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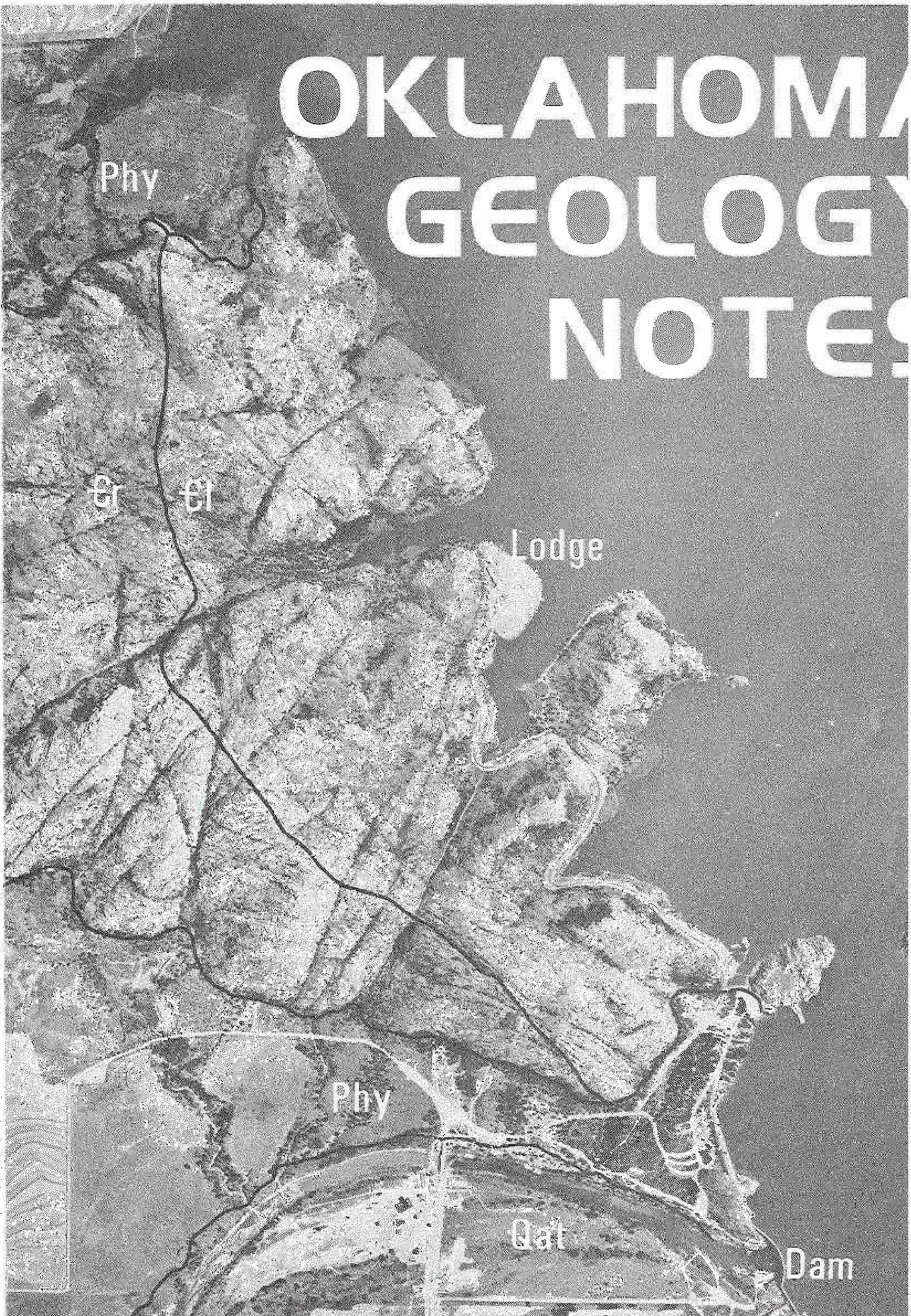
OKLAHOMA GEOLOGY NOTES



mineral resources of the State, with particular reference to the eastern counties and coal deposits. His contributions to the Survey are represented in 7 OGS bulletins, a circular, and 2 mineral reports. He also published numerous articles in State and national journals. A bibliography follows.

A truly indigenous Oklahoman, Malcolm was born on a farm near Hugo in the southeastern part of the State and grew up there, in McGee Valley, and near Ashland in the Choctaw Nation. Although he had no Indian blood, he was officially a Choctaw by virtue of an involved chain of events: his father and mother (John Thomas Oakes and Alice Cordelia Tucker Willis Oakes) were made members of the tribe, "intermarried citizens," according to Indian law, through his mother's previous marriage to a Britt Willis, whose first wife had been a Choctaw.

Malcolm's elementary education was begun at home and completed formally in the Ashland school. He attended high school at Waurika in Jefferson County, graduated in 1911, and enrolled at The University of Oklahoma the same year. He earned 2 bachelor's degrees and a master's degree from OU over a period of 11 years. A few things intervened to delay completion of his academic training. His B.S. degree in electrical engineering was awarded in 1916, and in 1916 and 1917 he functioned as an operating engineer for the Public Service Co. of Oklahoma in Tulsa. He re-enrolled at OU and obtained a B.A. in physics in 1919, but in between there was a war, and Malcolm was called.

He was inducted into the U.S. Army in 1917, joining the 90th Division at Camp Travis, Texas. He passed quickly through the ranks of private, corporal, and sergeant and then was discharged from his duties with the 90th to enter the First Signal Officers Training Camp at Leon Springs, Texas, where he was commissioned a second lieutenant in April 1918. He served as technical instructor and company commander in the States and then was sent overseas, where he was named a platoon commander for the Signal Corps. Although the Corps had been established as a service organization, not a combat organization, he was gassed, and for the rest of his life he felt some ill effects from the experience.

He received his honorable discharge from the service in February 1919, retaining status as a retired reserve officer. Malcolm had many stories to tell about this period of his life.

He had many stories to tell about every period of his life, and anyone who took time to listen heard them and learned a great deal about personal history intermingled with cultural history, economics, and geological history. It is one thing people remember most about Malcolm—his stories. It would be good if some of them could be recorded for the future, not only recalled by those who knew him.

At any rate, it was following his military service that Malcolm returned to The University of Oklahoma to enroll for his third academic degree. He started in the fall of 1919 to work on a master's degree in geology, which was awarded in 1922 following completion of a thesis on "The Helium Problem, Theories of the Origin of Helium in Natural Gas." In 1921, while studying for this advanced degree, he was hired by the Oklahoma Geological Survey as assistant geologist. He was promoted to the rank of geologist the following year.

The year after that was a bad year for the Survey. The appropriation for the OGS was vetoed by then Governor Jack Walton, and the staff had to look to other fields. This situation held only into 1924, when Governor Walton was himself vetoed, i.e., impeached and convicted, but by that time Malcolm Oakes was working as a geologist for Shell Petroleum Corp., supervising core drilling and other exploration programs. He remained with Shell until 1931, when he became a consultant.

The years following were bad years again for the Survey, and for most people as well. The Survey was once more the victim of politics, this time under Governor "Alfalfa Bill" Murray, and the OGS inventory was placed in custodianship under Charles E. Decker. But the economy, and with it the people, were victims of a more serious malady: the worst depression the world has ever known. Malcolm and his family rode out the depression on a farm near Edmond, with income provided by consulting appointments with several oil companies. In 1937 he returned to the Oklahoma Geological Survey, which had been reactivated in 1935, under the directorship of Robert H. Dott.

Oakes continued as a geologist with the Survey from his reappointment in 1937 until his retirement June 30, 1960. It took more than retirement to stop him, though, and until his death he maintained a special half-time consulting relationship with the OGS. Three of his most significant works were published during these "retirement" years: the reports on McIntosh, Okmulgee, and Muskogee Counties. It is highly unfortunate that death couldn't wait. The Oklahoma Geological Survey issued Oakes' Bulletin 122, *Geology and Mineral Resources (Exclusive of Petroleum) of Muskogee County, Oklahoma*, in September 1977, only 3 months after Malcolm was called into what we hope is even greater service.

A long, fruitful career ended July 3, 1977. A place that can never really be filled was left vacant. There never will be anyone else quite like Malcolm Christie Oakes.

Malcolm was as devoted to his family and his friends as to his career. In 1926 he married Lyra Bahrenburg, known to all as Patti, who shared the ups and downs for 51 years, and they had two daughters, Peggy Joyce (Pettybone) and Anne Catherine (Cramer). Patti, Anne, and a granddaughter survive him.

—Elizabeth A. Ham

Bibliography of Malcolm C. Oakes

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Manganese deposits of the Bromide district, Oklahoma: Economic Geology, v. 39, p. 412–443 (with W. E. Ham).

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1945 Utilization of Oklahoma coal: Oklahoma Academy of Science Proceedings, v. 25, p. 76–77.

1948 Chert River, an inferred Carboniferous stream of southeastern Oklahoma: Oklahoma Academy of Science Proceedings, v. 28, p. 70–71.

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1949 Mapping the Missouri-Virgil boundary in northeast Oklahoma: Oklahoma Academy of Science Proceedings, v. 30, p. 124–125.

1950 Equivalents of the Wewoka formation: Oklahoma Academy of Science Proceedings, v. 31, p. 77–78.

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1951 The proposed Barnsdall and Tallant formations in Oklahoma: Tulsa Geological Society Digest, v. 19, p. 119–122.

1952 Geology and mineral resources of Tulsa County, Oklahoma: Oklahoma Geological Survey Bulletin 69, 234 p. (with a chapter on oil and gas by G. S. Dille and a chapter on water resources by J. H. Warren).

1953 Krebs and Cabaniss groups, of Pennsylvanian age, in Oklahoma: American Association of Petroleum Geologists Bulletin, v. 37, p. 1523–1526.

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1955 The upper limit of the Seminole formation in Oklahoma: Oklahoma Academy of Science Proceedings, v. 34, p. 148–149.

1956 The Hogshooter formation in Creek County, Oklahoma: Oklahoma Academy of Science Proceedings, v. 35, p. 90.

1959 Geology of Creek County, Oklahoma: Oklahoma Geological Survey Bulletin 81, 134 p. (with a section on petroleum geology by Louise Jordan).

1963 Geology and water resources of Okmulgee County, Oklahoma: Oklahoma Geological Survey Bulletin 91, 164 p. (with W. S. Motts).

1967 Geology and petroleum of McIntosh County, Oklahoma: Oklahoma Geological Survey Bulletin 111, 88 p. (with Terry Koontz and others).

1977 Geology and mineral resources (exclusive of petroleum) of Muskogee County, Oklahoma: Oklahoma Geological Survey Bulletin 122, 78 p.

USGS Publications Released

A number of publications of interest to Oklahomans have been issued by the U.S. Geological Survey.

Flood Discharges

Techniques for Estimating Flood Discharges for Oklahoma Streams, by Wilbert O. Thomas and Robert K. Corley, provides valuable data for those involved in any type of construction in Oklahoma's watersheds. Information contained is vital also to flood-plain-management programs and the determination of flood-insurance rates.

Prepared in cooperation with the Oklahoma Department of Transportation and the Federal Highway Administration of the U.S. Department of Transportation, the 180-page report contains a location map for numerous rural and urban sites, a compilation of flood data through 1975, and equations for estimating peak discharges of floods at recurrence intervals ranging from 2 to 500 years using model parameters.

The report was issued as Water Resources Investigation 77-54. It is available for inspection at the Oklahoma Geological Survey and at the Office of the District Chief, U.S. Geological Survey, Water Resources Division, 201 Northwest 3d Street, Room 621, Oklahoma City, Oklahoma 73102 (phone, 405—231-4256). A limited number of single copies can be obtained on request to the district chief.

Vamoosa Aquifer

Hydrologic Data for the Vamoosa Aquifer, East-Central Oklahoma, by Joseph J. D'Lugosz and Roger G. McClaflin, has been issued as Open File Report 77-487 and was prepared in cooperation with the Oklahoma Geological Survey. The publication contains information on Hilliby Creek and Polecat Creek basins and data on depth to water levels and on water quality in the Vamoosa aquifer, plus stream-discharge data and monthly precipitation figures, for parts of Seminole, Pottawatomie, Creek, Lincoln, Payne, Osage, and Pawnee Counties. It is part of a larger study by the USGS and OGS of the geohydrology of the Vamoosa aquifer. Copies are available for inspection as noted previously. For information on obtaining the report, contact the USGS district chief.

Pecora 1 Symposium

Professional Paper 1015, *Proceedings of the First Annual William T. Pecora Memorial Symposium, October 1975, Sioux Falls, South Dakota*, edited by P. W. Woll and W. A. Fischer, can be obtained from the Branch of Distribution, U.S. Geological Survey, 1200 South Eads Street, Arlington, Virginia 22202, for $6.50. The 370-page report contains 30 papers of a symposium on the use of remote-sensing technology, particularly Landsat data, for mineral and mineral-fuel exploration. The material covered is both practical, in descriptions of techniques and actual exploration experiences, and theoretical, in discussions of tectonics.

Mineral-Classification Systems

Bulletins 1450-A and 1450-B are 1976 reports explaining the recently adopted standardized mineral-classification systems of the U.S. Bureau of Mines and the U.S. Geological Survey. The first describes mineral-resource classifications, and the second, coal-resource classifications. These reports can be obtained for 35 cents each from the Branch of Distribution at the address given previously.

Circulars on Water and Coal

Circular 745, *Water Consumption by Nuclear Powerplants and Some Hydrological Implications*, by E. V. Giusti and E. L. Meyer, is a 14-page report that tabulates data on the nation's nuclear power plants to 1985 and offers mapped estimates of water consumption by the plants. Estimated water usage ranges from 18 cubic feet to 30 cubic feet per second, depending on the technology used. River reaches with low flow of at least 300 cubic feet per second are also mapped, as are plant locations.

Circular 757, *Coal Geology and the Future—Symposium Abstracts and Selected References*, edited by C. R. Meissner, Jr., C. B. Cecil, and G. D. Strickler, contains papers presented at a coal symposium sponsored by the USGS in September 1976 at Reston, Virginia, for the purpose of identifying requirements for geological research in coal exploration, mining, and utilization. Abstracts and references included offer a good source of material for anyone wanting to pursue the subject further.

Both circulars are available at no cost from the Branch of Distribution at the address noted previously.

Energy Map

Miscellaneous Investigations Report I-1036 is an *Energy Resources Map of Colorado*, done at a scale of 1:500,000 and printed on a sheet 42 by 58 inches. It can be obtained for $1.75 from the Branch of Distribution, U.S. Geological Survey, Box 25286, Federal Center, Denver, Colorado 80225.

USGS Administrators Named

Two top U.S. Geological Survey posts have been filled recently. Dallas L. Peck, an internationally recognized authority on geothermal energy and volcanology, has been named chief geologist; Robert F. Evans has been designated an assistant director, responsible for coordinating activities in the 15-state central region.

Dr. Peck joined the USGS in 1951, and he served as assistant chief geologist for geochemistry and geophysics from 1967 to 1972. From 1972 until the present, he has conducted field and laboratory studies of granitic and metavolcanic rocks in the Sierra Nevada area of California. During this period, he also was a member of the Apollo 16 and 17 field-geology teams. A native of Spokane, Washington, Dr. Peck received his B.S. (1951) and M.S. (1953) degrees in geology from the California Institute of Technology and his Ph.D. degree in geology from Harvard University (1960).

Robert Evans received a B.S. degree in geology from Texas Western College in 1951, and he spent 4 years in private industry in oil and gas well-drilling and production activities before joining the USGS. He served as an acting assistant director in charge of the central region for 3 months pending his formal appointment. Prior to that, he was associate chief of the conservation division of the USGS at the National Center in Reston, Virginia. Oklahoma is in the central region, which also includes Arkansas, Colorado, Iowa, Kansas, Louisiana, Missouri, Montana, Nebraska, New Mexico, North Dakota, South Dakota, Texas, Utah, and Wyoming. The headquarters for the division is in Denver.

MAPPING IN OKLAHOMA'S COAL REGION PROGRESSES

Coal geologists with the Oklahoma Geological Survey have been active in mapping parts of the coal-bearing region of eastern Oklahoma. These mapping projects involve both 7.5-minute-quadrangle areas and county areas (fig. 1). Although the mapping is being done at a scale of 1:24,000 (1 inch = 2,000 feet), the maps, when completed, will be published at a scale of 1:63,360 (1 inch = 1 mile).

Mapping of the Hartshorne coals in Haskell and Le Flore Counties is nearing completion. This project covers the distribution, structure, mined areas, and resources of the Hartshorne coal beds. A similar mapping project was activated last December in Craig County (which included a small part of Nowata County), the State's most productive coal-mining area.

Special geologic studies of individual 7.5-minute-topographic map areas are progressing in Haskell, Le Flore, and Rogers Counties. The Survey has given partial support to seven geology graduate students from The University of Oklahoma and Oklahoma State University, who are preparing master's theses covering parts of these areas. These studies have resulted in detailed correlation of coals and related strata, a better understanding of depositional environments of the coals, and maps showing the distribution of the sulfur content in the coals. In particular, areas of low-sulfur coals ($\leq$ 1 percent) are being delineated.

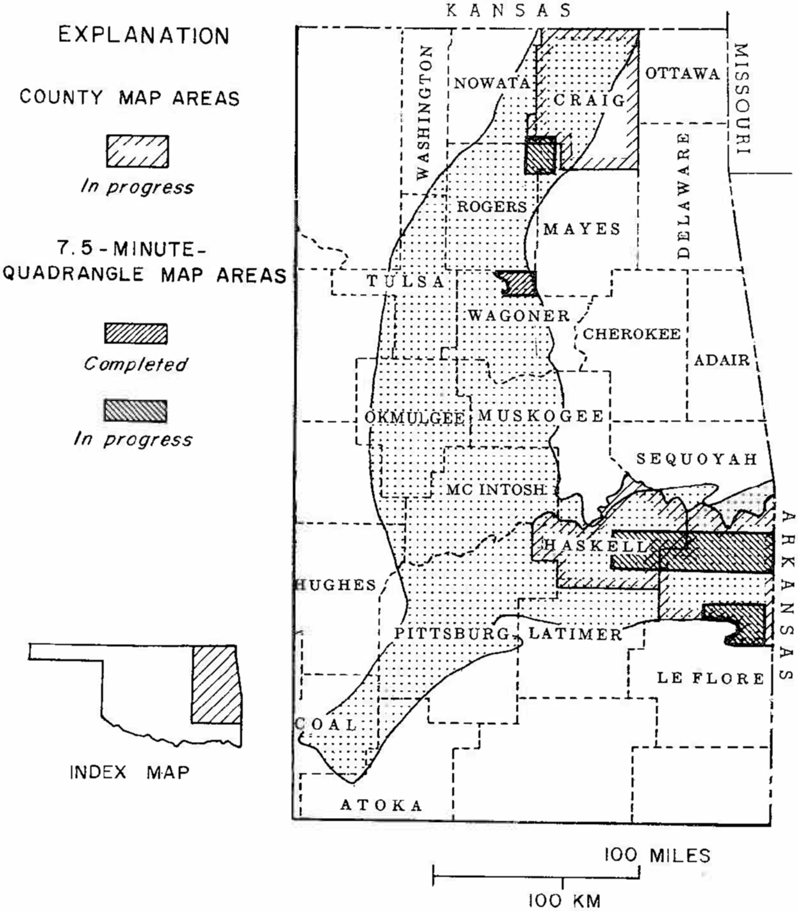


Figure 1. Map of eastern Oklahoma showing current OGS mapping projects. Coal-bearing region is indicated by stippling.

The first thesis study, in southeastern Rogers County, was completed in 1976, and most of the remaining six studies are expected to be completed by September 1978. These six areas cover the Chelsea quadrangle, mostly in northeastern Rogers County; the Lafayette quadrangle, in Haskell County; and the Bokoshe, Panama, Spiro, Hackett, and parts of the Heavener quadrangles, all in Le Flore County.

Mapping of additional quadrangles in the coal-bearing region is planned for the future.

—*S. A. Friedman*

Survey Welcomes New Editor Judy Russell

Judy Ann Russell joined the Oklahoma Geological Survey staff February 1 as an associate editor, in which capacity she will help prepare the Survey's reports and maps for publication. Her appointment became effective just after Rosemary Hardage had resigned her position as an associate editor to enjoy being a full-time wife and mother in her new home in Oklahoma City.

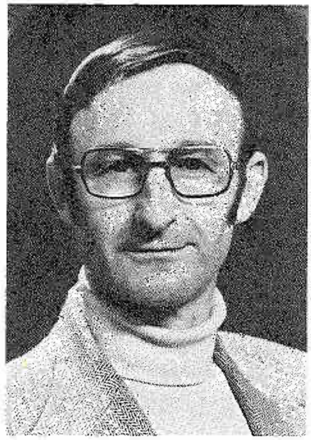
Judy comes here from a 4-year stint with the New Mexico Bureau of Mines and Mineral Resources at Socorro, where she prepared geological manuscripts for publication and in general performed similar duties to our OGS requirements. Thus she brings ideal qualifications as a geological editor to her new assignment.

A native Oklahoman, Judy hails from Enid. She received her B.S. degree in geology, with a minor in English, from Phillips University in 1972. She then spent a year in graduate school at The University of Texas at Austin before joining the New Mexico Bureau of Mines. While at Socorro, she entered graduate school at New Mexico Institute of Mining and Technology as a candidate for an M.S. degree in geology. At this point she has completed her course and field work as well as a first draft of her thesis, "Refractory-Clay Resources of the Dakota Sandstone, Northern New Mexico."

As both geologist and editor, she has taken an active part in scientific and professional associations. She is a member of the Clay Minerals Society, Sigma Xi, the Society of Economic Paleontologists and Mineralogists, the Association of Earth Science Editors, the Oklahoma City Geological Society, and the New Mexico Geological Society. At the 1976 AESE meeting she was a principal speaker.

Needless to say, Judy is a key addition to the Survey's editorial section, where she will collaborate with Bill Rose and Betty Ham, who are delighted to welcome her!

LeRoy Hemish Named Coal Geologist with OGS



LeRoy A. Hemish joined the staff of the Oklahoma Geological Survey in December as a coal geologist. LeRoy has been working with S. A. Friedman, the Survey's coal geologist since 1971.

As a result of increasing emphasis on the use of coal as an energy source and an increasing interest in Oklahoma's coal deposits, this second Survey position in coal research was established. LeRoy's initial project involves mapping the coal geology of Craig County in northeastern Oklahoma, where several mines are recovering coal from the Croweburg, Mineral, and Iron Post seams.

LeRoy came to the Oklahoma Survey from the North Dakota Regional Environmental Assessment Program, which was established by the legislature of that state to collect data and monitor projects affecting the natural environment, with special emphasis on mining of lignite areas. Prior to that he was employed for 6 months by the North Dakota Geological Survey at Grand Forks, where he served as research geologist in investigations of subsurface lignitic coal deposits. Also, he acted as a geologic consultant to coal companies in preparing mining plans.

A native of Canby, Minnesota, LeRoy received his early education in that southwestern Minnesota community. Following service in the U.S. Marine Corps and a period of operating his own 372-acre diversified farm near Canby, he enrolled at the University of South Dakota, where he received a B.S. degree cum laude in geology in 1974. He entered graduate school at the University of North Dakota the same year, earning an M.A. degree, also in geology, in 1975.

During his academic career he was named to Phi Eta Sigma, a freshman honor society, to the Dean's List, and to Phi Beta Kappa, international scholarship society. He received the Brookman Arts and Sciences Scholarship Award at USD and was named the outstanding graduating geology major, receiving the

Estwing Geology Award. At UND he was the recipient of the Old West Regional Commission Graduate Research Fellowship and served as a research fellow for the Department of Geology. He held summer employment as a geologist with both the South Dakata and North Dakota geological surveys.

LeRoy's wife is the former Janice E. Moravetz, also from Minnesota, who has a background in English education. Before moving to Norman she was on the English faculty at Mayville State College in Mayville, North Dakota. Prior to that she taught high-school English for 5 years in Minnesota.

It's a pleasure to have both Hemishes in Norman!

U.S. Board on Geographic Names Decisions

The U.S. Board on Geographic Names has approved 10 Oklahoma place names. These names were listed in the July through September 1977 issue of *Decisions on Geographic Names in the United States* (Decision List 7703).

Aubrey Canyon (variants: Arbury Canyon, Auberry Canyon, Aubry Canyon) has been adopted for a canyon, 14.5 kilometers (9 miles) long, that heads in Colorado at 37°02′33″ N., 102°32′52″ W., and trends south into Oklahoma to the Cimarron River valley 22.5 kilometers (14 miles) north of Boise City; Cimarron County, Oklahoma, and Baca County, Colorado; sec. 4, T. 5 N., R. 5 E., Cimarron Meridian (36°55′41″ N., 102°31′13″ W.).

Blacksmith Canyon (variant: Blacksmith Cañon) has been adopted for a canyon, 14.5 kilometers (9 miles) long, that heads in New Mexico at 36°59′55″ N., 103°07′00″ W., and trends east along the course of Blacksmith Creek into Oklahoma to North Carrizo Creek valley 10.5 kilometers (6.5 miles) north-northwest of Kenton; Cimarron County, Oklahoma, and Union County, New Mexico; secs. 7 and 18, T. 6 N., R. 1 E., Cimarron Meridian (36°59′37″ N., 102°59′30″W.).

Blacksmith Creek has been adopted for a stream, 17.7 kilometers (11 miles) long, that heads in New Mexico at 36°59′55″N., 103°07′00″W., and flows east-southeast through Blacksmith Canyon into Oklahoma to North Carrizo Creek 8.1 kilometers (5 miles) north of Kenton; Cimarron County, Oklahoma, and Union County, New Mexico; sec. 20, T. 6 N., R. 1 E., Cimarron Meridian (36°58′30″ N., 102°58′14″ W.).

Blue River (variant: Blue Creek) has been adopted for a stream, 145 kilometers (90 miles) long, that heads at 34°36′12″ N., 96°51′55″ W., and flows southeast to Red River 40 kilometers (25 miles) southeast of Durant; Bryan, Johnston, and Pontotoc Counties, Oklahoma; sec. 4, T. 8 S., R. 13 E., Indian Meridian (33°53′11″ N., 95°56′50″ W.).

Crow Creek has been adopted for a stream, 4.8 kilometers (3 miles) long, that heads at 36°07′55″ N., 95°57′00″ W., and flows southwest to the Arkansas River in Tulsa; Tulsa County, Oklahoma; 36°07′00″ N., 95°59′09″ W.

Cover Picture

QUARTZ MOUNTAIN AND LAKE ALTUS
WICHITA MOUNTAINS

The vertical aerial photograph, taken in 1957, was supplied by the U.S. Department of Agriculture, Agricultural Stabilization and Conservation Service. The scale is about 1:20,000, giving a width to the view of about 1.8 miles. Near the center of the photo is the Lodge in Quartz Mountain State Park, located off State Highway 44. Lake Altus is impounded on the North Fork of Red River along the Greer-Kiowa County boundary. The dam can be seen in the lower right of the photo.

Quartz Mountain is near the western end of the exposed part of the Wichita Mountain system. It is composed of two granites of the Wichita Granite Group (Cambrian): the coarse-grained Reformatory Granite (*Єr*), underlying the western half, and the medium-grained Lugert Granite (*Єl*), underlying the eastern part. The pronounced lineaments cutting both granites are fractures developed during major uplift of the Wichita axis in Early Pennsylvanian time. The fractures had little movement, but do provide channels for drainage and are therefore sites of vegetation.

The contact between the two granites can be discerned, in part, from the photo. To do this, note the more subdued fracture system trending more nearly east-west on the western side of the mountain. Such fractures formed along flow surfaces in the viscous granite magmas. Those on the west in the older Reformatory Granite are truncated toward the east by intrusion of the younger Lugert Granite. These granites of Quartz Mountain meet the surrounding red beds at an unconformity with the Permian Hennessey Shale (*Phy*) at the base of the mountain. South of the North Fork of Red River are alluvial and terrace deposits (*Qat*). (See *Oklahoma Geology Notes*, 1967, v. 27, p. 45–53.)

—*M. Charles Gilbert*

Editorial staff: William D. Rose, Elizabeth A. Ham, Judy A. Russell

Oklahoma Geology Notes is published bimonthly by the Oklahoma Geological Survey. It contains short technical articles, mineral-industry and petroleum news and statistics, an annual bibliography of Oklahoma geology, reviews, and announcements of general pertinence to Oklahoma geology. Single copies, seventy-five cents; yearly subscription, $4.00. All subscription orders should be sent to the address on the front cover.

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

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Little Blue Creek (variant: Little East Blue Creek) has been adopted for a stream, 16.1 kilometers (10 miles) long, that heads at 34°33′44″ N., 96°38′00″ W., and flows south to Blue River 4 kilometers (2.5 miles) southeast of Connorville; Johnston and Pontotoc Counties, Oklahoma; sec. 32, T. 1 S., R. 7 E., Indian Meridian (34°25′58″ N., 96°35′42″ W.).

Little West Blue Creek has been adopted for a stream, 27 kilometers (17 miles) long, that heads at 34°35′55″ N., 96°51′04″ W., and flows southeast to Blue River 5 kilometers (3 miles) northwest of Connorville; Johnston, Murray, and Ponototoc Counties, Oklahoma; sec. 16, T. 1 S., R. 6 E., Indian Meridian (34°28′18″ N., 96°40′42″ W.).

Murray Creek (variant: Murry Creek) has been adopted for a stream, 10.5 kilometers (6.5 miles) long, that heads at 34°40′32″ N., 97°51′20″ W., and flows northeast to Rush Creek 18.5 kilometers (11.5 miles) northeast of Marlow; Grady and Stephens Counties, Oklahoma; sec. 24, T. 3 N., R. 6 W., Indian Meridian (34°42′53″ N., 97°46′33″ W.).

Picture Canyon (variant: North Canyon) has been adopted for a canyon, 19.3 kilometers (12 miles) long, that heads in Colorado at 37°07′29″ N., 102°47′38″ W., and trends southeast to North Canyon 20.9 kilometers (13 miles) northeast of Kenton, Cimarron County, Oklahoma, and Baca County, Colorado; sec. 17, T. 6 N., R. 3 E., Cimarron Meridian (36°59′06″ N., 102°45′ 12″ W.).

Ute Canyon has been adopted for a canyon 9.7 kilometers (6 miles) long, that heads in Colorado at the junction of North and West Ute Canyons at 37° 00′17″ N., 102°34′55″ W., and trends south into Oklahoma to the Cimarron River valley 18.5 kilometers (11.5 miles) south-southeast of Campo, Colorado; Cimarron County, Oklahoma; Baca County, Colorado; secs. 31 and 32, T. 6 N., R. 5 E., Cimarron Meridian (36°56′30″ N., 102°33′30″ W.).

New Thesis and Dissertations Added to OU Geology Library

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

The Petrology of the Solid Silica Plus Feldspar Fraction of Recent Interbedded Muds and Sands, by Raymond G. Charles.

The following Ph.D dissertations have also been added to the library:

Contemporaneous Faults: a Mechanism for the Control of Sedimentation in the Southwestern Arkoma Basin, Oklahoma, by Michael William McQuillan.

Secular Variation of the Geomagnetic Field As Determined From Playa Lake Sediments, by Edwin Thomas Green.

STRATIGRAPHY OF THE BOKCHITO FORMATION (CRETACEOUS) IN SOUTHERN OKLAHOMA: DISCUSSION

Thomas A. Hart[1]

Introduction

This paper is in reference to that of Huffman (1977); it also views critically matters introduced in the paper of Huffman and others (1975) not previously questioned in the literature. My familiarity with the Bokchito Formation and its members derives from detailed field work in northwestern Bryan County, Oklahoma, and extended study of the literature of Cretaceous geology in Oklahoma and northern Texas. This work appeared in a thesis (Hart, 1970) done in partial fulfillment of the requirements for the master of science degree at The University of Oklahoma. Huffman directed this thesis and also theses of others on areal geology and Cretaceous stratigraphy in Choctaw, Bryan, and eastern Marshall Counties. From this unpublished work of graduate students and his own investigations, Huffman has written papers for publication (Huffman and others, 1975; Huffman, 1977; Huffman and others, report on Bryan County, Oklahoma, in preparation by the Oklahoma Geological Survey).

My field experience with rocks of the Bokchito Formation is in the broad outcrop belt from Lake Texoma eastward to just beyond Caddo Creek. I mapped the contacts of the members of the Bokchito recognized in 1970 in detail, largely by walking-out, and measured and described many sections and examined other exposures. The field notebooks from this work are extant.

For many years three units were recognized in southeastern Oklahoma and northern Texas for this part of the section, in upward sequence: Denton, Weno, and Pawpaw. These were treated as formations or as members of a larger formation. In several Oklahoma reports during the years just preceding the paper of Huffman and others (1975) these units were considered the three members of the Bokchito Formation.

Two new members were distinguished by Huffman and others (1975, p. 16–18): the Soper Limestone Member, removed from the top of the Denton, to replace the informal name "*Ostrea carinata* bed" or some similar term; and the McNutt Limestone Member, removed from the top of the Weno, to replace the name "Quarry lime(stone)." I had reservations about the introduction of these formal member names when first hearing of the idea (Huffman, oral communications, 1969–70), although certainly the old informal terminology was not very satisfactory. The species *Ostrea carinata* [=*Rastellum* (*Arctostrea*) *carinatum*] is virtually unknown in the bed at the top of the Denton in Oklahoma, whereas scattered *O. carinata* specimens are found stratigraphically lower in the upper Caddo Formation. No one ever quarries the sandy, corroded-looking

[1]Geologist, Tennessee Division of Geology, Memphis, Tennessee.

"Quarry" beds in Oklahoma, in contrast to former practice in Denton County, Texas (Winton, 1925, p. 27).

The new terms Soper and McNutt, however, pertain to lithologies that are interbedded in an irregular fashion with the characteristic lithologies of the Denton and Weno. There is every reason to believe that beds at one place called by one member name are laterally equivalent to those at another place called by a different name.

Huffman and others (1975, p. 16–18), in introducing the Soper and McNutt Limestone Members, altered the meanings of the names Denton and Weno —substantially in the case of the Weno. Huffman's (1977, p. 15) discussion of the Weno Clay Member[2] freely cites information from the theses he directed without taking into account the change in the meaning of "Weno" that has now been introduced. The introduction of the Soper Member is a more trivial innovation but also has certain incongruities.

The Pawpaw Sandstone Member[2] is generally unaffected by these nomenclatural changes, but Huffman (1977, p. 17) gives a discussion that contradicts exposures known to me, some of them even included by Huffman and others in a forthcoming report on Bryan County, Oklahoma (in preparation).

It may be noted that the thickness of the Bokchito Formation estimated by Taff (1902, p. 6) in the type area appears too small. Taff gave 140 feet, whereas all of the more recent estimates in the vicinity are considerably greater; my work nearby suggests at least 180 feet.

The columnar section of Huffman (1977, p. 12) does not indicate full ranges of variations in thicknesses in Oklahoma of the stratigraphic units listed except for the Grayson Formation. Greater variations are given elsewhere in the literature, in several cases even in the report accompanying the section.

Denton Clay Member and Soper Limestone Member

The Soper Limestone Member is defined by Huffman and others (1975, p. 16–17) as a single impure limestone bed, which is less than 2 feet thick, removed from the top of the Denton Member of former usage. Fortunately because of the small extent of the change, statements about the Denton can be taken from older reports, and little error will result if the change is not noted (in contrast to the corresponding situation for the Weno and McNutt Members). But it may be questioned whether so thin a unit deserves a formal stratigraphic name. In any case, Huffman split the Soper Member away from related beds kept in the Denton. When first hearing of the proposed name Soper (Huffman, 1969–70, oral communications), I assumed that these related beds would be included in the Soper. Not so, however. Limestone of the same appearance as that in the Soper occurs as much as 8 or 10 feet lower in the redefined Denton, such as that occurring near the C S½NE¼NE¼ sec. 13, T. 6 S., R. 10 E., and near the C SE¼SW¼NW¼ sec. 9, T. 6 S., R. 9 E. Elsewhere similar limestone even

[2]Actually the Weno contains much sandstone, and the Pawpaw is chiefly clay shale at many places.

more closely underlies the Soper, in some instances with associated marly beds containing the same abundant fauna (as in the SE¼NE¼SE¼SE¼ sec. 6, T. 6 S., R. 8 E.). At the *type locality* of the Soper there are *two* additional limestone beds retained in the Denton by Huffman and others (1975, p. 17, 32–33).

Weno Clay Member and McNutt Limestone Member

Huffman (1977, p. 15) makes the following statement:

> In Bryan County, the Weno Clay Member reaches a thickness of 80 to 90 feet in the northern part of the county (Hart, 1970, p. 81) and thickens southward to 109 feet in western Bryan County (Currier, 1968, p. 22). There the lower part consists of 45 to 50 feet of olive-gray shale with thin interbeds of brown, ferruginous sandstone and siltstone. Selenite crystals, limonite, marcasite concretions, and clay-ironstone concretions are present. Weathered slopes are littered with pieces of broken fragments of the ferruginous concretions.
>
> The upper Weno (30 to 40 feet) contains a lower zone of medium- to thick-bedded, ripple-marked, ferruginous sandstone and interbedded clays. The uppermost 20 feet consists of massive-bedded, yellow to orange, fine-grained, friable, fossiliferous, and micaceous sandstones. The Weno conformably succeeds the Soper Limestone Member. Fossils are exceedingly sparse in both the shale and sandstone facies of the Weno. Molds and casts of *Turritella*, *Protocardia*, *Nucula*, and *Corbula* are present in some of the sandstone layers.

This passage cites the work of Currier (1968) and Hart (1970) without regard to the substantial change in definition of the Weno since these reports were written. In Bryan County there are multiple beds of the sandy limestone and calcareous sandstone of the McNutt Member in many places, which, with the interbedded strata, attain a thickness of as much as 22 feet (Hart, 1970, p. 199). At other places only a single limestone bed is present, a few inches thick. Huffman (1977, p. 16) discusses this variation. Twenty-two feet is roughly a fifth of the thickness of the Weno of former usage, a stratigraphic unit with differing and recognizable subdivisions, so that careful rewriting of the descriptions was needed.

In some places, of course, the Weno is nearly the same as formerly described, where there is only one McNutt limestone bed, and evidently "Weno" at one place is equivalent to "McNutt" at another. The alternative explanation would be to suppose that the McNutt nearly pinches out between the Weno and the Pawpaw, rather than interfingering with the Weno. In this case the Weno plus McNutt would probably be thicker where the McNutt is thicker, and I believe that existing information will not support this correspondence. Although I do not consider the new nomenclature very convenient, I shall attempt to recast the description of these rocks to fit within this system.

The 90-foot Weno thickness cited by Huffman from Hart (1970, p. 80–81) is incomplete at the base, which was concealed beneath Lake Texoma at the time of measurement; probably the total would be closer to 100 feet. This of course is the Weno of former usage, including the McNutt, and the same is true of the 109-foot thickness cited from Currier (1968, p. 22). Huffman does not consider this distinction in either instance.

A lower unit of shale occurs in the Weno of old or new usage throughout northwestern Bryan County; it is about 45 to 50 feet thick near Lake Texoma. I did not record marcasite concretions in the unit.

In the Lake Texoma area the next overlying unit is about 25 to 30 feet thick and consists mainly of sandstone, with shale interbedded in the lowest few feet. Rather weak field evidence, particularly an exposure in the NW¼NW¼NE¼ NW¼ sec. 27, T. 6 S., R. 10 E., supports the existence of this unit farther east in northwestern Bryan County. Near the C N½SE¼NE¼ sec. 12, T. 6 S., R. 7 E. (Hart, 1970, p. 198–199), the sandstone directly underlies the McNutt at that unit's maximum recorded thickness. At other places, where the McNutt limestones occur in a smaller interval, an additional higher section is classified as Weno.

The interval between relatively well-defined Weno sandstone and the highest of the McNutt limestones happens to be rather poorly exposed except for the limestone beds. I carefully examined my field notes and also sections by Currier (1968) and Ganser (1968) reproduced in the report on Bryan County, Oklahoma, by Huffman and others (in preparation). This interval of Weno or McNutt certainly includes sizable intervals of shale and sandstone locally and must be radically different from place to place. Near the C N½SE¼NE¼ sec. 12, T. 6 S., R. 7 E., there is 17 feet of shale between 2 of the McNutt limestones. In the SW¼NW¼SW¼NW¼ sec. 12, T. 6 S., R. 8 E., 27 feet of sandstone underlies a single McNutt limestone. Various localities with multiple limestones suggest shale by the absence of exposure. Near the C SW¼NE¼NE¼ sec. 14, T. 6 S., R. 10 E., the poor exposures indicate sandstone associated with 3 McNutt limestones in a 10-foot interval. This last locality is perhaps important, because without it there would be greater reason to suspect that there is a "McNutt facies" of interbedded shale and sandy limestone and an "uppermost Weno facies" of sandstone with a single "McNutt" sandy limestone overlying it.

I must of course depend primarily upon field evidence in northwestern Bryan County, but clearly Currier (1968, p. 24, 65–66) and Ganser (1968, p. 28) found intervals with multiple limestone beds in the McNutt position in southwestern Bryan County and eastern Marshall County.

Huffman (1977, p. 16) states: "Fossils are rare in the McNutt Limestone except at places where an abundance of *Ostrea quadriplicata* Shumard occurs."— A curious remark, since I have found the typical McNutt to be an *O. quadriplicata* coquinite throughout northwestern Bryan County.

Pawpaw Sandstone Member

Huffman (1977, p. 17) makes the following statement about the Pawpaw Sandstone Member:

> In Bryan County, the Pawpaw Member is a complex sequence of clay shales, sandstones, and local lenses of very sandy, massive, calcarenite. . . . Lateral facies changes and eastward thinning characterize the Pawpaw along the present outcrop in Bryan County. In western Bryan County, sandstone predominates over subordinate amounts of sandy clay in a 42- to 45-foot-thick unit. The sandstone facies changes into shale eastward as indicated by the excellent exposure along Highway 70 east of Blue River in SW¼SE¼ sec. 27, T. 6 S., R. 10 E. In this exposure (south roadside only), a 16-foot lense of cross-bedded calcarenite occurs in the upper part of the Pawpaw (NE¼ sec. 34, T. 6 S., R. 10 E.).

The lateral facies changes are far more complex and occur within much shorter distances than Huffman indicates. In the NE¼SW¼NW¼NW¼ sec.

25, T. 6 S., R. 7 E., within a mile of Lake Texoma (which lies along the western edge of Bryan County), the upper 30 feet (about two-thirds) of the Pawpaw is chiefly clay shale, rather than sandstone as Huffman indicated. This exposure was not chosen for inclusion among measured sections by me (Hart, 1970), but I mentioned it (p. 101). All workers seem to agree that the Pawpaw is chiefly sandstone in exposures near Durant, the best showing the upper 27 feet or more of Pawpaw on Chukwa Creek in secs. 28 and 29, T. 6 S., R. 9 E.

Several exposures within 5 to 11 miles east of Durant are especially illustrative of the complex Pawpaw facies. These include (1) the SE¼SE¼NW¼SW¼ sec. 30, T. 6 S., R. 10 E., a 15-foot section, with limestone containing bioclastic material, overlain by a calcareous sandstone, similarly bioclastic, containing a soft sand lens; (2) 3.5 miles generally east of there, near the S¼ cor. SE¼ sec. 27, and adjacent sec. 34, T. 6 S., R. 10 E., cuts on U.S. Highway 70, the upper 25 feet of Pawpaw, chiefly shale, with sandy reefoid material 13 to 27 feet below the top contact; (3) 2.2 miles generally east, the NE cor. SE¼NE¼SE¼ sec. 25, T. 6 S., R. 10 E., 32 feet of virtually continuous sandstone; and (4) 0.2 mile east-northeast, the SW¼NE¼NW¼SW¼ sec. 30, T. 6 S., R. 11 E., 7.5 feet of calcareous bioclastic limestone, overlain by 10 feet with scattered exposures of a similar lithology, all resembling the McNutt Member, which I believe to be represented by additional beds a few feet lower. Mention may also be made of (5) quasi-hemispherical sandy limestone lenses directly underlying the Bennington Limestone at the top of the Pawpaw, in the SE¼ sec. 29, T. 6 S., R. 10 E., similar features also occurring on Chukwa Creek in the NW¼NW¼ sec. 28, T. 6 S., R. 9 E. Huffman (1977, p. 17) cites the exposure explained in example (2): "The sandstone facies changes into shale eastward . . ."—despite the inclusion in Huffman's manuscript on Bryan County (in preparation) of a measured section (Hart, 1970, p. 195–196) in the large sandstone interval given in example (3) above.

Huffman (1977, p. 17) cites reports of Bullard (1926, p. 43–44) and Ganser (1968, p. 30) on the thickness of the Pawpaw Member in eastern Marshall County, Bullard having reported 60 feet and Ganser 45 feet. It seems unlikely that these reports are without conflict, considering the close proximity of the two work areas. Ganser is in agreement with all the thesis workers in Bryan County.

Summary

The report of Huffman (1977) makes use of the terms Soper and McNutt for members of the Bokchito Formation, previously removed by him from the Denton and Weno Members, respectively. These terms present difficulties.

The Denton is still considered to contain calcareous beds associated with the overlying single limestone bed called Soper. The definition of the Weno was significantly changed in a way evidently making about 20 feet of sandy limestones and interbedded strata of the McNutt Member laterally equivalent to the upper Weno without limestones. Huffman (1977) presents apparently inaccurate thicknesses and descriptions of the Weno in Bryan County because he took information from other reports that had included the McNutt in the Weno. I have undertaken to describe the Weno-McNutt interval in terms of the new nomenclature. Apparently there are large thicknesses of shale at some places and of sandstone at others in the interval occupied by either the McNutt or the upper Weno.

Huffman (1977) indicates that the Pawpaw Member includes areas predominantly of either shale or sandstone much larger than I consider correct. He describes the Pawpaw as chiefly sandstone in western Bryan County and chiefly shale farther east in the county, contrary to exposures described by Hart (1970) and obviously known to Huffman.

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STRATIGRAPHY OF THE BOKCHITO FORMATION (CRETACEOUS) IN SOUTHERN OKLAHOMA: REPLY

George G. Huffman[1]

Introduction

In last February's issue of *Oklahoma Geology Notes*, I presented a short paper on the stratigraphy of the Bokchito Formation (Cretaceous) in southern Oklahoma (Huffman, 1977). This paper was designed to acquaint the reader with the general nature of the Bokchito Formation in southern Oklahoma and to illustrate the significance of thin, laterally persistent limestone marker beds for use in understanding the complex sequence of shallow-water marine and deltaic sediments that constitute the Bokchito Formation. The major intent was to demonstrate the general stratigraphic and geologic framework of the Bokchito with a minimum of detail.

Recently, Mr. Hart, a former graduate student at The University of Oklahoma, criticized my 1977 paper. Some of his comments are quite valid and have

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been incorporated in the final version of the Bryan County manuscript (in preparation), of which Hart is a junior author. Much of his criticism, however, appears unjustified and possibly stems from inexperience. As a graduate student, Hart spent 2 long field seasons in a 9-township area in north western Bryan County. His first season was rather inconclusive; however, he returned after 3 years in the army and completed the mapping project. His M.S. thesis (Hart, 1970), written on these 9 townships, consists of 215 pages of text and a geologic map.

In his criticism, Hart lost sight of the value of marker-defined units and their significance in understanding the Bokchito stratigraphy. He ignored the definition of a member as defined by the Code of Stratigraphic Nomenclature (American Commission on Stratigraphic Nomenclature, 1961, p. 651). Had he been more aware of these two concepts, he might not have taken issue with the naming of the Soper and McNutt Limestone Members, both of which are completely valid and have been approved by the U.S. Geological Survey for use in southern Oklahoma. The beds of poorly indurated marlstone that directly underlie the Soper Limestone at the type locality were excluded by the author from the original description because they are not laterally persistent and are seldom well exposed; whereas the hard, compact, fossiliferous, well-indurated Soper Limestone is present throughout southern Oklahoma, both in surface and subsurface. Thickening of the McNutt Limestone by addition of basal beds at the expense of the underlying Weno is entirely compatible with the application of member status to the unit. It must be emphasized that the Soper Limestone Member and the top bed of the McNutt Limestone Member represent contemporaneity of deposition and are valid lithologic-time markers, regardless of Hart's objections to their naming.

Concept of a Member

The American Commission on Stratigraphic Nomenclature (1961, Article 7, p. 651) defines a member as follows:

> A member is part of a formation; it is not defined by specified shape or extent. . . . Formations may be divided into formally defined and named members. In some formations, one or more formal members are established, while the remainder of the formation is undivided. . . . A member is established when it is advantageous to recognize a specially developed part of a varied formation. A member, whether named or unnamed, need not be mappable at the scale required for formations. . . . Although members normally are in vertical sequence, laterally equivalent parts of a formation that differ recognizably may also be considered members . . . .

Concept of Marker-Defined Units

Busch (1971) carefully defined and illustrated the concept of the Genetic Increment of Strata (GIS) and the Genetic Sequence of Strata (GSS) as applied to marginal marine sediments, especially of the littoral and delta environments. The GIS consists of an interval of strata representing one cycle of sedimentation, the upper boundary being a time-marker bed and the lower being a lithologic-time marker or an unconformity. The GSS is defined as two or more contiguous genetic increments of strata representing more or less continuous sedimentation.

In both definitions, Busch (1974, p. 26) emphasized that the lithologic-time markers are critical because they represent contemporaneity of deposition.

Marker-Defined Beds in the Bokchito Formation

The Bokchito Formation in southern Oklahoma is a classic example of a Genetic Sequence of Strata. It is bounded at the base by the top of the Fort Worth Limestone and at the top by the base of the Bennington Limestone. Both contacts are essentially conformable. The Bokchito Formation consists of three well-defined GIS units of member rank separated by thin but persistent limestone marker beds that have been given formal names and member rank by Huffman and others (1975).

The Denton Clay, the basal member of the Bokchito Formation, consists of 45 to 60 feet of blue-gray to brownish-gray clay shale with thin interbeds of siltstone. It becomes increasing calcareous upward, and beds of fossiliferous marlstone directly underlie the "*Ostrea carinata*" bed at places.

The name Soper Limestone Member was applied by Huffman and others (1975) to a thin but persistent lithologic-time marker previously called the "*Ostrea carinata*" bed. This informal name is inappropriate, because "*Ostrea carinata*" has been reassigned to *Rastellum* (*Arctostrea*) *carinatum* (Shumard), which occurs sparingly in the Soper Limestone but abundantly in certain beds in the upper Caddo (Fort Worth) Limestone. The Soper Limestone is a gray-brown to reddish-brown, hard, compact, fossiliferous unit that forms a prominent ledge or ledges capping the underlying Denton Clay. The Soper is conformable with the Denton, and the boundary is transitional through a few inches to nearly 2 feet of poorly indurated, fossiliferous marlstone as seen at the type locality near Soper, Choctaw County, Oklahoma. The Soper Limestone can be traced almost continuously across a four-county area, where it serves as a lithologic marker to separate the Denton Clay from the overlying Weno Clay. It represents transgression of the carbonate environment across a clastic sequence.

The Weno Member consists of from 80 to about 100 feet of shale and sandstone. The lower part includes 45 to 50 feet of gray shale with thin interbeds of brown, ferruginous sandstone and siltstone. The upper part consists of 30 to 40 feet of thin-bedded, rippled-marked sandstone and interbedded clays together with a 20-foot zone of massive-bedded, fine-grained, friable, micaceous sand. In most exposures that I have examined, the McNutt Limestone directly overlies this massive sandstone. At places Hart (1970) and Currier (1968) noted that beds of the "Quarry Limestone" were interbedded with clay shales in the upper part of the Weno, especially in western Bryan County.

The term McNutt Limestone Member was applied by Huffman and others (1975) to a 2- to 3-foot bed of arenaceous limestone exposed on the McNutt Ranch near Soper, Choctaw County, Oklahoma. This bed was previously called the "Quarry Limestone," a term most inappropriate, because the unit is too sandy for quarrying purposes in southern Oklahoma. Throughout most of Choctaw and Bryan Counties, the McNutt consists of a single bed of compact, resistant limestone characterized at places by an abundance of "*Ostrea*" *quadriplicata*. In western Bryan County, the McNutt Member thickens by the addition of lower beds of arenaceous limestone at the expense of the Weno Member. According to Hart (1970, p. 85), the "Quarry Limestone" may consist of 1, 2, or even 3 beds, and in a measured section (p. 119) he included a 4th bed located some 17 feet below the upper 3 and separated by a poorly exposed to unexposed shale section. This gave a maximum thickness of 22 feet for the McNutt. Whether this lower bed should be considered part of the McNutt Member, or simply as a lentil of limestone within the Weno, is an academic problem. The upper part of the McNutt Limestone is persistent and serves as a lithologic-time marker to separate the Weno from lithologically similar beds in the Pawpaw Sandstone Member. The McNutt Limestone forms a conspicuous marker on electric logs in wells in Bryan County, and reportedly to the south, in Denton and Tarrant Counties, Texas, it grades into a thick limestone section (Hart, 1970, p. 87). In southern Oklahoma, it represents gradation from a dominantly clastic environment to a carbonate environment owing to transgression and northward overlap.

The Pawpaw Sandstone Member is a complex sequence of clay shales, sandstone, and local lentils of sandy calcarenite. In Love and Marshall Counties, a basal shale section (16–22 feet) is overlain by red sandstone (36–38 feet). In Bryan County, Pawpaw facies are complex with localized but abrupt lateral changes. In the western part of the county, Hart (p. 101) mentioned one locality where the upper part of the Pawpaw is composed of 30 feet of clay shale. Eastward from there, sandstone predominates over subordinate amounts of shale in a 42- to 45-foot-thick section, as near Durant. The sandstone changes to shale eastward along Blue River (sec. 27, T. 6 S., R. 10 E.). In eastern Bryan and Choctaw Counties, the Pawpaw consists of 45 feet of red to yellow, cross-bedded, friable sandstone interbedded with gray and reddish-purple sandy clay. The abrupt lateral facies changes, the oxidation and red coloration, cross-bedding, and numerous molds and casts of a small molluscan fauna consisting of *Nucula*, *Protocardia*, and *Cyprimeria* suggest a deltaic origin for these beds. The overlying Bennington Limestone again represents the northward spread of carbonate facies across the nearshore and probably deltaic clastic environment.

Summary and Conclusion

The Bokchito Formation of southern Oklahoma is a classic example of a Genetic Sequence of Strata. Bounded above and below by major limestone units, it consists predominantly of clastics of the marginal marine environment including littoral and deltaic zones. The Bokchito consists of three well-defined GIS units of member rank, the Denton, Weno, and Pawpaw, separated by thin but persistent limestone marker beds that have been given member rank and formal names. Thus, two new stratigraphic names have been added to the Lower Cretaceous section of Oklahoma: the Soper and McNutt Limestone Members of the Bokchito Formation. In spite of the objections raised by Hart in his discussion, these are valid member names, and their usage is entirely in keeping with the rules and regulations established by the American Commission on Stratigraphic Nomenclature in the Code of Stratigraphic Nomenclature.

THE MINERAL INDUSTRY OF OKLAHOMA IN 1977[1] (Preliminary)

Robert H. Arndt[2]

The value of raw minerals produced in Oklahoma reached an all-time high of $3.5 billion in 1977, according to the Bureau of Mines, U.S. Department of the Interior (table 1). The increased value, approximately 25 percent above that of 1976, was provided largely by the mineral fuels, which generated about 96 percent of the total mineral value.

Crude-oil output declined for the ninth consecutive year. Conversely, the value continued the abrupt rise begun in 1973. The rapidly escalating price of intrastate gas was a key factor in pushing both output and value of natural gas to all-time highs in 1977. The total output of natural-gas liquids was virtually unchanged, but the value of the product rose. Substantially increased coal output achieved a record value of $78 million in 1977. The value of produced helium also increased.

Gains in oil and gas production were bolstered by a 23-percent increase in the average weekly number of active drilling rigs, according to the Hughes weekly rig count, and by discovery of 81 new oil and gas fields, the largest number in any year since the 1960's. Increased coal output reflected record production from the largest mine and more continuous mining throughout the industry than in 1976. Future underground mining of coal was anticipated in resource evaluation by several coal companies at sites in Le Flore County.

Sharp increases in most types of construction supported significant increases in the total quantity and value of gypsum, sand and gravel, and stone produced. In spite of high demand for brick, clay output and value decreased. Cement output and value increased in 1977 as full production resumed in plants that had undergone kiln conversions to use coal in 1976. Lime output and value decreased in 1977 as a result of a 10-week strike by employees of the State's only lime producer.

Feldspar (in feldspathic sand) and pumice (volcanic ash) showed increased value of output in 1977. Iodine production initiated in Oklahoma near Woodward is expected to supply as much as one-third of the nation's iodine needs. Produced salt and tripoli both experienced reduced value. Minor quantities of lead and zinc were recovered in clean-up operations.

The output of gasoline, jet fuel, distillates, and residual fuel oil, the principal products of 12 refineries, had an estimated value of $2.7 billion in 1977. Natural gas was processed at 82 plants. Helium was recovered at the Bureau of Mines Helium Facility at Keyes. Kerr-McGee Corporation prepared uranium hexafluoride.

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[1]Prepared January 1978 in the State Liaison Program Office-Oklahoma, U.S. Bureau of Mines, through a cooperative agreement between the USBM and the Oklahoma Geological Survey that calls for collecting information on all minerals except fuels.

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Deep-Water Carbonate Environments Subject of New SEPM Volume

The Society of Economic Paleontologists and Mineralogists announced the release of an important publication last fall entitled *Deep-Water Carbonate Environments.* Issued as Special Publication 25, the book contains more than 300 pages, which include 14 papers from specialists, an index, and about 300 illustrations. Editors for the volume are Harry E. Cook, U.S. Geological Survey, and Paul Enos, State University of New York at Binghamton.

The papers present new data on deep-water carbonate environments ranging in age from the Cambrian to the present with examples from Canada, the United States, Mexico, Africa, and modern ocean basins. The geologic settings of these studies include modern and ancient deep oceans, continental slopes and shelves, and continental-interior basins. The authors have sought to demonstrate that deep-water carbonate environments are not passive but active areas where both depositional processes and significant amounts of mass-wasting processes contribute to their development. Thus the volume should be of considerable interest to a broad range of earth scientists.

Deep-Water Carbonate Environments can be obtained by writing SEPM, P.O. Box 4756, Tulsa, Oklahoma 74104. The price is $12.00 to SEPM and AAPG members and $14.00 to others. Orders for delivery in Oklahoma require an additional 2 percent for sales tax (4 percent in Tulsa).

Oklahoma Facility Increases U.S. Iodine Production

Initial iodine production at Woodward, Oklahoma, a joint project of Amoco Production Co. and PPG Industries, has increased total domestic output of crude iodine by 250 percent. The facility is expected to approach capacity production of 2 million pounds per year in 1978. These figures are from the

Mineral Industry Surveys (December 1977) of the U.S. Bureau of Mines, Division of Nonmetallic Minerals.

Principal uses for iodine in 1977 included catalysts (for synthetic rubber), stabilizers (precursors for nylon), animal feed, inks and colorants, pharmaceuticals, sanitary and industrial disinfectants, and photographic film.

OKLAHOMA ABSTRACTS

AAPG-SEPM Regional Meeting, Rocky Mountain Section Denver, Colorado, April 3–6, 1977

The following abstracts are reprinted from the August 1977 issue, v. 61, no. 8, of the *Bulletin* of The American Association of Petroleum Geologists. The page numbers are given in brackets below the abstracts. Permission of the authors and of Gary Howell, AAPG publication manager, to reproduce the abstracts is gratefully acknowledged.

Petroleum Source-Rock Potential of Arbuckle Group (Cambrian-Ordovician), Oklahoma

A. LYNN CARDWELL, Union Oil Co. of California, Midland, Texas

Oil and gas have been produced from the Cambrian-Ordovician Arbuckle Group in the Mid-Continent for more than 50 years, but to date no satisfactory answer has been offered for the question of whether or not petroleum source beds are present within the group. The answer is important in determining whether significant petroleum can be expected in this thick and relatively unexplored section of carbonate rocks.

Detailed studies of the composition of oils produced from Arbuckle reservoirs compared with those from Pennsylvanian reservoirs showed no discernible differences. These studies, which included determination of the composition of gasoline-range hydrocarbons and C_{+15} saturated hydrocarbons, and the gross composition of the whole oils, strongly suggest that very similar source beds generated all the oils. Additional studies of the composition of the bitumen present in nonreservoir Arbuckle rocks showed very distinct hydrocarbon differences between the oils and rock bitumens. The Arbuckle rocks apparently were not the source beds for any of the oils investigated in this study, however, Pennsylvanian shales could have been important.

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.

Further studies of the thermal maturity and organic richness of the Arbuckle rocks by use of pyrolysis—gas chromatographic methods revealed that, in most of Oklahoma, the Arbuckle section is thermally mature but is deficient in organic matter. The sparsity of organic matter apparently is the reason that the Arbuckle Group has not acted as a significant petroleum source. The lack of adequate source beds within the Arbuckle section indicates that significant amounts of petroleum cannot be expected far below the top of that unit unless there are other source beds in favorable position (i.e., a fault contact can be demonstrated). [1374-1375]

Ordovician Oil Accumulation at Northeast Lucien Field, Noble County, Oklahoma

RALPH O. KEHLE and STEVEN D. HULKE, Turk, Kehle and Associates, Austin, Texas

An anomalous oil accumulation occurs in the Middle Ordovician Marshall Sandstone (Simpson Group) at Northeast Lucien field, a northeast-trending nose at the north end of Lucien field, Noble County, Oklahoma. Many other nearby structures are dry, apparently because Late Ordovician growth of the large anticlinal structure to the south at Lucien field resulted in drainage of oil from a wide area surrounding Lucien. Structures that developed later within this previously drained area are barren. Because there was no structural closure at Northeast Lucien on the Viola Limestone (late Middle Ordovician age) during pre-Mississippian times, the Northeast Lucien structure should have been dry. Instead, over 1 million bbl of oil have been produced from five wells in the Marshall sandstone.

At Northeast Lucien, oil apparently originally was trapped stratigraphically along a northwest-trending pinchout of the Marshall sandstone, a reworked eolian sand deposited in a sabkha. This sandstone had a southwest dip of 90 ft/mi (17 m/km) by the beginning of late Middle Ordovician (basal Viola) time. Before Woodford Shale deposition (Late Devonian), a syncline with its axis parallel with the pinchout developed just southwest of the pinchout, thereby isolating part of the stratigraphically entrapped oil from the emerging Lucien structure on the south, and prohibiting drainage. Later deformation resulted in the formation of the northwest-trending nose at Northeast Lucien, which localized the stratigraphic accumulation in its present position. [1382]

Petrology and Diagenesis of Deep-Water Sandstones, Ouachita Mountains, Arkansas and Oklahoma

ROBERT C. MORRIS, KENNETH E. PROCTOR, and MICHAEL R. KOCH, Northern Illinois University, DeKalb, Illinois

The Stanley and Jackfork Groups of the Ouachita Mountains consist of 18,000 ft (5,500 m) of interbedded sandstones and shales deposited during the Late Mississippian and Early Pennsylvanian. This flysch facies is dominated by a succession of westerly directed, deep-marine fans built up by turbidity currents and sandy-debris flows. Interest in their hydrocarbon potential has led to study of textures, compositions, and diagenetic alterations of these sandstones.

The Stanley sandstones are generally feldspathic and quartz wackes. Most are poorly sorted; mean grain sizes are the very fine sand range, with an average of 8% feldspar and 14% matrix. They have an average of 5% silica cement, but many specimens contain none. Porosities range from 0.5 to 26% and permeabilities from 0.05 to 23 md. Jackfork sandstones are predominantly quartz arenites, which tend to be moderately to poorly sorted, with mean grain sizes in the fine to very fine-sand range. They contain an average of 2% feldspar, 5% matrix, and 9% quartz cement. Porosities range from 0.5 to 14% and permeabilities from 0.05 to 9 md.

Pressure solution, silica cementation, and calcitization of plagioclase have acted to reduce the reservoir potential. Corrosion and dissolution of framework grains of quartz, feldspar, and garnet have increased secondary porosity. The presence of halloysite and kaolinite distinguishes permeable sandstones affected by surface leaching from sandstones unaffected by leaching. The sandstones display a random variation in porosity and permeability both laterally and vertically. Thick-bedded, scoured proximal turbidites and sandy debris flows commonly have the most favorable textures. Characteristics associated with the retention of favorable reservoir potentials include poor sorting, small mean-grain sizes, and high matrix content. Well-sorted quartz arenites are poor reservoirs because their pores were filled completely with silica cement. [1384]

AAPG-SEPM Regional Meeting, Gulf Coast Section Austin, Texas, October 26–29, 1977

The following abstract is reprinted from the September 1977 issue, v. 61, no. 9, of the *Bulletin* of The American Association of Petroleum Geologists. The page number is given in brackets below the abstract. Permission of the author and of Gary Howell, AAPG publication manager, to reproduce the abstract is gratefully acknowledged.

Paleozoic Tectonics of Southern Margin of North America

JACK L. WALPER, Texas Christian University, Fort Worth, Texas

Several aulacogens, the failed-arm troughs radiating from RRR triple junctions, marked the southern margin of the early Paleozoic North American continent. Two, the Delaware aulacogen in West Texas and the Wichita in southern Oklahoma, now consist of paired basins and uplift trending at high angles from the rifted continental margin. The Reelfoot aulacogen lies beneath the Mississippi

Embayment, and the Mount Rogers trends from southwest Virginia across North Carolina, then beneath the Piedmont into South Carolina. Although the rifting of the continent and opening of the proto-Atlantic (Iapetus) ocean was an early Paleozoic event, still older Precambrian basement trends may have influenced the location of these features. The final stages of their geotectonic evolution was influenced by the late Paleozoic continental collisions that formed Pangaea, and their presence controlled the shape of the resulting Ouachita-Marathon orogenic belt and also may have influenced the subsequent rifting and breakup of that supercontinent during the Mesozoic.

The Delaware aulacogen, adjacent to the Diablo-Coahuila platform (a Precambrian orogenic trend) produced the early Paleozoic Tobosa basin before the continental collision that formed the Delaware basin and the Central Basin range. It determined the location of the Rio Grande embayment, a Mesozoic aulacogen formed during the breakup of Pangaea. The Wichita aulacogen, also probably influenced by an ancient Precambrian basement trend, gave rise to the early Paleozoic southern Oklahoma "geosyncline," again long before late Paleozoic continental collision initiated the transcurrent stage that produced the Anadarko basin and the Wichita-Arbuckle uplift. Troughs of thick early Paleozoic sedimentary rocks also mark positions of the Reelfoot and Mount Rogers aulacogens, but these now lie beneath the younger deposits of the Mississippi embayment and the allochthonous Piedmont respectively. All of these aulacogens influenced deposition on the retreating North American plate margins, and then, as a result of subsequent plate convergence, influenced the geometry of later Paleozoic orogenic belts and the location of associated foreland basins. [1549]

ERDA Third National Symposium
Tulsa, Oklahoma, August 30–September 1, 1977

The following abstracts are from papers presented at the Third Annual ERDA National Symposium on Enhanced Oil and Gas Recovery and Improved Drilling Methods. The Division of Oil, Gas, and Shale Technology of the U.S. Energy Research and Development Administration sponsored the conference in cooperation with The University of Tulsa and the *Oil and Gas Journal*. The authors' permission to publish the abstracts is gratefully acknowledged.

Polymer Enhanced Waterflooding: A Status Report of the North Stanley Project, Osage County, Oklahoma

B. MAITLAND DUBOIS, Kewanee Oil Co., Shidler, Oklahoma; JARL P. JOHNSON and J. W. CUNNINGHAM, Kewanee Oil Co., Tulsa, Oklahoma

The object of this project is to determine if additional oil can be recovered from a highly heterogeneous reservoir, that is nearing its economic limit, by using a polymer plug to improve sweep efficiency.

Preparation of the project for polymer injection included a reservoir analysis, an injection well workover program, installation of polymer mixing equipment, and stabilization of production prior to commencing polymer injection.

The first definite indication of an oil response to polymer injection was observed during September 1976, when production increased 15 BOPD above the previous month's production. Production has continued to increase with 144 BPD of tertiary oil being produced during April 1977. Water production has also responded to polymer injection and has decreased by approximately 13 percent in 11 months.

North Burbank Tertiary-Recovery Pilot Test—Two-Year Status Report

R. F. KLEINSCHMIDT, J. C. TRANTHAM, D. F. BONEAU, and H. L. PATTERSON, Phillips Petroleum Co., Bartlesville, Oklahoma

A Phillips/ERDA tertiary pilot test was initiated in May 1975 on a 90-acre tract of the North Burbank Unit using a surfactant/polymer system developed specifically for this oil-wet reservoir. Phillips is the operator for 18 working-interest owners. During the past year the surfactant slug was injected without difficulty and was followed by most of the polymer solution in decreasing stepwise concentrations. The first tertiary oil production was observed early in 1977. By mid-May the tract produced about 185 BPD, over three times the level that would be expected from continued waterflooding. Peak production from this tract is not expected until mid-1978. There are insufficient data at this time to confirm the predicted production curve.

ERDA's Micellar-Polymer Flood Project in Northeast Oklahoma

R. D. THOMAS, C. J. WALKER, and F. W. BURTCH, Bartlesville Energy Research Center, ERDA, Bartlesville, Oklahoma

ERDA's Bartlesville Energy Research Center is conducting a micellar-polymer flood in Delaware-Childers Field in Northeast Oklahoma. The test site is a 2½-acre inverted five-spot with twinned central injection wells and eight surrounding water-injection wells. The producing horizon is the Bartlesville sand. The three-phase injection program consists of a 0.1 PV saline preflush, a 0.1 PV micellar slug and 0.4 PV mobility control buffer. Injection of micellar fluid was started on April 28, 1976, following 5 months of brine preflush. Micellar injection was completed and polymer injection started Oct. 5, 1976. Calculations based on laboratory results and reservoir properties indicate that the total recovery should be 50 percent of the estimated 70,000 bbl of oil in place.

Heavy Oil Resources of Kansas-Missouri-Oklahoma

JACK S. WELLS, Missouri Department of Natural Resources, Division of Geology and Land Survey, Rolla, Missouri; W. J. EBANKS, JR., Kansas Geological Survey, Lawrence, Kansas; and JOHN F. ROBERTS, Oklahoma Geological Survey, Norman, Oklahoma

An ERDA-funded program to inventory heavy-oil deposits occurring within Pennsylvanian sandstones in northeastern Oklahoma, southeastern Kansas and western Missouri was started in June of 1976. Specific information about the thickness and areal extent of the several sandstone bodies that contain oil and the distribution of oil within them is being compiled and evaluated for resource-base figures for each of the three states.

Core drilling to complement existing data is being carried out within the three states. Thirty-three test holes have been drilled and logged in Kansas. By the end of August 1977, an estimated 16 test holes are projected for completion in Oklahoma and an estimated 50 test holes are projected in Missouri.

Preliminary maps indicate that the areal extent of oil-saturated sandstone within the tri-state area is somewhat less than had previously been calculated. Occurrences are discontinuous and appear as relatively small pods in areas where gross sand thickness seems to be the greatest.

GSA Annual Meetings, Seattle, Washington November 7–9, 1977

The following abstracts are reprinted from *Abstracts with Programs* of The Geological Society of America, v. 9, no. 7. Page numbers are given in brackets below each abstract. Permission of the authors and of Mrs. Jo Fogelberg, managing editor of GSA, to reproduce these abstracts is gratefully acknowledged.

Geochemistry and Petrology of Uranium-Bearing Pegmatite Dikes, Wichita Mountains, Oklahoma

ZUHAIR AL-SHAIEB and RICHARD E. HANSON, Department of Geology, Oklahoma State University, Stillwater, Oklahoma

Riebeckite-aegirine pegmatite dikes, genetically related to the peralkaline Cambrian Quanah Granite, contain 40 to 100 ppm uranium. A typical example of these dikes is located on the western edge of the U.S. Wildlife Refuge in the

Wichita Mountains. This dike is east-west and is essentially vertical. It consists of an aplitic core with a xenomorphic, granular texture which grades outward into a coarsely crystalline phase, which in turn grades into the host rock. A pronounced banding is due to preferred orientation of black riebeckite and (or) green aegirine crystals and light-colored feldspars and to gradational texture. The dike is composed mainly of quartz, microperthite, orthoclase, albite, riebeckite, aegirine, and small quantities of hornblende. Two distinct generations of albite were observed: an early stage associated with K-feldspars and a later hydrothermal stage. Presumably hydrothermal, microcrystalline quartz, usually in the form of veins, cuts across primary minerals. An outstanding feature is the abundance of the alkaline-rich riebeckite and aegirine, which represent overlapping periods of crystallization. Much of the aegirine has undergone corrosion and resorption. Zircon is relatively abundant; it evidently was an early crystallization product.

Fission tracks show that the uranium is associated with both aegirine-riebeckite and refractory minerals such as zircon and allanite. It was not determined whether uranium occurs as submicroscopic mineral inclusions in Na-rich minerals, or if it is fixed in their lattice structures. It is proposed that uranium in these dikes is related to a late uranium-rich hydrothermal stage which followed an early magmatic phase. [877]

Precambrian Geology and Geochronology of the Central Interior Province, North America

R. E. DENISON, Consultant, Dallas, Texas; E. G. LIDIAK, Department of Earth & Planetary Sciences, University of Pittsburgh, Pittsburgh, Pennsylvania; M. E. BICKFORD, Department of Geology, The University of Kansas, Lawrence, Kansas; and E. B. KISVARSANYI, Missouri Department of Natural Resources, Rolla, Missouri

Archean rocks whose ages range from about 2.5 b.y. to perhaps 3.8 b.y. underlie the eastern Dakotas. The southern extent of these rocks is undefined. Igneous and metamorphic rocks with ages of 1.6-2.5 b.y. occur in the adjoining western Dakotas, Nebraska, northern Kansas, northern Missouri, and presumably, Iowa. The Sioux Quartzite unconformably overlies these older rocks in eastern South Dakota.

The eastern and southern parts of the central interior are underlain mainly by rhyolitic volcanic and epizonal igneous rocks that extend from southern Wisconsin to far West Texas. These felsic rocks range in age from 1.5 b.y. in southeastern Missouri to 1.0 b.y. in western Texas. Apparent ages east of the Mississippi River are 1.1-1.5 b.y., but some of the rocks may be older.

Basalt, gabbro, and sedimentary rocks are associated with extensional rift zones. Best known is the 1.1 b.y. Keweenawan rift that extends from Lake Superior to Kansas. Other basaltic rift zones may occur in the Michigan basin, along the LaSalle anticline, and in Kentucky.

East of the rhyolitic terrane is the subsurface extension of the Grenville

Front. It trends through central Ohio and into Kentucky and Tennessee. Basement rocks are mainly high grade metamorphic rocks, granite, and anorthosite; apparent ages on micas are 0.9-1.0 b.y.

The region prior to about 1.7 b.y. ago was characterized by eugeosynclinal sedimentation and orogenic tectonic styles. Stabilizing of the continental interior was reflected in the deposition of orthoquartzites beginning about 1.6 b.y. ago. Subsequent igneous activity, sedimentation, and tectonics were dominantly anorogenic except for orogenic events and sedimentation along the margins of the stable interior. [947-948]

Volcanic Ash Beds in Continental Deposits of the Southern High Plains: Their Bearing on the Time of the Blancan-Irvingtonian Faunal Transition

GLEN A. IZETT, U.S. Geological Survey, Denver, Colorado

A combination of properties can be used to group Pleistocene ash beds based on their chemical and mineralogic compositions, direction of detrital remanent magnetization (DRM) and isotopic ages. An overlapping pattern of ash localities, whose source areas were Yellowstone National Park (YNP) Wyo. and Ida. and the Jemez Mountains (JM) in New Mex., occur in the Southern High Plains and care must be used to identify and determine their source areas. At Mt. Blanco and Tule Canyon in the Texas Panhandle and at the Borchers Ranch in Meade County, Kans., two ash beds occur at each locality separated by sediments containing fossils that have a bearing on the Blancan-Irvingtonian Land Mammal transition. Near Mt. Blanco, Tex., the Guaje ash bed (1.4 m.y. old; JM source; reverse DRM) overlies deposits containing the type Blancan Land Mammal assemblage; a lower ash (source unknown; reverse DRM) lies in the fossil mammal bearing sequence. At Tule Canyon, an ash bed (about 1.2-1.3 m.y. old, JM source; reverse DRM) occurs near the base of a 30 m thick sequence at a level where Blancan and Irvingtonian fossils (*Mammuthus, Stegomastodon mirificus, Equus simplicidens, Equus semiplicatus*) coexist. In the upper part of this sequence, a Pearlette Type O ash (0.6 m.y.; YNP source; normal DRM) overlies deposits containing an Irvingtonian fauna (Cudahy-Rock Creek). Near Borchers Ranch, Kans., a Type B Pearlette ash (1.9 m.y.; YNP source) occurs near the top of a 6 m thick sequence containing the Borchers fauna (Blancan); a second ash bed (about 1.2-1.3 m.y. old; JM source; reverse DRM) occurs 10 m higher, 3 m below remains of *Mammuthus*. Thus the Blancan-Irvingtonian transition occurred about 1.2-1.3 m.y. ago in the Southern High Plains. [1034]

Environmental Control of Patterns of Hierarchial Diversity among Late Paleozoic Ostracoda

ROGER L. KAESLER and R. MICHAEL PETERSON, Department of Geology and Museum of Invertebrate Paleontology, Lawrence, Kansas; MICHAEL D. BRONDOS, Phillips Research Center, Bartlesville, Oklahoma

A benefit that accrues from the use of the information statistic as a measure of species diversity is the ability to partition diversity into additive components contributed by various categories in the taxonomic hierarchy. For example, one can compute components of diversity due to orders, families within orders, genera within families, and species within genera. As a result, it is possible to draw inferences about evolutionary and paleoecological trends within higher taxa on the basis of the study of their species. Hierarchical diversities of assemblages of Virgilian and Wolfcampian ostracodes from the Midcontinent were computed to test the hypothesis that Order Palaeocopida contributed little to overall species diversity except in demonstrably nearshore, shallow-water environments. Genera within Order Palaeocopida contributed 7 percent or less to the species diversity of assemblages from the open-marine facies of the Virgilian Beil Limestone, but in the nearshore facies they contributed nearly 12 percent. In contrast, the component of diversity of podocopid genera within superfamilies remained nearly constant, and the component of podocopid superfamilies decreased from 35 to 20 percent. Similar trends were recognized within assemblages from the Wolfcampian Hamlin Shale and Americus Limestone. There Order Palaecopida showed higher components of diversity in rocks formed in tidal flats and lagoons than in more open-marine environments; and in assemblages from shales immediately overlying algal stromatolites, palaeocopids clearly predominated. Although the palaeocopids were by no means restricted to the nearshore, their presumed inability to compete with podocopids in more normal-marine environments may have contributed to their ultimate demise at the end of the Permian.
[1042]

Petroleum Data System—A Network of Energy Information

PATRICIA A. TRACY, Information Systems Programs, The University of Oklahoma, Norman, Oklahoma

The Petroleum Data System is a comprehensive computer base of petroleum information. PDS is available worldwide through the General Electric time-sharing network. It has received widespread usage since its release in April 1976. The software supporting PDS is a group of general purpose software packages. A

Table 1.—Mineral Production in Oklahoma[1]

Mineral	1976 Quantity	1976 Value (thousands)	1977 (preliminary) Quantity	1977 (preliminary) Value (thousands)
Clays (thousand short tons)	1,155	$ 1,678	1,116	$ 1,551
Coal (bituminous) (thousand short tons)	3,635	58,102	4,795	78,000
Gypsum (thousand short tons)	1,120	5,822	1,256	6,908
Helium:				
High-purity (million cubic feet)	243	7,686	279	8,952
Crude (million cubic feet)	181	2,172	123	1,476
Natural gas (million cubic feet)	1,726,513	866,710	1,824,978	1,452,683
Natural-gas liquids:				
Natural gasoline and cycle products (thousand 42-gallon barrels)	10,894	74,416	11,011	85,855
LP gases (thousand 42-gallon barrels)	31,620	179,602	31,339	231,770
Petroleum (crude) (thousand 42-gallon barrels)	161,426	1,484,297	151,390	1,504,817
Pumice (volcanic ash) (thousand short tons)	1	W	1	W
Sand and gravel (thousand short tons)	10,037	19,050	10,800	21,600
Stone (thousand short tons)	19,535	37,339	21,060	41,405
Value of items that cannot be disclosed: cement, feldspar, iodine, lead, lime, salt, tripoli, zinc, and values indicated by symbol W	XX	53,100	XX	65,795
Total	XX	$2,789,974	XX	$3,500,812

W Withheld to avoid disclosing individual company confidential data; included with "Value of items that cannot be disclosed." XX Not applicable.

[1] Production as measured by mine shipments, sales, or marketable production (including consumption by producers).

driver program links the packages together and provides the interface between the packages and the time-sharing network. These packages handle the problems of information storage and retrieval, applications, and graphics. They have proved to be adaptable to a wide variety of applications. In addition to PDS, The University of Oklahoma plans to make available data bases on coal, geothermal, and minerals. These data bases will be accessed via the same operating procedure as PDS, creating a complete energy-information network. [1205]

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"Generate in '78"

Oklahoma City will be the site of the 1978 annual convention of The American Association of Petroleum Geologists and The Society of Economic Paleontologists and Mineralogists. The meetings will be held April 9–12 in the Myriad Convention Center, with the Oklahoma City Geological Society serving as host. The theme chosen, "Generate in '78," indicates the direction of primary focus for the meetings: both timely and vital, the major emphasis will be on exploration for new energy sources.

This year's convention, the sixth since 1918 to be held in Oklahoma City, holds special significance for geologists from the Norman campus of The University of Oklahoma as the culmination of a year's planning by staff members of the Oklahoma Geological Survey and the School of Geology and Geophysics.

Harvey Blatt and Patrick K. Sutherland, faculty members in the School, are co-chairmen with Rod W. Tillman, of Cities Service Oil Co. in Tulsa, for the SEPM technical programs. William D. Rose, geologist/editor for the Survey, is chairman of this year's Matson Award Committee, and Kenneth S. Johnson, OGS economic and environmental geologist, is a member of the committee. The Matson Award was established in 1957 by the George C. Matson family to recognize the speaker presenting the best AAPG paper at the annual convention. Papers are judged on both scientific quality and excellence in presentation.

S. A. Friedman, coal geologist with the OGS, as a councillor of the new Energy Minerals Division of AAPG, has been in charge of selecting papers for this division for the Oklahoma City meeting. The Energy Minerals Division was formed at last year's meeting by a vote of the AAPG House of Delegates. Friedman will also co-chair a coal symposium sponsored by the Energy Minerals Division and will lead a preconvention field trip to study Desmoinesian coal deposits in the Arkoma basin in eastern Oklahoma.

Two other field trips will be led by OGS and School personnel. A preconvention trip over the regional geology of the Arbuckle Mountains will have as co-leaders Robert O. Fay and Thomas W. Amsden, OGS geologists, and Rodger E. Denison, a Dallas consultant and an OU graduate and former OGS staff member. John S. Wickham, acting director and professor of the School of Geology and Geophysics, will lead a post-meeting trip to examine the structure and stratigraphy of the Ouachita Mountains and Arkoma basin, along with Boyd Haley of the U.S. Geological Survey, Charles G. Stone of the Arkansas Geological Commission, and Glenn Visher of The University of Tulsa. Other field trips will be offered to cover trace fossils and paleoecology in the Ouachitas, Pennsylvanian limestone units of eastern Kansas, uranium mineralization in the Wichita Mountains, and the Upper Cretaceous section of western and central Kansas.

In addition to previously mentioned participation in the convention, OU geologists will lead three of the regular technical sessions. Johnson will be coleader with Kent Chamberlain of the University of Nevada for a session on "Sedimentary Processes and Modern Sand Deposition," Sutherland will co-chair a session, "Stratigraphy II," with D. L. Zachry of the University of Arkansas, and Amsden will be co-chairman with R. L. Ethington, University of Missouri at Columbia, of a session covering paleontology and stratigraphy.

Johnson will also present a paper on "Permian Salt Deposits in the Texas Panhandle and Western Oklahoma." Sutherland will give a paper co-authored with Robert C. Grayson, Jr., and Grant D. Zimbrick, graduate students at OU, on "A Reevaluation of the Morrowan-Atokan Series Boundary in Northwestern Arkansas and Northeastern Oklahoma." Grayson will present a paper on "Depositional Environments and Conodont Biostratigraphy of the Wapanucka Formation (Lower-Middle Pennsylvanian), Frontal Ouachita Mountains, Oklahoma." Thomas L. Thompson, professor of petroleum geology in the School, will talk on "Southern Oklahoma Oil in the Context of Plate Tectonics."

Charles J. Mankin, director of the Oklahoma Geological Survey, plans to meet with several groups during the convention. His principal involvement will be with the AAPG Continuing Education Committee. Chairman of the group in 1971–73, Dr. Mankin has held continuing membership on this committee, which was formed in 1966 to advance the training of professional geologists as the science has progressed. He will also attend a meeting of the AAPG Committee on Academic Liaison, which was organized to provide closer cooperation between AAPG and academic institutions that offer programs compatible with the association's goals in advancing the science of geology and its relationship to exploration for petroleum and natural gas.

As one of seven coordinators, a member of the advisory committee, and editor for this region, Mankin will be working with a group at the convention involved in an AAPG project on Correlation of Stratigraphic Units in North America (COSUNA). The project is proceeding under a contract from the U.S. Geological Survey. Also, as national president of the American Geological Institute, Dr. Mankin will chair a meeting of the Board of Directors of that body, meeting in conjunction with the AAPG/SEPM convention.

An important component of the annual AAPG/SEPM national meetings is the offering of preconvention short courses and colloquia. Short courses will be offered April 8 and 9 on "Physical and Chemical Constraints on Petroleum Migration," "Facies Analysis and Its Role in Seismic Stratigraphic Interpretation," "Evaporites," and "Trace Fossils." Six colloquia to be held April 9 will cover carbonates, coastal sedimentation, computer technology, environmental geology, evaporites, and fusulinids.

For further information, contact AAPG Headquarters, P.O. Box 979, Tulsa, Oklahoma 74101 (phone, 918—584-2555).

USGS Issues Maps on Transportation of Energy

The U.S. Geological Survey recently published a series of 19 maps illustrating the movement and methods of transportation for oil, gas, coal, nuclear-fuel materials, electricity, and other forms of movable energy in the United States. The maps were part of a report by the Senate Committee on Energy and Natural

Resources and the Senate Committee on Commerce, Science and Transportation and were prepared jointly by the USGS and the Congressional Research Service of the Library of Congress. Most of the maps are based on 1974 data, with some based on 1975 data. They are printed on 19- × 28-inch sheets at a scale of 1:7,500,000 (1 inch equals 118 miles).

Maps include: no. 1–421, *Natural Gas Movement by Pipelines: 1974*; no. 6–426, *Coal Resources and Distribution: 1974*; no. 11–431, *Total Crude Oil Movement: 1974*; and no. 19–439, *Total Interstate Energy Movement: 1974*. The cost is $1.50 per map, and the maps can be purchased from the USGS Branch of Distribution, Box 25286, Building 41, Federal Center, Denver, Colorado 80225.

AAPG Announces Recent Publications

Three recent publications from The American Association of Petroleum Geologists are of a broad range of interest.

Seismic Stratigraphy—Applications to Hydrocarbon Exploration, Charles E. Payton, editor, Memoir 26. This publication is the result of the First Research Symposium on Seismic Stratigraphy held at the 1975 AAPG annual meeting and from the school on seismic stratigraphy operated jointly by AAPG and the Society of Exploration Geophysicists. Price: members (AAPG-SEPM), $18; nonmembers, $22.

Reefs and Evaporites—Concepts and Depositional Models, James H. Fisher, editor, Studies in Geology 5. This 204-page book gives opposing theories and models of reef and evaporite formation. Price: members (AAPG-SEPM), $15; nonmembers, $18; catalog number, 804.

Fracture-Controlled Production, John R. Kostura and John H. Ravenscroft, compilers, Reprint Series 21. A valuable reference for geologists working in fractured reservoirs, this publication is a compilation of 13 papers from 1949–73 AAPG Bulletins and Memoirs 16 and 18. Price: members (AAPG-SEPM), $5; nonmembers, $6; catalog number, 770.

Publications are available from AAPG, P.O. Box 979, Tulsa, Oklahoma 74101.

U.S. Department of Energy Issues Uranium-Geology Reports

The Grand Junction, Colorado, office of the U.S. Department of Energy (DOE) has issued two reports on uranium. *Preliminary Favorability for Uranium in Northeastern Oklahoma and Southeastern Kansas* presents results of a study of Pennsylvanian and older rock units in northeastern Oklahoma and southeastern Kansas. The major structural features in this region are the Nemaha anticline, the Ozark uplift, and the Cherokee basin.

Uranium Favorability of Southwestern Oklahoma and North-Central Texas represents the results of an assessment of the uranium favorability of rocks of

Late Pennsylvanian and Early Permian age in southwestern Oklahoma and north-central Texas. Mapping of subsurface depositional systems was the main emphasis of the study.

Both reports were prepared by Bendix Field Engineering Corp., operating contractor for DOE's Grand Junction facility. The first report, 13 pages, GJBX-84(77), dated November 1977, and the second report, 110 pages plus 11 plates, GJBX-75(77), dated October 1977, are on open file at the Oklahoma Geological Survey, 830 Van Vleet Oval, Norman, and can be purchased on microfiche from Bendix Field Engineering Corp., Technical Library, P.O. Box 1569, Grand Junction, Colorado 81501; the cost is $3.00 each.

Stratigraphic Atlas and Volume on Evolution of North America Issued

Two publications of general interest to geologists were issued recently by Princeton University Press.

Stratigraphic Atlas of North and Central America, by T. D. Cook and A. W. Bally, which represents the culmination of 60 years of work by exploration staff members of Shell Oil Co., contains 192 maps showing types and distribution of specific stratigraphic units. Underlying stratigraphy, radiometric dates, and hydrocarbon reservoirs are also shown, and references are included for each map. The atlas also contains 14 stratigraphic sections and 21 cross sections. The price is $50.00 clothbound and $15.00 spiral-bound.

Also, Philip B. King's *The Evolution of North America* has been issued by the press in a thoroughly revised edition. This volume combines the historical and regional geology of North America, with a view to evaluating the role of the various regions in the evolution of the continent. The 216-page illustrated second edition is evailable in cloth for $25.00; paperbound copies are $9.50.

These books can be ordered from Princeton University Press, Box A, Princeton, New Jersey 08540. Orders of $25.00 or less should be prepaid.

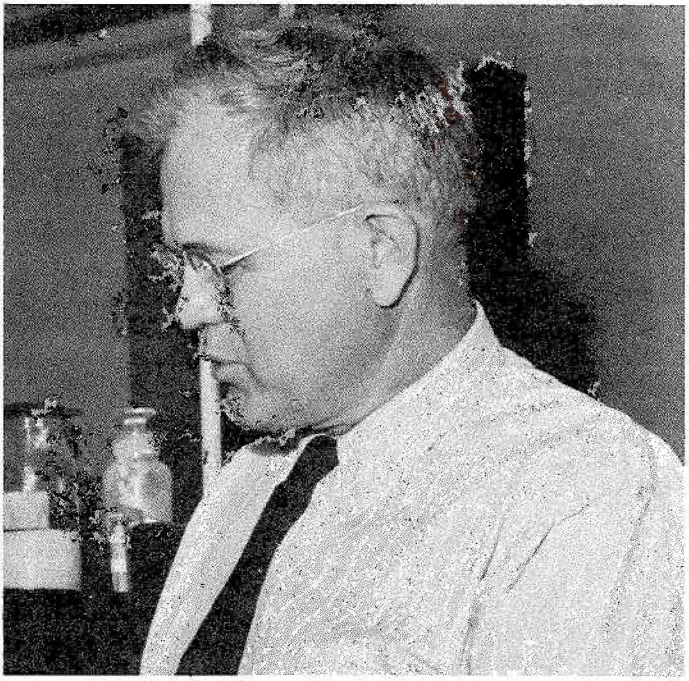
Kansas Bibliography Released

A cumulative *Bibliography and Index of Kansas Geology Through 1974,* compiled by the American Geological Institute, has been published by the Kansas Geological Survey as Bulletin 213.

The 61 pages of bibliographic entries in triple columns are indexed in detail by subject matter, counties, and rock units. An outline map showing Kansas counties is incorporated for convenience, as are a generalized geologic map and a cross section of the state.

This publication should be of great interest as a valuable and time-saving tool to anyone seeking geological information on Kansas and surrounding areas. It can be obtained from the Kansas Geological Survey, 1930 Avenue A, Campus West, Lawrence, Kansas 66044. The price is $3.50.

MALCOLM CHRISTIE OAKES
(1890–1977)



Malcolm C. Oakes, long-time geologist with the Oklahoma Geological Survey and a stalwart in the annals of Oklahoma geology, died July 3 of last year.

Malcolm Oakes' period of service with the Oklahoma Geological Survey may never be equaled. He was with the OGS for a total of 42 years—25 years on a full-time professional basis and 17 more years as a half-time consultant. He served under 5 of the 7 directors the Survey has had in its 70-year history, working under Charles W. Shannon in his initial appointment, then under Robert H. Dott until Dott resigned in 1952. William E. Ham was acting director during 1952–54, and Carl C. Branson, from 1954 to 1967. Most recently Oakes served under Charles J. Mankin, who was named director in 1967. The only OGS directors who antedated Malcolm Oakes were Charles N. Gould and D. W. Ohern.

He was a 53-year member of The American Association of Petroleum Geologists and a 31-year fellow of The Geological Society of America. He was a member of the American Association for the Advancement of Science, American Geophysical Union, Oklahoma Academy of Science, Oklahoma City Geological Society, and Tulsa Geological Society.

Oakes was known for his broad knowledge of Oklahoma geology and the