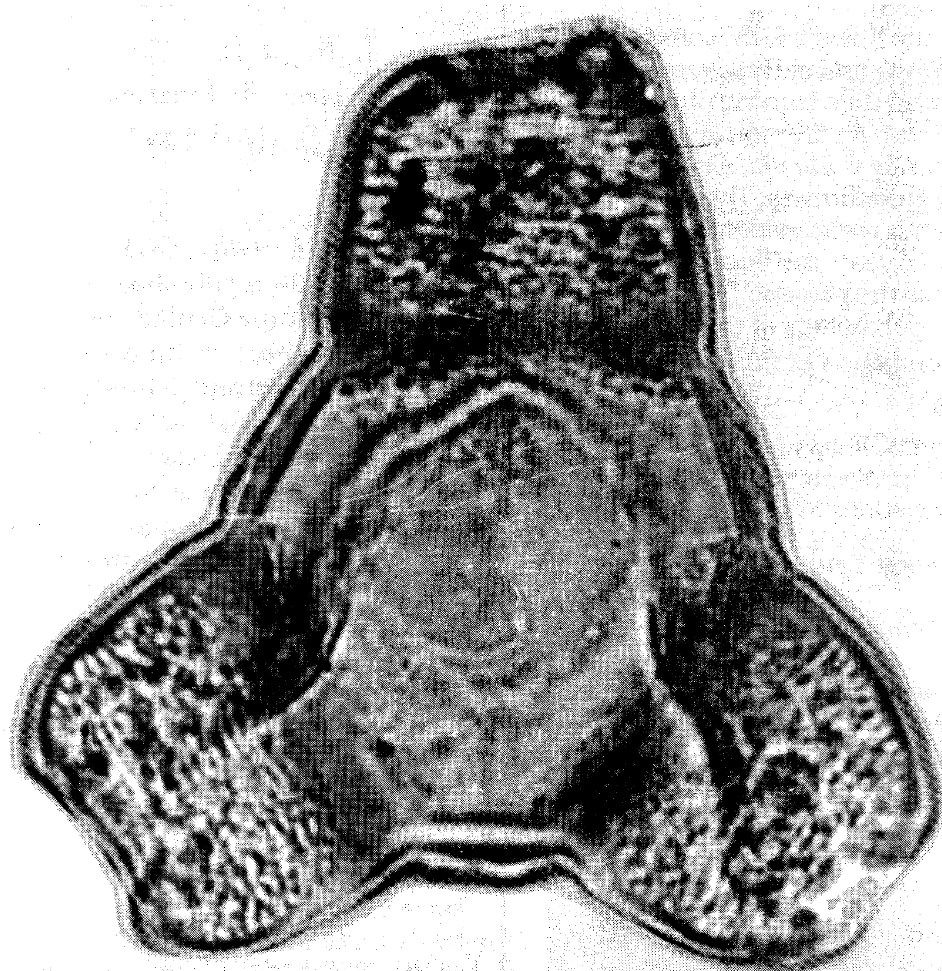
OKLAHOMA GEOLOGY



February 1995

Vol. 55, No. 1

On The Cover —

Fossil Pollen Grain of Evening Primrose, Okmulgee County

A photomicrograph of a fossil pollen grain of the Evening Primrose (*Oenothera* sp.) is featured on the cover. The pollen grain was the best preserved of ones found in a peat sample recovered at a depth of ~48 ft below the surface in a borehole drilled on a terrace of the Deep Fork of the Canadian River in Okmulgee County. The ^{14}C age of the peat is 20,980 ± 1,000/1,140 yr B.P., and the fossils are probably the oldest Pleistocene specimens reported. Evening Primrose belongs to the plant family Onagraceae, which consists of about 20 living genera and 650 species. More than two dozen are native to Oklahoma. The family, which has been observed in the Miocene Brandon Lignite of Vermont and the Oligocene–Pliocene of Germany, has a history of about 35 million years (Traverse, 1955).

In Oklahoma, the flowers form conspicuous clusters in late spring and early summer, first blooming white and then turning pink as they age (see inset photo). A common commercial member of the family is *Fuchia*, a tropical species raised in greenhouses. The discovery of the fossil pollen is some evidence that for many thousands of years the flora of Oklahoma has been similar to the present. (For further discussion of the palynology of the Deep Fork peat, see article on page 4 of this issue.)

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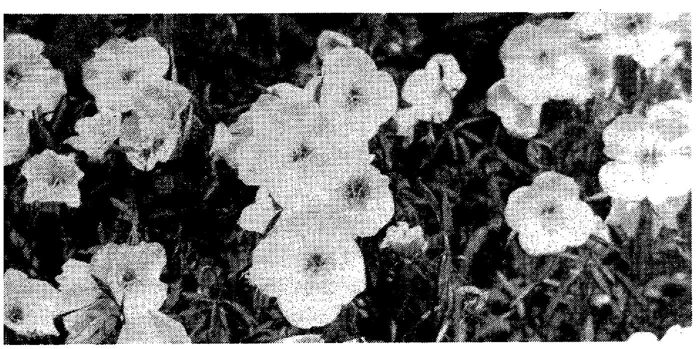

Evening Primrose in full bloom.

OKLAHOMA GEOLOGICAL SURVEY

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OKLAHOMA GEOLOGY NOTES, ISSN 0030-1736, is published bimonthly by the Oklahoma Geological Survey. It contains short technical articles, mineral-industry and petroleum news and statistics, abstracts, notices of new publications, and announcements of general pertinence to Oklahoma geology. Single copies, $1.50; yearly subscription, $6. Send subscription orders to the Survey at 100 E. Boyd, Room N-131, Norman, OK 73019. Short articles on aspects of Oklahoma geology are welcome from contributors; general guidelines will be sent on request.

This publication, printed by the Oklahoma Geological Survey, Norman, Oklahoma, is issued by the Oklahoma Geological Survey as authorized by Title 70, Oklahoma Statutes 1981, Section 3310, and Title 74, Oklahoma Statutes 1981, Sections 231–238. 1,500 copies have been prepared for distribution at a cost of $902 to the taxpayers of the State of Oklahoma. Copies have been deposited with the Publications Clearinghouse of the Oklahoma Department of Libraries.

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VOL. 55, NO. 1

BURIED PEAT DEPOSIT, OKMULGEE COUNTY, OKLAHOMA

LeRoy A. Hemish[1] *and L. R. Wilson*[2]

Introduction

Discoveries of buried peat deposits in Oklahoma are rare. Most peat deposits are related to river deposits and have been found in association with the Canadian River and its tributaries in east-central Oklahoma. The discovery described here is covered by ~48 ft of alluvial deposits along the south side of the Deep Fork of the Canadian River in central Okmulgee County (Text-fig. 1). Hereafter, the peat bed is referred to as the Deep Fork peat. Its lateral extent is not known. The fortuitous discovery of the buried peat occurred during an Oklahoma Geological Survey (OGS) drilling program designed to locate and evaluate coal beds for a mapping project in Okmulgee County. The peat was recovered from the interval drilled from 47.5 ft to 58 ft, through which the drill pipe "dropped" rapidly. The core barrel was attached, but it proved to be almost empty when pulled from the hole. Less than a handful of woody peat was the only recovery. L. R. Wilson (personal communication, 1994) reported a similar situation at a drill site in western Oklahoma where a 30-ft-long drill pipe "dropped" as though it had gone into a hole. The driller believed that quicksand had been drilled. Perhaps part of the 11-ft interval drilled in Okmulgee County was quicksand, but confirmation cannot be made because of a lack of sample recovery. The total thickness of the peat is uncertain.

Stratigraphic Setting

The hole in which the peat was discovered (OGS Core Hole C-OO-4) was drilled on a dissected terrace of the Deep Fork, tributary of the North Canadian River just west of U.S. Highway 75 in the NW¼NW¼SE¼NW¼NE¼ sec. 5, T. 12 N., R. 13 E. (Text-fig. 1). The terrace is the first one above the modern flood plain. Strata overlying the peat are composed primarily of silt and clay with lesser amounts of very fine grained sand (Text-fig. 2). Reddish tones of these unconsolidated alluvial deposits indicate a western provenance; the bulk of the material probably is derived from erosion of Permian-age rocks in central Oklahoma. The base of the peat bed rests on ~0.5 ft of coarse, unconsolidated sand composed mostly of well-rounded clasts of quartz and chert. The source of this reworked sand is unknown; however, the chert conglomerates of the Vamoosa Formation (Virgilian) are a likely source. The Deep Fork of the Canadian River and its tributaries cut through the exposed Vamoosa Formation in northern Okfuskee County and southern Creek County upstream from the site of Core Hole C-OO-4. The Vamoosa Formation consists of a succession of conglomerates, sandstones, and shales that contain subangular to well-rounded white chert pebbles as well as chalcedony, quartz, and quartzite (Ries, 1954). The reworked sand is underlain unconformably by hard, gray siltstone of the Pennsylvanian-age Senora Formation.

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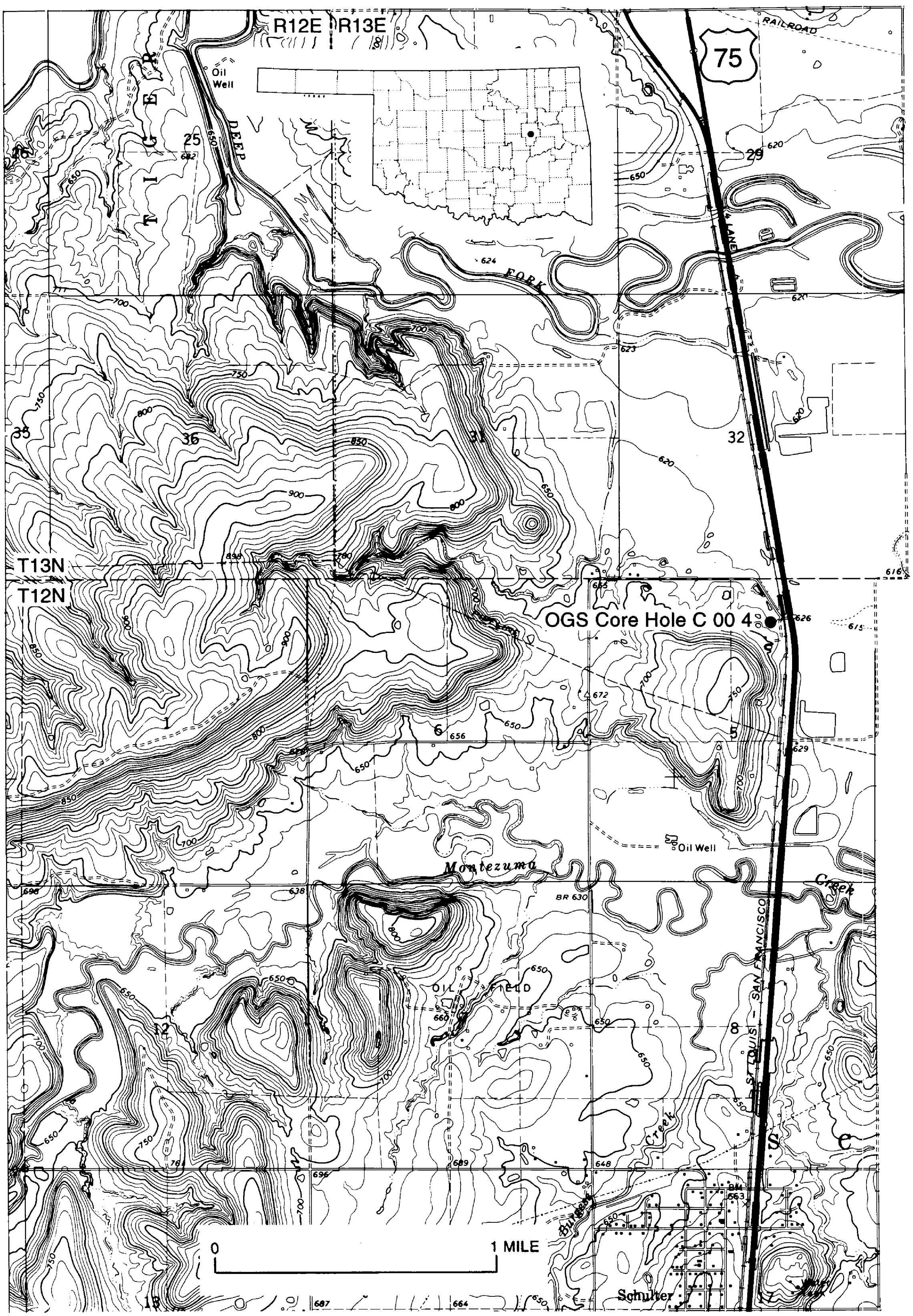
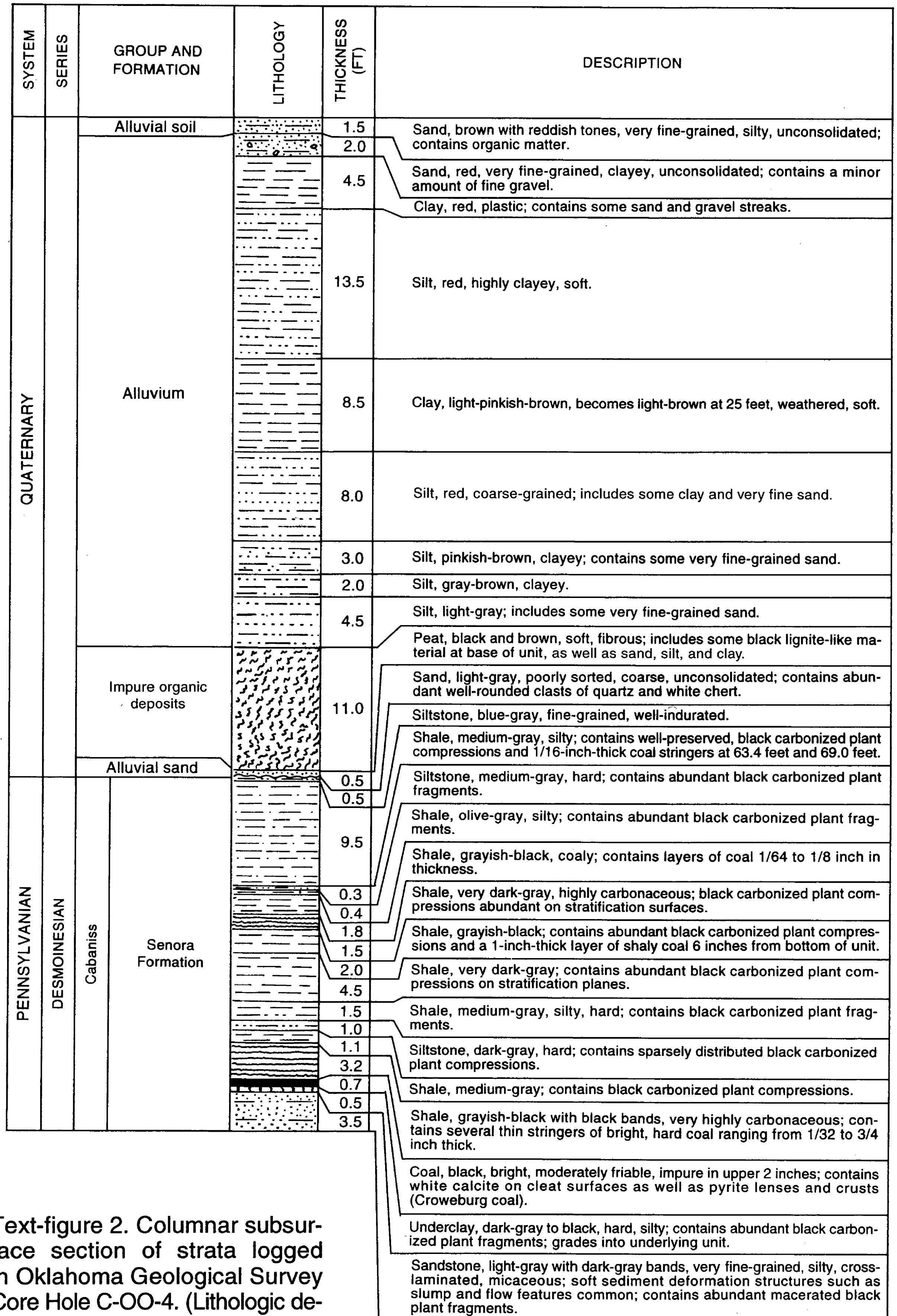


Text-figure 1. Map showing location of Oklahoma Geological Survey Core Hole C-OO-4, ~2 mi north of Schulter, in south-central Okmulgee County. Location of buried peat deposit in Okmulgee County shown on inset index map of Oklahoma.



Text-figure 2. Columnar subsurface section of strata logged in Oklahoma Geological Survey Core Hole C-OO-4. (Lithologic descriptions by LeRoy A. Hemish.)

In OGS Core Hole C-OO-4, the eroded top of the Senora Formation was found at an elevation of 568 ft above sea level (~50 ft below the modern flood plain), indicating that the ancestral Deep Fork had at one time cut a channel much deeper than the elevation of the present-day channel. The ancestral channel may have been cut to this elevation during the Pleistocene in a periglacial environment.

Matsch (1976, p. 79) stated that rivers not directly linked to glacial activity responded to increases or decreases in discharge and load by cutting or filling their valleys. He stated that in cooler parts of the continent, wetter climates resulted in larger discharges that widened and deepened many river valleys. The evolution of the Deep Fork occurred during a period when periglacial conditions existed in Oklahoma—a time when the climate of the region would have been cooler and wetter.

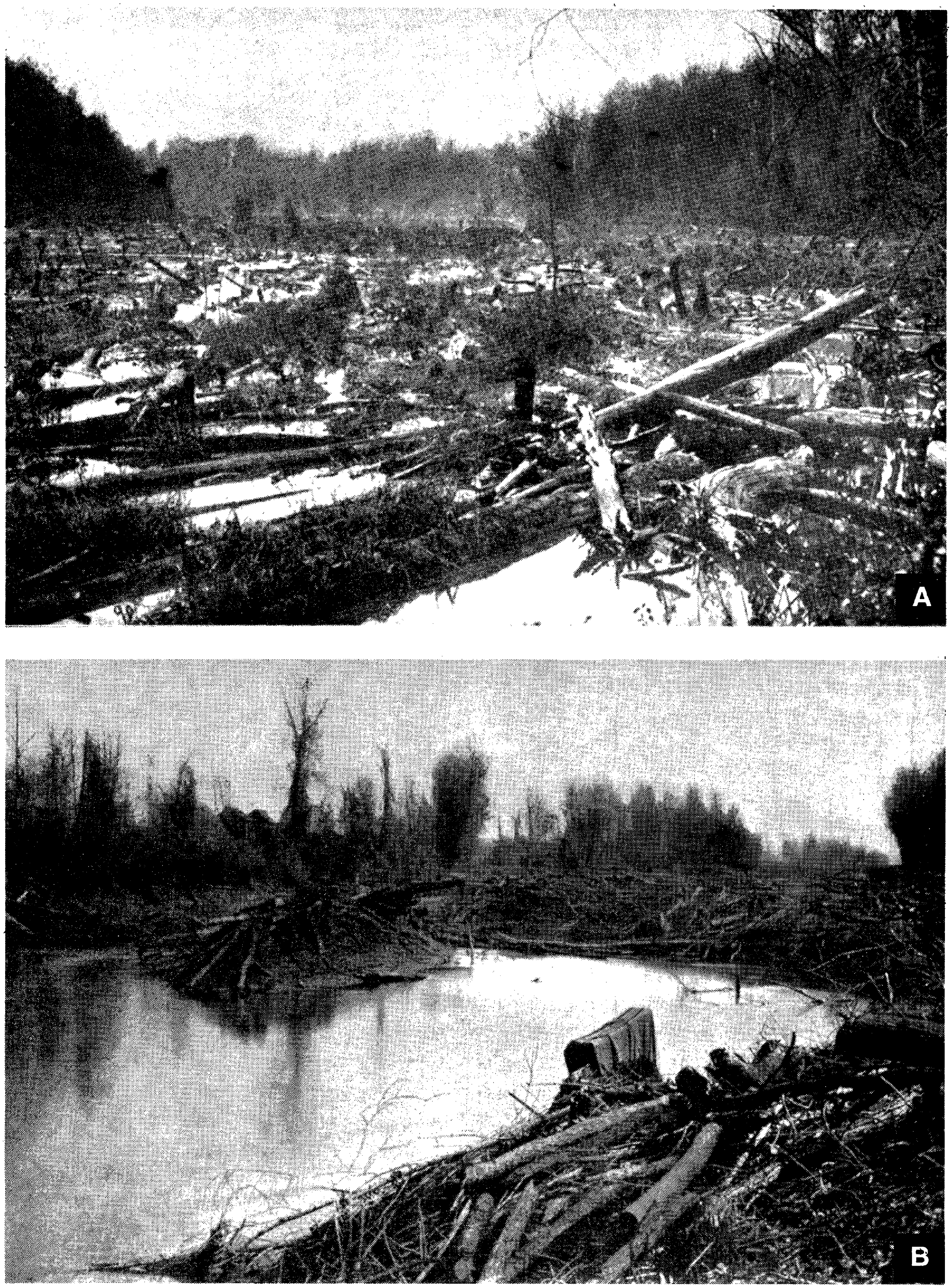
The valley of the Deep Fork was partially filled with sediment during the complicated Quaternary history of Oklahoma. The elevations of the terraces along the river today (the study terrace is at ~650 ft above sea level) indicate that the valley was filled with sediment to a level considerably above the modern-day flood plain (which is at an elevation of ~615 ft in the vicinity), and that the stream has since cut down to its present position.

Development of the Peat Deposit

Peat consists of plant materials in various stages of preservation that generally accumulate in water-saturated environments where the lack of oxygen inhibits decomposition. The Deep Fork peat consists mainly of very weathered angiospermous wood. In addition, the peat also contains minor components of upland pollen, reworked bituminous coal particles, and clay.

Details of the deposition of the Deep Fork peat are unclear because of small recovery of sample. Peats that develop from plants that grew *in situ*, or were not transported any significant distance, are called autochthonous. Those peats that form from plant remains transported from their original sites are called allochthonous. Stach and others (1982, p. 19) state that allochthonous deposits are rich in mineral matter. Samples of the Deep Fork peat contain considerable clay mineral matter, but it is unclear whether the minerals are part of the peat bed or whether they are impurities introduced from overlying strata during drilling. The interpreted thickness of the deposit and the mixture of sediments and organic material comprising the peat suggest that the deposition was primarily allochthonous. The materials comprising the deposit may have been deposited in a single flood event. Flood waters in the ancestral Deep Fork and its tributaries almost certainly would have transported a large amount of vegetal and mineral matter. Evidence for this can be observed during flooding events along the modern Deep Fork. A likely explanation for the depositional history of the peat was that it originated as a logjam in a sharp meander or in an oxbow of the ancestral Deep Fork. L. R. Wilson (personal communication, 1994) observed the formation of such a deposit during a flood stage of the Deep Fork.

Damming of rivers by floating trees and driftwood in areas of heavily timbered bottom lands is not uncommon. Veatch (1906, p. 60–61) reported such occurrences on the Red River near the Arkansas/Louisiana state line. He described a "Great Raft," which was more properly a complex series of logjams, each completely filling the river (Text-fig. 3). The effect of the initial jam was to pond the water immedi-



Text-figure 3. Great Red River Raft (circa 1873). *A*—One of several timber jams composing the Red River Raft. Location: Channel of Red River, sec. 29, T. 23 N., R. 14 W. From Veatch, 1906. *B*—Main channel of Red River showing silt accumulated during period of logjam. Location: T. 21 N., R. 14 W. From Veatch, 1906. (Photographs by R. B. Talfor.)

ately above it and force the river to find a new outlet in a low place in the bank above the jam.

Verification of the hypothesis that the Deep Fork peat originated as a logjam cannot be made from a single drill hole. Because the peat deposit is not exposed, the relationship of the various constituents that make up the peat body cannot be seen.

Quaternary Geologic History

During the late Quaternary Period, Pennsylvanian-age rocks were exposed at the surface in the area of this report in central Okmulgee County. The rocks dipped west-northwest away from the Ozark uplift at low angles at that time, just as they do now, generally about 30–50 ft per mile. Resistant sandstones formed cuestas, or highland ridges, that stood above surrounding, easily eroded shale plains. In general, the topography probably appeared much as it does today, with somewhat greater relief. Drainage patterns had been established and streams occupied the same valleys they do now. Much of the drainage was structurally controlled, particularly tributaries of the Deep Fork of the Canadian River such as Burgess Creek and Montezuma Creek (Text-fig. 1). Water gaps, cut through resistant sandstone ridges north and east of Henryetta, suggest that the ancestral Deep Fork may have been captured by a tributary of the Canadian River, probably during the Pleistocene.

Like most large valleys, the Deep Fork system has had a complicated history which cannot be determined in detail. The Deep Fork is presently an underfit stream; that is, it appears too small to have eroded the valley in which it flows. (The valley of the Deep Fork is >2 mi wide in the vicinity of OGS Core Hole C-OO-4.) Undoubtedly, during periods of climatic change in the Quaternary (pluvial periods corresponding in time to Pleistocene glacial substages), the Deep Fork carried much larger volumes of water.

Flooding in modern times has deposited deep, silty alluvium in Creek and Lincoln Counties (Harper and Reed, 1958). This deposition occurred when logjams collected in the channel of the Deep Fork. The flow of flood waters was decreased and the adjacent flood plain was raised >10 ft in those two counties. The thickness of alluvial deposits recorded in the log of OGS Core Hole C-OO-4 (Text-fig. 2) shows that the valley of the Deep Fork was deeper than it is at present. Investigations such as those by Harper and Reed (1958) show how valley-filling can occur.

During the time the Deep Fork peat was deposited, the ancestral Deep Fork apparently was a graded stream, or one that had attained "that slope or gradient which under existing conditions of discharge and channel characteristics was just sufficient for transportation of its load" (Thornbury, 1969, p. 106). The valley would have been in a state of equilibrium, neither being deepened nor filled. When the competence of the ancestral Deep Fork decreased, the valley-filling stage began. During a periglacial flooding event, a logjam could have been covered almost immediately after it formed by sediments that the river was no longer able to transport. Through time, ~50 ft of alluvium was depostied above the logjam, ensuring that it was not lost through decay or erosion.

Radiocarbon dating of the Deep Fork peat gave an age of 20,980 ± 1,000/1,140 yr B.P. (I. C. Stehli, DICARB Radioisotope Co., Norman, Okla., personal communication, 1984). Flint (1971, p. 560) provisionally used the name Late Wisconsin in a time-stratigraphic sense for the period 25,000 to 10,000 B.P. as defined in terms of ^{14}C dates. The period around 20,000 B.P. was comparatively cold and wet; it was named the Tahoka Pluvial (climatic term) from a study in nearby northwestern Texas by Wendorf and others (1961). The assemblage of pollen types found in the Deep Fork peat, however, suggests that the climate in Oklahoma was similar to what it is presently.

Two other sites in Oklahoma where preserved plant material was found were reported by Wilson (1966, 1972). At the Domebo site (Caddo County), located in the stream valley of the Domebo Branch of Tonkawa Creek, ^{14}C dates of 11,045 B.P. and 10,123 B.P. were determined from two stumps buried at different horizons (Wilson, 1966, fig. 35). A study of fossil pollen assemblages suggested that paleoecological conditions at the Domebo site in the Late Pleistocene were much like modern ecological conditions.

At the Tesesquite Creek site, located several miles east of Kenton in Cimarron County, samples of wood from stumps found in the growth position were analyzed and dated at 343–603 B.P. (Wilson, 1972). The stumps were rooted in blue-black clays lithologically similar to other widespread clays associated with Pleistocene drainages in Oklahoma. The clays have been dated, on the basis of included organic materials, as 21,360 ± 1,250 yr B.P. (Myers, 1965), an age similar to the age of the Deep Fork peat.

Composition and Ecological Interpretations of the Deep Fork Peat

The fortuitous discovery of a >20,000-year-old Pleistocene peat deposit associated with the Deep Fork of the Canadian River has made it possible to construct a glimpse of the biota and its ecology during an almost unknown portion of Oklahoma's "Ice Age." Although glacial ice did not extend into Oklahoma during the Pleistocene, the State was under periglacial conditions several times. At least one episode occurred after the deposition of the Deep Fork peat (Wilson, 1966). The small amount of organic material recovered from the Deep Fork drilling limits description of the conditions and flora in what is now east-central Oklahoma ~20,000 years ago, but enough has been found to indicate a great similarity to the present-day physical and vegetative environment.

The composition of the deposit recovered for palynological study was a mixture of sand, clay, woody and fibrous tissues, amorphous organic sediments, and several cubic-millimeter fragments of coal. The last contained a number of Paleozoic (Pennsylvanian) palynomorphs that are unlike those reported for the Henryetta (Croweburg) coal that occurs lower in the drilled section. Six grams of the material were submitted for ^{14}C analysis and gave an age date of 20,980 ± 1,000/1,140 yr B.P. (I. C. Stehli, DICARB Radioisotope Co., Norman, Okla., personal communication, 1984). The remainder of the sample, a volume of several cubic centimeters, minus the sand, weighed ~12 g.

Sample processing was standard except that an ultrasonic treatment was applied briefly. Sixteen permanent microscope slides were prepared using Okol as a mounting medium on the cover glasses, which in turn were mounted with Canada Balsam. The microscope slides are cataloged with collection numbers OPC 1561-1 through OPC 1561-16 in the Oklahoma Museum of Natural History Palynological Collection. These microscope slides are numbered consecutively preceded by a

Table 1. — Fossils from the Deep Fork Peat (Pleistocene)

Biota	Number of specimens
Algae	
Desmid resting spore	1
Pseudoschizaea sp.	2
Protozoa	
Arcella sp.	2
Fungi (spores)	8
Ferns	
Polypodaceae	1
Gymnospermae	
Pine (*Pinus* sp.)	7
Juniper (*Juniperus* sp.)	2
Angiospermae	
Dicotyledoneae	
Oak (*Quercus* sp.)	12
Hickory (*Carya* sp.)	8
Chenopodium sp.	1
Oenothera sp.	3
Compositae sp.	23
Tricolpate pollen	1
Triporate pollen	4
Monocotyledoneae	
Sedge pollen	3
Grass pollen	4
Unknowns (poorly preserved)	14
Pennsylvanian palynomorphs	
Laevigatosporites sp.	1
Acanthotriletes sp.	1
Verrucosisporites sp.	1
Cadiospora sp.	1
Cristatisporites sp.	1
Florinites sp.	1
Remysporites?	1
Schopfipollenites sp.	1
Quasillinites sp.	1
Other fossils	
Leaf tissues	many
Woody tissues	many
Seeds	2
Flower (*Artemesia*?)	1

hyphen and the specimens on the slides are ringed with ink and adjacently numbered. These numbers are also preceded by a hyphen on the record sheet (for example, OPC 1561-5-4).

Palynomorphs and other organic materials observed on the 16 microscope slides are listed in Table 1. Photogenic specimens are illustrated on Plates 1–3 (see p. 14–19). Most of the unillustrated fossils are found within ink rings on the various slides.

The fossil palynomorph assemblage suggests a rather inclusive number of ecological habitats: (1) aquatic (algae and Protozoa), (2) moist valley (ferns, grasses, sedges, fungi, cottonwood), (3) hillsides and terraces (oak, hickory, and elm), and (4) upland (herbaceous plants belonging to the Compositae family, *Oenothera,* and numerous plant species represented as tricolpate and triporate pollen types).

Pine and juniper pollen occur sparsely; only seven grains of pine and two of juniper were observed, and they probably were transported from a western locality as pine is not native in central Oklahoma. This question of the origin of pine pollen was raised also about the Domebo deposit (Wilson, 1966). Because pine pollen occurs in the topmost surface soil at the Domebo site in essentially the same abundance as in the Deep Fork peat (Table 1), the fossil pine pollen was considered to have been transported from western pine forests by prevailing southwesterly winds. Current snow residue studies in Norman by L. R. Wilson give additional support to this theory, as western pine pollen often occurs in abundance in snow residues weeks before the local trees shed their pollen. Atmospheric pollen transport is probably more important in palynological studies than has been recognized.

The aquatic element in the fossil assemblage consists of Protozoan *Arcella* remains, as well as algae (desmid resting spores and the problematic "living fossil" *Pseudoschizaea* [Table 1]). The last is well known from the Tertiary and earlier (Christopher, 1976) and is present in many Oklahoma Pleistocene terrace deposits. It has been collected once in a snow residue deposit in Norman. The source may have been from a nearby flood plain since the living organism is associated with aquatic deposits.

Fragments of leaf and wood tissues are associated with the spores and pollen in the peat. Grass and sedge tissues are present; other plants are represented by net-veined tissues, some of which are preserved only as vascular structures. Much of the wood tissue is macerated; some tissues, however, are well preserved (Pl. 1), but not definitely identifiable to the genus. A few specimens appear to be charcoal fragments, which, if true, suggests the occurrence of forest fires during that part of the Pleistocene.

The abundance of hickory and oak pollen in the assemblage of palynomorph fossils leads to what is probably the most conclusive observation about the flora of the area during that part of the Pleistocene. It strongly suggests that the area was an oak/hickory region quite similar to the present. The associated fossils do not contradict that conclusion.

The Paleozoic (Pennsylvanian) spore and pollen flora (from coal fragments in the deposit) associated with the Pleistocene fossils conclusively indicates that the Deep Fork deposit was transported to the place where it was collected and is not a deposit of local development. The coal itself cannot be identified through the limited assemblage in the fragment. Several of the spore genera have not been observed in the Henryetta (Croweburg) coal that occurs below the Deep Fork deposit (Text-fig. 2), but do occur in coals that crop out upstream, and are stratigraphically above the Henryetta (Croweburg). None of the specimens are preserved well enough to make specific identification certain.

A final observation and hopeful suggestion for further investigations into the Pleistocene of Oklahoma may begin with a word about the animal life probably contemporaneous with the Deep Fork peat. Many midwestern local faunas have been found and a number have been described that contain a large and varied number of extinct and extant species; however, relationships between faunas and floras have been sadly neglected. During and after Deep Fork depositional time Oklahoma had an extensive fauna of invertebrates as well as large mammals, many of which are now extinct. These latter include mammoth, mastodon, giant bison, horses, bears, beaver, and many small mammals. During the last 11,000 years, man has been a resident of Oklahoma and he too has had a checkered record during a period several thousand years ago. The cause may have been largely climatic changes. Certainly we have had a climatic progression that has been important to biological continuance, and it probably was responsible for many extinctions, but much study is needed to determine the details. An exhaustive review of these problems is treated in the recent book by Pielow (1991).

Summary

Discovery of a buried peat deposit associated with an ancestral phase of the Deep Fork of the Canadian River in Okmulgee County, Oklahoma, and subsequent investigations permit the following statements and interpretations to be made.

1) The ancestral Deep Fork, during the Pleistocene, had at one time cut a channel to a depth ~50 ft lower than the elevation of the present-day channel.

2) An 11-ft-thick, impure deposit of silt, clay, wood, and other organic material accumulated in this channel, probably in a sharp meander or oxbow.

3) The deposit (Deep Fork peat) is interpreted to be associated with a logjam, similar to ones that have occurred in historical times on the Red River and in recent times on the modern-day Deep Fork. It was preserved by rapidly deposited alluvium that sealed off oxygen, thus preventing decay of the organic material.

4) Radiocarbon dating of the Deep Fork peat gave an age of 20,980 ± 1,000/1,140 yr B.P., a period that was comparatively cold and wet.

5) Examination of palynomorphs and other organic materials comprising the Deep Fork peat strongly suggests that the area was an oak/hickory region quite similar to the present.

6) The association of fossils in the Deep Fork peat indicates that the deposit was transported to the place where it was collected. The allocthonous nature of the buried peat supports the interpretation that it originated as a logjam.

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PLATES

Photomicrographs of Specimens from the Deep Fork Peat (Pleistocene)

Oklahoma Museum of Natural History Palynological Collection

Explanation of Plate 1

Figure 1. Carbonized wood fragment. OPC 1561-5-4.

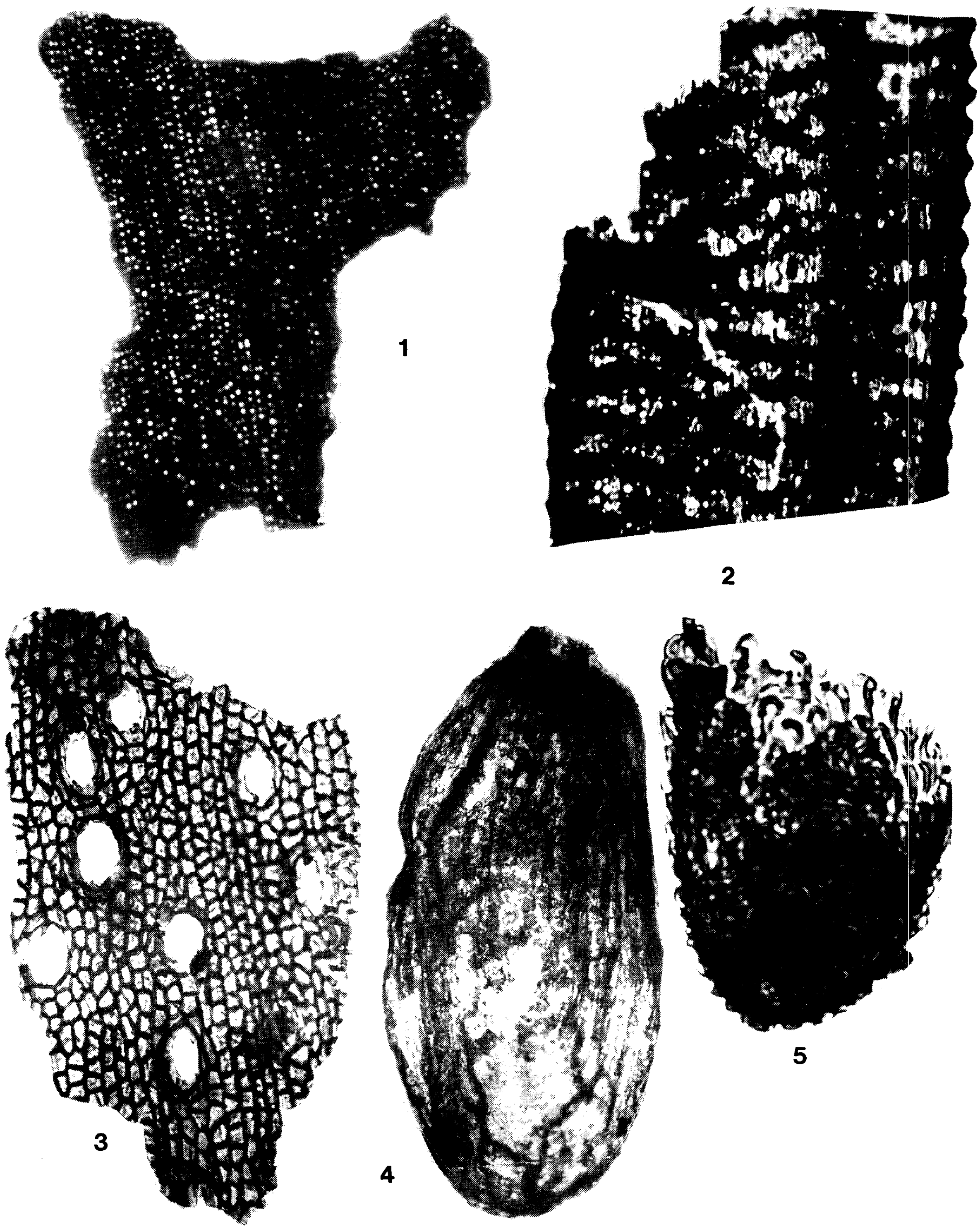
Figure 2. Carbonized wood fragment, possibly elm. OPC 1561-4-2.

Figure 3. Lower epidermis of a mesophytic leaf tissue showing stomata with guard cells destroyed. OPC 1561-1-3.

Figure 4. Small unidentified seed, 64 × 548 microns. OPC 1561-1-2.

Figure 5. Flower fragment, possibly of *Artemesia*?. OPC 1561-1-8.

Plate 1



Explanation of Plate 2

Figure 1. Cluster of fungus spores. OPC 1561-5-15.

Figure 2. Fern spore (Polypodaceae). OPC 1561-3-1.

Figure 3. Pine pollen (*Pinus* sp.). OPC 1561-2-1.

Figure 4. Oak pollen (*Quercus* sp.). OPC 1561-3-3.

Figure 5. Oak pollen (*Quercus* sp.). OPC 1561-5-8.

Figure 6. Hickory pollen (*Carya* sp.). OPC 1561-2-3.

Figure 7. Hickory pollen (*Carya* sp.). OPC 1561-1-1.

Figure 8. Tricolpate pollen (unidentified). OPC 1561-5-3.

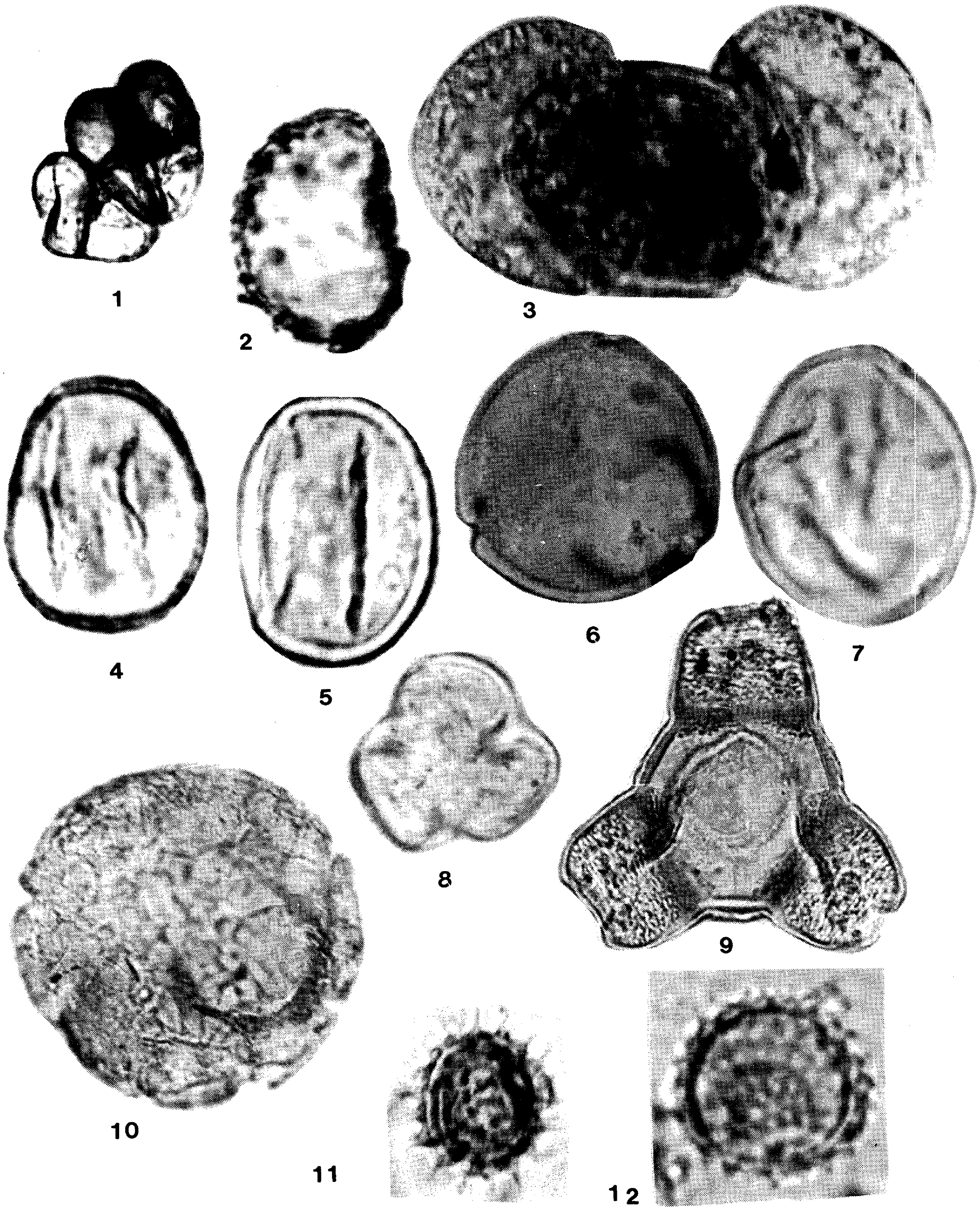
Figure 9. Evening primrose pollen (*Oenothera* sp.). OPC 1561-4-6. (Same specimen as shown on the cover of this issue.)

Figure 10. Triporate pollen (unidentified). OPC 1561-4-3.

Figure 11. Composite pollen sp. (long spined type). OPC 1561-2-11.

Figure 12. Composite pollen sp. (short spined type). OPC 1561-5-1.

Plate 2



Explanation of Plate 3

Figure 1. *Laevigatosporites* sp. OPC 1561-2.

Figure 2. *Acanthotriletes* sp. OPC 1561-5-12.

Figure 3. *Cristatisporites* sp. OPC 1561-5-6.

Figure 4. *Cadiospora* sp. OPC 1561-2-5.

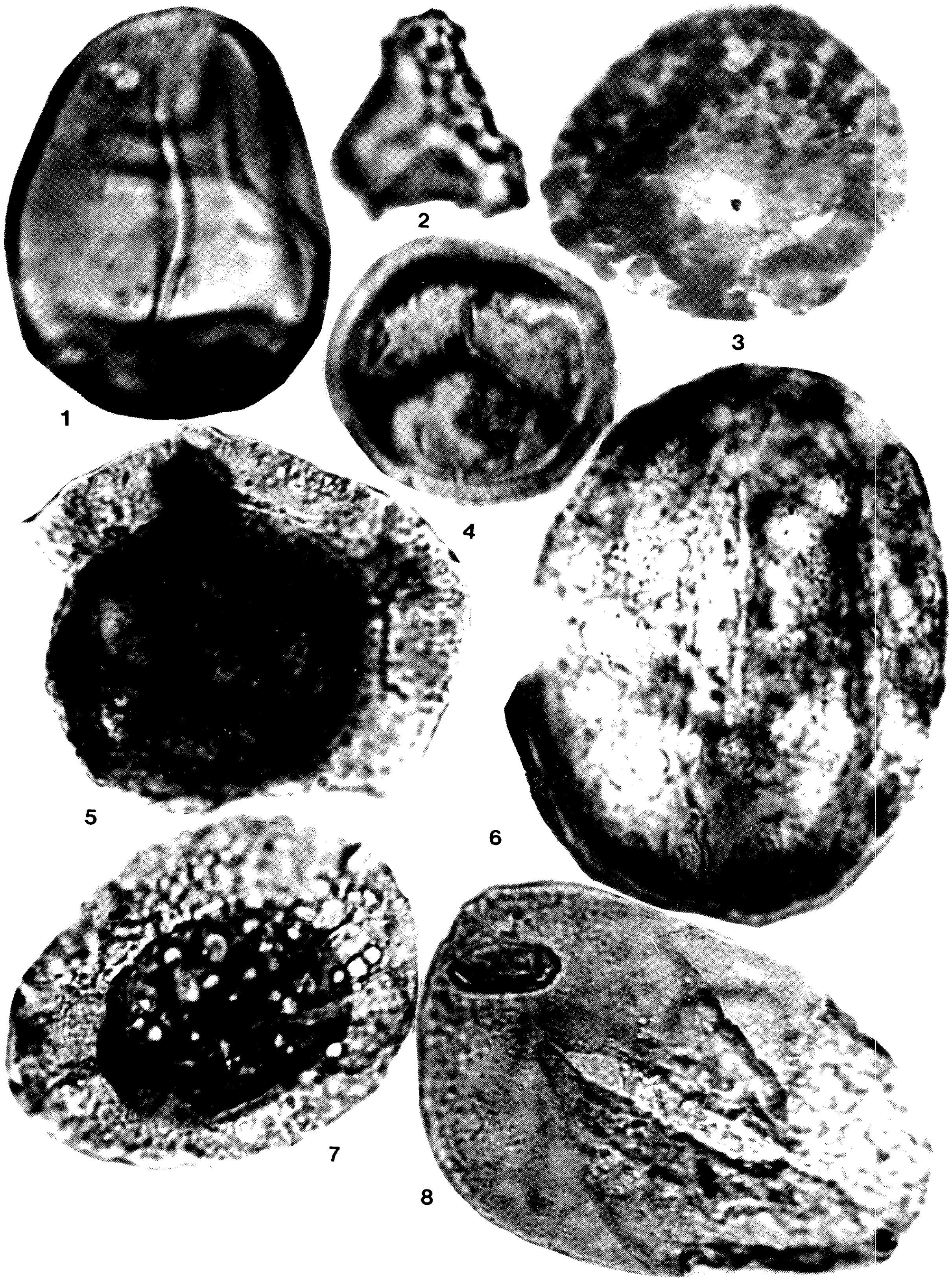
Figure 5. *Remysporites*?. 49 microns. OPC 1561-2.

Figure 6. *Schopfipollenites* sp. OPC 1561-5-5.

Figure 7. *Florinites* sp. OPC 1561-4-4.

Figure 8. *Monoletes* sp. OPC 1561-2-8.

Plate 3



First PTTC Problem-Identification Workshop Held

Charles J. Mankin

The South Mid-Continent Region of the Petroleum Technology Transfer Council (PTTC) program, described in the December 1994 issue of *Oklahoma Geology Notes* (p. 224), held its first Problem-Identification Workshop on January 28 in Sarkeys Energy Center on the campus of the University of Oklahoma. The one-day program drew 81 registrants (15 operators and 66 other interested individuals).

The opening general session was devoted to brief presentations by representatives of several groups involved with the petroleum industry in communication and technology transfer. The presenters were: Mike Smith—Oklahoma Secretary of Energy; Jack Shadle, Jr.—Executive Director, Oklahoma Commission on Marginally Producing Oil and Gas Wells; Steve Jones—Gas Research Institute program for the Oklahoma Independent Petroleum Association; Mike Terry—Oklahoma Energy Resources Board; and Arfon Jones—BDM/Oklahoma.

Both operators and other participants then were divided equally among three working groups that met concurrently to identify the petroleum industry's priority needs for information and technology in the categories of production, reservoir, regulation, and other issues. A coordinator and an assistant assigned to each working group moderated discussion and recorded the issues identified. A master list then was compiled, which included the needs identified by each working group for each category.

In the concluding general session, each participant was asked to identify the top three to five issues in each of the categories. Operators received master lists printed on colored paper so the issues they identified as most important could be distinguished from those identified by other participants. The same agenda and procedure will be used in the second Problem-Identification Workshop.

The combined results from the Problem-Identification Workshops will be the basis for identifying topics for the Focused-Technology Workshops, which will begin this fall. In addition, these needs will be addressed through materials to be incorporated in the primary and satellite resource centers that each region will establish.

The Oklahoma Geological Survey and our colleagues from the other organizations supporting the PTTC recognize that the petroleum industry is the largest economic activity in the region, and will be well into the 21st century. While we cannot affect the world price of crude oil, it is in our collective best interest to address issues that can increase production and/or reduce operating costs and, thereby, improve an operator's bottom line. With your assistance, I believe that we can make a difference.

The second Problem-Identification Workshop will be held at the Green Country Area Vo-Tech in Okmulgee, Oklahoma, on March 21, 1995. For information and registration, please contact:

Michelle Summers
Oklahoma Geological Survey
100 East Boyd, Room N-131
Norman, Oklahoma 73019
(405) 325-3031 *or* (800) 330-3996
FAX 405-325-7069

AIPG AND OGS JOINT CONFERENCE

Norman, Oklahoma, April 21–23, 1995

The American Institute of Professional Geologists, Oklahoma Section, and the Oklahoma Geological Survey are hosting a joint conference on "The Profession of Geology," to be held at the Sarkeys Energy Center, University of Oklahoma, Norman.

Symposia topics include:

- ***Petroleum geology*** (exploration and development)
- ***Environmental geology*** (hydrogeology/contaminants)
- ***Economic geology*** (nonmetallic and metallic)
- ***Potpourri*** (engineering geology, forensic geology, etc.)

Registration cost for the conference is $35 ($25 without luncheon); $10 for students. A short course on "The Business of Geology" will be offered April 22–23; cost is $300. A field trip to southern Oklahoma will take place on April 23; cost will be announced later.

For more information, contact:

Michelle Summers
Oklahoma Geological Survey
100 E. Boyd, Room N-131
Norman, OK 73019
(405) 325-3031 *or* (800) 330-3996
FAX 405-325-7069

Presentations are still needed. Please contact Skip Honeyman, Davis Bros., L.L.C., One Williams Center, Suite 2000, Tulsa, OK 74172; phone (918) 584-3581.

UPCOMING *Meetings*

Geological Society of America, Northeastern Section, Annual Meeting, March 20–22, 1995, Hartford, Connecticut. Information: Gregory McHone, Graduate Liberal Studies Program, Wesleyan University, 255 High St., Middletown, CT 06457; (203) 344-7930, fax 203-344-7957.

Seismological Society of America, Annual Meeting, March 22–24, 1995, El Paso, Texas. Information: Nancy Sauer, RDD Consultants, Inc., 1163 Franklin Ave., Louisville, CO 80027; (303) 665-9423, fax 303-655-9413.

The Ames Structure and Similar Features Workshop, March 28–29, 1995, Norman, Oklahoma. Information: Kenneth S. Johnson or Jock A. Campbell, Oklahoma Geological Survey, 100 E. Boyd, Room N-131, Norman, OK 73019; (405) 325-3031, fax 405-325-7069.

Geotechnical Earthquake Engineering and Soil Dynamics, International Conference, April 2–7, 1995, St. Louis, Missouri. Information: Shamsher Prakash, Dept. of Civil Engineering, University of Missouri, Rolla, MO 65401; (314) 341-4489, fax 314-341-4729.

Geological Society of America, Southeastern Section, Annual Meeting, April 6–7, 1995, Knoxville, Tennessee. Information: Robert D. Hatcher, Jr., Dept. of Geological Sciences, University of Tennessee, Knoxville, TN 37996; (615) 974-2366, fax 615-974-2368.

Geological Society of America, South-Central/North-Central Sections, Joint Annual Meeting, April 27–28, 1995, Lincoln, Nebraska. Information: Robert F. Diffendal, Conservation and Survey Division, 133 Nebraska Hall, University of Nebraska, 901 N. 17th St., Lincoln, NE 68588; (402) 472-2663, fax 402-472-2410.

Northeastern Friends of the Pleistocene, Annual Conference, May 13–14, 1995, Portland, Maine. Information: Woodrow Thompson, Maine Geological Survey, State House Station 22, Augusta, ME 04333; (207) 287-7178, fax 207-287-2353.

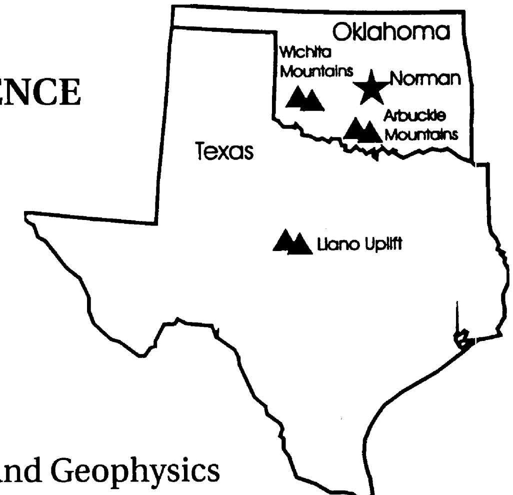
Geological Society of America, Rocky Mountain Section, Annual Meeting, May 18–19, 1995, Bozeman, Montana. Information: Stephen G. Custer, Dept. of Earth Sciences, Montana State University, Bozeman, MT 59717; (406) 994-6906, fax 406-994-6923.

Walter A. Bell Symposium on Paleobotany and Coal Science, May 28–June 1, 1995, Sydney, Nova Scotia. Information: Edwin L. Zodrow, University College of Cape Breton, P.O. Box 5300, Sydney, Nova Scotia B1P 6L2, Canada; fax 902-562-0119.

American Association of Petroleum Geologists, Southwest Section, Annual Meeting, June 3–7, 1995, Dallas, Texas. Information: Robert Richter, Ensearch Exploration, Inc., Suite 1300, Two Energy Square, 4849 Greenville Ave., Dallas, TX 75206; (214) 987-6304.

Oklahoma City Gem and Mineral Show and Convention, sponsored by the Rocky Mountain Federation of Mineralogical Societies, Inc., June 9–11, 1995, Oklahoma City, Oklahoma. Information: Dan McLennan, Oklahoma Mineral and Gem Society, Inc., P.O. Box 26523, Oklahoma City, OK 73126; (405) 525-2692.

12th INTERNATIONAL CONFERENCE ON BASEMENT TECTONICS



Norman, Oklahoma
May 21–26, 1995

Sponsored by the OU School of Geology and Geophysics and the Oklahoma Geological Survey, with the assistance of the University of Texas, Austin, Department of Geological Sciences, for the International Basement Tectonics Association, Inc., the conference will be held at the facilities of the School of Geology and Geophysics in the Sarkeys Energy Center, 100 E. Boyd, at the University of Oklahoma in Norman.

Conference themes:

- Fracture Development, Reactivation, and Mineralization
- Evolution of Basement of North American Plate (particularly its southern parts)
- Probing of Basement: Geophysical and Geochemical Methods
- Response of Cover Rocks to Basement Deformation
- Continental Scientific Drilling of Basement

Proposed field trips:

- Llano region of south-central Texas: 1.2 Ga orogenic granites and tectonics of the Texas Craton
- Basement rocks of the Arbuckle Mountains: 1.4 Ga granites and metamorphic rocks of the southern margin of the North American plate in the Proterozoic
- Wichita Mountains: 0.5 Ga bimodal igneous basement of southern Oklahoma aulacogen

For information, contact:

M. Charles Gilbert
School of Geology and Geophysics
810 Sarkeys Energy Center
University of Oklahoma
Norman, OK 73019
(405) 325-3253; fax 405-325-3140

Ground-Water-Quality Assessment of the Central Oklahoma Aquifer, Oklahoma—Analysis of Available Water-Quality Data through 1987

Ground-water quality data for the Central Oklahoma Aquifer were compiled as part of the National Water Quality Assessment Program in this 74-page USGS water-supply paper by David L. Parkhurst, Scott C. Christenson, and Jamie L. Schlottman. (This report supersedes open-file report 88-728.)

A total of 4,439 chemical analyses were obtained from federal, State, and local agencies. The sampling sites were mapped and analyses were compared to water-quality standards. Contingency tables were used to investigate the relation of geologic unit and depth to the occurrence of constituents that exceeded water-quality standards.

Order W 2357-B from: U.S. Geological Survey, Water Resources Division, 202 N.W. 66th St., Bldg. 7, Oklahoma City, OK 73116; phone (405) 843-7570, fax 405-843-7712. A limited number of copies are available free of charge.

Geohydrology of the Ozark Plateaus Aquifer System in Parts of Missouri, Arkansas, Oklahoma, and Kansas

J. L. Imes and L. F. Emmett wrote this 127-page USGS professional paper, which is one of five chapters reporting the findings of the Central Midwest Regional Aquifer-System Analysis (RASA) Program. The Ozark Plateaus aquifer system contains three aquifers and two confining units of regional extent. Regional ground-water flow in the Ozark Plateaus aquifer system is away from regional ground-water divides in southern Missouri and northern Arkansas to the Osage and White Rivers interior to the Ozark area and the Mississippi, Missouri, Neosho, and Arkansas Rivers and the Mississippi Embayment at the boundaries of the flow system. Steady-state simulation of regional ground-water flow in the aquifer system indicates about 6% of precipitation enters the regional flow system.

Order P 1414-D from: U.S. Geological Survey, Map Distribution, Box 25286, MS 306, Federal Center, Denver, CO 80225. The price is $12.50; add 25% to the price for foreign shipment.

Water-Level Changes in the High Plains Aquifer; Predevelopment to 1992

Written by J. T. Dugan, Timothy McGrath, and R. B. Zelt, this water resources investigations report contains 56 pages.

Order WRI 94-4027 from: U.S. Geological Survey, Map Distribution, Box 25286, MS 306, Federal Center, Denver, CO 80225. The price is $4 for microfiche and $35.25 for a paper copy; add 25% to the price for foreign shipment.

Hydrologic Data for the Alluvium and Terrace Deposits of the Cimarron River from Freedom to Guthrie, Oklahoma

Existing and new ground-water-resources data collected for the alluvium and terrace deposits along the Cimarron River between Freedom and Guthrie, Oklahoma, were compiled for this 231-page open-file report by Gregory P. Adams, DeRoy L. Bergman, David J. Pruitt, Jayne E. May, and Joanne K. Kurklin. Prepared in cooperation with the Oklahoma Geological Survey, data for this report were collected as part of an investigation to provide the quantitative information necessary for effective management of the ground-water resource. Data include well and test-hole records, consisting of ground-water levels, depth of wells, principal aquifer, and primary use of ground water. Also reported are concentrations of common chemical constituents, selected trace elements, organic analyses, and tritium analyses of water samples from wells completed in the Cimarron River alluvium and terrace deposits and Permian geologic units. Winter and summer base-flow discharge measurements of the river and its tributaries are presented along with water-quality data from the measuring sites. Continuous water-level and precipitation-gauge data are presented graphically.

Order OF 94-504 from: U.S. Geological Survey, Water Resources Division, 202 5N.W. 66th St., Bldg. 7, Oklahoma City, OK 73116; phone (405) 843-7570, fax 405-843-7712. A limited number of copies are available free of charge.

Suitability of Ponds Formed by Strip Mining in Eastern Oklahoma for Public Water Supply, Aquatic Life, Waterfowl Habitat, Livestock Watering, Irrigation, and Recreation

The results from a study of coal ponds formed by strip mining in eastern Oklahoma are contained in this USGS open-file report by Renee S. Parkhurst. The 192-page report includes water-quality data on 25 ponds created by mining from the Croweburg, Iron Post, and McAlester coal seams, as well as six other non-coal-mine ponds located in the coal-mining area. In 1985, the ponds were sampled for major ions and trace metals, chlorophyll, phytoplankton, benthic invertebrates, and nutrients. The data were analyzed statistically for maximum, minimum, mean, and median values, which were compared to State and federal water-quality criteria for domestic water supplies, aquatic life, waterfowl habitat, livestock watering, irrigation, and recreation.

Order OF 94-324 from: U.S. Geological Survey, Water Resources Division, 202 N.W. 66th St., Bldg. 7, Oklahoma City, OK 73116; phone (405) 843-7570, fax 405-843-7712. A limited number of copies are available free of charge.

Computer-Science Guest-Lecture Series at Langston University Sponsored by the U.S. Geological Survey: Abstracts, 1992–93

Compiled by Karen S. Steele, this USGS open-file report contains abstracts from the eight computer-science presentations in the 1992–93 USGS-sponsored guest-lecture series at Langston University, Langston, Oklahoma.

Order OF 94-86 from: U.S. Geological Survey, Water Resources Division, 202 N.W. 66th St., Bldg. 7, Oklahoma City, OK 73116; phone (405) 843-7570, fax 405-843-7712. A limited number of copies are available free of charge.

The Oklahoma Geological Survey thanks the Geological Society of America and the authors for permission to reprint the following abstracts of interest to Oklahoma geologists.

Stratigraphic Significance of the Occurrence of *Amorphognathus Ordovicicus* in the Richmondian Stage of the Cincinnatian (Upper Ordovician) in Eastern Indiana

PETER MACKENZIE and *STIG M. BERGSTRÖM*, Dept. of Geological Sciences, Ohio State University, Columbus, OH 43210

The index of the youngest conodont zone in the Ordovician Atlantic conodont zonal scheme is *Amorphagnathus ordovicicus* Branson and Mehl. Originally described from the Thebes-Maquoketa boundary beds in eastern Missouri, this species has subsequently been found from Texas to the Canadian Arctic in North America as well as in southern and northwestern Europe. In sections with good graptolite control in North America and Europe, it appears somewhat below the base of the *D. complanatus* (*ornatus*) Graptolite Zone. No typical specimens of A. ordovicicus have previously been known from the Cincinnatian reference standard in the Cincinnati region, but recently characteristic elements were recovered from the uppermost Arnheim and lowermost Waynesville formations of the Richmondian Stage in outcrops near Brookville in eastern Indiana. The ancestor of *A. ordovicicus* is *A. superbus* (Rhodes), and in other sections, the evolutionary transition between the two species occurs in a narrow stratigraphic interval. At Brookville, specimens of *A. ordovicicus* occur together with *A. superbus* and transients within an equally narrow stratigraphic interval, and we interpret this as representing the speciation event when the latter species gave rise to *A. ordovicicus*. This is supported by the fact that only elements *A. superbus* have been found in older Cincinnatian strata. The base of the *A. ordovicicus* Zone, taken at the level of appearance of typical representatives of the zonal index, is a biostratigraphically highly significant and useful reference level. For instance, it occurs in the upper Viola Springs Formation of Oklahoma, the uppermost Dubuque Formation of Iowa-Minnesota, the uppermost Fjäcka Shale in Sweden and coeval strata in Estonia, and in the Cautleyan Stage of the Ashgillian Series in Britain.

Reprinted as published in the Geological Society of America, *1994 Abstracts with Programs*, v. 26, no. 5, p. 51.

The Frasnian-Famennian Boundary (Upper Devonian) in Black Shale Sequences: U.S. Southern Midcontinent, Illinois Basin, and Northern Appalachian Basin

D. J. OVER, Dept. of Geological Sciences, SUNY College at Geneseo, Geneseo, NY 14454

The Frasnian-Famennian (F/F) boundary in the Woodford Shale of the U.S. southern Midcontinent, Sweetland Creek Shale of the Illinois Basin, and the Hanover Shale of the northern Appalachian Basin is recognized to a discrete horizon. In each locality the

boundary is marked by evidence of a disconformity; phosphate nodules, concentration of conodonts, or coated and corroded grains. The Woodford Shale consists of finely laminated pyritic organic-rich shale containing interbeds of greenish shale and chert. The F/F boundary horizon is marked by a concentration of conodonts and phosphatic nodules. The boundary lag horizon contains *Pa. linguliformis, Pa. subperlobata, Pa. delicatula delicatula,* and *Pa. triangularis.* Underlying laminations contains *Ancyrognathus ubiquitus* and *Pa. triangularis* indicating that the disconformity is within the uppermost MN Zone 13 or Lower *triangularis* Zone.

The upper portion of the Type Sweetland Creek Shale consists of dark organic-rich shales. The F/F boundary is located within an interval containing three green shale interbeds. *Palmatolepis triangularis* in the absence of Frasnian species first occurs in the middle green shale. The fauna below the middle green interbed is characterized by *Pa. bogartensis, Pa. boogaardi, Pa. linguliformis, Pa. triangularis,* and *Ag. ubiquitus.*

In the thick Upper Devonian clastic sequence of the northern Appalachian Basin the F/F boundary is within an interval of interbedded pyritic green and organic-rich silty shales of the Hanover Shale. At Irish Gulf strata containing *Pa. bogartensis, Pa. triangularis, Pa. winchelli, Ancyrodella curvata,* and *Icriodus alternatus.* The conodont fauna transition is below a conodont-rich laminae containing a Famennian fauna that marks the boundary horizon.

Reprinted as published in the Geological Society of America, *1994 Abstracts with Programs*, v. 26, no. 5, p. 56.

Stretognathodus-Based Upper Missourian, Virgilian, and Lower Wolfcampian (Upper Kansimovian–Asselian) Conodont Biostratigraphy of the Midcontinent, U.S.A.

SCOTT M. RITTER, Dept. of Geology, Brigham Young University, Provo, UT 84602

Abundant to moderately abundant conodont faunas were recovered from marine facies of most of 52 successive major, intermediate, and minor depositional cycles comprising the Upper Missourian–lower Wolfcampian Lansing, Douglas, Shawnee, Wabaunsee, Admire, and Council Grove Groups in the Midcontinent U.S.A. (Kansas, Oklahoma, Nebraska, and Missouri). These *Idiognathodus*- and *Streptognathodus*-dominated faunas permit recognition of seven biostratigraphic intervals defined chiefly upon first occurrences of *Streptognathodus* species. These are in ascending order, the (1) *Streptognathodus gracilis* interval (Plattsburg Limestone), (2) *Streptognathodus simulator–S. pawhuskaensis* interval (Stanton Limestone through Oread Limestone), (3) *Streptognathodus pawhuskaensis* n. subsp. A interval (Clay Creek Limestone Member of the Kanwaka Shale through Spring Branch Limestone Member of the Lecompton Limestone), (4) *Streptognathodus* n. sp. B interval (base of Queen Hill Shale Member of the Lecompton Limestone through Pony Creek Shale Member of the Wood Siding Formation), (5) *Streptognathodus* n. sp. D interval (Brownville Limestone Member of the Wood Siding Formation through Onaga Shale, (6) *Streptognathodus wabaunsensis* interval (Falls City Limestone through Roca Shale, and (7) *Streptrognathodus barskovi* interval (Grenola through Beattie Limestones). The diagnostic Permian genus *Sweetognathus* first appears in the lower part of the *S. barskovi* interval. The base of the the *S.* n. sp. D interval coincides with the traditional placement of the Pennsylvanian–Permian boundary in the Midcontinent.

These intervals correlate with selected Upper Carboniferous–Lower Permian conodont zones of Russia.

Reprinted as published in the Geological Society of America, *1994 Abstracts with Programs*, v. 26, no. 5, p. 58.

Biostratigraphic Utility of the Disjunct Conodont Platform Element *Idiognathodus* in the Pennsylvanian of the Southern Midcontinent

ANGELA K. BRADEN and *WALTER L. MANGER*, Dept. of Geology, University of Arkansas, Fayetteville, AR 72701

The conodont platform element *Idiognathodus* appears in the upper Morrowan Series and ranges through the entire Pennsylvanian System, where it is typically abundant and easily identified. At least a dozen form-species have been proposed within the concept of this genus, suggesting potential biostratigraphic value. Indeed, its appearance in the Lower Pennsylvanian correlates with the base of Westphalian A on a worldwide basis. Zonations utilizing this taxon have been proposed for portions of the succeeding Pennsylvanian System, but widespread application and even acceptance of those schemes is lacking, in no small part because of difficulty with consistent form-species recognition.

The element is amenable to simple shape-analysis. Our analysis of 12 parameters involving the oral surface of this form-genus from specimens figured in the literature suggests that less than one-third of the proposed form-species have been recognized with any consistency. Furthermore, differentiation of the various form-species from any stratigraphic level in the southern midcontinent by morphometrics is difficult, even in assemblages well constrained by other biostratigraphically sensitive fossil groups. Consequently, we urge caution in the proposal of new-form species within this taxon, and the application of zonations based upon its occurrences. Reconstruction of the apparatus containing this platform may provide some additional resolution, but that apparatus may not be any more consistent in its variation than the element itself.

Reprinted as published in the Geological Society of America, *1994 Abstracts with Programs*, v. 26, no. 5, p. 6.

Sequence Stratigraphy of Carboniferous–Permian Boundary Strata from the North American Midcontinent

CARTER E. KEAIRNS and *DARWIN R. BOARDMAN, II*, School of Geology, Oklahoma State University, Stillwater, OK 74078

Based on recent conodont biostratigraphy, the correlated base of the Permian corresponds to the base of the Red Eagle Limestone, Council Grove Group of the North American Midcontinent. This study documents the sequence stratigraphy of uppermost Carboniferous Foraker Limestone, Council Grove Group through the basal Permian Red Eagle Limestone, Council Grove Group.

The Foraker Limestone consists of six transgressive-regressive cycles of sedimentation that can be traced from northern Kansas to northern Oklahoma. Three of these cycles had sufficient water depths at or near highstand necessary to form marine condensed sections that are represented by either black shales or glauconitic and phosphatic carbonates with an abundant off shore *Streptognathodus* dominated conodont fauna. All of these transgressive-regressive cycles are capped by marginal marine *Adetognathus* dominated silty shales.

The lower Johnson Shale consists of red blocky mudstone that is interpreted to represent paleosols. These paleosols are interpreted to represent lowstand deposits. The upper Johnson Shale contains gray fossiliferous shale with thin fossiliferous limestones. These strata are interpreted to represent the initial flooding event of the Red Eagle Sequence.

Maximum flooding of the Red Eagle Sequence is represented by black shale in northern Kansas and by glauconitic, phosphatic carbonate in southern Kansas and northern Oklahoma. These highstand deposits represent marine condensed sections and are characterized by an abundant offshore *Streptognathodus* dominated fauna.

The glacial-eustatic sea-level rise that produced the Red Eagle Sequence appears to represent the greatest rise of sea-level throughout the Carboniferous–Permian boundary interval.

Reprinted as published in the Geological Society of America, *1994 Abstracts with Programs*, v. 26, no. 7, p. A-432.

Discovery of the Chickasaw Bryozoan Reef in the Middle Ordovician of South-Central Oklahoma

CLIFFORD A. CUFFEY, Dept. of Geological Sciences, Ohio State University, Columbus, OH 43210; and *ROGER J. CUFFEY*, Dept. of Geosciences, Pennsylvania State University, University Park, PA 16802

Bryozoans began reef-building early in their history, as known mostly from Ordovician Appalachian localities. We have now found another early bryozoan reef, but out in the Mid-Continent, which can further elucidate that phylum's involvement in this ecologically intriguing activity.

The new find is located high on the west side of the roadcut of U.S. Highway 177, 0.5 km (0.3 mi) south of its junction with Oklahoma Highway 18, just south of the Chickasaw National Recreation Area (southeast of Sulphur, Murray County; center NW¼ sec. 11, T. 1 S., R. 3 E., Sulphur South 7.5′ quadrangle). The reef is low in the Mountain Lake Member of the Bromide Formation (Simpson Group); it is thus basal Blackriveran, and hence only slightly younger than the earliest known bryozoan reefs (Chazyan). Exposed as a dark-gray-weathering block 0.5 m high by 1 m wide, it is a crust-mound consisting of massive micrite containing many (30–90% by volume) sheet-like encrusting trepostomes, and a few massive trepostomes; flanking beds are not well developed. Conspicuous on its weathered surface are silicified zoaria with large zooecia and many diaphragms, reminiscent of *Batostoma*, the principal bryozoan frame-builder in the earliest bryozoan reefs (Lake Champlain and Mingan Islands). The Chickasaw bryozoan reef rests on a thin crinoidal grainstone; this foundation bed is bowed down under the reef mass, thus suggesting initial growth of bryozoan crusts in the shelter of a depression on the sea floor (as in the Niagara Gorge bryozoan reefs). Overlying the reef are limestones which are partly micritic and partly fossiliferous (especially crinoidal), whose complex variations require further study, especially in relation to reef termination.

Reprinted as published in the Geological Society of America, *1994 Abstracts with Programs*, v. 26, no. 5, p. 11.

Adaptive Advantage of, and Mechanism for, Intraspecific Heterochrony in *Mesolobus Obsoletus* (Brachiopoda) from Dysaerobic and Brackish Paleoenvironments, Pennsylvanian of Oklahoma

C. A. CUFFEY, Dept. of Geological Sciences, Ohio State University, Columbus, OH 43210

The ontogeny and morphology of 16 samples of the chonetid *Mesolobus obsoletus*, collected from "Shale 3" (Lake Murray Fm., uppermost Atokan–basal Desmoinesian) in the northern Ardmore Basin, were studied morphometrically. Each sample was divided into size classes (~age classes) based on specimen length. Lithofacies and biofacies analysis indicates that these chonetids inhabited prodeltaic and interdistributary bay paleoenvironments characterized by a gradient in oxygen concentration and salinity.

Mesolobus obsoletus from aerobic and marine paleoenvironments have strongly convex pedicle valves with a deep sulcus and prominent mesial fold within (strongly convex variety). Pedicle valves of specimens from increasingly dysaerobic and brackish paleoenvironments are progressively less convex, and sulcus and mesial fold strength progressively decreases until both are absent (weakly convex variety). These trends occur in all size classes. Adults from the most dysaerobic and brackish paleoenvironments resemble the smallest juveniles from aerobic and marine environments. This morphologic gradient is interpreted as a paedomorphocline. Because the adults from each sample attain the same size, neotenous processes are presumed to be responsible.

Specimens of the weakly convex variety contain a smaller shell cavity (~soft tissue volume) relative to the soft tissue surface area exposed to sea water than do specimens of the strongly convex variety. I infer that the adaptive advantage of this neoteny in *M. obsoletus* is that a greater surface area:volume ratio for soft tissues increased oxygen absorption and decreased oxygen demand, which compensated for reduced oxygen in dysaerobic paleoenviroments. Likewise, reduced soft tissue volume increased osmoregulation efficiency in brackish water.

I infer that *M. obsoletus* evolved from its *Neochonetes* spp. ancestors by two mutations of the regulatory genes that control growth vectors in the median region of the commissure. Initially, *N. henryi* evolved from *N. dominus* by one such mutation that increased the dorsal component of the growth vectors to produce a sulcus. Subsequently, *M. obsoletus* evolved from *N. henryi* by another such mutation that reversed the growth vectors within the sulcus to produce a mesial fold. Thus, the genotype of *M. obsoletus* was to produce a sulcus and mesial fold. But in dysaerobic and brackish paleoenvironments, adaptive pressures suppressed the genotype such that it was not expressed phenotypically.

Reprinted as published in the Geological Society of America, *1994 Abstracts with Programs*, v. 26, no. 7, p. A-56.

Coral Base-Plates on Brachiopod Shells: A New Method for Determining the Post-Mortem Orientation and History of Brachiopods

C. A. CUFFEY, Dept. of Geological Sciences, Ohio State University, Columbus, OH 43210; *A. J. ROBB, III*, Mobil Exploration and Production, U.S., Liberal, KS 67901; *J. T. LEMBCKE*, School Geology and Geophysics, University of Oklahoma, Norman, OK 73019; and *R. J. CUFFEY*, Dept. of Geosciences, Pennsylvania State University, University Park, PA 16802

For fossil brachiopods, the postmortem orientation and the time duration between death and burial is normally inferred by taphonomic methods. Herein, we describe a new paleobiological technique for determining these two factors of brachiopod paleoecology, and illustrate it with an example from the Lower Devonian of Oklahoma.

Small gum-drop-shaped corals, *Favosites conicus* Hall (Tabulata), are epizoans on *Meristella atoka* Girty (Athyridacea) in the Haragan Formation. Their coralla grew over the brachiopods' commissures, indicating that the brachiopods were dead when the corals were encrusting their shells. Furthermore, the corals grew beyond the brachiopods' shells and out onto the sediment-water interface, thus preserving their base-plates (also called holothecae) projecting from the brachiopods' shells.

The postmortem orientation of each brachiopod can be determined by measuring the angle between the base-plate (approximately horizontal) and (1) the postero-lateral part of the commissure (lateral angle) and (2) the anterior part of the commissure (anterior angle). When the commissure (both lateral and anterior pans) is parallel to the base plate, both angles are considered horizontal (000°); both angles increase as the brachiopod shell is rotated counter-clockwise through 360°. For most specimens of *Meristella atoka,* the lateral angle ranges from 340°–350° and the anterior angle ranges from 355°–005° thus indicating that the dominant post-mortem orientation of *Meristella atoka* was nearly horizontal resting on the middle of its pedicle valve. The length of time between the brachiopod's death and its burial by sediment can be estimated using the life-span of the epizoic coral species. In this case, previous work suggested that *Favosites conicus* coralla lived for about one year (Gibson and Broadhead, 1989). Thus, *Meristella atoka* shells probably remained unburied on the sea floor for at least that long. This is also supported by the abundance of epizoic bryozoans that were post-mortem associates of *Meristella atoka.*

Reprinted as published in the Geological Society of America, *1994 Abstracts with Programs*, v. 26, no. 7, p. A-56.

Late Paleozoic Conifers in the Marine Environment

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Twenty years of intensive collecting have yielded extensive (40,000+) and diverse permineralized terrestrial plant organs from marine offshore units (Mississippian through Lower Permian) in midcontinent North America. The plant organs are petrifactions preserved as pyrite, limonite after pyrite (as a modern weathering product), and calcium phosphate, and include seeds, cones, stems, leafy twigs, roots, and petioles. Cellular detail can be extremely good, although the outer layers of cells have almost always been lost by bacterial degradation and perhaps abrasion prior to burial. A generalized depositional interpretation at this time involves rapid transgressions and slow regressions of sea level. The plant remains were permineralized in reducing (dysoxic and anoxic) environments; plants in well oxygenated environments were destroyed by bacterial action and benthic detritophytovores. Fossil conifers are represented by woody twigs with leaves and woody stems with branch scars (*Tylodendron* sp.). However, most of the conifer specimens exfoliated their leaves prior to burial and during surficial weathering leaving decorticated wood (*Dadoxylon* sp.) which cannot be reliably separated from other wood. Conifer leafy twigs probably survived long distance transport because of the imbricated leaf attachment and thick cuticles that retarded rapid water logging. Because of such taphonomically significant biological features, the oldest North American conifers (Desmoinesian = Westphalian C/D in Oklahoma) are known only from offshore marine oxygen deficient environments.

Reprinted as published in the Geological Society of America, *1994 Abstracts with Programs*, v. 26, no. 5, p. 52.

Paedomorphic Pennsylvanian Pelecypods

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The advent of the alivincular ligament which characterizes the Pteriidae has heretofore been shrouded in mystery. Derivation from a pterineid duplivincular ligament, requires a major reorganization of the fibrous and lamellar ligament components. Paedomorphic development whereby certain juvenile character states are extended into adulthood is a simple means of deriving the alivincular ligament in pterioids.

Two small pterioid bivalves from the Buckhorn Asphalt of south-central Oklahoma had evolved the alivincular ligament grade by the mid-Pennsylvanian (Desmoinesian). A variety of extant bivalves possess a small resilifer or primary ligament pit during their early ontogenetic stages. Retention of the pit into adulthood is a simple means of establishing the alivincular condition. The alivincular ligaments of the Buckhorn Asphalt pterioids are judged to have evolved in this manner. Additionally, paedomorphosis probably led to the establishment of the alivincular ligament in pteriids. This transmutation is so simple that iterative episodes are not unlikely, rendering identification of a single pteriid ancestor very difficult. The simplicity of this transformation serves to illustrate the power of heterochrony in evolutionary change, and suggests that it may be a common means of deriving the alivincular ligament in other groups of bivalves.

Small size afforded several advantages to these animals. As animal size approached that of the sediment grains, the adaptive discontinuity between infaunal and epifaunal existence decreased. The small size of these pterioids and the shelly nature of the substrate facilitated a nestling stage in the transition from infaunal to epifaunal existence. They are still somewhat prosocline and have yet to develop a sharply defined auricle and byssal notch stablization mechanism, but their small size allowed them to exploit sheltered microhabitats in the interim. That a major structural change in ligament grade accompanied the transition from infaunal to epifaunal existence is not coincidence. The small size which enabled them to make a life habit change resulted from paedomorphic development, as did the transition from the duplivincular to alivincular ligament.

Reprinted as published in the Geological Society of America, *1994 Abstracts with Programs*, v. 26, no. 7, p. A-375.

Paleokarst, Paleosol, and Rocky-Shore Deposits at the Mississippian–Pennsylvanian Unconformity, Northwestern Arkansas

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The Mississippian–Pennsylvanian unconformity in northwestern Arkansas contains pedogenically altered regolith preserved in low-lying areas on paleokarst on the Chesterian Pitkin Limestone. The regolith is succeeded by transgressive rocky-shore deposits of the Cane Hill Member, Hale Formation (type-Morrowan). Pitkin cements reflect extensive, meteoric, phreatic diagenesis prior to karstification, and paleokarst features include large, dissolution-fragmented Pitkin lithoclasts with numerous solution pipes on a low-relief surface. The overlying, pedogenically altered regolith contains calcretized lithoclasts in clay matrix, suggesting a shift from ever-wet conditions to more seasonal rainfall prior to the Pennsylvanian transgression. That shift may represent local climatic change or short-term fluctuations in mid-Carboniferous tropical climate. The latter interpretation may support global climate models that predict warmer, wetter tropics during periods of high-latitude cooling. Basal Cane Hill strata consist of high-energy, shoreface, boulder-cobble conglomerate containing reworked Pitkin clasts. The conglomerate contains an unequivocal rocky-shore community consisting of encrusting bryozoans and corals, *Trypanites*, acrothoracican barnacle borings, and, possibly, the earliest occurrence of *Gastrochaenolites*. Preservation of poorly indurated paleosol beneath high-energy transgressive deposits suggests very rapid transgression consistent with a glacio-eustatic mechanism. Truncated Pitkin strata were removed by karstification and sub-aerial erosion during the hiatus and not by erosion during transgression.

Reprinted as published in the Geological Society of America *Bulletin*, v. 106, p. 634, May 1994.

Flood Chronostratigraphy of an Alluvial Channel in the South-Central Great Plains: Black Bear Creek, Oklahoma

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Late Holocene paleoflood reconstruction of the Black Bear Creek basin in north-central Oklahoma was chronologically developed based upon slackwater deposition and radiocarbon dating of associated paleosols. Major paleoflood events occurred 3,590 ±80 years B.P., and 1,150 ±100 years B.P. Assumptions developed for application in semi-arid, bedrock channels were tested and modified. Maximum accumulation of slack-water deposits were not found at the intersection of the mouths of present-day junctions but were located some 400 meters up-tributaries. These sites can be explained by the response of the alluvial floodplain during catastrophic flood events. An estimate of flood stage was not found by tracing slackwater units up-tributaries, physically tracing slackwater units up-tributaries was possible in some cases 8 km. A more accurate measurement was determined by measuring up-terrace perpendicular to the tributary. Aggradation and degradation of the channel were determined to be insignificant, because the floodplain would be the most impacted feature in an alluvial setting. A model was developed to simulate the preflood landscape by removing the amount aggraded above the paleosols. A computer program, the HEC-2 Water Surface Profile was implemented to determine the paleodischarge that could emplace slackwater units at the surveyed elevations.

Assessing the flood frequency distribution of rare floods in the south-central Great Plains will contribute to the knowledge of paleoclimate and landscape evolution. Records of such events are useful in planning human use of floodplains and adjacent property. The flood frequency analysis was improved with the use of the historical floods in conjunction with the systematic record.

Reprinted as published in the Geological Society of America, *1994 Abstracts with Programs*, v. 26, no. 1, p. 23.

Groundwater Fluctuations Estimated from Rainfall and Evaporation Data

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Long-term weather, stream discharge and groundwater data from the Little Washita Watershed (60,000 ha.) in central Oklahoma are used to model variations in water resources due to global climate change and its impact on agriculture. However, because of budgetary constraints, gaps exist in the groundwater records. Because of the strong relationship between precipitation and evaporation to a watershed budget, a multiple regression analysis was done using annual rainfall, evaporation, and groundwater levels as data. Groundwater wells with 10 years of consecutive data and proximal weather recording equipment were used. Evaporation data were collected from a Class A evaporation pan at a nearby weather station. Correlation coefficient of the multiple regression (r2) is 73% and comparison of observed and calculated groundwater levels also show a regression coefficient of 73%. With the resulting equation, existing rainfall and evaporation data provides an estimate of groundwater levels to fill the gaps in the groundwater database. Because several complex factors are combined into the constant of the equation, such as depth to water table, similar lithology, and infiltration rates, it is recommended that this equation be used only for wells that display similar lithology and water table depth and are close to the original well.

Reprinted as published in the Geological Society of America, *1994 Abstracts with Programs*, v. 26, no. 1, p. 5.

Relation of Lithologic Variations in Permian Rocks of the Central Oklahoma Aquifer to Water Quality

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Ground water from Permian red-bed units of the Central Oklahoma aquifer varies in quality partly because of the lithologic heterogeneity established during sediment deposition. Water types vary from Ca–Mg–HCO_3, with pH 6.0, to Na–HCO_3, with pH 9.6. Locally, the Na–HCO_3 water contains dissolved arsenic (As), chromium (Cr), selenium (Se), and uranium (U) in concentrations that exceed existing and proposed U.S. EPA drinking-water standards.

Permian geologic units in the aquifer include the Chase, Council Grove, and Admire Groups, the Wellington Formation, and the Garber Sandstone. Within the 3,000 mi^2 aquifer, these units accumulated in similar fluvial and deltaic environments that resulted in complexly interbedded sandstone and mudstone, with minor siltstone and conglomerate. The abundance of clay-rich rocks in the aquifer varies areally because of depositional controls and truncation by erosion. Water chemistry can be directly related to the distribution of the clay-rich rocks. Where sandstone exceeds 60% in unconfined parts of the aquifer the water is a Ca–Mg–HCO_3 type as a result of dissolution of dolomite cement. Unconfined parts of the aquifer where sandstone is less than 40%, and most confined parts of the aquifer contain Na–HCO_3 water. This water forms by dolomite dissolution and exchange of dissolved Ca and Mg for Na bound to clays.

Clay-rich rocks are the source of most dissolved Cr, Se, and U. The most likely As source is diagenetically altered sandstone that is cemented by yellow-brown iron oxides. Extractable Cr is disseminated on clays and iron oxides. Most dissolved Se and U is attributed to reduced (green) zones found in some argillaceous sandstones overlain by paleosols, sandstones incised into mudstones, and mudstones. These reduced rocks are thought to be remnants of widespread zones of reduction that were partially destroyed by oxidation. Results of this investigation have been used to produce regional models of water quality intended to locate wells that will produce water of drinking-water quality.

Reprinted as published in the Geological Society of America, *1994 Abstracts with Programs,* v. 26, no. 7, p. A-205.

Occurrence and Distribution of Agricultural Chemical in Ground Water of the Ozark Plateaus Physiographic Province—Arkansas, Kansas, Missouri, and Oklahoma

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A total of 100 ground-water samples were collected and analyzed for nitrate and 88 pesticides as part of the U.S. Geological Survey National Water-Quality Assessment Program. Samples were collected from 50 shallow domestic wells and 50 springs that obtain water from the Springfield Plateau and Ozark aquifers.

Nitrate concentrations in ground-water samples ranged from less than 0. 1 to 7.1 milligrams per liter. Nitrate concentrations were significantly higher in water samples collected from springs than in samples collected from wells. Nitrate concentrations also were significantly higher in samples collected from the Springfield Plateau aquifer than from the Ozark aquifer.

Pesticides were detected in 20 water samples collected from springs and 9 samples collected from wells. Pesticides were detected in 17 samples collected from the Springfield Plateau aquifer and 12 samples collected from the Ozark aquifer. A total of 14 pesticides were detected, with a maximum of 4 pesticides detected in any one sample. Maximum concentrations ranged from 0.002 microgram per liter for DCPA to 0.23 microgram per liter for tebuthiuron. The most commonly detected pesticides were atrazine (14 detections), prometon (11 detections), and tebuthiuron (7 detections).

The occurrence and distribution of nitrate and pesticides probably are related to their chemical properties, local land use, and site characteristics, which could affect the susceptibility of the ground water to surface contamination.

Reprinted as published in the Geological Society of America, *1994 Abstracts with Programs*, v. 26, no. 7, p. A-361.

Prediction of Soil Arsenic Bioavailability Based on Speciation and Bioaccessibility Data

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The oral bioavailability of arsenic in soil from Anaconda, Montana, site of a historic copper smelter, has been determined in rabbits and monkeys. Both studies demonstrated that soil arsenic absorption was reduced when compared with the bioavailability of arsenic dissolved in water. In assessing exposures to arsenic in soil at other sites, it would be advantageous to be able to assess bioavailability without conducting additional laboratory animal studies. In support of that goal, speciation and bioaccessibility analyses were conducted with soil samples from a former zinc smelter site in Oklahoma. The results of these analyses were then compared with the results of similar analyses with the Anaconda soil samples used in the animal studies. This comparison was complicated by the fact that arsenic-bearing phases were rarely observed in the Oklahoma samples due to low arsenic concentrations. Additionally, several samples contained substantial quantities of lead arsenate, presumably from its prior use as a pesticide. With the exception of the lead arsenate, the predominant species from both locations were iron arsenic oxide and other metal arsenic oxides. The expected solubility of arsenic-bearing phases was consistent with results of *in vitro* analyses of bioaccessibility, suggesting that the Montana bioavailability data may be used to predict bioavailability of arsenic in the Oklahoma soils.

Reprinted as published in the Geological Society of America, *1994 Abstracts with Programs*, v. 26, no. 7, p. A-432–433.

Magnetic Susceptibility Logs from Sedimentary Environments

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Magnetic susceptibility in rocks varies with the content of iron-bearing minerals, and particularly with that of magnetite and other members of the iron-titanium solid solution series. Recent papers on induction logging (Barber et al., 1992; Strickland et al., 1992) have shown that thin beds with fairly modest values of magnetic susceptibility (50 μcgs units) produce appreciable responses on the X-component (quadrature) of the induction signal. Barber et al. and Strickland et al. were able to model induction log responses across thin layers of low magnetic susceptibility; field examples are reproduced satisfactorily. The question then arises: how common in sediments are variations in magnetic susceptibility and what is their magnitude?

We use an eccentered slimhole probe which contains a single ferrite-core solenoid to measure susceptibility. After borehole corrections, changes in self-inductance of the solenoid are proportional to changes in susceptibility. To minimize the effect of temperature changes upon self-inductance, the solenoid is contained within an insulated cavity where the temperature is maintained constant to within a fraction of 1°C. The probe is calibrated in test pits constructed of concrete with different concentrations of magnetite and also by comparison with core measurements.

To illustrate common variations in magnetic susceptibility that occur with depth and rock type, we present magnetic susceptibility logs from different geological environments. An example from a sandstone-shale sequence in eastern Oklahoma shows that the susceptibility ranges from 5 to 50 μcgs units, correlating well with the density log; susceptibility increases as density increases. High-susceptibility beds with thicknesses of a few feet occur frequently in the sequence. For limestones penetrated by the same borehole, susceptibility has values less than 10 μcgs units.

Logs from Cretaceous shales show quite low susceptibility, less than 20 μcgs units. In contrast, logs from volcanics and volcanigenic sediments show very high values of susceptibility, in the range 1,000 to 2,000 μcgs units. Most of the above examples show that susceptibility varies considerably within a given lithologic unit, indicating that magnetic minerals are seldom distributed uniformly.

Reprinted as published in *The Log Analyst*, v. 34, no. 2, p. 45, March/April 1993.

Processes and Patterns of Intraplate Seismicity

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During the past two decades, important constraints on the processes driving intraplate seismicity have been defined. In most intraplate areas, in situ stress measurements, bore-hole breakouts, and faulting styles inferred from earthquake focal mechanisms yield a relatively simple picture in which the seismicity results from a regionally uniform principal stress field that correlates with the stresses expected from plate-driving forces. Such a stress field is not likely to vary much with time except as a result of major plate reorganizations or changes in plate motions. In intraplate areas of moderate to high heat flow, the plate-driving forces are sufficiently large (and the lower crust and upper mantle may be sufficiently weak) that stress is transmitted mainly through the brittle upper crust. In areas of relatively low heat flow, such as shields (~40 mW/m^2), the lower crust and upper mantle appear to be so strong that the cumulative strength of the lithosphere exceeds the plate-driving forces. Thus, the contrast between seismicity in shield areas and surrounding non-shield areas may largely result from whether the lower crust and mantle support an appreciable fraction of the plate-driving forces. In some places, local stress perturbation due to lateral variations in crustal structure may modify the stress field; thus, local stresses can help explain the common association of seismicity with ancient structures such as old continental rifts or suture zones.

Intraplate defomation from large earthquakes appears to be episodic, with active periods (of one or more moderate to large events) separated by lengthy periods of quiescence. In contrast to the regionally and temporally uniform intraplate stress field, geologic and geodetic strain rates indicate marked contrasts between short-term (<10,000 years?) and long-term (>1 million years?) deformation rates. Reoccupation of triangulation stations in the New Madrid seismic zone indicate a strain rate roughly one-third that of the San Andreas fault. Paleoliquefaction and trenching studies of the New Madrid and Charleston earthquakes suggest multiple Holocene events, but there are no surface fault scarps or other evidence of comparably high, long-term deformation rates. Trenching and geologic studies of recent intraplate surface ruptures in Australia, India, Canada, and Oklahoma, (USA) indicate time intervals between active episodes of at least tens to hundreds of thousands of years, and possibly millions of years (Ungava, Canada).

A key to understanding intraplate seismicity is defining the self-limiting, feedback processes responsible for time-varying rates of deformation. One such process could be a slow pore-pressure buildup at depth ever millions of years from grain boundary flow culminating in a period of active faulting The resulting deformation and fracturing of the surrounding crust could permit relatively rapid dissipation of the high pore pressure through fracture-induced flow. Continued grain boundary fluid flow at depth could then geochemically seal the newly opened fractures, permitting pore pressure to rebuild.

Reprinted as published in the Geological Society of America, *1994 Abstracts with Programs*, v. 26, no. 7, p. A-382.

Subsidence Beneath a Playa Basin on the Southern High Plains, U.S.A.: Evidence from Shallow Seismic Data

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Shallow seismic data from Sevenmile Basin, a large ephemeral lake (playa) basin in the Texas Panhandle, reveal that subsidence has been an important agent in basin formation. Several hypotheses exist for the origin of thousands of playa basins on the Southern High Plains of Texas and New Mexico, including eolian deflation, evaporite or carbonate dissolution and subsidence, piping, and animal activity. Sevenmile Basin is 5.5 × 3.6 km across and 14 m deep and contains 20 m of lacustrine and eolian sediments that interfinger with the Quaternary Blackwater Draw Formation. Below these sediments is the upper Tertiary Ogallala Formation, which overlies Permian or Triassic bedrock. Seismic reflection and refraction data were collected from the unlithified and variably saturated clastic sequence beneath Sevenmile Basin to investigate the geological history and hydrogeological framework of playa basins, which recharge the regionally important Ogallala aquifer.

Three-layer velocity models provide good solutions for reversed refraction data. Near-surface p-wave velocities (layer 1) range from 349 to 505 m/s, layer 2 velocities range from 806 to 851 m/s, and layer 3 velocities range from 2,037 to 2,161 m/s. Shallow test holes and drillers' logs suggest that layer 1 is composed of playa and upper Blackwater Draw Formation deposits, layer 2 consists of lower Blackwater Draw Formation and upper Ogallala Formation deposits, and layer 3 represents a competent and partly saturated zone near the top of the Ogallala aquifer. Reflection sections show a middle Ogallala reflector, a reflector at the top of Permian or Triassic bedrock, and internal bedrock reflectors that indicate a structural low beneath Sevenmile Basin. Increasing relief with age, from 14 m at the surface to 70 m on the middle Ogallala reflector to 110 m at the base of the Ogallala, is interpreted as evidence of subsidence of underlying Permian evaporite-bearing strata before or during Ogallala deposition. Ogallala and Blackwater Draw Formation thicknesses greater than bedrock relief suggest that subsidence continued during Ogallala deposition and may continue to the present. Virtually all playa basins on the Southern High Plains are underlain by Permian evaporite-bearing strata; some basins have been affected by dissolution-induced subsidence. Shallow seismic methods are an ideal approach to determine the relative importance of subsidence in basin formation.

Reprinted as published in the Geological Society of America *Bulletin*, v. 106, p. 233, February 1994.

Stratigraphic and Structural Contexts of Clastic Plugs in Northeast New Mexico, Southeast Colorado, and Northwest Oklahoma Panhandle

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About 138 sandstone and breccia clastic plugs of varying size have been reported in the study area. Many more exist, however, especially in Colorado and Oklahoma. The plugs and host strata are locally mineralized with small amounts of Cu, Ag, Au, and U.

Clastic plugs are restricted to a 120-m-thick interval of Triassic and Jurassic strata comprising, in ascending order, uppermost Travesser F, unnamed unit, Sloan Canyon F, Sheep Pen Ss (all Upper Triassic), Exeter Ss (Middle Jurassic), and lower Morrison F (Upper Jurassic). The unnamed unit, which is distinct and mappable, has been variously included in the Travesser and Sloan Canyon in past studies. The Triassic/Jurassic contact is an important regional unconformity.

A paleogeologic map on the unconformity reveals a previously unrecognized monocline involving Triassic strata. The monocline trends NE across the study area for about 35 km. The SE side is down relative to the NW side, and structural relief is at least 90 m. The unnamed unit, which exhibits the steepest dips (up to 6 degrees), delineates the monocline. Local sinuosities in the monocline are responsible for anticlinal and synclinal structures reported by previous workers. Clastic plugs occur only in proximity of the monocline and on the SE side.

Reprinted as published in the Geological Society of America, *1994 Abstracts with Programs*, v. 26, no. 1, p. 24.

Heat Flow and Paleoclimatic Studies at the Gypsy Boreholes, North-Central Oklahoma

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In 1988 British Petroleum Exploration developed a field site (Gypsy Site) in North-central Oklahoma, 96.70° W., 36.36° N., for the purpose of studying petroleum reservoir characterization. The focus of this field study was the Gypsy sandstone, a geologic unit in the lower part of the upper Pennsylvanian Vamoosa Formation. As part of the reservoir characterization study, 6 wells, each approximately 1,400 ft (~425 m) deep were drilled within a square ~225 m on a side. To date, more than $2,500,000 has been spent in drilling the wells and conducting geological and geophysical studies at the Gypsy site.

The Gypsy boreholes provide opportunities for both terrestrial heat flow and paleoclimatic studies in this part of the south-central U.S. Heat flow through the Gypsy interval determined from equilibrium temperature logs and thermal conductivity measurements on core samples is 71±7 m W/m^2. This estimate is somewhat higher than average heat flows of ~50–60 mW/m^2 in the region; however, heat flow data in the south-central midcontinent are sparse.

The thermal gadient in the upper ~150 m of the Gypsy boreholes is noticeably lower than the average gradient in the lower section of the wells. Higher temperatures in the upper sections of these boreholes may represent higher thermal conductivities or a transient warming event related to deforestation or climatic change. To discriminate between these hypotheses, we have drilled a new hole at the Gypsy Site and cored continuously from surface to ~125 m. Thermal conductivity measurements are now in progress. However, visual inspection of the cores shows them to be ~65% shale, which is usually of relatively low thermal-conductivity. Correspondingly, higher temperatures in the upper sections of the Gypsy boreholes are probably not due to simple changes in lithology, and may reflect a warming trend initiated in the mid 1800's at the end of the little ice age.

Reprinted as published in the Geological Society of America, *1994 Abstracts with Programs*, v. 26, no. 1, p. 3.

A Five Feldspar Granite, Wichita Mountains, Oklahoma

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The Cambrian Mount Scott alkali feldspar granite of southwestern Oklahoma has a complex crystallization history. Rifting within the Southern Oklahoma Aulacogen produced this A-type granite. There are five distinct feldspars visible in the texture of the rock; early-crystallizing orthoclase *(perthite), anorthoclase (antiperthite), plagioclase rims,* and late-crystallizing *alkali feldspar* and *plagioclase.* These comprise three distinct geochemical groups. Large (1–5 mm), pink, ovoid-shaped perthites comprise 2 to 6% of the mode, varying greatly in composition from sample to sample (Or_{60-40}). Gray, ovoid antiperthites (1–4 mm, 4–13% mode), many with pink rims, darken the rock. Their geochemistry varies between Or_{20} and Or_{35} and are more ternary than their perthite counterparts. The pink rim indicates the limit of oxidization within these grains. Many ovoid crystals have plagioclase rims (An_{10-20}). Alkali feldspar (Or_{60-90}, 20–36% mode) nucleated around the rims of the ovoids. Small plagioclase crystals (An_{8-15}) are a minor phase and are more abundant in microgranitic samples.

Early cystallization of substantial amounts (~10–20% xstals) of feldspar and quartz with lessor hornblende, biotite, apatite, and fluorite occurred at depths of ~6–8 km. The magma then rapidly ascended to ~0.5 km, intruding into coeval Carlton rhyolite. The rapid ascent of the magma resulted in resorption of the early phases, producing the ovoid shape of these crystals, Plagioclase rims surround some of the ovoid grains and precipitated as a result of magma decompression during ascent. Variation in volatile activity, particularly fluorine, may have inhibited rim growth in certain localities. Magmatic fluorite is abundant in many of the samples, and can be found as inclusions within gray ovoids. Alkali feldspar and quartz precipitated in granophyric to microgranitic textures, along with minor amounts of plagioclase, apatite, fluorite, sphene, zircon and magnetite. Plagioclase crystallization commenced after depletion of the potassic component. Subsolidus processes included oxidization of the mafic phases, magnetite, and iron within the alkali feldspar and exsolution of the alkali feldspar. The geochemistry and textures have allowed interpretation of this complex crystallization history, but the conditions and domains of equilibration among these distinct phases are problematic.

Reprinted as published in the Geological Society of America, *1994 Abstracts with Programs*, v. 26, no. 7, p. A-369.

Sedimentary Facies in an Incised Valley in the Pennsylvanian of Beaver County, Oklahoma

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The fill of an incised valley in the subsurface beneath Beaver County, Oklahoma, preserves the sedimentary response to a major cycle of base-level change that took place in the Anadarko basin at the end of the Mississippian and the beginning of the Pennsylvanian (Morrowan). The valley-fill sequence includes heterolithic clastic sediments of the lowstand systems tract (LST) and estuarine and marine sediments of the transgressive system tract (TST). Deltaic sediments within the TST record a minor cycle of base-level change and a small drop in relative sea-level within the major cycle of sea-level change at the boundary between the Mississippian and Pennsylvanian in the Anadarko basin.

Conglomerates above the heterolithic facies of the LST formed as a transgressive lag on the ravinement surface at the base of the TST. Siliciclastic tidal sediments overlie the conglomerates and in turn are overlain by crinoidal limestones that record a relative deepening of the water and the establishment of open marine conditions within the estuary. Above the limestones are deltaic deposits indicating a minor drop in relative sea-level during which riverine conditions were established within the estuary. The sediments of the LST and the initial stages of the TST are confined to the axis of the paleovalley and do not extend high onto its walls. In most places, shales deposited as shelf muds overlie the unconformity between the Mississippian and Pennsylvanian. The shales represent the later stages of the TST when sea-level rise resumed following the episode of deltaic sedimentation and marine waters drowned the pre-existing topography.

Reprinted as published in the Geological Society of America, *1994 Abstracts with Programs,* v. 26, no. 7, p. A-245.