, fig. 4). Upper view of left valve, with right valve in place, ×0.7.

Figure 22. Same as figure 21. Outer view of left valve, ×0.6.

b′. Posterior lobe not prominent:
T. tucumcarii (Marcou, 1855). Tucumcari Shale (figs. 23-24).

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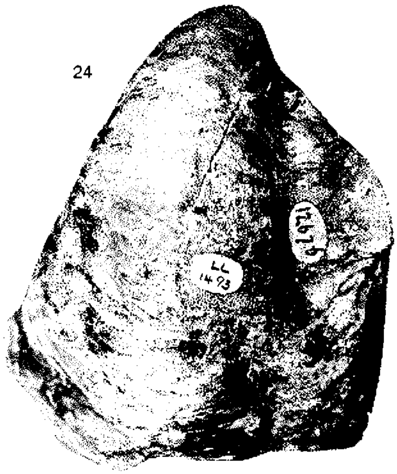

Figure 24. Same as figure 23. Outer view of left valve, ×0.7.

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Dr. H. B. Stenzel of Louisiana State University kindly reviewed the manuscript and made valuable suggestions for its improvement.

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Figure 23. *Texigryphaea tucumcarii* (Marcou, 1855). Holotype, LL1493 (previously 12676) British Museum of Natural History, London, from Tucumcari Shale, Mount Tucumcari (Pyramid Mountain), south of Tucumcari, New Mexico (same as Marcou, 1855, pl. 21, fig. 3). Inner view of left valve, ×0.64.

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International Geothermal Symposium Set Up for San Francisco

The Second United Nations Geothermal Symposium will be held in San Francisco, California, May 20-29. The symposium is being organized by the United Nations Secretariat in cooperation with the U.S. Department of the Interior, the National Science Foundation, the U.S. Energy Research and Development Administration (which supersedes the Atomic Energy Commission), the State of California Resources Agency, and the University of California. In addition, the Geothermal Resources Council, The American Association of Petroleum Geologists, and public and private development corporations are providing assistance.

Organizers of the conference expect about 1,200 scientists, engineers, and industry personnel from 50 countries to participate in the symposium. Participants will attend in their personal capacities and not as formal representatives of governments. Simultaneous interpretation into English, French, and Spanish has been arranged for the technical sessions. Abstracts of papers accepted for the program will be translated into these languages and will be available at the symposium. Papers accepted for publication in the proceedings volume will be printed in the language (English, French, or Spanish) in which they were submitted.

Papers were invited on all aspects of the development and use of geothermal resources. Approximately 300 papers will be accepted for publication in the volume of abstracts from the meeting and in the symposium proceedings. Only 70 papers will be chosen for oral presentation. A directory will be published listing names and addresses of all those who attend the symposium plus other interested persons. Individuals who wish to be included in the directory even though they are not attending the symposium can apply for inclusion by writing to United Nations Geothermal Symposium, P.O. Box 7798, San Francisco, California 94120. The same address should be used for anyone desiring to order copies of the abstract volume.

OU Centers Cooperate to Provide Energy Data

The Federal Energy Agency (FEA) has awarded $248,900 to the Center for Economic and Management Research (CEMR) of the College of Business Administration at The University of Oklahoma. The grant will be used to study petroleum and natural-gas production, costs, and prices at the field level, and in the process the Center will develop a data base on oil and gas production at the field level.

CEMR will utilize data capabilities of the Oil Information Center (OIC) on OU's north campus to provide geological and geophysical information and to assist with data acquisition. The computerized data base developed by OIC uses the Generalized Information Processing System (GIPSY) developed at OU, and the data base is in the process of making available all public information on oil and gas fields in the United States. The program began in 1969, when the U.S. Geological Survey contracted development of its Petroleum Data System to OIC. The system uses hardware and software compatible with CRIB (Computerized Resources Information Bank), the USGS system for all mineral-resource information. More than 65,000 oil- and gas-pool records, plus a separate file of well records, are included. Information in the file consists of the official name of the field or pool and its location by county, size, cumulative and annual production, geologic occurrence, type of entrapment, age of reservoir, engineering data, temperature, pressure, petrophysics, and analysis of crude oil, brine, and natural gas. The file does not contain all information on every field or pool but does include information on all for which data are available from nonproprietary sources.

Data gathered by CEMR will provide a means for monitoring price activities in interstate and intrastate markets and identifying prices in several small geographic areas. When these are combined with the physical characteristic of specific producing fields that can be provided by the Oil Information Center, these data will provide a new approach for analyzing market prices and production costs.

Monthly information on petroleum and natural-gas production by field, for state and public lands now classified as producers, will be included. Wellhead prices of various grades and qualities of crude oil and natural gas will be compiled each month for the same period covered by production data, and the CEMR will be able to evaluate from a smaller perspective the effect of two-tiered oil pricing on production provided by separate price structures for *old* and *new* oil.

The energy-research activities at OU are now focused primarily on domestic energy-policy issues. However, because of the interrelationship of international petroleum prices and domestic exploration, the research program is developing an interrelated international component as well.

Taking a long-range view of the possibilities and implications of the University's attempts to provide sound information to industry and government officials about our domestic energy supplies, OU President Paul Sharp expressed hope that the grant provided by the Federal Energy

Agency would give "OU the opportunity to use its expertise in attempting to solve some of the energy problems which face our world today."

Oklahoma Coal Versus Wyoming Coal

Oklahoma Gas and Electric Company (OG&E) plans to burn approximately 3.6 million short tons of low-sulfur coal annually at its new Muskogee generating station. The company plans to ship subbituminous coal 1,200 miles by train from strip mines to be developed near Gillette, Wyoming. Unit trains (consisting of coal-hopper cars only) will carry 10,000 tons of coal daily to the Muskogee plant. Public Service Company of Tulsa has just announced plans for a similar coal-burning electricity-generating plant at Oologah, Oklahoma, and this company also plans to use Wyoming coal, so this is not an isolated case.

Why transport Wyoming coal to Oklahoma? Not because Oklahoma has no low-sulfur coal, and not because 3, or even 6, million tons annually cannot be mined in Oklahoma. The Oklahoma Geological Survey's report, *Investigation of the Coal Reserves in the Ozarks Section of Oklahoma and Their Potential Uses* (Friedman, 1974), revealed that our State contains 7.2 billion tons of remaining bituminous coal resources. About one-half of this amount is considered recoverable, and the average sulfur content is approximately 2.2 percent. However, OG&E plans for delivery of the subbituminous coal from Wyoming to begin in 2 years. The company needed a commitment from the coal-mining industry about 3 years ago in order to plan for future expansion. Oklahoma's coal industry was not large enough to make this commitment, and the State's coal resources were not identified and delineated adequately at that time. In addition, most of our State's low-sulfur bituminous coal is suitable for coke manufacture and metallurgical use. It is premium coal that currently sells for $20-$50 per ton f.o.b. It is understood that the price of Wyoming coal, on delivery to Muskogee, will probably be under $15 per ton.

As a further comparison, in 1974 Peabody Coal Company, Bill's Coal Company, Leon's Coal Company, and Sierra Coal Corporation combined to produce approximately 1.5 million short tons of *high-sulfur bituminous* coal in Craig, Muskogee, Nowata, and Rogers Counties, Oklahoma. They shipped this coal by rail and truck to electricity-generating plants in Missouri and Iowa (where the companies received approximately $18 a ton after delivery), because these states permit utilities to use high-sulfur coal. At present, environmental regulations in Oklahoma prohibit utilities from using high-sulfur coal.

Thus, simple economics plus environmental regulations have compelled OG&E to import coal from Wyoming rather than using Oklahoma coal for their new plant at Muskogee. Oklahoma coal companies can make more money by selling their low-sulfur coal for specialized purposes or by transporting high-sulfur coal to other states.

—*S. A. Friedman*

Two Energy-Related Publications Begin Operation

The following item was kindly called to our attention by Kathleen Salzberg, Arctic and Alpine Research, Boulder, Colorado:

Environment Energy Contents Monthly, a new monthly periodical, promises to be of interest to persons in energy and environmental work. The publication presents tables of contents from over 400 American and overseas scientific and professional journals that include articles and papers on environment, ecology, and energy, all in original format. The cost of a 1-year subscription to the periodical, which begins publication in April, is $16.00. Additional information is available from Environment Energy Institute, P.O. Box 1450, Portland, Oregon 97207.

The second item was spotted in the *AESE Blueline,* the quarterly newsletter of the Association of Earth Science Editors. It appeared originally in the July-August 1974 issue of *Information (published by Science Associates International).*

Energy Abstracts, a monthly information publication from Engineering Index, Inc., is the first publication of its kind in the United States to deal exclusively with energy-related information. Produced by EI's existing information system, *Energy Abstracts* uses computerized publishing techniques to isolate items specifically related to energy in five predetermined categories. The categories, also available in individual published subsets, are (1) energy sources; (2) energy production, transmission, and distribution; (3) energy utilization; (4) energy conservation; and (5) energy conversion. All indexing and abstracting appears in English, regardless of the source of the original material. The publication is available as complete coverage (9 issues, $181.50) or classified and arranged separately in the above-listed subsets. The complete package can also be obtained in computer-processable magnetic-tape format. For further information, contact John H. Veyette, Jr., Engineering Index, Inc., 345 East 47th Street, New York, New York 10017.

Bureau of Mines Issues Mineral Summaries

A new publication, entitled *Commodity Data Summaries, 1975,* was issued recently by the U.S. Bureau of Mines. The 193-page report summarizes 1974 mineral-industry data, listing mineral commodities from A to Z (i.e., aluminum to zirconium). Furnished is "information on the domestic-industry structure, government programs, tariffs, and salient statistics for 95 individual minerals, metals, and fuels" (from explanation on title page). World-resource data have been provided by the U.S. Geological Survey.

The book is available without charge from the Branch of Publications Distribution, U.S. Bureau of Mines, 4800 Forbes Avenue, Pittsburgh, Pennsylvania 15213.

Dean McGee Honored by AAPG

Dean A. McGee has been awarded the Sidney Powers Memorial Medal, the highest honor bestowed by The American Association of Petroleum Geologists. The medal was presented at AAPG's 60th annual convention (held April 7-9 in Dallas) in recognition of his service to the organization. He has served as chairman of the board of trustees of the AAPG Foundation since 1967; he has been awarded Honorary Membership in AAPG, and he received the association's Public Service Award last year.

The chairman of the board and chief executive officer of Kerr-McGee, Dean McGee has been active in public relations for the petroleum industry for a number of years, and he has devoted a great deal of his time to public service. OU students, faculty members, and staff, in addition to the general public, were able to hear Mr. McGee's analysis of the energy situation last year when he appeared at The University of Oklahoma as part of the energy-lecture series.

Handbook of Oil-Industry Terms Now Available

The book division of Petroleum Publishing Company, publisher of the *Oil and Gas Journal,* has recently issued *Handbook of Oil Industry Terms and Phrases,* by R. D. Langenkamp of Gulf Oil Corporation.

Referenced in the volume are some 2,100 historic and new terms used throughout the petroleum industry, covering such major divisions as exploration, production, pipelining, refining, and petrochemical manufacture. Included, for instance, are entries relating to the still developing offshore and subsea technologies, coal gasification, and geographic-political considerations.

Author Langenkamp, with 28 years of experience in the industry and 10 years as editor of a major-company magazine, has checked entries against authoritative sources, including oilmen in the field.

The 175-page handbook can be ordered for $6.95 from Petroleum Publishing Company, P.O. Box 1260, Tulsa, Oklahoma 74101.

Swamps Don't Plague OU Geology Librarian

The Okefenokee Swamp and the Everglades are two areas of the United States in which the constituents of coal and the conditions necessary for initial phases of coal formation are present. These two fluid environments were the target for participants in The Geological Society of America's Coal Division field trip, held last November in conjunction with GSA's annual meetings in Miami Beach. About 80 geologists, geochemists, and others signed up for the coal-geology trip, including S. A. Friedman and L. R. Wilson, geologists with the Oklahoma Geological Survey, and myself—librarian for The University of Oklahoma Geology and Geophysics Library.

Our field party gathered in Jacksonville, Florida, Thursday afternoon, November 14. Friday morning, we entered the Okefenokee Swamp at Folkston, Georgia, in eight flat-bottomed, aluminum boats. The Okefenokee is a 600-square-mile region of swamps (forested wetlands) and marshes (wetlands covered by herbaceous vegetation) bounded by elongated ridges that roughly parallel the shore.

The marshes, known locally as *prairies,* generally have a water depth of less than 3 feet. Aquatic plants, both floating (white water lily and bladderworts) and emergent varieties (never-wet, spike rush, red root, maidencane, and sedge) occupy the prairie. Tree houses, or oval clumps of bay and cyprus trees and shrubs, such as titi, harrah bush, and holly, also occur in the swamp. Each of these vegetational communities produces a distinctive peat that is weakly acid and has a low humic-acid content.

At various points in our 9-hour excursion, we crawled out of the boats to slosh to tall easels that supported 4- by 6-foot posters used to illustrate information about vegetational communities; the occurrence, thickness, and rate of vegetative accumulation; geochemistry of the peats and water; and the origin and occurrence of islands. Walking or bouncing on the islands or accumulated bottom material causes quaking movements. Therefore, the Choctaw Indians named the area *Okefenokee,* which means quivering earth.

The Okefenokee's waters come from rainfall, surface runoff, and springs. Drainage by the Suwanee River and the St. Mary's River is subject to and characterized by sudden sharp rises that flush out dissolved organic matter from the peat masses. Cores of the vegetational matter indicate that (1) prior to human habitation, more upland vegetation thrived in the swamp; (2) sedimentation in the area occurs at an average rate of 1 inch every 53 years; (3) the oldest material in the swamp is between 5,000 and 6,700 years B.P.; and (4) the greatest peat thicknesses are 101-166 inches.

The second area of investigation, the Everglades-Mangrove Swamp complex of southern Florida, is blanketed by peat that has low humic acid and neutral pH. After an early-morning flight from Jacksonville on Saturday, the group arrived in Miami and drove through a truck-garden area to Everglades National Park. As the elevation neared sea level, the pine trees were replaced by elongated *hammocks* composed of cypress and bay trees that are interspersed throughout the saw-grass plain.

Participants in the Coal Division field trip, held prior to the GSA annual meetings in Miami Beach last November, wade through the warm water of the Everglades to study colorful charts and maps used to facilitate discussions. (Photograph courtesy of L. R. Wilson.)

At Flamingo, Florida, we boarded a large flat-bottomed tour boat and glided in Whitewater Bay Saturday afternoon and Sunday. Aboard the boat, in the warm water, or on the degraded peat within a dense mangrove forest, we discussed the form and occurrence of the bay and its islands, shoreline processes and their effect on the swamp environment, the geochemistry of the peat and water, the formation of coal macerals, the occurrence of sulfur and pyrite, and peat stratigraphy at a variety of sites.

Handling the logistics of moving 80 people plus equipment from the northern to the southern tip of Florida and transporting them through the marine environments was quite a job. Trip leaders William Spackman, Arthur D. Cohen, Peter H. Given, and Daniel J. Casagrande, and trip administrators Russell R. Dutcher and Jane P. Dolson, are to be commended; among the notable achievements, easels were always in place and discussions began promptly.

A field trip provides an opportunity to study fellow travelers as well as the ostensive object of the journey. I find that geologists are willing to listen to my comments and answer my questions. I also find that meeting authors of journal articles or books found in the Geology Library creates a closer kinship to the material. Participants in the coal field trip came from the United States and Canada and from industry, government, and academia. We were cold in the Okefenokee Swamp and hot in the Everglades. We waded through the murky but clean swamp water, over and under the red mangrove roots (sinking into the glob), and we talked about our work, our lives, and the geologic phenomena we were seeing.

—Claren Kidd

OGS Reprints Bulletins on Haskell, Le Flore Counties

By means of its small offset press, the Oklahoma Geological Survey has recently reprinted two of its bulletins, numbers 67 and 68, that had been out of print since 1968. Both were reprinted without plates and photographs but with all line illustrations and tables. A resurgent interest in Oklahoma's coal resources has prompted these reprintings.

Bulletin 67, *Geology and Mineral Resources of Haskell County, Oklahoma,* by Malcolm C. Oakes and M. M. Knechtel, was originally published in 1948, and Bulletin 68, *Geology and Coal and Natural Gas Resources of Northern Le Flore County, Oklahoma,* by M. M. Knechtel, in 1949. Both cover adjacent areas in the Arkoma or McAlester basin of eastern Oklahoma.

Although the plates have been omitted, plate 1 of Bulletin 67, a geologic map of Haskell County, is being reprinted without color and will be available in the near future for sale separately. Similar plans are being made for the geologic map of northern Le Flore County, which accompanies Bulletin 68.

Bulletins 67 and 68 can be ordered from the Oklahoma Geological Survey for $2.00 and $1.50, respectively, by writing to the address on the front cover.

Librarians Compile Bibliographies

The Council of Planning Librarians' most recent list of exchange bibliographies includes three that we would like to call to the attention of *Oklahoma Geology Notes* readers. *Environmental Design: An Analysis of the Field: Its Implication for Libraries; and a Guide to the Literature,* 1975, prepared by Delma J. Wheater, School of Librarianship, the University of British Columbia, is available for $8.50 (order number 747-748, 87 pages).

Bibliography: Environmental Geomorphology, 1975, was compiled by Susan Caris and Marie Pavish, Department of Geography, The University of Chicago (number 760, 32 pages, $3.00); and *Water Resource Development: A Selected Research Bibliography* was prepared by Prakash C. Sharma, Department of Sociology, University of North Alabama, Florence (14 pages, $1.50).

These bibliographies can be purchased from the Council of Planning Librarians, Exchange Bibliographies, P.O. Box 229, Monticello, Illinois 61856.

Geologic Map of the United States
A Review

William D. Rose[1]

Geologic Map of the United States (exclusive of Alaska and Hawaii), compiled by Philip B. King and Helen M. Beikman, with geologic cartography by Gertrude J. Edmonston. U.S. Geological Survey, 1974, scale 1:2,500,000, 2 sheets plus explanation. $5.

Explanatory Text to Accompany the Geologic Map of the United States, by Philip B. King and Helen M. Beikman. U.S. Geological Survey, 1974, 40 p. Professional Paper 901. $1.25.

The new *Geologic Map of the United States* (exclusive of Alaska and Hawaii), compiled by Philip B. King and Helen M. Beikman, published by the U.S. Geological Survey, is the first to show the nation's bedrock geology at a scale as large as 1:2,500,000 (1 inch = 40 miles) since the old 1932 *Geologic Map of the United States* by Stose and Ljungstedt, also published by the U.S. Geological Survey. Thus it is a landmark achievement. The map set is in two sections plus a third section containing the explanation. When mounted, the map has dimensions of 48 by 110 inches.

Readers will remember several geologic maps of the United States since the 1932 map, of course, but either they were at a smaller scale or were not designed to portray the bedrock geology. These include the Longwell *Tectonic Map of the United States* (1944), the Cohee *Tectonic Map of the United States* (1962), the Goddard *Geologic Map of North America* (1965), the Flawn and Kinney *Basement Map of North America* (1967), and the King *Tectonic Map of North America* (1969). But only this most recent product has actually superseded the 1932 map. Needless to say, our understanding of the geology has been refined considerably in the 42-year interim and is so reflected in the new map.

A companion piece to the map set—actually a necessary ingredient—is a well-illustrated 40-page report by King and Beikman entitled *Explanatory Text to Accompany the Geologic Map of the United States,* which has been issued as USGS Professional Paper 901. As well as an essential explication of how the geologic map is to be interpreted and used, much of the report is a fascinating account of past and present maps and map-making in North America.

A recounting of the current project reveals that plans were made for a new geologic map as early as 1955, when King was asked to undertake the compilation. Work did not begin until much later, however. The compilation team was completed with the addition of Beikman and Gertrude J. Edmonston, the latter serving as geologic cartographer.

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[1]Geologist-editor, Oklahoma Geological Survey.

Principal sources for the geologic map are listed in the explanatory text on a state-by-state basis—a helpful data source in itself. A most instructive section follows on the methods used in the final compilation. Further sections describe in adequate detail the map units, symbols, colors, and practice of geologic representation.

The 1974 map has a sprightlier look than the 1932 map, not only because of the wider range of colors but also because of the more "finished" appearance of land areas outside the United States, which are a screened brown in the newer version (white or blank in the older). Also, bathymetric contours have been added for offshore areas. The subsea contours are apparently in meters, although nowhere is this clearly stated.

The map explanation (called "legend" in this case) is readily usable and is laid out so that all units are represented in one vertical arrangement from Precambrian through Cenozoic. The Precambrian divisions follow the new W, X, Y, and Z classification and so permit more accurate correlations between regions. Successive columns to the right portray rocks of approximate correlative age by the following categories: stratified sequence, continental deposits, eugeosynclinal deposits, volcanic rocks, plutonic and intrusive rocks, and metamorphic rocks. At the bottom of the explanation is a correlation diagram of Permian strata from Arizona to the Midcontinent. The arrangement of the elements in the explanation is a definite improvement over the practice of grouping units by major geologic province, which resulted in several separate explanations on the 1932 map.

Although hewing mainly to the shades of color traditionally used for systemic and series distinctions, the wider color range of the newer map facilitates differentiation of most units. For example, a vast improvement has been noted over the 1932 map in portraying the Mississippian and Pennsylvanian sedimentary units. This is readily seen by comparing outcrop belts of these units in the Appalachian, Eastern Interior, and Midcontinent regions. Differentiation of units likewise has been improved for the coastal plains, especially the Mississippi embayment.

Another welcome feature of the new map is portrayal of the approximate subcrops of bedrock units beneath younger cover, as in the Mississippi embayment and southwestern Minnesota. This practice is in keeping with the primary goal of the map to portray bedrock geology. Also new on the 1974 map are the limits of Wisconsin and older glaciation, shown by heavy green lines.

Here in Oklahoma, map users will be aware of several departures (actually outmoded holdovers) from current usage by the Oklahoma Geological Survey. The principal source of Oklahoma information for the compilation was Miser's 1954 *Geologic Map of Oklahoma,* now badly in need of revision. On the new map, for example, the basal Permian unit includes rocks that have now been assigned an uppermost Pennsylvanian age by the OGS; units shown as Triassic in Texas and Beaver Counties, in the Panhandle, are wholly or partly Early Cretaceous in age; and the core area of the Ouachita Mountains is now considered no older, in Oklahoma at least, than Middle Ordovician instead of Cambrian.

One way in which the 1932 map seems better is in having contact lines of lighter weight than those of the new map, which seem unnecessarily heavy. Faults are shown in lines of distinctly heavier weight, though, so they are unmistakable; also, many more faults are delineated on the new map than on the old, a definite improvement.

The base for the new map has been printed in gray and is appropriately visible through the geology in most regions of the country. In much of the Basin and Range province, however, the base has been severely obscured by the bright colors used for igneous units, making geographic orientation difficult. In this province, the black base of the old map would have been preferable. Of course, two sets of bases would be hard to combine into one map!

On balance, the new *Geologic Map of the United States* is an outstanding contribution to the geological literature, and the compilers and cartographer deserve our praise. Geologists, students, and educators will find it invaluable.

The map set can be ordered for $5.00, prepaid, from Branch of Distribution, U.S. Geological Survey, 1200 South Eads Street, Arlington, Virginia 22202. The companion explanatory text, Professional Paper 901, can be ordered from the same address for $1.25. The map set and text are also for sale by the Oklahoma Geological Survey for the same prices. I recommend that the map set and text be purchased (and used) together.

Toward a More Aesthetic Offshore Production Technology?

In a news release received in February, we note that the U.S. Geological Survey is seeking comments from industrial organizations "on the current status of technology in subsea well completion techniques and subsea production systems." As the agency responsible for supervising offshore drilling operations, the USGS is interested in the impact of requiring some underwater completions as a condition to granting certain leases on the outer continental shelf.

Apparently, the new underwater well systems are considered more aesthetically pleasing, in some quarters at least, than conventional drilling platforms. So if some people prefer less obtrusive operations and completions (although chances are they would see few from shore anyway), then maybe the industry should try to come up with the right technology to put them into operation.

Personally, though, we consider the sight of an operating rig in a new province not only aesthetically pleasing but downright exciting. And in the meantime, we'll dust off our rallying cry: On to Georges Bank!

USGS Releases Aeromagnetic Map of Wichita Mountains

Aeromagnetic Map of the Wichita Mountains Area, Southwestern Oklahoma is the title of a map recently placed on open file by the U.S. Geological Survey. The map, at a scale of 1:62,500 (approximately 1 inch = 1 mile), covers an area of about 1,500 square miles in and around the Wichita Mountains and shows the earth's total-intensity magnetic field in that area. The map has been contoured on intervals of 20 and 100 gammas. Flight paths are also indicated.

Released as USGS open-file report 75-16, the map is available for inspection at the Oklahoma Geological Survey; also, blueline copies of the map can be obtained from the Survey for $2.00 apiece by writing to the address on the front cover. The map has also been deposited at USGS libraries in Reston, Virginia, Denver, Colorado, and Menlo Park, California. In addition, it may be examined at the USGS office, Room 1-C-45, 1100 Commerce Street, Dallas, Texas 75202.

AAPG-SEPM Rocky Mountain Sections Meet in Albuquerque

"Rocky Mountain Energy Resources—Discovery and Development" will be the theme for the 1975 joint meeting of the Rocky Mountain Sections of The American Association of Petroleum Geologists and the Society of Economic Paleontologists and Mineralogists. The organizations will meet June 1-4 in Albuquerque, New Mexico. Technical sessions will be held on oil and gas; coal; sedimentology, sedimentary petrology, paleontology-paleoecology; uranium; geothermal energy; and stratigraphy and structural geology.

Environmental issues will receive their share of attention at the meetings. The keynote address will be "Environmentally Sound Resource Development—Can We Have Our Cake and Eat It, Too?" by John W. Rold, director of the Colorado Geological Survey. In addition, the AAPG Environmental Committee is sponsoring a workshop Sunday afternoon, June 1, in conjunction with the AAPG-SEPM meetings. Panelists from various governmental agencies and concerned industries will discuss the impact of state and federal land-use planning on energy-mineral resource development.

Also scheduled for June 1 are two 1-day field trips, one to the eastern margin of the San Juan basin, between San Ysidro and Cuba, New Mexico, and the other to visit significant outcrops in the Pennsylvanian section of central New Mexico.

For additional information or for registration forms, contact AAPG headquarters, P.O. Box 979, Tulsa, Oklahoma 74101. Student housing can be arranged on the University of New Mexico campus by contacting Ben Donegan, P.O. Box 3400, Albuquerque, New Mexico 87110.

GSA Annual Meeting, Northeastern Section
Syracuse, New York, March 6-8, 1975

The following abstract is reprinted from the *Abstracts with Programs* of The Geological Society of America, v. 7, no. 1. The page number is given in brackets below the abstract. Permission of the authors and of Mrs. Jo Fogelberg, managing editor of GSA, to reproduce the abstract is gratefully acknowledged.

Enhancing the Environmental Impact Assessment Process: The Earth Scientists' Role

BRUCE B. HANSHAW and EDGAR IMHOFF, U.S. Geological Survey, Reston, Virginia

We are currently working toward improving environmental decision-making by developing a methodology for enumerating, analyzing, and assessing environmental impacts. Specific goals are to: (1) Modify and improve the initial environmental impact and identification approach of U.S.G.S. Circular 645, providing added detail on activities and expanding the description of impacts; (2) Develop a systematic classification of impacts by linking potential environmental effects with proposed activities; and (3) Test the networks, classifications, and descriptions comprising the methodology by applying it to environmental problems of a major action in a specific area.

Assessing all aspects of environmental impact requires cooperation of a wide range of specialists. The earth scientist can contribute much to a team of scientists, engineers, and others concerned with tracing all the consequences of a proposed major action. By training, outlook, and experience earth scientists are ideally suited to perform the roles of: integrators of natural science information; interpreters of likely future events based on knowledge of the past and of properties and dynamics of earth materials; and analyzers of physical phenomena in terms of possible socio-economic significance as well as intrinsic environmental values.

It is not sufficient simply to provide interpreted data and participate actively in multidisciplinary endeavors. To be truly involved in environmental issues, earth scientists must take the additional steps necessary to insure that their inputs are made known to those higher in the decision-making process.

[70-71]

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

GSA Annual Meeting, South-Central Section
Austin, Texas, March 13-14, 1975

The following abstracts are reprinted from the *Abstracts with Programs* of The Geological Society of America, v. 7, no. 2. Page numbers are given in brackets below each abstract. Permission of the authors and of Mrs. Jo Fogelberg, managing editor of GSA, to reproduce the abstracts is gratefully acknowledged.

Source and Depositional Environment of the Upper Triassic Sandstones of the Texas High Plains

GEORGE B. ASQUITH, Department of Geology and Killgore Research Center, West Texas State University, Canyon, Texas, and SCOTT L. CRAMER, Union Texas Petroleum, Midland, Texas

The Upper Triassic of the Texas Panhandle is represented by the non-marine Dockum Group. The Tecovas Formation, the basal unit of the Dockum Group, is composed of multicolored shales and siltstones and a few lenticular fine to very fine grained sandstones. These lenticular sandstones represent point bars deposited by meandering streams. The Tecovas Formation is overlain by the coarser grained sandstones and conglomerates of the Trujillo Formation. These highly cross stratified sandstones with numerous cut and fill structures represent a braided alluvial sheet. A plot of stratification ratio versus bed relief index for the Trujillo sandstones indicates that transverse bar deposits are predominate over longitudinal bar deposits. This predominance of transverse bar deposits indicates deposition in the distal portions of a braided stream system (Smith, 1970).

The source area for the Upper Triassic sandstones was the highlands of the Ouachita-Marathon tectonic belt to the east and southeast of the present Triassic outcrops. This is based on the sediment dispersal pattern and the presence of vein quartz and chert pebbles, whose most likely source is the Ouachita-Marathon tectonic belt. The downstream distance from highlands of the Ouachita-Marathon tectonic belt to the Triassic outcrops varies from 210 to 330 miles. These distances are well within the range of distal braided stream deposits as determined by Smith (1970) for the South Platte-Platte River in Colorado and Nebraska and the Silurian Clastics of Northeastern United States. [142]

Delineating Woodland Areas in the Red River Basin from ERTS-1 and Skylab Imagery: Relation to Geologic Formations and Soil Types and Potential for Fiber Production

ROBERT D. BAKER and DOUGLAS GRANT, School of Forestry, Stephen F. Austin State University, Nacogdoches, Texas

Woodland in the Red River Basin in Texas, Oklahoma and New Mexico is being delineated by standard photographic interpretation methods from ERTS-1 and Skylab imagery under a contract funded by the U.S. Forest Service, to complete its Conservation Needs Inventory for the basin. Ground

checking of the woodland is being performed, to test the efficiency of woodland vegetation mapping from spacecraft imagery. Tree growth rate samples are also obtained; woodlands thus delineated are correlated with the underlying geologic formations and broad soil groups in the basin to determine soil/site relationships. Extrapolation is made to predict potential productivity of woodlands in the basin for production of wood fiber should national requirements increase. [143]

Use of the Water Table Aquifer Model to Project Depletion of the Ogallala Aquifer—High Plains of Texas

ANN E. BELL, Ground-Water Data and Protection Division, Texas Water Development Board, Austin, Texas

The High Plains of Texas cover an area of about 35,000 square miles, and includes the Canadian River basin and the upper parts of the Red, Brazos, and Colorado River basins within the State. In this area of limited water supplies, the saturated part of the Ogallala Formation (Pliocene age) constitutes the principal source of ground water and virtually all of the municipal, industrial, and irrigation water supply. Therefore, ground water is extremely important to the economy of the area as well as to the State and Nation.

Annual water-level measurements, made in hundreds of selected water wells throughout the High Plains, show that the ground-water supply in the Ogallala aquifer is being depleted. During the past three decades, the withdrawal of ground water has greatly exceeded the natural recharge to the aquifer.

The immediate need for current data in regard to the Ogallala aquifer has resulted in a concerted effort by the Texas Water Development Board to utilize high speed computers to conduct evaluation and projection studies of this ground-water resource. A Water Table Aquifer Model was developed to calculate estimates of the current volume of water in storage in the 45-county study area and to make estimates of the projected depletion of this natural resource by decade periods through the year 2020. In addition, estimates and projections of pumpage and pumping levels for the same time span were calculated by the computer model. In developing the model, special emphasis was given to the geohydrology of the area. [146-147]

Lower Pennsylvanian (Morrowan) Biotic Associations—A Comparison with a Modern Patch Reef Developed on a Carbonate Mud Substrate

RENA MAE BONEM, School of Geology and Geophysics, The University of Oklahoma, Norman, Oklahoma

Examination of Morrowan bioherms in northeastern Oklahoma results in recognition of four faunal associations which have recognizable vertical succession and horizontal distribution. These associations include: 1) stromatolitic blue-green algae dominating the core and outer mound layers; 2) pelmatozoans and pediculate brachiopods developed on topographically high areas within intermediate mound layers; 3) fenestrate and arborescent bryozoa and goniatites restricted to depressions on intermediate layers; and 4) a cryptic biota of michelinid and rugose corals and encrusting bryozoans which dominate the fauna within local cavities. Development of mounds first requires stabilization of the substrate by stromatolites of the first association followed by other associations. The trophic relation within these associations described by position, nutrients preferred, and feeding mode, helps further explain the distribution and relationships of organisms within the Morrowan bioherms.

Many Paleozoic communities develop on lime mud substrates rather than on clean carbonate sand areas generally studied as modern analogs to ancient biohermal developments. Increased suspended material within a carbonate mud environment may result in development of different trophic groups and permit deeper water biota to occur at shallow depths because of decreased light penetration. These factors should be considered when examining ancient communities developed in carbonate mud environments. [149]

Geohydrology of the Vamoosa Aquifer

JOSEPH J. D'LUGOSZ, Water Resources Division, U.S. Geological Survey, Oklahoma City, Oklahoma

The Vamoosa aquifer is a major potential source of ground water in east-central Oklahoma. About 18 cities currently pump from the aquifer, but the amount of water withdrawn is insignificant when compared to the total amount of water in storage.

At the type locality, near the town of Vamoosa, the westward dipping aquifer is distinguished by presence of coarse chert conglomerates, arkosic conglomerates, and reworked chert pebbles and cobbles that represent a pre- and a post-Vamoosa unconformity. The sandstone-shale ratio in the aquifer grades from 60/40 in the south to 20/80 in the north. Water-bearing sandstones, interbedded with shales and silty shales, are cross bedded, light colored, fine to very fine grained, and consist entirely of quartz. The well sorted and well rounded character of the particles is typical of a high-energy depositional environment. The Vamoosa ranges in thickness from 125 feet to more than 1,000 feet.

Wells in the Vamoosa yield from 25 to 600 gallons per minute, depending on well depth and saturated thickness. Aquifer tests made by the U.S. Geological Survey in the vicinity of Seminole indicate an average transmissivity and hydraulic conductivity of 430 square feet per day and 7 feet per day, respectively; storage ranged from 0.0001 to 0.0003. Additional tests using wells about 2 miles northwest of Seminole gave a transmissivity of 200 square feet per day. The decrease in transmissivity is mainly due to the northward decrease in the sand-shale ratio. Wells pumping about 150 gallons per minute should be spaced at least 2,500 feet apart within the City of Seminole, but should be spaced 8,000 feet apart farther north.

Chemical analyses show that the aquifer produces a bicarbonate water (108-480 milligrams per litre) that contains low concentrations of sulfate (40 milligrams per litre) and chloride (50 milligrams per litre). In some areas the aquifer has been infiltrated by saline water, which has resulted in the degradation of the entire fresh-water zone. [159-160]

Detection of Small Local Earthquakes in Oklahoma with a High-Pass Vertical Seismograph

J. E. (JIM) LAWSON, JR., Leonard Earth Sciences Observatory, The University of Oklahoma, Leonard, Oklahoma

A high-pass vertical ground motion visual writing seismograph has detected an average of one local earthquake in Oklahoma each 40 days during 29 months of operation. The seismograph's passband extends from 2 Hz to 50 Hz in contrast to the 1Hz to 3Hz passband of "standard" short period seismographs. The displacement magnification exceeds 100,000 across the 2Hz to 50Hz passband, peaking at 250,000 at 30Hz. The highpass seismograph also records at a higher paper speed (90 mm/minute) than the 60 mm/min "standard" speed. Published studies of high frequency ground noise suggest that the magnification could be increased by a factor of 10, particularly at frequencies above 10Hz. However, at the higher frequencies, noise from wind, thunder, and even footsteps near the seismometer vault can cause severe disturbances. The enhanced high frequency response of the seismograph is useful in recording some local earthquakes too small to be seen on standard short period records. The greatest advantages of the high-pass seismograph are ease of visual detection of small local earthquakes recorded on the seismogram, and ease of discrimination between the small population of local natural earthquakes and the very large population of quarry blasts.

[182]

A Preliminary Report on Petrified Wood from the Ogallala Formation of Northwest Oklahoma

MICHAEL R. LEE, ROBERT A. GASTALDO, and LAWRENCE C. MATTEN, Department of Botany, Southern Illinois University, Carbondale, Illinois

Two hundred fifty fragments of silicified wood were collected in Beaver County, Oklahoma in an area four miles south of Gate. The wood occurs in the Pliocene Ogallala formation. A compression flora of the same age containing leaves and seeds was described almost forty years ago by Chaney and Elias. No petrified plant remains have been described from the Beaver County flora. The study of the petrified plant remains should expand our knowledge of the Beaver County flora because genera in a petrified flora often differ from genera found in a compression flora. In addition, identification of a flora component using wood anatomy can help verify identification of a compression based on leaf morphology. Such a case is that of *Robinia oklahomensis* (Berry) Brown found as a compression and the identification of a fossil wood specimen comparable in its wood anatomy to the extant *Robinia pseudo-acacia*. The presence of petrified wood in the Ogallala formation opens the possibility for the study of the Neogene high plains flora based upon this type of preservation.

[182-183]

Intraspecific Variation in Arkanites Relicutus **(Cephalopoda, Ammonoidea) from Morrowan Strata, Arkansas and Oklahoma**

WALTER L. MANGER, Department of Geology and University Musuem, University of Arkansas, Fayetteville, Arkansas, and RALPH W. RICE, Department of Geology, University of Arkansas, Fayetteville, Arkansas

The reticuloceratid ammonoid *Arkanities relictus* (Quinn, McCaleb, and Webb) occurs commonly in strata of the Prairie Grove Member, Hale Formation (Morrowan) in Arkansas and less frequently in equivalent units in Oklahoma. Pronounced differences in conch proportions and ornament occur among individuals of this species. Statistical analysis of this variation suggests dimorphism that is probably sexual in origin and the possibility of dominant-recessive characters.

Analysis of associated conodonts and other ammonoid species occurring with stratigraphically and geographically isolated populations of *Arkanites relictus* suggests zonal differences in the ages of these assemblages. Phyletic drift in conch proportions can be documented between populations of different age thus establishing a basis for more precise biostratigraphic correlation within this interval.

[212-213]

Lithostratigraphy and Conodont Biostratigraphy of the St. Joe Formation (Lower Mississippian), Northwest Arkansas

JOHN DAVID McFARLAND III, Geology Department, University of Arkansas, Fayetteville, Arkansas

Lithostratigraphic subdivisions of Lower Mississippian strata in northern Arkansas have been traditionally recognized as the chert-bearing Boone Formation with the chert-free St. Joe Limestone Member at its base. In Oklahoma and Missouri usually four formations can be recognized in the equivalent interval between the Devonian Chattanooga Shale and the chert-bearing limestone. These formations include (in ascending order) the Bachelor, Compton, Northview and Pierson Formations. Recent investigations suggest that the Compton-Pierson sequence is readily recognizable in northwest Arkansas, but is not uniformly present throughout the area. In addition, a thin shale is sporadically developed immediately above the Chattanooga that may be a facies equivalent of the Bachelor Formation. This investigation supports previous suggestions that the St. Joe should be raised to formational rank with the Compton-Pierson units as members.

Conodonts recovered from the St. Joe Formation in northwest Arkansas may suggest a diachronous, unconformable contact with the underlying Devonian Chattanooga Shale. The Kinderhookian-Osagean Series boundary falls within the St. Joe Formation, usually near or at the base of the Pierson member.

[217]

Ordovician Vertebrate Remains from the Arbuckle Mountains of Southern Oklahoma

CLAIR RUSSELL OSSIAN, Geoscience Group, Atlantic Richfield Company, Dallas, Texas

Fragmentary plates and scales of *Eriptychius* (Agnatha: Heterostraci) have been recovered from the Viola Limestone (Middle Ordovician: Black River Stage). Previous Ordovician vertebrate remains have been reported only from various sites in the Harding Sandstone of the eastern Cordilleran Geosynclinal Region (Colorado to Wyoming, and equivalent beds in Montana and South Dakota), and the Gull River Limestone (western Ontario).

The new materials were collected from a shallow marine environment, lending additional support to a marine origin for the earliest chordates. The habitat and distribution of the earlier discoveries will be compared with the new finds. [222-223]

Interpretation of Aeromagnetic Patterns and Basement Structure from ERTS Imagery

REX M. PETERSON, Remote Sensing Center, Conservation and Survey Division, University of Nebraska, Lincoln, Nebraska

For this new technique imagery from the Earth Resources Technology Satellite (ERTS) is viewed with an electronic image-enhancing system and separate overlays are prepared for each of the four ERTS spectral bands, plus color composites, plus imagery from different seasons, resulting in 15 to 20 transparent overlays of the same area. The composite overlay shows a dense pattern of lineaments, circles, and other curvilinears. When the overlays are projected onto aeromagnetic maps, it can be seen that the circular and sub-circular patterns correspond surprisingly well to magnetic closures and that lineaments correspond to disruptions in patterns of aeromagnetic contours. In the Midcontinent Gravity High of the central United States, where this technique is being tested, aeromagnetic patterns correspond well to Precambrian basement topography. It is postulated that in addition to renewed movement on basement faults, flexing of rock (and glacial drift) above the basement by diurnal earth tides causes fracturing in patterns corresponding to basement topography. Traces of fractures are visible on the landscape because of the effect of fracturing on erosion, topography, soils, and vegetation, but many fracture traces are so subtle they don't appear on any one image; hence the need for multispectral and multiseason imagery. [225]

Comparison of the Utility of Multi-Level Imagery to Monitor Strip-Mine Reclamation

MARY ALICE SOULE, Remote Sensing Laboratory, University of Kansas Center for Research, Inc., Lawrence, Kansas

Aerial photography and ERTS imagery are available over the southeast corner of Kansas where strip-mining has been used to recover coal.

ERTS imagery band 7 was considered to be of greatest value in the delineation of the mined area; however, only general data were derived from these images, primarily changes in the area covered by active mines.

High-altitude RB-57 color infrared photography could be used to detect features such as depressions containing standing water if the size of the feature was on the order of 5-10 meters or more.

Low-altitude photography (approximately 1600 meters above terrain) was used as the basis for a pilot study to evaluate the use of photography in acquiring data without extensive field study. Anomalies on sites reclaimed from old abandoned spoil could be related to the mining method.

Low-altitude oblique photography was also evaluated because of its low cost to the coal company, an especially important factor for small operators. Identification of problem areas was easily achieved using landmarks such as haulage roads and section roads.

[236]

The Evolution of the Delaware Aulacogen in West Texas

JACK L. WALPER, Department of Geology, Texas Christian University, Fort Worth, Texas

Late Precambrian or early Cambrian rifting of a continent that North America was a part of, produced as a result of plume-generated uplifts a number of "failed arms" or aulacogens in the process of separation. One of these long-lived, deeply subsiding troughs is the Wichita aulacogen in southern Oklahoma, recognized and described as such by both Soviet and American geologists. Another, located in West Texas where it localized deposition in the early Paleozoic Tobosa Basin, left as documents of its history, the Delaware Basin and the Central Basin Platform. The area of greatest subsidence, caused by incipient spreading and downwarp and marked by the thick sedimentary package of that early Paleozoic basin, is now occupied by the Delaware Basin and Central Basin Range just as was the case in southern Oklahoma where the Wichita aulacogen formed and was destined to receive a thick prism of Paleozoic rocks before collapsing in late Paleozoic time to form the Wichita-Arbuckle Mountains and the Anadarko Basin. The Delaware aulacogen, likewise, was destroyed in the late Paleozoic when the Afro-South American plate collided with North America to form Pangea and the Ouachita-Marathon orogenic belt and thrust it in broad salients into the two aulacogens, which were areas of crustal weakness. Compressive stresses, transmitted far into the adjacent foreland, deformed the thick package of sedimentary rock in both the Wichita and Delaware aulacogens into the Wichita-Arbuckle Mountains and Central Basin Range respectively.

[243]

GSA Annual Meeting, Southeastern Section
Memphis, Tennessee, April 9-12, 1975

The following abstracts are reprinted from the *Abstracts with Programs* of The Geological Society of America, v. 7, no. 4. Page numbers are given in brackets below each abstract. Permission of the authors and of Mrs. Jo Fogelberg, managing editor of GSA, to reproduce the abstracts, is gratefully acknowledged.

Evidence for Interaction between a Ouachita Crustal Chip and a Mississippian Embayment Rift

JOHN B. GUSTAVSON, International Oil & Gas, Inc., Memphis, Tennessee

The drift of the Ouachita Mountains as a crustal chip is suggested to have taken place along a transform fault. The onset of the drift was Early Jurassic. A spreading seafloor offshore of West Florida furnished the oceanic crust for the northwesterly movement. The Louann anhydrite supports the concept, as do heat flow maps. Seismicity, crustal depression and the precise alignment of domal structures and alkaline ultramafic rocks along the Mississippi Embayment axis suggest a major crustal weakness which at times of tensional stress took the form of a rift, and under compressional forces as a trench perpendicular to the transform fault. To the South of the Interior Platform a subduction zone was associated with the trench into which carbonates of the frontal edge of the Ouachita chip were subducted. Rifting again occurred in the Late Cretaceous and nepheline syenite and alkaline ultramafics were intruded into the Ouachita chip together with carbonatites from the remobilized carbonates. Drifting continued until the chip collided against the Ozark Uplift, the fractured rocks of which together with the northern flank of the Ouachitas were rapidly eroded to form the Arkansas Valley. The economic implications of this model, if correct, include the direction of mineral exploration to areas along the crustal weakness axis in West Tennessee. Further, a mobile belt of Paleozoic age and with possible polymetallic sulfide mineralization may have been carried along with the Ouachita chip. District zoning in the Ouachitas of antimony, lead, zinc and silver occurrences support the model.

[494]

Appalachian-Ouachita Structure and Plate Tectonics

WILLIAM A. THOMAS, Department of Geology, Georgia State University, Atlanta, Georgia

Subsurface data define a belt of deformed Paleozoic rocks that extends beneath the Gulf coastal plain from the Appalachian Mountains to the Ouachita Mountains. Distinctly different stratigraphic sequences are ex-

posed in the Appalachians and Ouachitas, but transitional aspects of the sedimentary facies are recognizable in well data. The curve in the structural front from the Ouachita salient into the Alabama Appalachian recess is similar in both geometry and scale to the exposed curve from the Pennsylvania Appalachian salient into the New York recess. Sedimentary facies distributions are related to structural outlines in similar patterns in the two salients. Ouachita curvature has been attributed to large-scale megashears along which the structural system is offset; however, available subsurface data do not indicate large-scale strike-slip offsets. In addition, analogy with the Pennsylvania salient suggests that no large-scale transverse strike-slip faults (megashears?) are necessary to explain Ouachita curvature.

Tectonic models of the Ouachita salient generally have been designed to introduce a late curvature into a presumed originally straighter structural system. Regional stratigraphic synthesis indicates that Paleozoic sediments accumulated around a large-scale curve in the continental margin at the position of the Ouachita salient. Thus, the structures of the Ouachita salient subsequently formed along an arcuate trace within the preexisting curve. Possibly the original curve in the continental margin was produced by a transform fault, the present trace of which extends southeastward from near the center of the Ouachita salient into Mississippi.

[543-544]

Montana Site Selected for Forum on Geology of Industrial Minerals

The 11th Forum on Geology of Industrial Minerals will be held in Kalispell, Montana, June 18-20. The forum is sponsored by Flathead Valley Community College and the Montana Bureau of Mines and Geology. Technical sessions will be held Wednesday afternoon (June 18) and all day Thursday. Fourteen papers will be presented, about zeolites, silica, talc, limestone, sodium, sulphate, vermiculite, bentonite, sapphires, phosphate, potash, and soda ash. A field trip to a vermiculite mine near Libby, Montana, has been scheduled for Friday.

The forum announcement reports that Flathead Valley is the gateway to Glacier National Park and the Bob Marshall Wilderness area and suggests that the meeting offers a fine chance to combine business and pleasure.

For detailed information on registration, housing, and vacation facilities, please contact Lawrence F. Rooney, P.O. Box 607, Whitefish, Montana 59937, or Richard B. Berg, Montana Bureau of Mines and Geology, Montana College of Mineral Science and Technology, Butte, Montana 59701 (area code 406, 792-8321).

State Water Resources Board Investigates Tillman County Aquifer

The Oklahoma Water Resources Board has released Hydrologic Investigations Publication 58, *Ground Water Resources of Tillman Terrace Deposits, Tillman County, Oklahoma,* by Ginia Wickersham. Water levels in the Tillman terrace deposits (which encompass an area of approximately 285 square miles) have been declining during the past 10 to 20 years, and in November 1968 the Water Resources Board declared Tillman County to be a critical ground-water area.

Publication 58 consists of 3 large map sheets folded in an envelope. Sheet 1 covers the geology of the area, chemical-quality data for ground water, a well-inventory and depth-to-water map, a section defining the terminology used in the investigation, and selected references.

Sheet 2 depicts the loss of saturated thickness and generalized water-level changes in the Tillman terrace deposits from 1952 to 1974. Sheet 3 is devoted to ground-water usage in the area. According to information released in Publication 58, withdrawal of ground water for irrigation has increased fourfold from 1953 to 1973, and total pumpage exceeds recharge from precipitation as shown in the accompanying hydrographs.

Copies of the investigation can be obtained for $2.50 each from the Oklahoma Water Resources Board, Fifth Floor, Jim Thorpe Building, Oklahoma City, Oklahoma 73105.

USNC Sponsors Energy Forum, Revises Energy Encyclopedia

May 15-16, in Washington, D.C., the United States National Committee of the World Energy Conference will hold an inquiring forum, "Energy for the Nation: Who Will Pay the Bill?" The USNC was formed to provide broad technical management and policy considerations relative to all aspects of energy in the United States. The organization was host to the Ninth World Energy Conference (held in Detroit last September), which attracted 4,100 participants from 83 nations. Its opening sessions were presided over by President Gerald Ford.

Information about the forum to be held in May can be obtained by writing to the Engineers Joint Council, 345 East 47th Street, New York, New York 10017.

The third edition of *The Survey of Energy Resources,* a comprehensive reference encyclopedia prepared for the 1974 World Energy Conference, can be obtained for $37.50 by writing to the Publications Department at the same address.

New Thesis and Dissertation Added to OU Geology Library

The following M.S. thesis has been added to The University of Oklahoma Geology and Geophysics Library:

Evaluation of Data from the First Earth Resources Technology Satellite for the Purpose of Structural Analysis in the Anadarko Basin, Oklahoma and Texas, by Gerald J. Petzel.

The following Ph.D. dissertation has also been added to the library:

Palynology of the Denton Shale (Lower Cretaceous) of southeastern Oklahoma, by Frederick Huston Wingate.

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