)L. 42, NO. 1 FEBRUARY 1982

OKLAHOMA GEOLOGY NOTES

OKLAHOMA GEOLOGICAL SURVEY, THE UNIVERSITY OF OKLAHOMA

On the cover—

Steel Hopper and Derrick, Picher, Oklahoma

More than a billion dollars' worth of zinc and lead was marketed from Oklahoma's Picher Field in the years between 1904 and 1975. The field, which straddles the Oklahoma–Kansas state line, covered more than 4,000 acres of land.

Most of the surface facilities, such as buildings, mills, and head frames, either have been dismantled or destroyed by fire and vandalism. However, one hopper–derrick facility, now surrounded by wheat fields and pasture land, provides us with one of the last links to the region's mining past.

This hopper–derrick, pictured on the cover, was used to hoist ore to the surface from the interior of the 250-foot-deep Little Greenback Mine. After the ore was loaded into half-ton-capacity cans, a hoisterman positioned near the top of the derrick would lift the loaded cans through a 5- × 7-foot shaft to a platform in the derrick itself. The ore was then dumped into a raised round hopper before being transferred to rail cars and shipped to a central mill for processing. A good crew could hoist up to a thousand cans in an 8-hour day.

Kenneth V. Luza

Oklahoma Geology Notes

Editor: Connie Smith
Editorial Staff: Elizabeth A. Ham, William D. Rose

Oklahoma Geology Notes is published bimonthly by the Oklahoma Geological Survey. It contains short technical articles, mineral-industry and petroleum news and statistics, reviews, and announcements of general pertinence to Oklahoma geology. Single copies, $1; yearly subscription, $4. All subscription orders should be sent to the Survey at 830 Van Vleet Oval, Room 163, Norman, Oklahoma 73019.

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

VOL. 42, NO. 1 FEBRUARY 1982

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Contents

This publication, printed by The University of Oklahoma Printing Services, Norman, Oklahoma, is issued by the Oklahoma Geological Survey as authorized by Title 70, Oklahoma Statutes 1971, Section 3310, and Title 74, Oklahoma Statutes 1971, Sections 231–238. 1,800 copies have been prepared for distribution at a cost to the taxpayers of the State of Oklahoma of $2,325.

A NOTE ON THE HARAGAN TRILOBITE *DICRANURUS HAMATUS ELEGANTUS*

K. S. W. Campbell[1]

Since the subspecies *Dicranurus hamatus elegantus* Campbell, 1977, was described from the Early Devonian (Helderbergian) Haragan Formation (Campbell, 1977, p. 124), a fine new specimen of the cephalon and thorax has become available (fig. 1). It shows some structures not previously known, and makes a better reconstruction possible. The specimen is cataloged as OU 5274, near Clarita, Coal County, Oklahoma, in the eastern Arbuckle Mountains; *Phacops* level about 35 feet above bench in center of section. The specimen is reposited in the School of Geology and Geophysics of The University of Oklahoma.

The genal spine is longer and more delicate than shown in previous reconstructions, and it curves back in an even arc so that its tip lies opposite the fifth thoracic ring in the flattened individual. In life position, it would have projected posterodorsally. The spine tapers gradually throughout its length; its terminus was probably bluntly pointed.

The posterior pleural spines of the thorax are essentially as shown by Campbell (1977, text-fig. 34). In particular, the short fifth spine, the very robust fourth, and the unusually slender eighth are confirmed. With regard to these posterior spines, however, the following points should be noted: the fourth is longer and more gently tapering than expected; the sixth is a little constricted where it passes the level of the axis of the seventh segment, and it tapers evenly to a rather sharp terminus a little behind the fourth; the seventh is the longest of all, being approximately 1.2 times the length of the fourth, and it is more evenly tapering and more acute than previously recognized; the ninth is shorter than the eighth; and the seventh, eighth, and ninth are progressively more convergent, as the specimen figured on plate 36, figure 1, suggested (Campbell, 1977).

Because details of the thorax of *D. hamatus* remain unknown, these new features do not help in the differentiation of the subspecies, although they do confirm the differences noted previously between the subspecies and the Bohemian *D. monstrosus* (Barrande). On the other hand, the similarities between *D. hamatus elegantus* and the two Australian species *D. longispinus* (Mitchell) and *D. kinglakensis* (Gill) are further emphasized. Gill (1947, p. 11) reported that on the latter species the fourth and fifth thoracic spines are the longest, but this is not correct. The fourth is certainly very long, but the fifth is greatly reduced. The fourth and sixth spines are more posteriorly directed, and the eighth and ninth are wrapped around the pygidium to a greater extent than in the corresponding species of *D. hamatus elegantus.*

[1] Department of Geology, The Australian National University, Canberra, A.C.T.

Figure 1. *Dicranurus hamatus elegantus* Campbell, 1977, ×3, OU 5274. Haragan Formation, Old Hunton Townsite, NW¼ sec. 8, T. 1 S., R. 8 E., Coal County, Oklahoma.

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FEDERAL MINERAL ROYALTIES IN STATE INCREASE BY 40 PERCENT DURING 1980

Federal collections of royalties on production of oil, gas, coal, and other minerals on federal and Indian lands in Oklahoma in 1980 totaled $23,064,598, an increase of 40.6 percent over the previous year, according to the U.S. Geological Survey.

The increase in royalties resulted primarily from a small increase in oil production and sharp increases in prices for oil and gas. Gas production declined slightly.

More than $1.8 million in royalties collected from leases on federal lands in Oklahoma will be distributed to the State by the U.S. Bureau of Land Management. The USGS also collected $18.5 million in royalties for production on Indian lands in Oklahoma. This money will be paid to Indian tribes or individual Indians.

Royalties collected on oil production from federal lands are subject to the "windfall profits tax" that went into effect March 1, 1980. About $170,000 of the Oklahoma royalty collections will be transferred by the USGS to the Internal Revenue Service as windfall profits tax.

Oil and gas production accounted for the bulk of the royalties—a total of $22.2 million—in Oklahoma, said J. Ronald Jones, deputy division chief for the USGS Royalty Management Program at the Survey's headquarters in Reston, Virginia.

In 1980, Oklahoma accounted for less than 1 percent of the record-high $2.96 billion the USGS collected in royalties nationwide for production of oil, gas, coal, and other minerals on federal and Indian lands and offshore leases.

Since the federal government began collecting the royalties in 1920, it has collected more than $210 million through 1980 for production on federal and Indian lands in Oklahoma, based on a production value of $1.99 billion.

GROWTH RINGS IN PENNSYLVANIAN FOSSIL WOOD FOUND IN OKLAHOMA

Kathryn N. Jensen[1]

A specimen of Pennsylvanian-age cordaitean wood collected in 1967 by the late Herschell Dupree from a locality in sec. 3, T. 2 N., R. 6 E., near Fittstown, Pontotoc County, Oklahoma, has been found to exhibit growth-ring structure. A section of the specimen contains approximately 35 growth rings ranging from weak to strong in development. According to Granville Morgan (personal communication, 1980), this specimen was found lying on the eroded surface of the Woodford Shale (Devonian) during a collecting trip of the Oklahoma Gem and Mineral Society. Microscopic examination, however, revealed the wood to be a species of *Dadoxylon (Cordaites)* and therefore not endemic to the Woodford Shale.

It is most likely that the Fittstown specimen was preserved in the overlying Seminole Formation (Pennsylvanian, Missourian), which contains much fossil wood and is exposed approximately 100 m southwest of the site where the fossil wood was found. It is logical to assume that the cordaitean wood was let down by erosion onto the Woodford Shale.

At present, three species of cordaitean wood are known from Oklahoma (table 1), including *Cordaites recentium* (Dawson) Penhallow 1900 (Goldring, 1921), *Cordaites michiganensis* Arnold 1931 (Tynan, 1959), and *Dadoxylon adaense* Wilson (1963). Excellent preservation of the Oklahoma species permits their detailed comparison. Transverse, radial, and tangential thin sections were prepared from the Fittstown specimen and are available for examination in the Fossil and Modern Wood Collection of The University of Oklahoma's Stovall Museum of Science and History (Wood Collection no. 12). These sections furnish the morphological information included in table 1.

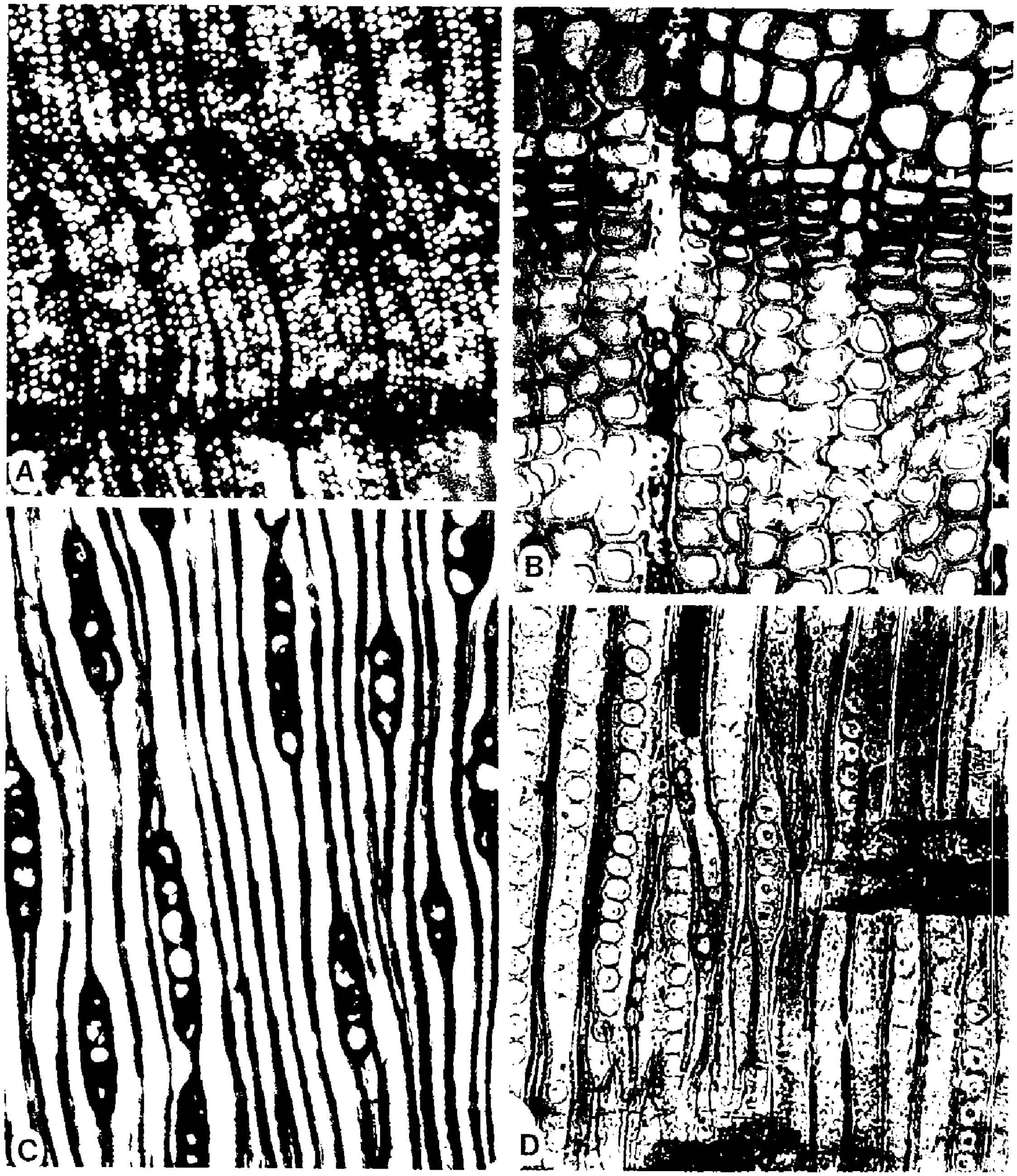
The specimen identified as *Cordaites recentium* was collected near Bartlesville, Oklahoma, and described by Goldring (1921). It shows distinct growth rings, and until the present specimen was discovered it was the only Pennsylvanian wood in Oklahoma known to have developed growth-ring structures. The Bartlesville specimen comes from the Upper Pennsylvanian, below the Americus Formation (Virgilian Series) (Goldring, 1921). The Fittstown specimen has several morphological characters similar to *Cordaites recentium*, yet the differences are significant enough to demand additional study and description.

Growth rings may offer a basis for deductions in interpreting seasonal and environmental changes (Antevs, 1925; 1953; Chaloner and Creber,

[1]Under contract to Marathon Resources, Inc., Denver, Colorado.

TABLE 1.—COMPARISON OF OKLAHOMA CORDAITEAN WOODS

Morphology	*Cordaites recentium* (Dawson) Penhallow 1900	*Cordaites michiganensis* Arnold 1931	*Dadoxylon adaense* Wilson 1963	*Dadoxylon (Cordaites)* Fittstown, Okla., specimen
Transverse section				
Diameter of tracheid (microns)	47–53	35–45	39–53	35–45
Shape of tracheid	Slightly compressed	Square to rectangular; variable in size and shape	Fairly uniform	Round to hexagonal; variable in size and shape
Growth rin[redacted]s	Present	Lacking	Lacking	Present
Tangential section				
Wood rays	Uniseriate; some biseriate near middle	Uniseriate; some biseriate near middle	Uniseriate; some biseriate near middle	Uniseriate; some biseriate in middle
Length	Single ray cell crosses 1–2 tracheids	Single ray cell crosses 1–3 tracheids	Single ray cell crosses 1–5 tracheids	Single ray cell crosses 1–4 tracheids
Number of cells high	7–22	1–33, 70 percent less than 10	1–36, most 9–15	2–14
Radial section				
Rows of bordered pits	Single	Chiefly 2 (2–4)	Chiefly 2 (1–3)	Single
Pit arrange[redacted]ment	Single	Alternating	Alternating	Single
Shape	Round	Hexagonal	Hexagonal	Round
Dimensions of bordered p[redacted]ts (microns)	15.6–22	12.8	19–21	15–25



A. Transverse section of cordaitean wood from Fittstown, Pontotoc County, Oklahoma, showing one complete growth ring and parts of two others. Slide 12–1.[1]
B. Transverse section of same specimen, showing detailed parts of two growth rings. Lower part, with flattened cells and thicker walls, is considered terminal growth of one season, and enlarged cells with thinner walls, beginning of next. Slide 12–1.
C. Tangential section of same specimen, showing longitudinal views of tracheids and cross sections of wood rays, which in this photomicrograph range from 2 to 7 cells high. In some sections wood rays are up to 14 cells high. Slide 12–4.
D. Radial section of same specimen, showing longitudinal sections of two wood rays and bordered pits on radial walls of tracheids. Slide 12–4.

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[1]Stovall Museum of Science and History, The University of Oklahoma, Fossil and Modern Wood Collection.

1973; Fritts, 1972); a lack of growth rings in most cordaitean specimens of Pennsylvanian age in Oklahoma is considered indicative of a nonseasonal climate at that time. This is substantiated by paleogeographic reconstructions that place the Oklahoma region in the equatorial belt when the continent Gondwanaland was united during the Pennsylvanian (Dott and Batten, 1976).

The development of growth rings in the Fittstown specimen may be evidence of environmental changes caused by the Ouachita–Marathon orogeny. The orogenic activity created regional changes in elevation, which in turn may have affected precipitation patterns. The development of growth rings appears to be a significant morphological response to changing ecological conditions and offers supporting evidence that environmental changes occurred and seasonal climatic conditions developed in Oklahoma during Missourian time of the Pennsylvanian Period.

My appreciation is expressed to the Stovall Museum of Science and History for making available the fossil specimen collected by Herschell Dupree; to Granville Morgan for his aid in locating the source of the specimen; and to L. R. Wilson, George Lynn Cross research professor emeritus in The University of Oklahoma School of Geology and Geophysics, under whose direction the study was made.

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Helen Brown, OGS assistant to the director, checks Survey files with Kenneth S. Johnson, associate director.

CHAMBER OF COMMERCE HONORS HELEN BROWN

Helen Brown, assistant to Oklahoma Geological Survey director Charles J. Mankin, was named Employee of the Month for January by the Norman Chamber of Commerce.

As assistant to the director, Brown provides overall management of the budget affairs of the OGS and carries out routine operations for the director's office.

Brown has been with the Survey since 1963, and assumed the position of assistant to the director in 1980. A special plaque honoring Brown was placed in the Survey lobby during January, and a reception was given in her honor.

MARCH 29–30 GSA MEETING SET FOR OU

The South-Central Section of the Geological Society of America will hold its 16th annual meeting this spring on the Norman campus of The University of Oklahoma.

The March 29–30 meeting will be housed in the Oklahoma Center for Continuing Education (OCCE) complex, a facility that includes large and small conference rooms, a variety of housing, and a restaurant.

The meeting will consist of two days of symposia and voluntary papers, four field trips, a welcoming party, luncheon, and the annual banquet.

Two symposia focusing on petroleum potential in key provinces of Oklahoma will highlight the meeting. The symposia, each lasting a full day, are "Petroleum Potential of the Ouachita Mountains," co-chaired by George Viele and Kaspar Arbenz, and "Wichita Mountains/Anadarko Basin Relationships," co-chaired by M. Charles Gilbert and Suzanne Takken.

Other symposia will deal with "The Atokan Series and Its Boundaries," "Seismotectonics of the Nemaha Ridge," "Cenozoic Volcanism in Trans–Pecos Texas," and "Development of the Ouachita–Marathon System."

Seven general sessions will be held on the subjects of igneous petrology–geochemistry, economic geology–structural geology, sedimentology–sedimentary petrology, stratigraphy–general geology, hydrogeology, paleontology–stratigraphy, and geomorphology–geologic mapping.

Preregistration is required for the four field trips. Field-trip 1, "Basement Rocks and Overlying Cambrian-Ordovician Sedimentary Rocks of the Eastern Wichita Mountains," will leave at 7:00 a.m. on March 26 and return at 5:00 p.m. on March 28.

Field-trip 2, "Lower Pennsylvanian (Morrowan and Atokan) Stratigraphy in South-Central Oklahoma," will leave at 7:00 a.m. on March 27 and return at 5:00 p.m. on March 28.

Field-trip 3, "Structural Styles of the Ouachita Mountains," will leave at 6:00 p.m. on March 30. Return to Norman will be at 5:00 p.m., and to the airport in Oklahoma City, 6:00 p.m., on April 1.

Field-trip 4, "Geologic Setting of the Arbuckle Mountains of Southern Oklahoma," leaves on March 29 at 8:00 a.m. and returns to Norman at 5:00 p.m. the same day. This trip is being sponsored by the Texas and Kansas–Oklahoma chapters of the National Association of Geology Teachers—a group that will also meet with the GSA group in Norman.

A registration desk will be open in the main lobby of the Forum Building at OCCE from 2:00 to 6:00 p.m. on Sunday, March 28; from 7:30 a.m. to 5:00 p.m. on Monday, March 29; and from 8:00 a.m. to 5:00 p.m. on Tuesday, March 30

The on-site registration fee is $25 for nonstudents and $10 for students. Preregistration fees (prior to March 13) are $20 and $5 respectively.

Preregistrants should pick up their materials at the registration desk. All persons attending the technical sessions, field trips, or other formal functions must be registered.

For more information and preregistration forms, see the December 1981 issue of *GSA News and Information* or contact Kenneth S. Johnson, Oklahoma Geological Survey, 830 Van Vleet Oval, Room 163, Norman, OK 73069 (phone 405–325-3031).

SPECIAL PUBLICATION SERIES TO INCLUDE BIBLIOGRAPHY

The annual bibliography and index of Oklahoma geology has, for many years, been a standard feature that readers of *Oklahoma Geology Notes* have come to expect in the August issue.

Beginning with the bibliography for 1980, however, this information will be published separately as part of the Oklahoma Geological Survey's Special Publication series.

The decision to remove this listing from the *Notes* was made after a number of factors were taken into consideration. It was felt that a separate cover and assignment to a regular series would make the bibliography and index more visible in publication lists and library catalogs as well as on library shelves.

In the past, the great amounts of time and effort required to compile and print the bibliography have made coordination with a particular issue of the *Notes* a most difficult task for the editorial section of the OGS. Removal of this lengthy item from the *Notes* will not only help scheduling but will also make available more space for articles, abstracts, and other news items that would normally appear in the publication.

The 1980 bibliography and index of Oklahoma geology is now in press, and we hope that our readers will approve of the decision and find that the annual bibliographies will be even handier and more useful in this new format.

GEOGRAPHIC-NAME DECISIONS LISTED

The U.S. Board on Geographic Names recently approved the following Oklahoma place names that were published in the July through September 1981 issue of *Decisions on Geographic Names in the United States* (Decision List 8103):

East Fork Glover River: stream, 34 km (21 mi.) long, heads on the N slope of Spring Mountain at 34°29′28″ N, 94°51′52″ W, flows SW to join the West Fork to form Glover River 27 km (17 mi.) NNE of Wright City; McCurtain Co., Okla.; sec. 7, T 3 S, R 23 E, Indian Mer.; 34°18′37″ N, 94°56′05″ W. **Not:** East Fork Glover Creek.

Glover River: stream, 48 km (30 mi.) long, heads at the junction of its East and West Forks at 34°18′37″ N, 94°56′05″ W, flows S to Little River 7.2 km (4.5 mi.) SE of Wright City; McCurtain Co., Okla.; sec. 19, T 6 S, R 23 E, Indian Mer.; 34°01′11″ N, 94°56′15″ W. **Not:** Glover Creek.

Horse Head Creek: stream, 16.1 km (10 mi.) long, heads at 34°09′50″ N, 94°58′55″ W, flows S to Little River 1.6 km (1 mi.) SSE of Wright City; McCurtain Co., Okla.; sec. 10, T 6 S, R 22 E, Indian Mer.; 34°02′51″ N, 94°59′33″ W. **Not:** Horsepen Creek.

Rock Creek: stream, 11.3 km (7 mi.) long, heads at 34°09′05″ N, 94°59′39″ W, flows SSW to Little River 1.6 km (1 mi.) NW of Wright City; McCurtain Co., Okla.; sec. 32, T 5 S, R 22 E, Indian Mer.; 34°04′13″ N, 95°01′08″ W. **Not:** Little Rock Creek, Wolf Creek.

West Fork Glover River: stream, 37 km (23 mi.) long, heads on Wildhorse Mountain at 34°30′24″ N, 94°55′42″ W, flows S to join the East Fork to form Glover River 27 km (17 mi.) NNE of Wright City; McCurtain Co., Okla.; sec. 7, T 3 S, R 23 E, Indian Mer.; 34°18′37″ N, 94°56′05″ W. **Not:** West Fork Glover Creek.

USGS INCREASES MAP PRICES

Recent increases in map prices by the U.S. Geological Survey have now begun to show up at the sales counter of the Oklahoma Geological Survey. Increases have amounted to approximately 60 percent.

The *State of Oklahoma* base map, without highways, has risen in price from $1.50 to $2.50, while the same map with highways has gone up to $3.25.

All 7.5- and 15-minute topographic maps have increased from $1.25 to $2. The state topographic map and 1:250,000-scale quadrangle maps now sell for $3.25 rather than $2.

The *Geologic Map of Oklahoma* sells for $6 and the *Geologic Map of the United States* sells for $8.

OIL–GAS ASSOCIATION FORMED

As reported in the Oklahoma Petroleum Council's December Newsletter, the Oklahoma–Kansas Oil & Gas Association was formed when the Oklahoma Petroleum Council merged with the Kansas–Oklahoma Division, Mid-Continent Oil & Gas Association, at the beginning of the year.

The new association plans to move from its Fourth National Bank Building location to 700 Adams Office Building, 403 South Cheyenne in Tulsa. The group will be a division of the Mid-Continent Oil & Gas Association.

The only title change announced was that of James O. Kemm, executive manager, Oklahoma Petroleum Council, who will become the executive vice-president for public relations, Oklahoma–Kansas Oil & Gas Association.

Joy Hampton

Cynthia Williams

Michelle Summers

THREE NEW STAFF MEMBERS FOR OGS

Louisa Joy Hampton, Cynthia Elaine Williams, and Michelle J. Summers are recent additions to the staff of the Oklahoma Geological Survey.

Joy Hampton, a native of Meeker, Oklahoma, graduated from Central High School in Oklahoma City, attended Oklahoma City University, and earned a bachelor of science degree in geology at The University of Oklahoma. She did graduate work in geology at OU, leaving the campus to do seismograph work with a field crew.

She has also worked as a sample geologist for Stanolind and as a mud engineer and instructor for Mud Control Laboratories. For 14 years she served as a petroleum geologist for the Oklahoma Corporation Commission.

Hampton returned to the OU campus in 1979 to become a petroleum geologist for the Energy Resources Center, working in the Information Systems Programs (ISP), specifically with the Petroleum Data System (PDS), the Energy Information Administration (EIA), and the U.S. Geological Survey's Computerized Resources Information Bank (CRIB). At present she holds a joint appointment as petroleum geologist with OGS and ISP, where she is involved in a PDS contract for Oklahoma.

Hampton is a woman of many interests, but she says her prime hobbies are crocheting, sewing, her home, and growing greenery, not to mention caring for two canine friends.

Cynthia Williams, who is working as a chemist in the OGS analytical-chemistry laboratory, was born and grew up in Arkadelphia, Arkansas. She graduated from Peake High School there and received her B.S. degree in chemistry from Ouachita Baptist University, also in Arkadelphia.

Following graduation from OBU, she taught mathematics in high schools in Okolona, Wilmot, and Crossett, Arkansas, and in a high school and junior high school in Dayton, Ohio. She later served for six years as a chemistry instructor and laboratory teacher at Sinclair Junior College in Dayton. She has also worked as a quality control analyst in the chemical division of Georgia Pacific Corp. in Crossett, testing resins used in making plywood and also functioning in operational aspects of the plant.

Her husband, Capt. Ray Charles Williams, Sr., is a chaplain for the U.S. Air Force and is stationed at Tinker Air Force Base, near Oklahoma City. They have two sons, Ray Charles, Jr., aged 10, and Everett Brooke, who is 7.

Williams expects to receive a master's degree in chemistry from The University of Oklahoma in May of this year. Her thesis is a "Study of the Motion of Water in Sandstone for Enhanced Oil Recovery."

Michelle Summers is working for the Survey on special assignment as geological data coordinator on the ISP program with Joy Hampton, continuing work she has been doing at the OU Energy Resources Center on the PDS, CRIB, and EIA programs.

Summers is from Minneapolis and has attended the University of Minnesota in Minneapolis and the University of California, Davis, where she served as administrative assistant to the director of the computer center. She has been with ERC for the past seven years.

She has a 13-year-old daughter, Tasha, who is a student at Longfellow Middle School in Norman.

Summers' favorite after-work activities are tennis and swimming. She is also an artist and enjoys drawing.

HIGHWAY GEOLOGY SYMPOSIUM PLANNED FOR VAIL, COLORADO

An announcement and call for papers has been made for the 33d Annual Highway Geology Symposium and Field Trip scheduled for September 15–17 in Vail, Colorado.

The theme of the 1982 symposium is the effect of environmental considerations on geotechnical aspects of highway design and construction. The meeting will be held in conjunction with the Northwest Geotechnical Workshop, which will take place on September 13 and 14.

An all-day field trip is scheduled for Thursday, September 16, and will include visits to Interstate Highway 70 on Vail Pass and to I-70 projects under construction in Glenwood Canyon.

For further information, contact: Jeffrey L. Hynes, Colorado Geological Survey, 1313 Sherman Street, Room 715, Denver, CO 80203/(303)866-2611; or Martin C. Everitt, U.S. Forest Service, 11177 W. 8th Avenue, Box 25127, Lakewood, CO 80225/(303)324-4405.

GEOLOGICAL SOCIETIES ANNOUNCE OFFICERS

New officers and executive committees for the 1981–82 year have been announced by the following geological and geophysical societies in Oklahoma:

Ardmore Geological Society

President, **Fred B. Jones**, independent consultant
Vice-President, **James Hallett**, Quinton-Little Co.
Secretary-Treasurer, **R. D. Wilkinson**
Past President, **J. D. Garrison**, Westheimer-Neustadt Corp.
Executive Committee: **J. D. Garrison**, Westheimer-Neustadt Corp.; **R. W. Allen**, consultant

Geophysical Society of Oklahoma City

President, **Bill Haselwood**, Energy Reserves Group
First Vice-President, **Marc Pottorf**, Terra Resources, Inc.
Second Vice-President, **Cliff Hanoch**, Union Texas Petroleum
Secretary, **Ken Ainsworth**, Amarex, Inc.
Treasurer, **Jim Peterson**, Peterson Associates
Past President, **Clint Hutter**, Texas Pacific Oil Co.

Geophysical Society of Oklahoma City executive committee for 1981–82. Left to right: Jim Peterson, Ken Ainsworth, Cliff Hanoch, Marc Pottorf, and Bill Haselwood.

Geophysical Society of Tulsa

President, **Donald E. Wagner**, Amoco Production Co.
First Vice-President, **John T. O'Brien**, Phillips Petroleum Co.
Second Vice-President, **Gregory W. Finn**, Seismograph Service Corp.
Secretary, **Roger M. Borcherding**, Texaco U.S.A.
Treasurer, **Janet L. Borgerding**, Cities Service Co.
Editor, **John L. Blum**, Mapco Production Co.
Editor-Elect, **Lee Bennett**, Conoco, Inc.
Past President, **Robert A. Wyckoff**
District Representatives: **Robert A. Wyckoff, Donald E. Wagner, S. W. Fruehling**

Oklahoma City Geological Society

President, **Jerry E. Upp**, Tenneco Oil Co.
First Vice-President, **John G. Borger II**, R. L. Burns
Second Vice-President, **G. Phil Spurlin**, consultant
Secretary, **Carroll L. Kinney**, Mewbourne Oil Co.
Treasurer, **George L. Ten Eyck**, Kepco, Inc.
Shale Shaker Editor, **Robert F. Lindsay**, Gulf Oil
Library Director, **J. W. McHugh**, consultant
Social Chairman, **Glenn L. Blumstein**, Jake L. Hamon
Public Relations Chairman, **Bruce Woodhouse**, Tenneco Oil Co.
Past President, **W. P. Anderson, Jr.**, Exok, Inc.

Geophysical Society of Tulsa, Inc., executive committee for 1981–82: Front row, seated, left to right: Robert A. Wyckoff, Donald E. Wagner, and S. W. Fruehling. Back row, standing, left to right: Gregory W. Finn, Janet L. Borgerding, John T. O'Brien, John L. Blum, Lee Bennett, and Roger M. Borcherding.

Oklahoma City Geological Society executive committee for 1981–82. Front row, seated, left to right: W. P. Anderson, Jr., John Borger II, Jerry Upp, G. Phil Spurlin, and Jim McHugh. Back row, standing, left to right: George L. Ten Eyck, Glenn L. Blumstein, Carroll Kinney, Bert Wessman, Robert F. Lindsay, and Bruce Woodhouse.

Tulsa Geological Society

President, **Dan R. Schenck**, Cities Service Co.
First Vice-President, **Richard Behling**, Weinkauf Petroleum Corp.
Second Vice-President, **Ken Proctor**, consultant
Secretary, **Roger Berg**, Andover Oil Co.
Treasurer, **Lyle G. Bruce**, Essex Exploration Co.
Editor, **Norman J. Hyne**, University of Tulsa
Newsletter Editor, **Jonathan Lee**, Texaco U.S.A.
Past President, **Edward D. Pittman**, Amoco Production Co.
Councilors, **James Cunliffe**, Cities Service Co.; **Nancy M. Hart**, Sunrise Exploration; **Victoria MacLeod**, Oklahoma Petroleum Management

ANOTHER 'FIRST' MARKED BY HISTORICAL MONUMENT

A monument dedicated recently in Barnsdall takes note of another of Oklahoma's "firsts" in the history of the petroleum industry.

The 8-foot-high granite marker, co-sponsored by the Oklahoma Historical Society and the Oklahoma Petroleum Council, pays tribute to the first petrochemical plant in the Southwest, which was built at Tallant, north of Barnsdall, in 1926. The plant was enlarged several times and its operations expanded to help meet the nation's needs during World War II. It continued in operation until 1954.

The monument in Barnsdall stands beside the Bigheart Historical Museum on Main Street. It was unveiled and dedicated on October 26, 1981, by representatives of the sponsoring organizations, local civic leaders, historians, legislators, and former employees of the Tallant plant.

It is the 17th in a series of markers erected by the council and the Oklahoma Historical Society since 1964.

The text of the Barnsdall monument, written by the council's historical committee and the Oklahoma Historical Society, is as follows:

"PATRIARCH PETROCHEMICAL PLANT OF THE SOUTHWEST— The manufacture of chemicals from petroleum had its beginning in the Southwest at the Tallant gas processing plant located 3 miles north of here at the bend of State Highway 11 and Bird Creek.

"Built in 1926 by a Cities Service Company subsidiary, the plant process was the research answer to red rust produced in transmission to market of natural gas from the Burbank, Oklahoma field.

"The liquid by-product of Burbank gas treatment was first processed into a formaldehyde preservant and alcohols. Processing refinements produced other petrochemicals used in solvents, photographic chemicals, preservatives, medical products, refrigerants, safety glass, adhesives, and disinfectants.

"World War II shifted production of Tallant petrochemicals to high-priority war effort necessities, contributing to development of all-weather plywoods for assault boats, pontoon bridges, torpedo boats, planes and aircraft carrier decking.

"Another Tallant petrochemical was used in making shatter-proof glass that protected crews of bombers and other war craft.

"On battlefields, derivatives of Tallant petrochemicals gave relief from pain to the injured, went into wartime medicines and anesthetics, disinfected against disease and kept intransit foods refrigerated.

"Recognized as the patriarch petrochemical plant, it was retired in 1954 and the complex at the bend of Bird Creek partially dismantled. But, the process that had its beginning in 1926 is still used elsewhere. —Oklahoma Historical Society, with Oklahoma Petroleum Council, 1981."

NOTES ON NEW PUBLICATIONS

In-Situ *Mining Research Proceedings: Bureau of Mines Technology-Transfer Seminar, Denver, CO, August 5, 1981*

Compiled by the staff of the Bureau of Mines, this publication consists of 107 pages and 37 figures that give an overview of the *in-situ* mining research currently being carried out by that organization. The papers emphasize both the environmental and the productivity aspects of the *in-situ* mining method.

Topics covered include restoration of ground water, selection of lixiviants, *in-situ* mining of commodities other than uranium, costs, resistance measurements, acid-leach mining case-history, and the use of branched boreholes.

Free copies of Information Circular 8852 can be obtained from: Section of Publications, Bureau of Mines, U.S. Department of the Interior, 4800 Forbes Avenue, Pittsburgh, PA 15213.

Colonial National Historical Park, Virginia

A new topographic map of colonial Virginia, showing the Jamestown, Williamsburg, and Yorktown areas on one side and historic Yorktown battlefield maps and other features on the reverse, is now available from the U.S. Geological Survey.

The multicolored map, which was prepared by the USGS in cooperation with the National Park Service, is the first single map of the entire colonial Virginia area to comply with national map-accuracy standards.

The map was prepared in commemoration of the bicentennial of the surrender of Lord Cornwallis, commander of the British troops during the Revolutionary War, to General George Washington on October 19, 1781.

Especially useful to visitors is the topographic map that was compiled from eight standard USGS quadrangle maps, which depicts a wide range of surface features including several classifications of roads, airports, parks, rivers and lakes, scenic overlooks, golf courses, hospitals, trailer parks, boat ramps, and picnic areas.

Order map no. 37076–B5–PF-025 from the Eastern Distribution Branch, Map Section, U.S. Geological Survey, 1200 South Eads Street, Arlington, VA 22202. Orders must specify map name and number, and include check or money order for $2 payable to the U.S. Geological Survey.

Plate-Tectonic Maps of Circum-Pacific Region

Published by The American Association of Petroleum Geologists, these full-color maps of the Northwest, Northeast, and Southeast Quadrants depict active plate boundaries, plate-motion vectors, major intraplate faults, seismic epicenters, Holocene volcanic activity, and magnetic lineaments. Accretionary terrane along the Pacific rim is shown on the Northeast map sheet. The final two maps in this 1:10,000,000 series, the Southwest and Antarctica sheets, are scheduled for publication later this year.

The basic Circum-Pacific Map Series consists of five 1:10,000,000-scale maps and a basinwide map at a scale of 1:20,000,000.

The plate-tectonic maps are available from AAPG, P.O. Box 979, Tulsa, OK 74101. Price: $8 each. Also available are full-color geographic maps at $12 each or $30 for a set of six maps and base maps, for plotting purposes, at $6 each or $20 for a set of six maps.

SEPM Reprint Series 10: Diagenesis of Carbonate Rocks: Cement-Porosity Relationships

This volume of reprints from the *Journal of Sedimentary Petrology* reflects more than two decades of progress toward our understanding of what makes and breaks porosity in carbonate rocks. The source of inspiration, energy, and advance that culminated in this progress was provided by the major oil companies of the United States. Starting in the 1950's the enormous petroleum reservoirs discovered in carbonate rocks in the Pennsylvanian and Permian of west Texas, in the Devonian of Canada, and in the Middle East prompted the oil companies to increase their effort in carbonate research.

A most important part of this effort related to the study of the development and retention of porosity or conversely to the loss of porosity through the precipitation of cement.

The sequence of papers in this reprint volume follows the development and change in emphasis of our understanding of carbonate diagenesis and cement-porosity relationships.

Order from: Society of Economic Paleontologists and Mineralogists, P.O. Box 4756, Tulsa, OK 74104. Price: $9 to SEPM and AAPG members, $11 to nonmembers. Tulsa orders, add 5 percent. Add 2 percent for other Oklahoma orders.

A Guide to Obtaining Information from the USGS, 1981

A guidebook explaining how to obtain a wide range of products and information from the U.S. Geological Survey has been revised and is again available free upon request.

The 1981 guidebook was prepared to assist in obtaining USGS maps, reports, and other information products, and to aid in locating both general and specific unpublished information.

The publication shows addresses and telephone numbers of more than 30 USGS public-service offices, including libraries, Public Inquiries Offices, National Cartographic Information Centers, publication-distribution centers, and the Open-File Services Section.

Order Circular 777 from: U.S. Geological Survey, Text Products Section, Eastern Distribution Branch, 604 South Pickett Street, Alexandria, VA 22304.

The Geologic Story of the Great Plains

USGS Bulletin 1493, by D. E. Trimble, is a nontechnical description of the origin and evolution of the landscape of the Great Plains.

Order from: Eastern Distribution Branch, Text Products Section, U.S. Geological Survey, 604 South Pickett Street, Alexandria, VA 22304. Price: $4.50.

Changes in Stratigraphic Nomenclature by the U.S. Geological Survey

Published by the USGS as Bulletin 1502-A, this publication by N. F. Sohl and W. B. Wright is available from: Eastern Distribution Branch, Text Products Section, U.S. Geological Survey, 604 South Pickett Street, Alexandria, VA 22304. Price: $4.25.

Bedrock Geology, Altitude of Base, and 1980 Saturated Thickness of the High Plains Aquifer in Parts of Colorado, Kansas, Nebraska, New Mexico, Oklahoma, South Dakota, Texas, and Wyoming

This map by J. B. Weeks and E. D. Gutentag consists of two sheets, latitude about 32° to about 43°, longitude about 96° to 106°. Scale 1:2,500,000. Both sheets are 20 by 41 inches.

Order from: Western Distribution Branch, U.S. Geological Survey, Box 25286, Federal Center, Denver, CO 80225. Price: $3 per set.

Energy Crisis

In this four-volume set, Lester Sobel and the editors of *Facts on File* trace the developments of the energy crisis from 1969 through mid-1980.

Order from: *Facts on File*, 460 Park Ave. S., New York, NY 10016. Price: $17.50 each volume, $49.95 for the four-volume set.

Atomic Energy and the Safety Controversy

Grace Ferrara and the editors of *Facts on File* examine worker safety, waste disposal, nuclear accidents, anti-nuclear protests, legislation, and many other aspects of this energy-related question.

Order from: *Facts on File*, 460 Park Ave. S., New York, NY 10016. Price: $17.50.

World Energy: The Facts and the Future

This analysis of the world energy situation is written for both the layman and those working in energy-related fields. The 350-page book contains about 150 tables and also makes use of charts and diagrams.

The book examines the structure and development of world energy during the last decade and projects the likely developments in supply and demand in the year 2000.

Order from: *Facts on File*, 460 Park Ave. S., New York, NY 10016. Price: $22.50.

Annual Review of Energy, Volume 5

Editor Jack M. Hollander and associate editors Melvin K. Simmons and David O. Wood have gathered together 12 articles in this 440-page book. Included are chapters on "The Role of Governmental Incentives in Energy Production: An Historical Overview," by Joseph P. Kalt and Robert S. Stillman; "Public Opinion About Energy," by Barbara C. Farhar, Charles T. Unseld, Rebecca Vories, and Robin Crews; and "Coal Clean-Up Technology," by Kurt E. Yeager.

Order from: Annual Reviews, Inc., 4139 El Camino Way, Palo Alto, CA 94306. Price: $20 U.S.A., $21 elsewhere.

Annual Review of Earth and Planetary Science, Volume 9

This 502-page clothbound volume contains 16 articles covering a wide range of topics. Included in the contents list are: "Mechanics of Motion on Major Faults," by Gerald M. Mavko; "Free Oscillations of the Earth," by Ray Buland; "Ice Age Geodynamics," by W. R. Peltier; and "Ancient Marine Phosphorites," by Richard P. Sheldon.

Order from: Annual Reviews, Inc., 4139 El Camino Way, Palo Alto, CA 94306. Price: $20 U.S.A., $21 elsewhere.

Geographic Names Information System (GNIS)

The purpose of this system, established by the U.S. Geological Survey, is to provide basic name data from numerous sources. The system consists of approximately two million name entries with information about the feature name and its geographic location by coordinates. The name file was developed from published 7.5-minute topographic quadrangles.

In areas where 7.5-minute quadrangles have not been published, 15-minute quadrangles or 1:250,000-scale maps provided the basic name data.

Presently available are alphabetical finding lists consisting of spiral-bound computer printouts of name files. Included in each state list are definitions, the Federal Information Processing Standards code designation, quadrangle-map names in alphabetical order and numerical sequence, and alphabetical listings with coordinates. Some state files are also available in microfiche.

Unedited computer printouts, specialized searches, and computer tapes can also be purchased.

GNIS, developed by Geographic Names Information Management, Branch of Names, Office of Geographic Research, National Mapping Division, is the basis for Professional Paper 1200, to be published by the U.S. Geological Survey beginning in 1982. Prior to publication, the interim materials described may meet the needs of a wide variety of potential users.

For Oklahoma, a printout is available for $12, while a magnetic tape is available for $40.

For more information, or to order, write to: U.S. Geological Survey, NCIC, 507 National Center, Reston, VA 22092. The Survey can be reached by calling (703)860-6045.

Demonstrated Reserve Base of Coal in the U.S. on Jan. 1, 1979

The U.S. Department of Energy has released this as the first in a series of annual summaries on minable coal. The report is on file at the Oklahoma Geological Survey offices in Norman.

Energy

The Institute for Energy Analysis, Oklahoma State University, has identified energy alternatives for Oklahoma industry, government, and citizens in this volume.

Evaluations of statewide resources, their production and consumption, and their impact on the economy are included. A view of selected research programs in progress at OSU is also provided.

The report is on file at the Oklahoma Geological Survey offices in Norman.

The Geologic Story of Colorado National Monument

Author S. W. Lohman has included a description of the history, geology, and scenic features of the Colorado Plateau province in this 142-page U.S. Geological Survey publication. Most features are illustrated by color photographs, maps, and diagrams, and the report describes six guided trips through and around the area.

Order Bulletin 1508 from: Eastern Distribution Branch, Text Products Section, U.S. Geological Survey, 604 South Pickett Street, Alexandria, VA 22304. Price: $5.

Organic Maturation Studies and Fossil Fuel Exploration

Edited by J. Brooks, this book provides a platform for current research, developments, applications, and discussion on organic maturation of sedimentary organic matter against the requirements of petroleum exploration. This 442-page book contains papers by geologists, geochemists, chemists, and palynologists. The material was presented at a symposium held at the Fifth International Palynological Conference, Cambridge, England, July 3–5, 1980.

Order from: Academic Press, 111 Fifth Avenue, New York, NY 10003. Price: $60.

Chemical Analyses of Coal from the Krebs Group (Pennsylvanian), Arkoma Basin, Eastern Oklahoma

Issued as USGS Open-File Report OF 81-0894, this publication by R. T. Hildebrand consists of 43 pages.

Order from: Open-File Services Section, Western Distribution Branch, U.S. Geological Survey, Box 25425, Federal Center, Denver, CO 80225. Price: $3.50 microfiche, $5.50 paper copy.

Principles of Benthic Marine Paleoecology

Arthur J. Boucot has written this book in order to emphasize that a thorough understanding of historical biogeography and animal-community history can supplement understanding of the evolutionary process. Primarily, this 480-page book deals with the paleoecology of the shallow-water-marine environment and provides information for reconstructing the continental shelf shallow-water environments.

Robert S. Carney, of the National Science Foundation, has provided contributions on bioturbation, biodeposition, and nutrients.

Order from: Academic Press, Inc., 111 Fifth Ave., New York, NY 10003. Price: $58.

How to (Try to) Find an Oil Field

Geologists from the Houston Geological Society hope that readers of this recent publication will sense some of the adventure, uncertainty, and risk associated with petroleum exploration.

The authors discuss how the geologist works, what techniques he relies on, and what tools are at his disposal. Also briefly described are drilling, leasing, production, refining, petroleum reserves, and the history of oil exploration.

Authors of the book are Doris M. Curtis, Patricia Wood Dickerson, Donald M. Gray, Helen M. Klein, and Evelyn Wilie Moody. Most readers will recognize Doris Curtis as past president of the American Geological Institute, and many Oklahoma readers will remember Pat Wood Dickerson as a former associate editor of the Oklahoma Geological Survey.

Order from: PennWell Books, P.O. Box 21288, Tulsa, OK 74121. Price: $20 (plus tax for residents of Alabama, California, Oklahoma, Texas, and Washington, D.C.)

The Encyclopedia of Mineralogy

Edited by Keith Frye, this volume contains more than 140 articles by internationally recognized experts on specific areas of mineralogical interest.

Published in November 1981, Volume IVB contains 912 pages.

Order from: Academic Press, Inc., 111 Fifth Ave., New York, NY 10003. Price: $95.

STRATIGRAPHIC STUDY PUBLISHED BY OGS

A report on the *Significance of Limestones of the Marmaton Group (Pennsylvanian, Desmoinesian) in Eastern Oklahoma* has been issued by the Oklahoma Geological Survey (OGS) as Bulletin 131. The report was prepared by George W. Krumme of Krumme Oil Co., which has its headquarters in Bristow, Oklahoma.

The report presents the results of an intensive investigation of the surface and subsurface rocks of a 200-foot series of limestone banks of the Middle-Pennsylvanian Marmaton Group and their correlatives farther south in the McAlester Basin portion of the Arkoma Basin. The area covered extends from the Ahloso Fault—on the north flank of the Arbuckle Uplift—to the Kansas border, and from the central Oklahoma Nemaha Ridge eastward to the outcrop in Hughes County and northeastward into Craig County. Structural provinces and features in the area include the Northeast Oklahoma Platform, McAlester Basin, Seminole Uplift, and Nemaha Ridge.

The rocks in this region now dip gently westward at about 1°, but the slope on which they were deposited was much different—with the dip toward the southeast. The entire section shows thinning to the north and west away from the McAlester Basin, which indicates a source from the geosynclinal facies of the rising Ouachita Mountains in southeastern Oklahoma and a sea that pushed northward with the uplifting of the Ouachitas.

Lateral changes in rock type are common, making it difficult to correlate formations on the basis of both time of deposition and physical characteristics such as composition and thickness.

These variations have created numerous problems in petroleum exploration, and the work that Krumme has done in correcting previous miscorrelations in stratigraphic interpretation of strata will be of great interest to geologists and drillers active in the area.

His determinations are based strongly on detailed examination of electric logs. Krumme has not only amended some stratigraphic correlations but also has interpreted the paleogeography, and hence paleoenvironments, of Middle Pennsylvanian time. His conclusions agree well with neighboring areas and suggest the existence of a seaway that during this time extended from northern Texas to the Appalachians.

Bulletin 131 can be obtained from the Oklahoma Geological Survey by writing to the address given inside the front cover. The price is $6 for paperback copies, and $10 for hardbound.

OKLAHOMA ABSTRACTS

American Quaternary Association, Sixth Biennial Meeting, Orono, Maine, August 18–20, 1980

The following abstract is reprinted from the *Abstracts and Program* of the American Quaternary Association's Sixth Biennial Meeting, August 18–20, 1980. The page number is given in brackets below the abstract. Permission of the author and of James E. King, treasurer of AQA, to reproduce the abstract is gratefully acknowledged.

Corresponding Geomorphic, Archeologic, and Climatic Change in the Southern Plains: New Evidence from Oklahoma

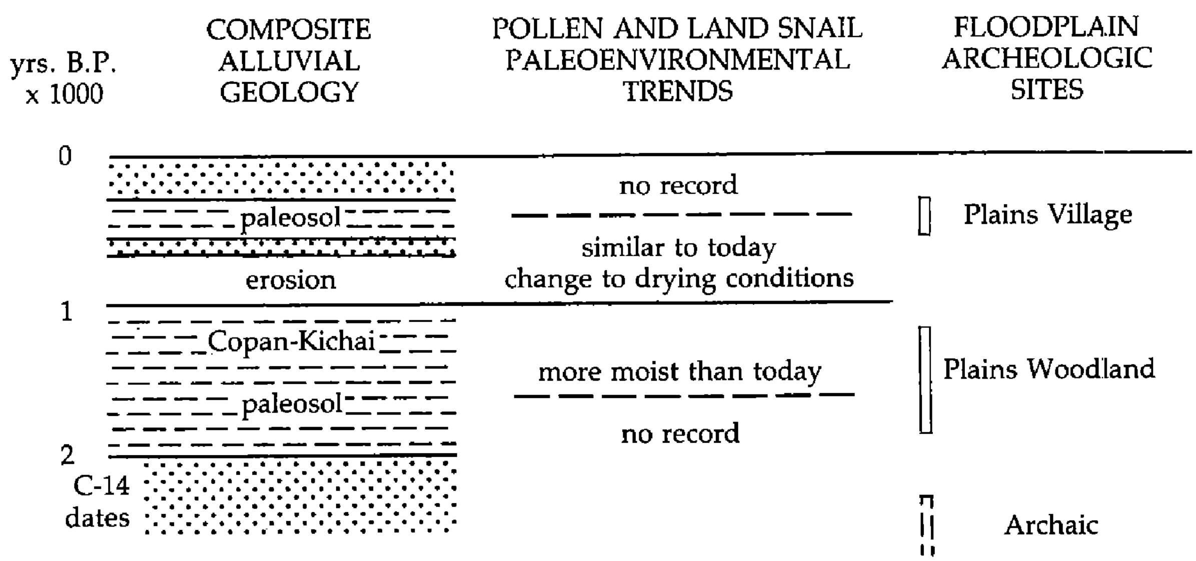
STEPHEN A. HALL, Department of Geography, North Texas State University, Denton, TX 76203

Recent investigations of 12 rockshelter and floodplain archeologic sites in northeastern and southwestern Oklahoma show a consistent pattern of late Holocene alluviation, erosion, and soil formation that corresponds to evidence for a changing regional climate. Rapid valley filling was in progress 2600 years B.P., especially in the sandy southwestern portion of the state; by 2050 years B.P. alluviation slowed, resulting in the development of the Kichai paleosol. The 80-cm thick floodplain paleosol accumulated until about 1050 years B.P. when its development was terminated by erosion. At about the same time in northeastern Oklahoma, beginning about 1800 years B.P., the Copan paleosol began forming. Accumulation of the 1-meter thick Copan paleosol ended soon after 1200 years B.P. when it was eroded during a period of channel cutting. After the Copan and Kichai paleosols were eroded, the channel cuts were filled and buried by alluvium. Between 400 and 600 years B.P. floodplain aggradation again slowed, resulting in the formation of a weakly developed 30-cm thick paleosol. This younger paleosol, where preserved, is buried by as much as 50 cm of alluvium or colluvium.

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

Pollen and land snail records from rockshelter and alluvial sites indicate that from at least 1600 to about 1200 years B.P. the climate of Oklahoma was more moist than it is today. The moist period coincides with slow floodplain aggradation and the development of the Copan-Kichai paleosol. Beginning about 1200 years B.P., shifts in pollen and land snail frequencies indicate a change to drier conditions that in turn coincide with erosion and incision of the valley floors. These pollen and land snail records do not extend later than about 500 years B.P.

The prehistoric occupation of the valley floors coincides with periods of soil formation. The Copan-Kichai paleosol contains Plains Woodland and the younger, overlying paleosol contains Plains Village remains. The presence of the Plains Woodland people in the valleys corresponds to the period of more moist climate. The paleoenvironmental record for Plains Village time is at present inconclusive. Alluvial sites are seldom found outside the context of paleosols except for scattered occurrences of Archaic age hearths and artifacts in pre-Copan-Kichai paleosol sediments. Rockshelters bordering the alluvial valleys, such as Big Hawk Shelter in Osage County, do not show a break in occupation but were inhabited during paleosol formation, channel incision, and alluviation.



[89]

AAPG Mid-Continent Section Biennial Meeting Oklahoma City, Oklahoma, September 20–22, 1981

The following abstracts are reprinted from the *Bulletin* of The American Association of Petroleum Geologists, v. 65, no. 8. Page numbers are given in brackets below the abstracts. Permission of the authors and of Myron K. Horn, AAPG editor, to reproduce the abstracts is gratefully acknowledged.

Arkoma Basin Model: Middle Ordovician Through Early Devonian

THOMAS W. AMSDEN, Oklahoma Geological Survey, Norman, OK 73019

The Arkoma is a structural-sedimentary basin covering much of eastern Oklahoma and western Arkansas, and extending south to the Choctaw fault. (This report covers only the Oklahoma part of the basin.) In general the basin deepens and thickens toward the south, a pattern which was well developed by Simpson time (early Middle Ordovician), but which was sharply interrupted during Middle Ordovician (late Bromide) and not resumed until after Early Devonian. During this interregnum the sediments are represented largely by a succession of thin but widespread carbonate units separated by diastems and unconformities. This period began with an intertidal environment which extended over most of the basin (late Bromide; Fite), followed by a succession of widespread, shallow carbonate seas, generally with prolific faunas including many representatives of the sessile benthos, separated by times of uplift of varying intensity and duration. The only significant departure from this pattern is the Upper Ordovician Sylvan Shale, a calcareous mudstone and shale representing an environment which inhibited almost all of the sessile benthos, the only persistent organisms being graptolites and chitinozoans. Carbonate sedimentation was resumed following this shale episode, continuing to the end of the Early Devonian. This depositional model produced a body of sediments whose total thickness does not exceed 500 ft (152 m), and which neither individually nor collectively shows any directional thickening. Early Devonian deposition was followed by a prolonged period of uplift accompanied by extensive erosion and truncation. The region was then submerged by the advancing Chattanooga (Woodford) sea, and the pattern of southward subsidence and thickening again resumed. [1495]

Transitional Desmoinesian to Missourian Cyclic Deposits on Opposite Shores of Arkoma Seaway

ALLAN P. BENNISON, Geological Consultant, Tulsa, OK 74119

Distinctive differences between Late Desmoinesian to early Missourian cyclic deposits on opposite shores of the Pennsylvanian Arkoma seaway were noted during outcrop mapping in eastern Oklahoma.

The north shore deposits conform to the classical Mid-Continent Pennsylvanian cyclothem. A regressive blanket sandstone is succeeded in turn by underclay, coal, and carbonaceous shale, transgressive calcareous shale and/or limestone, black fissile shale with phosphate nodules, and, finally, gray shale with calcareous to sideritic inclusions that becomes upward increasingly silty to sandy.

The south shore deposits that border the Ouachita and Arbuckle uplifts in southeastern Oklahoma reveal a more symmetrical cycle than for the preceding. Both transgressive and regressive sandstones are present, and, although exceedingly lenticular, converge northward to enclose a fluviatile tongue of red beds and conglomeratic lenses. The subjacent and superjacent transgressive marine wedges contain fossiliferous gray to black shales. Limestones are usually thin and developed near tops and bottoms of shale sequences.

Seaway deposits are much more variable. High sea-level phase is characterized by subtidal gray shale with subordinate bioturbated siltstone to sandstone. A low sea-level phase commonly consists of intertonguing north and south shore deposits.

Effects of eustatic oscillations of sea level were imprinted on an episodically subsiding depositional trough. Many stratigraphic horizons that reflect sea-level reversals are useful for regional correlations. Application of this concept to the polycyclic Holdenville formation of Hughes County indicates its northward continuation as the Memorial shale and the overlying Jenks and Tulsa sandstones and associated shales of Tulsa County previously miscorrelated with the Seminole Formation. In the subsurface these sandstones become the oil productive Cleveland sandstones. These correlations are supported by fossil determinations. [1495]

Uranium Mineralization in North-Central and Southwestern Oklahoma

SALMAN BLOCH and KENNETH S. JOHNSON, Oklahoma Geological Survey, Norman, OK 73019

At least three types of uranium occurrences are known in the study areas. In north-central Oklahoma (Enid 2 × 1° Quadrangle) several "red-bed" uranium-copper shows occur in the Oscar group and Wellington Formation. The mineralization is associated with plant debris and is confined to gray, fine-grained sandstone lenses within a red-bed sequence. The most reasonable source for the Cu and U are the red beds, with Cu and U released by subsurface breakdown of minerals. The maximum Cu and U concentrations are 2.95% and 125 ppm, respectively. In contrast, the "Kupferschiefertype" copper deposits in southwestern Oklahoma (Creta and Mangum) contain only up to 12 ppm U.

In southwestern Oklahoma (Clinton 2 × 1° Quadrangle) carnotite and tyuyamunite occur in siltstones of the basal part of the Doxey formation. Although the origin of the mineralization is not entirely clear, the common association of uranium with the red-to-gray interfaces may reflect the location of primary ore at a redox interface, since uranium shows little tendency to migrate during oxidation of deposits containing appreciable vanadium. In addition, interpretation of approximately 700 ground-water analyses using the WATEQFC program yielded suggestions as to possible targets for further investigation in the Clinton Quadrangle.

The third type of uranium occurrence is associated with petroliferous areas. Of these, the Cement oil field has produced the only commercial uranium deposit in Oklahoma. Less well known is a small occurrence in Kiowa County (in the Hennessey group) where uranium is associated with pyrobitumen nodules. The nodules contain between 2,225 and 10,110 ppm U. Available field, microscopic, and geochemical evidence suggest that the pyrobitumens are secondary, i.e., alteration products of crude oil. Uranium was provided by ground water.

Petroliferous areas in Oklahoma hold the greatest potential for discovery of significant uranium mineralization. Oil-field brines can, in some places, be a useful tool in exploration for such mineralization. While high radium-226 concentrations in natural waters are not a specific indicator of subsurface uranium mineralization, relatively high ratios of Ra-226/Ra-228, Ra-226/Ba, Ra-223/Ra-228, and Ra-223/Ba in such waters from sedimentary terranes may better reflect the presence of uranium accumulations in the subsurface. Available analyses of several radioactive oil-field brines and springs from various parts of Oklahoma indicate that these waters do not meet the above criteria and are not, therefore, surface expressions of buried uranium mineralization. [1495]

COCORP Deep Seismic Reflection Traverse Across Southern Oklahoma Aulacogen

J. A. BREWER, Department of Geological Sciences, Cornell University, Ithaca, NY 14853

COCORP deep seismic reflection profiles across the width of the southern Oklahoma aulacogen, from the Hardeman basin on the south, through the Wichita Mountains and Anadarko basin on the north, reveal basement deformation that necessitates major revision of ideas about the geologic history.

The profiles south of the Wichita Mountains show that the Precambrian crust is highly layered to depths of 10 to 13 km over an area at least 2,500 km^2, and probably much more. Judging by COCORP surveys elsewhere in the United States, such extensive Precambrian layering is very unusual. The layered crust can be interpreted as a large Proterozoic basin, probably filled mainly with clastic sediments and felsic volcanics since these lithologies are widespread in the Precambrian of the southern Mid-Continent region.

The layering is truncated on the south side of the Wichita Mountains, and under the mountains is either absent or only present in a highly altered form. The truncation is probably caused by Precambrian faults in conjunction with granitic intrusions. Pennsylvanian compression reactivated these faults.

The COCORP profiles across the northern flank of the Wichita Mountains and into Anadarko basin are in an early stage of processing, but preliminary results suggest that the Precambrian layering that is so distinctive south of the mountain does not extend beneath the Anadarko basin. Crystalline rocks of the Wichita Mountains appear to have thrust north along a moderately dipping fault, overlapping the basin by 8 to 9 km. The attitude of the fault at depth beneath the mountains is unclear at present.

Simple models for the southern Oklahoma area as an aulacogen must be revised to consider the complex Precambrian history revealed by the COCORP data. [1496]

Washita Valley Fault System—A New Look at an Old Fault

W. G. BROWN, 700 S. Colorado Boulevard, Chevron USA, Inc., Denver, CO 80222

With the application of plate tectonic concepts to southern Oklahoma, the structural style has more recently been characterized as a wrench fault system. In particular, the Washita Valley fault (WVF) is generally considered by many geologists to be a major left-lateral strike-slip fault with an offset of approximately 40 mi (64 km).

The map most commonly used to demonstrate this magnitude of lateral offset is the basal Oil Creek sand distribution map. The zero edge of the basal Oil Creek sand provides the necessary piercing point to judge lateral offset along the WVF. However, the published basal Oil Creek map depicts the present-day distribution of the sand which is the result of cumulative movements since the deposition of the basal Oil Creek sand. Individual orogenic episodes must be sorted to determine what contribution possible strike-slip movements have made toward the present-day basal Oil Creek sand distribution.

To unravel these various orogenic episodes a palinspastic restoration must be made. In such a sequential restoration, the last movement should be restored first or the known movements restored first to determine the unknown movements. In this presentation, the observable folds along the WVF have been "unfolded" and the known reverse faults have been restored to a pre-fault position. When this has been accomplished the partly restored basal Oil Creek sand map may be used to determine the amount of lateral offset on the WVF.

The resulting restoration indicates that the commonly quoted figure of 40 mi (64 km) of lateral offset is too large. Surface and subsurface data demonstrate that the crustal shortening represented by folds and reverse faults alone can account for the present-day basal Oil Creek sand distribution and thus very little strike-slip movement is needed along the Washita Valley fault system. [1496]

Petrologic Factors Controlling Internal Migration and Expulsion of Petroleum from Source Rocks: Woodford–Chattanooga of Oklahoma and Arkansas

JOHN B. COMER, Department of Earth Sciences, University of Tulsa, Tulsa, OK 74104

Upper Devonian-Lower Mississippian black shales are excellent oil source rocks throughout Oklahoma and much of western Arkansas. Black shales were deposited in shallow-water shelf or epeiric sea environments in the north and deep basins in the south (i.e., Arbuckle province). Silty black shale is more common in the north whereas silicified black shale increases to the south. Overall low rates of clastic sedimentation and high planktonic organic productivity prevailed over the entire region. The small amounts of clastic silt and clay came from the north and northeast with local derivation from the Nemaha ridge and Ozark dome. Some silt was probably contributed from the northwest along the axis of the southern Oklahoma aulacogen (Anadarko basin). Primary carbonate deposition occurred locally on or near a distal southern platform between the Arbuckle and Ouachita provinces (Pauls Valley uplift).

Diagenesis in the Woodford-Chattanooga source rock section proceeded through the following relative time sequence: (a) silicification, chiefly by recrystallization of radiolarians, which probably followed the reaction conversion of amorphous opal-A to opal-CT to chert; (b) dolomitization of deep basin opal or chert and shallow-platform carbonate laminae; (c) tectonic faulting, folding, and associated fracturing and stylolitization predominantly associated with the late Paleozoic Arbuckle and Ouachita orogenies; (d) late silicification and mineralization along fractures contemporaneous with (e) generation and expulsion of petroleum.

The principal expulsion mechanism for these Upper Devonian-Lower Mississippian oil source rocks is "whole oil" migration through coarser grained matrix pores, stylolites, and fractures, rather than diffusion on a molecular scale. Diffusion migration does occur but appears only to affect internal migration over a few millimeters within the source rock, and thus cannot account for expulsion of large volumes of oil.

Preliminary calculations based on source rock extract data indicate that approximately 147 billion bbl of oil have been generated within Woodford shales in the 23,000 sq mi (598,000 sq km) geographic area of southern and western Oklahoma underlain by the Woodford formation.

Minimum relative oil expulsion efficiency appears to have been approximately 18 to 19% of the oil generated within the Woodford. Thus, at least 27 billion bbl of oil have been expelled into adjacent formations in southern and western Oklahoma while 120 billion bbl of oil remain in the source rock. [1497]

Hydrocarbon Occurrences in Frontal and Central Ouachita Mountains, Oklahoma

JOSEPH A. CURIALE, Union Oil Co. of California, P.O. Box 76, Brea, CA 92621; WILLIAM E. HARRISON, Oklahoma Geological Survey, Norman, OK 73019

Hydrocarbons in the frontal and central Ouachitas are in three distinct forms: crude oil, asphaltite, and as organic matter disseminated in potential source rocks. Each of these types has been examined geochemically, in an attempt to correlate oil to asphaltite and oil to source rock. In addition, the general source rock potential of the central Ouachitas has been evaluated. Results show that the crude oil produced to date is chemically mature and

largely undergraded, although production is as shallow as 148 ft (45 m) in one field. The asphaltite is predominantly grahamite throughout the Ouachitas, and correlates geochemically to the crude oil, as indicated by similar stable carbon isotope ratios. An examination of the Ouachita section for source potential indicates that several formations are high enough in organic carbon to have produced oil, although some may be ruled out on the basis of the type of organic matter present.

Association of oil and asphaltite along the strike of the Windingstair fault indicates that this listric reverse fault may have served as a migration conduit. Geochemical similarities between analyses of asphaltite from the Upper Ordovician Bigfork and that from the Mississippian Stanley group further indicate the possibility of vertical migration. Finally, migration along a listric fault, with subsequent near-surface degradation of the oil, would provide a concise explanation for the close association of near-surface solid asphaltite with sightly deeper liquid oil. [1497]

Enhanced Oil Recovery Using High-Pressure Inert-Gas Injection, East Binger (Marchand) Unit, Caddo County, Oklahoma

R. A. EASTERLY, W. C. FREDERICKS, and L. D. HUDSPETH, Phillips Petroleum Co., Oklahoma City, OK 73102

September 1981 will complete four years of high-pressure inert-gas injection in the East Binger Unit area. The process was designed to attain miscible conditions in the low permeability Marchand sand, and although complete miscibility is yet to be obtained because of lower than desired injectivity, stimulation has occurred.

Recent development of the East Binger Marchand field began in 1972. The productive Marchand sand, i.e, Hogshooter sand, is found at an average depth of 10,000 ft (3,048 m) and is of the Pennsylvanian Hoxbar series. The sand generally lies on top of the Hogshooter regional marker, a black low-density shale. The sand is a turbidite depositional feature with some postdepositional bedding deformation, the latter supported by evidence of minor east-west fracturing between some injectors and producing wells.

The major part of the East Binger field was unitized August 1, 1977, and through careful planning, inert flue-gas injection began September 10, 1977. The urgency with which the operators completed the unitization task was predicated by the rapid decline in bottom-hole pressure and predicted primary on only 10.7% of OOIP. Computer simulator studies predicted an additional recovery of 24.7 MMSTB if miscible fluid displacement could be attained in the reservoir.

Flue gas is purchased from Production Operators, Inc., plant facility centrally located in the unit area. The dehydrated gas is delivered to the unit at 4,800 psi and distributed to 17 injection wells. Injectivity has been lower than desired, due partly to lube oil carry-over plugging the low permeable Marchand sand. Other operational problems, and subsequent revision to net hydrocarbon sand thickness, have resulted in a reduction in predicted ultimate recovery from 33.4 to 21.0 MMSTB. Operational problems are being corrected, and infill drilling to develop part of the unit on 80-acre (32 ha.) spacing is in progress. These actions should assure the current predicted ultimate of 21.0 MMSTB will be realized. [1497]

Future Hydrocarbon Potential of Viola Limestone in Oklahoma

JAMES L. EVANS, Davis Oil Co., Tulsa, OK 74101

The Viola Limestone as a potential hydrocarbon source has been recognized for years in the literature, but only in the last couple of years has the industry actively pursued this target as a primary reservoir. The Viola is stratigraphically similar to the Hunton formation and produces from both fracture porosity and primary porosity zones. The Viola can be subdivided into three units with characteristics similar to the Bois d'Arc, Henryhouse–Haragan, and Chimneyhill members of the Hunton. Little formation water has been encountered and the higher prices for crude oil have made economic entire trends heretofore left undeveloped. Some of these trends are untested at any horizon, and others are thoroughly tested for the shallower zones, but virtually untested for Viola. The most active trend to develop has been along the north flank of the Marietta basin in southern Oklahoma. There has been great interest in the Viola on both sides of the Arbuckle Mountains, and in a new discovery along the complex mountain front province of the Anadarko basin. In addition, there are numerous OWWO attempts along the southern end of the Central Oklahoma platform.

Few wells in the Viola have the capability to produce without large frac treatments, and some require some special treatments for paraffin and other impurities. To date, no H_2S has been encountered. The future of Viola development across large parts of Oklahoma is excellent with some very promising trends still untested. [1497]

Comments on Structure within Wichita Mountains Crustal Block

M. CHARLES GILBERT, Virginia Polytechnic Institute and State University, Blacksburg, VA 24060, and Oklahoma Geological Survey, Norman, OK 73019

Work in preparation for a new map of the Wichita Mountains has led to revisions of the surface structure within the exposed igneous rocks. As the presumed faulting pattern will have bearing on the development of regional tectonic models, it is important to document clearly whether major structural discontinuities exist inside this crustal block. Fault distributions within the main igneous outcrops in the eastern Wichitas have been shown on the Oklahoma state geologic map and carried forward in *Oklahoma Geol. Survey Hydrologic Atlas 6*. These faults can be grouped into two categories based on stratigraphy: those separating rocks of the *same* stratigraphic unit, and those separating rocks of *different* stratigraphic units. Field work over the period of 1977 to the present now shows that all those previously accepted faults which allow contact of different igneous lithologies are actually *intrusive* contacts. Accordingly, such faults do not exist. No unequivocal major faults (i.e., separations of tens to hundreds of meters) have been identified in the igneous rocks although prominent lineaments do exist.

The work described above plus new published stratigraphic information on the igneous sequence leads to several speculative ideas on regional deformation associated with the Wichita arch. These ideas follow somewhat the reasoning advanced by Ham, Denison, and Merritt, but with modifications as required by new data.

(a) The integrity of the main Wichita Mountains horst block results from its underlying gabbroic substrate (Raggedy Mountain gabbro group) rather than the covering, thin Wichita granites, or Carlton rhyolite.

(b) Intrusion of the Roosevelt gabbros as small plutons into the Glen Mountains layered complex marks the beginning of the Wichita Mountains block as a structural unit. This timing is not yet well-dated but is clearly pre-rhyolite and pre-granite in age.

(c) Few faults will be found in areas underlain by much gabbro. For example, faults bounding the south side of the Anadarko basin may indicate the most northerly extent of gabbro. Basement beneath the Anadarko basin should have little gabbro. [1498]

Middle Atokan Delta Systems in Arkoma Basin of Arkansas

RICHARD A. HAINES, Peppard and Associates, Denver, CO 80202

The Arkoma basin, located in southeast Oklahoma and west-central Arkansas, is a Pennsylvanian basin which produces gas exclusively, primarily from stratigraphic traps in Atokan and Morrowan sandstones. Many analogies can be made with the Gulf Coast basin; low-angle normal faults, growth faults (both large and small), and abundant sand deposition in a shallow-marine environment.

A series of large growth faults separates the shelf from the deep basin. These faults were active during middle Atokan, adding thick additional section to the deep basin. No correlation exists at this time between the shelf and deep basin sandstones in the middle Atokan.

Throughout the Morrowan and Atokan, a series of delta systems developed across the northern shelf of the basin, mainly from the middle Atokan; the Alma, Carpenter 'B,' Morris, Tackett, and Areci sandstones. Although variable in lateral extent, thickness, and location all have a northeast source and a broad lateral distribution along the shelf. Post-Pennsylvanian erosion has removed the upper distributary part of the above delta systems.

All middle Atokan sandstones produce gas from stratigraphic traps within distributary mouth bars, barrier bars, and delta front sands. All are complicated by normal faults. [1498]

Gas Potential of Ouachita Facies, Atoka and Pushmataha Counties, Oklahoma

GARY W. HART, Independent Geologist, 1301 S. Broadway, Edmond, OK 73034

Atoka and Pushmataha Counties lie along the westernmost exposure of the Ouachita facies in southeast Oklahoma. Eight gas wells have been completed in this isolated exploration area, and six exploratory tests are in the drilling or completion stage. Seven of the completed wells are productive from the Mississippian Stanley sands, and produce at low daily rates. In mid-summer of 1980, a gas well was completed from the Arkansas Novaculite of Early Mississippian–Devonian–Silurian age, and from the Bigfork Chert of Ordovician age. Although a production history is not available on this well, an extensive lease play has resulted, and increased exploratory drilling has begun. The Novaculite–Bigfork production appears to be primarily fracture controlled, but will deliver gas at commercial rates. Only five tests in this general area were ever drilled deep enough to penetrate the Novaculite and/or Bigfork in the past, with three reporting commercial flows of gas, but owing to being in an isolated area with no gas pipeline, exploration has been at a lull since the late 1950s. With the new drilling technology known today, the greatly improved stimulation methods, and adequate gas market conditions, this area will provide new exploratory targets in the 1980s. [1499]

Coal Geology of Northern Part of Northeast Oklahoma Shelf Area

LEROY A. HEMISH, Oklahoma Geological Survey, Norman, OK 73019

Nine commercially important coal beds are present in the northern part of the shelf area of northeastern Oklahoma. Included in the area are parts of Craig, Mayes, Nowata, and Rogers Counties. The coal beds are of Desmoinesian (Middle Pennsylvanian) age. From oldest (lowest) to youngest (highest) they are: Rowe coal, Drywood coal, Bluejacket coal, Weir–Pittsburg coal, Mineral coal, Fleming coal, Croweburg coal, Iron Post coal, and Dawson coal.

Tonnages of resources and reserves were estimated for coal beds 10 in. (25 cm) or more in thickness for depths to 100 ft (30 m), and for coal beds 14 in. (35 cm) or more in thickness for depths greater than 100 ft (30 m). Methods used to calculate figures were adaptations of standard methods used by the U.S. Bureau of Mines and the U.S. Geological Survey. Remaining resources of coal for the four-county area total 1,063,466,000 short tons, of which 110,584,000 short tons are in the reserves category. In the entire four-county area the coal bed with the most remaining resources and reserves is the Weir–Pittsburg, with 490,869,000 short tons, and 31,055,000 short tons, respectively.

Coals of the area are predominantly of high volatile A-bituminous (hvAb) rank. Coal from the Croweburg bed has the highest overall quality and has an average sulfur content of less than 1%. Other coals in the study area have sulfur percentages averaging above 3.5%.

All coal produced in the four-county area during the time of the study was mined by surface methods. Production of coal peaked in the late 1970s, with 3,666,645 short tons reported mined in 1977, and 3,462,816 short tons reported mined in 1978. Rising production costs, a depressed market, and environmental restrictions have contributed to a decline in production in recent years. [1499]

Anadarko Basin—A Model for Regional Petroleum Accumulations

G. W. HILL, JR., ENI Exploration Co., Dallas, TX 75221

Many basins being explored today can be viewed as regional petroleum accumulations. The Anadarko basin is used to describe how its depositional and orogenic history, its patterns of deposition and subsequent patterns of hydrocarbon accumulation, and its basic geochemical aspects all combine to make this basin a unique regional petroleum accumulation. The explorationist must view each basin as a unique entity and fully understand its regional characteristics to efficiently compete for the petroleum reserves therein. [1499]

High-Constructive, Tidally Influenced Deltaic Sedimentation in Arkoma Basin: Desmoinesian Hartshorne Sandstone

D. W. HOUSEKNECHT, Department of Geology, University of Missouri, Columbia, MO 65201

The Hartshorne Sandstone and associated fine-grained facies of the Arkoma basin were deposited in a high-constructive, tidally influenced delta system which prograded longitudinally from east to west in an elongate, foreland basin during Ouachita suturing.

Prodelta facies (generally mapped as upper Atoka) comprise dark gray, unfossiliferous shales. Delta front facies deposited near the mouth of an active distributary channel include interlaminated siltstones and sandstones of distal bar origin and ripple-bedded and trough cross-bedded sandstones of distributary-mouth bar origin. Delta front facies deposited in interdistributary areas comprise lenticular, wavy, and flaser-bedded sandstones, siltstones, and shales deposited under the influence of tidal currents. Delta plain facies comprise sandstone, siltstone, shale, and coal deposited in distributary channels, interdistributary bays, crevasse splays, marshes, and swamps. Distributary channel sandstone bodies display shoestring geometry (50 to 60 m thick, 1 to 3 km wide, tens of km long) and internally are unidirectionally trough crossbedded. Their linear geometry and thickness relative to other delta facies suggest that channels were structurally localized, that the delta was elongate, or a combination of the two. Interdistributary bay facies comprise locally fossiliferous shale and silty shale. Crevasse splay facies coarsen upward from shale through ripple-bedded sandstone to trough cross-bedded sandstone. Marsh and swamp facies comprise carbonaceous shale and coal.

In Arkansas, the Hartshorne displays a single, progradational sequence of prodelta, delta front, and delta plain facies. In Oklahoma, the prodelta and delta front facies are capped by a complex assemblage of delta plain facies which records at least three episodes of active sedimentation followed by delta plain abandonment. Understanding the genesis of these delta plain facies will enhance petroleum and coal exploitation efforts within the Hartshorne of the Arkoma basin. [1499]

Methane Production Potential from Hartshorne Coal Beds in Deep Parts of Pittsburg, Coal, and Hughes Counties, Oklahoma

ANTHONY T. IANNACCHIONE, U.S. Bureau of Mines, P.O. Box 18070, Pittsburgh, PA 15236; DAVID W. HOUSEKNECHT, University of Missouri, Columbia, MO 65201

Bureau of Mines investigations show the Hartshorne coal beds of the Arkoma basin are among the most gassy in the United States. The Hartshorne coal beds in Haskell and LeFlore Counties, Oklahoma, contain 1.1 to 1.5 Tcf of methane; these coal beds are expected to contain a similarly high methane content in deep parts of the basin farther west in Pittsburg, Coal, and Hughes Counties.

Various geophysical logs from gas wells were used to analyze thickness and sedimentary facies of the Hartshorne formation in the Arkoma basin. Bulk density and sonic logs indicate the presence of lower and upper Hartshorne coal beds with an apparent thickness of up to 8 ft (2.4 m), flanking a linear body of Hartshorne Sandstone in Pittsburg and Coal Counties. The natural gas produced from wells along this and other linear trends of thick Hartshorne Sandstone probably originated in the associated coal beds.

The depth of the coal (up to 4,000 ft or 1,219 m) and its proximity to several gas fields producing from the Hartshorne Sandstone suggest a high methane content (200 to 600 cu ft/ton) for the Hartshorne coal beds in the western parts of the Arkoma basin. However, methane content is not as high as in coal beds farther east at similar depths because of the lower rank (less thermal maturation and therefore lower gas generation) of coal beds in Pittsburg, Coal, and Hughes Counties. Effective placement of gas drainage wells should take into consideration the thickness and depth of coal, possible communication with the natural gas-bearing Hartshorne Sandstone, and rank of associated coal beds. [1500]

Harrisburg Trough, Stephens County, Oklahoma—An Update

MARK I. JACOBSON, 700 S. Colorado Boulevard, Chevron USA, Inc., Denver, CO 80222

On the northeast edge of the Wichita Mountain uplift, northwest of Loco, Oklahoma, is a depositional syncline with Pennsylvanian sediments from Atokan through Virgilian. This depositional syncline was named the Harrisburg trough by Harlton. Sedimentary onlap relations within the Harrisburg trough suggest that it formed as a topographic valley that was at times partly above and below sea level. Seismic evidence indicates that this buried valley (canyon?) has paleotopographic relief of more than 10,000 ft (3,048 m). Atokan drainage in the Harrisburg trough was from the southeast to the northwest. Continued erosion of the highlands of Mississippian through Ordovician rocks, and located mainly to the south but also present to the north, provided the clastics deposited in the trough.

The compression that probably caused the uplifted source areas continued through Virgilian time and folded the northeast flank of the Harrisburg trough into the Northwest Velma and West Velma anticlinal hydrocarbon traps. Future hydrocarbon discoveries will probably find production in stratigraphic traps of Atokan sands that pinch out or onlap the flanks of the trough. [1500]

Ouachita Facies, an Overview

L. S. MORRISON, Lamima Corp., Ardmore, OK 73401

Since the discovery of oil in the Arkansas Novaculite in Marshall County, Oklahoma, in February 1977, several significant wells have been drilled in southeastern Oklahoma and in Grayson County, Texas. Sands in the Stanley formation and parts of the Bigfork formation have proven to be productive. An unnamed sand zone in the Womble that occurs about 200 ft (60 m) below the Bigfork has had significant shows and indicates that it too will be productive.

Structural problems and stratigraphic surprises will probably be exposed as wildcat drilling continues. [1500]

Geothermal Energy Resources in Mid-Continent

DON W. STEEPLES, Kansas Geological Survey, University of Kansas, Lawrence, KS 66045

Awareness of the energy availability problems in the United States has led to increasing curiosity about and interest in geothermal energy. The U.S. Department of Energy has contracted with state agencies in several Mid-Continent states to evaluate geothermal prospects in the Mid-Continent region. The data being gathered will augment and update the data published by the AAPG from their geothermal survey conducted about 10 years ago. The DOE program not only includes support for accurate geothermal gradient and heat flow measurements, but also includes programs in gravity, aeromagnetics, and geochemistry.

This program will not discover any new "Old Faithful" type of geothermal resource. However, preliminary indications are that heat pump applications for space heating may be economically viable in this decade, especially in southeastern Kansas and northeastern Oklahoma. Geothermal gradients in that region are in the 50°C/km (2.8°F/hundred ft) range in the upper 300 m of the sedimentary section. The gradients decrease drastically below this relatively shallow depth to about 15 to 20°C/km (0.8 to 1.1°F/hundred ft). It is not yet clear whether this change in gradient is due to changes in thermal conductivity in the sediments or to hydrothermal convection.

Low-grade geothermal energy could be produced from brine that comes to the surface as a by-product of oil production. Such energy could be used for space heating or even to eventually drive oil well pumps as low-temperature-differential engines are developed. The energy that could be extracted from such brine is six times the energy required to pump it if initial temperature is 150°F/km (66°C) and final temperature is 100°F (38°C) and a lift of 3,000 ft (915 m) with 50% pump efficiency is assumed. [1500]

Goddard Sand Study, East Ardmore and Caddo Fields

J. S. VIETTI and S. D. ADAMS, 700 S. Colorado Boulevard, Chevron USA, Inc., Denver, CO 80222

Chevron and three partners began developing the East Ardmore structure near Ardmore, Oklahoma, in 1974–75. The discovery well and first offset both produced gas from the Mississippian Goddard sands. The drilling program was abruptly halted when a zero sand well was drilled less than 1 mi (1.6 km) from the producing wells, thus a structural prospect became a stratigraphic problem. A study of the Goddard sand on nearby Caddo anticline was conducted to determine the sedimentary environment of the Goddard. These data were then used by analogy to help determine the Goddard sand distribution on the East Ardmore structure.

The sand study was used to help interpret the 3-D seismic survey that was shot in an attempt to seismically map the Goddard sand distribution at Ardmore. The results of the 3-D survey will be briefly discussed and data will be shown to explain the selection of the Chevron City of Ardmore 3-No.1 drill site. The results of the study are summarized below.

(a) The Goddard sands are marine and relatively discontinuous. (b) The Goddard sand interval at Caddo probably represents a submarine or barrier bar. The sands were carried by currents and collected as a sand shadow on the lee side of growing structures. The sands were subsequently winnowed of clay and silt. (c) Truncation of the upper part of the Caney shale on local structures indicates early structural growth. (d) The 3-D seismic survey at East Ardmore supports the idea that the Goddard sands are discontinuous and erratic. [1501]

Subunconformity Seismic Stratigraphic Exploration

J. A. WARD, Teknica Inc., Houston, TX 77002

Seismic stratigraphic exploration is particularly applicable to exploration for unconformity traps. Typical upstructure truncation and angularity can often be detected with conventional seismic displays. More subtle traps created by lateral truncation of secondary porosity in either limestone or chert are more difficult to explore for using the seismic tool. Often sophisticated data processing techniques like Seislog® aid in identification of the reservoir-seal relation. Comparison of the Seislog expression of a structural unconformity with a low relief erosion surface provides insight into seismic stratigraphic exploration for subunconformity fields.

South Laredo field, Webb County, Texas, serves as a classic upstructure unconformity. Eocene Wilcox sandstones are either progressively truncated at the flanks of the Salado uplift or preserved in rotated fault blocks. On Seislog, unique high velocity sandstone beds progressively lose thickness updip beneath a low-velocity shale. This truncation provides clear evidence for the trap.

In contrast, erosional plays that search for shale overlying porous carbonate rocks or chert often need to recognize units with similar velocity. At

Star Lacey field in Kingfisher County, Oklahoma, porous Hunton is not a distinct unit but, on Seislog, exhibits velocity comparable with the overlying Woodford Shale. The seismic trap expression is created by anomalous Woodford thicks which represent the superposition of shale over Hunton porosity. The chert trap at Nicols field, Kiowa County, Kansas, similarly is based on a subtle slope change on the Seislog at the shale reservoir interface. Seislog colors separate the gentle character formed when shale overlies porous chert to the steep slope generated by shale over nonporous carbonate rock.

The expression of the fields on Seislog provides encouragement that seismic data can successfully locate unconformity-type reservoirs. The subtle nature of the features, however, suggests that careful integration with subsurface data is required to maximize exploration efforts. [1501]

Ordovician Viola Limestone, Southeast Joiner City Field, Oklahoma

JOHN R. WAUGH II and JAMES S. CROMPTON, 700 S. Colorado Boulevard, Chevron USA, Inc., Denver, CO 80222

The Viola Limestone has become one of the major exploration objectives in southern Oklahoma. Several fields have been discovered along the northern flank of the Marietta basin in the past five years, and Viola exploration continues to expand along this trend.

Southeast Joiner City field in Carter and Love Counties, Oklahoma, has been an area of recent Viola activity. Structurally, it is a NW–SE trending anticline, bounded on the southwest by a small reverse fault, and on the northeast by the southern limb of the Rock Creek nose.

In July 1979, Chevron USA deepened the J. S. Bates et al 1 to the Viola and completed the well for an IP of 654 BOPD. A total of 11 Viola wells have since been completed in Southeast Joiner City field by Chevron, and one additional well by Petro-Lewis. Total field production from the Viola as of November 9, 1980, was 266,039 bbl.

The Viola Limestone in Southeast Joiner City can be divided into three units, on the basis of log character and sample description. The upper unit, 450 ft (137 m) thick, is composed of very fine to microcrystalline, dense limestone, tan to brown to grayish brown in color. The middle unit, approximately 150 ft (46 m) thick, is characteristically an argillaceous limestone. The lower unit, 450 ft (137 m) thick, is similar to the upper Viola unit, but is characterized by an increase in siliceous limestone with depth. The lowermost 100 to 130 ft (30 to 40 m) of the lower Viola is predominantly dark brown to black, microcrystalline, highly siliceous limestone. Well cuttings from this section commonly contain abundant evidence of fracturing. Low matrix porosity through the entire section, combined with the lack of correlation between well potential and structural position, indicates that production is related to fracture porosity. Several methods, including both dipmeter and acoustic velocity related fracture logs, have been used to predict or identify fracturing. [1502]