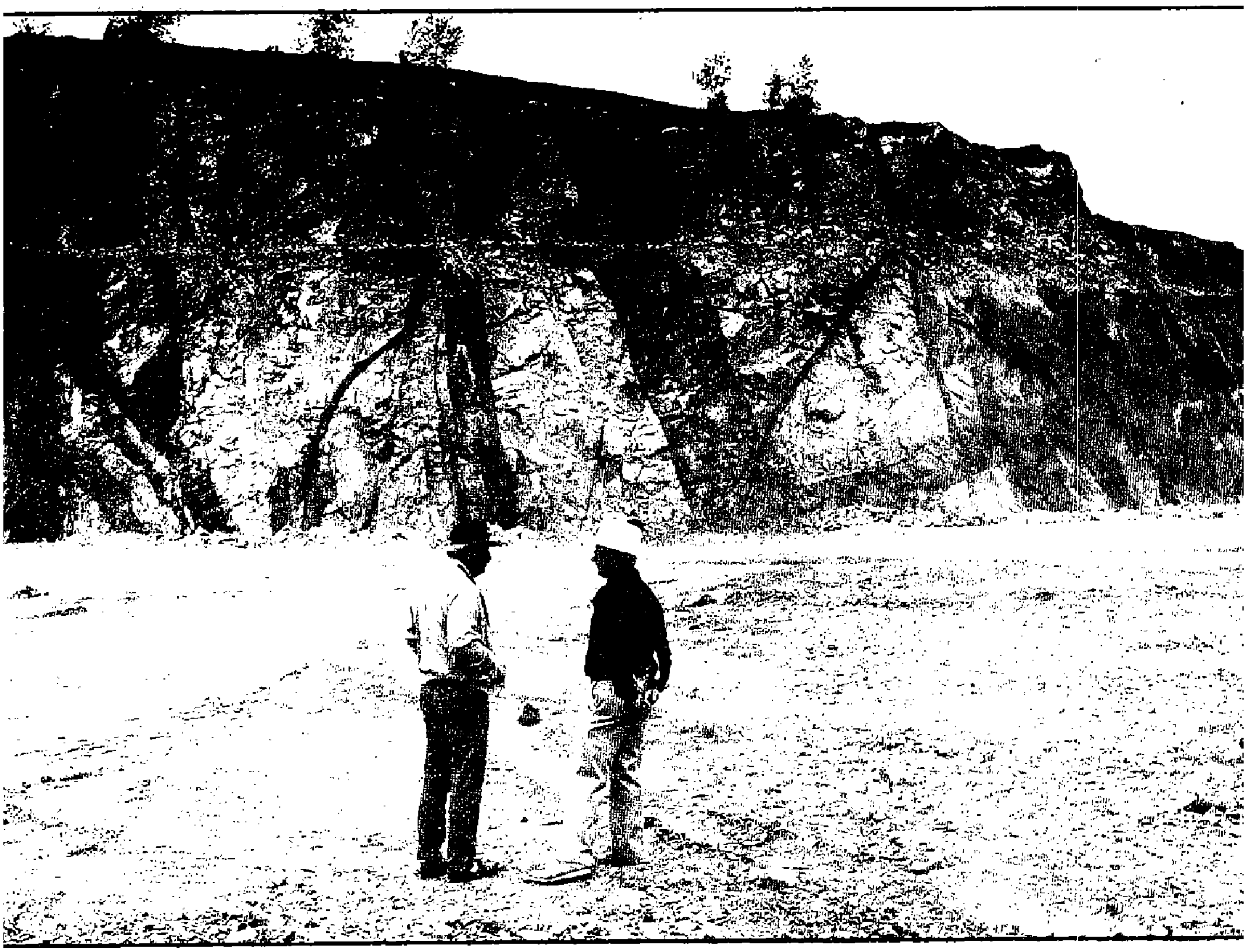
OKLAHOMA GEOLOGY



December, 1994

Vol. 54, No. 6

On The Cover —

Meridian Quarry, Johnston County, Oklahoma

Meridian Quarry, south of Mill Creek, Johnston County, Oklahoma (secs. 20 and 29, T. 2 S., R. 5 E.). This quarry is mining the Proterozoic Troy Granite (~1.4 Ga) and the included dikes for railroad ballast. A spectacular series of large, diabase dikes cuts through the granite and partially melted and recrystallized wall rock. Some of the dikes are multiple, most are steeply dipping, but some are intruded at low angles, and many show branching relations. The quarry wall is 20–30 m high. Ralph Weaver of Davis, Oklahoma, and Prof. C. W. Harper, Jr., School of Geology and Geophysics, University of Oklahoma, are discussing the field relationships.

M. Charles Gilbert
University of Oklahoma

OKLAHOMA GEOLOGICAL SURVEY

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OKLAHOMA GEOLOGY Notes

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VOL. 54, NO. 6

Petroleum Technology Transfer Council Program Due to Begin

Charles J. Mankin[1] *and Mary K. Banken*[2]

The Oklahoma Geological Survey (OGS), in cooperation with Geological Information Systems (GIS) and the Oklahoma Commission on Marginally Producing Oil and Gas Wells (MWC), will initiate the Petroleum Technology Transfer Council (PTTC) Program for the South Mid-Continent Region in January 1995. This effort is part of a national program to provide information and technical assistance to the domestic petroleum industry and is funded in part through a grant from the U.S. Department of Energy. The South Mid-Continent Region, including the states of Arkansas and Oklahoma, is one of 10 U.S. oil- and gas-producing regions involved in this program.

Initial development of the Oklahoma portion of the program is scheduled with the execution of the contract in January 1995. The Arkansas portion of the program is scheduled to begin during 1996. However, to facilitate development next year, planning with representatives from Arkansas will begin in 1995.

The Oklahoma portion of the program will involve personnel from the two State agencies (OGS and MWC) and from an organized research unit (GIS) at the University of Oklahoma. The responsibilities of each unit are as follows:

Charles J. Mankin	OGS	General administration and resource center technical assistance
Mary Banken	GIS	Digital-data development and computer-system management
Jack Shadle	MWC	Information and technology transfer programs

Staff members from the three organizations will be involved in various elements of the project. Those with particular and continuing responsibilities include Michelle Summers (OGS), Workshop Coordinator; Jane Weber (OGS), Geosystems Extension Laboratory Supervisor; Connie Smith (OGS), Public Information and Newsletter Editor; Rob Moody (GIS), Information Technology Manager; David Brown (GIS), User Technical Support; and Michael Earls (MWC), Education Coordinator.

Program Oversight

Oversight for the program in each region is provided by a Petroleum Advisory Group (PAG). The PAG for the South Mid-Continent Region is a 40-member body of operators and company representatives from Oklahoma and Arkansas. Mr. L. O. Ward from Enid, Oklahoma, is chair of the PAG for the South Mid-Continent Re-

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[1]Director, Oklahoma Geological Survey.

[2]Director, Geological Information Systems, University of Oklahoma.

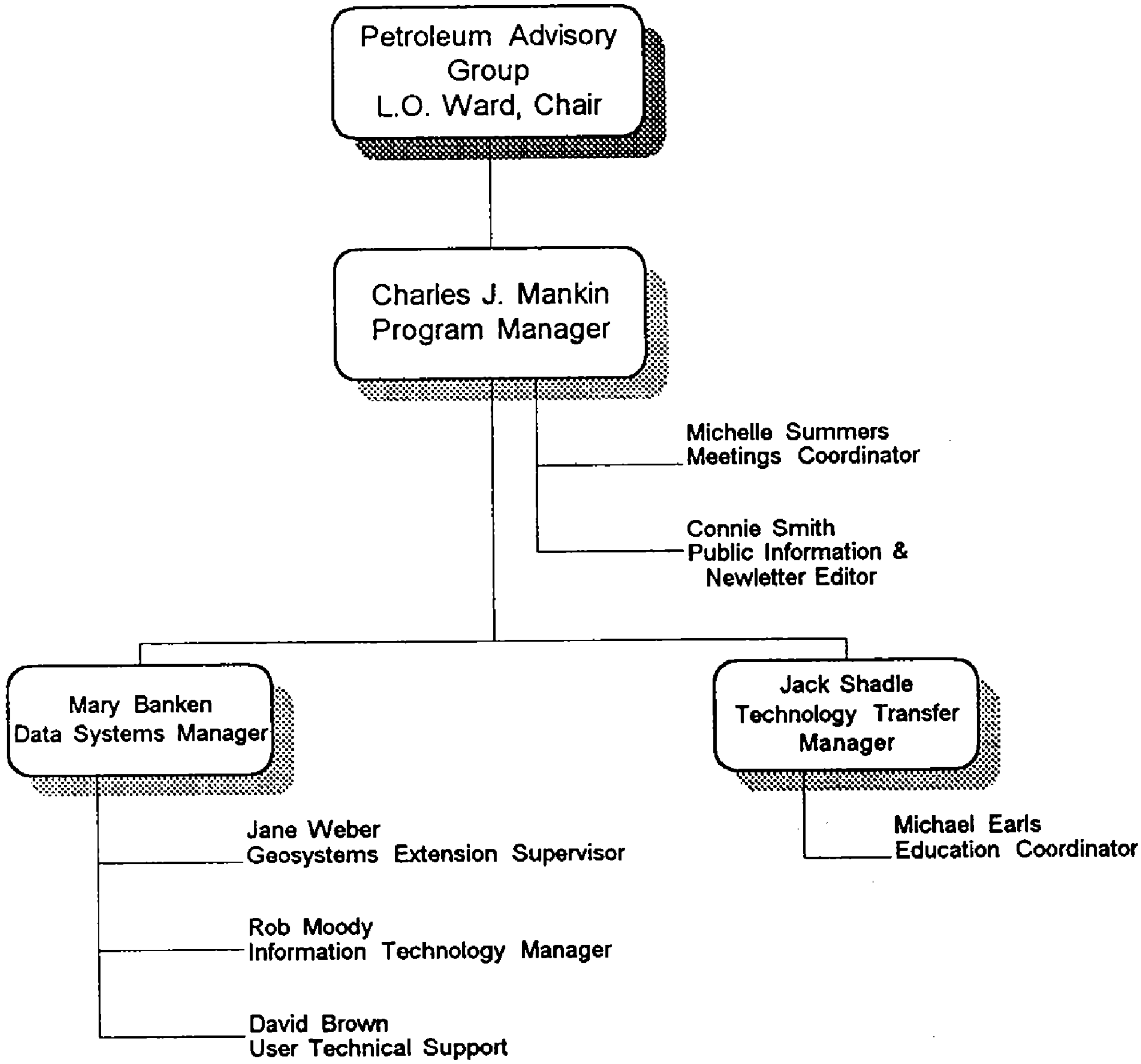


Figure 1. Organizational chart for the South Mid-Continent Region technology transfer program.

gion. An organizational chart depicting unit relationships and the identified responsibilities is shown in Figure 1.

PTTC Program Objectives

The objectives of the PTTC Program are to identify the primary information and technology needs of the domestic petroleum industry, to obtain or identify sources of that information and technology, and to disseminate those findings to the industry. The ultimate goal of the PTTC Program is to help the domestic petroleum industry to remain competitive with foreign sources of supply. While the world price of crude oil is established by those in control of large international supplies and cannot be influenced readily by domestic actions, finding and development costs *can* be affected by information and technology. Also, operators who become proactive in addressing environmental and health and safety concerns can save on costly remedial actions.

The PTTC Program is focused on the transfer of information and technology to petroleum operators, and other programs in the South Mid-Continent Region have similar goals. Examples include the natural-gas technology transfer program conducted by the Oklahoma Independent Petroleum Association through support from the Gas Research Institute; the University of Tulsa's technology transfer program as a part of their involvement with the management and operations contract for the U.S. Department of Energy's facilities at Bartlesville, Oklahoma; and petroleum-related work being conducted at the Sarkeys Energy Center at the University of Oklahoma. It is in the best interests of all concerned to coordinate our efforts and to cooperate where possible.

Workshops

The first step of the PTTC program within each region is a series of Problem-Identification Workshops at which operators can identify their priority information and technology needs. These workshops will be followed by Focused-Technology Workshops to address the priority concerns that the operators have identified. In addition to holding these workshops, each region is to establish a primary resource center and one or more satellite resource centers.

Resource Centers

Each primary resource center is to be a repository of regional petroleum information and technology, accessible to operators and other interested parties. Available information will include computerized files of petroleum statistics for the region; logs, cores, and samples; geoscience library holdings; case studies of reservoirs and fields; and descriptions of revelant petroleum technologies. Each primary resource center is to have adequate staff to address operators' inquiries on a timely and complete basis.

The satellite resource centers will be mini-versions of the primary resource centers and will contain duplicate material to the extent practical. In addition, each satellite resource center will be linked electronically to its primary resource center so that digital data can be transmitted on demand. Transfer of non-duplicable material (e.g., cores, samples, and limited editions of special studies) will be an important function of the satellite centers. The staff at the satellite centers will serve as facilitators to aid operators and other interested parties in using the resources of the program.

South Mid-Continent Region Program

The program for the South Mid-Continent Region is scheduled to begin in January 1995, with the first Problem-Identification to be held on Saturday, January 28, in the Sarkeys Energy Center on the campus of the University of Oklahoma. An announcement of that workshop has been mailed to each of the State's 5,300 operators. A second P-I workshop is scheduled for March at the Green Country Vocational Technical School in Okmulgee, Oklahoma.

These P-I workshops will be followed by Focused-Technology Workshops to be held in various parts of the region to facilitate operator participation in the program. Technology specialists will present the programs at the F-T workshops, and the format of each workshop will be tailored to provide for the most effective transfer of information and technology.

Resource Center Components

The primary resource center for the South Mid-Continent Region will be located at the OGS offices in the Sarkeys Energy Center on the campus of the University of Oklahoma and will be available for public access in April 1995. The components of this center include the Geosystems Extension Laboratory (a computer-user facility), the Youngblood Energy Library, the log library, and the core and sample library.

The Geosystems Extension Laboratory contains digital petroleum data files and the computer hardware and software to access and manipulate these data. The digital data files are contained in the Natural Resources Information System (NRIS), which has been under development by the OGS and GIS for several years. These files include Oklahoma oil- and gas-production data by lease for each month from 1979 to present, lease files, field files, and completion reports for all oil and gas wells of record. At present, more than 375,000 completion reports are on file; with the completion of Osage County within the year, more than 400,000 records will be available. Other files that will be added to the system include regional digital data from the recently completed natural gas atlas and the digital data that are being developed in connection with the study of fluvial-dominated, deltaic, light-oil reservoirs in Oklahoma. All of these data are accessible through a client-server network, with plans to permit future access through modems and remote-access networks such as Internet.

National digital data also will be incorporated into the computer-user laboratory through arrangements to be developed by the national PTTC organization with the U.S. Department of Energy and other data providers. Such data will include drilling, completion, production, and consumption information as well as appropriate special studies.

The hardware and software in the laboratory will allow access to the data in the system and will provide capabilities to manipulate that data to produce tables, maps, reports, and other analytical results. Thus, an operator who has sufficient computer skills can use the laboratory to develop maps of fields and enhance those maps with information from various studies. For those operators who do not have such skills, professional center staff can provide limited assistance in the generation of such products. Or, operators can use their own consultants to accomplish such tasks.

In the future, high-end workstations will be added to the computer-user laboratory to facilitate reservoir-simulation studies and, perhaps, allow limited capabilities in reservoir-level geophysical processing. The center does not anticipate developing full-scale geophysical processing capabilities because that area is well developed in the private sector. Other capabilities will depend upon the needs identified by the operators and other users of the laboratory.

The Youngblood Energy Library, located in Sarkeys Energy Center, is the repository for more than 88,000 volumes in the earth sciences and more than 136,000 topographic and geologic maps. The Library specializes in energy-related materials and has extensive holdings for Oklahoma, the rest of the U.S., and major oil- and gas-producing regions around the world. Reference materials of special interest include Petroleum Abstracts and the CD-ROM version of GeoRef. While the University of Oklahoma has initiated a special fee of $50.00 for non-university users of the library system, the Youngblood Energy Library has been exempt from that fee because of the extensive holdings of OGS material and support provided by the Survey. Access to Youngblood Energy Library materials can be obtained either in person or by interlibrary loan through the satellite resource centers or other participating libraries.

The OGS maintains two additional libraries that are of value to operators: the core and sample library and the log library. The core and sample library currently houses 76,542 boxes of cores from 3,310 wells in Oklahoma and more than 83,000 boxes of samples from more than 33,500 wells in the State. A computerized data system is in place for the core collection that permits searches for core materials by operator, geographic, and stratigraphic locations. A similar system is being developed for well samples. This computerized information is being incorporated into NRIS and will be available through the Geosystems Extension Laboratory.

Other data files available through the primary resource center include technical reports produced through the U.S. Department of Energy's Bartlesville Project Office. This Fossil Energy series contains technical descriptions of DOE-funded projects on the development of information and technology directed at improved oil recovery. Another document series, Advanced Fossil Energy Technologies, produced by the Office of Scientific and Technical Information of the U.S. Department of Energy, contains abstracts on a variety of developing fossil energy technologies concerned with coal, petroleum, and natural gas.

Satellite Centers

Two South Mid-Continent Region satellite resource centers are scheduled to open during the first three years of the program. The first satellite center will be developed in eastern Oklahoma (at a site yet to be determined) during the second year of the program. That center will have access to all of the resources of the primary center either on-line or through an interlibrary-loan process. The satellite center also will have the computer facilities to carry out many of the same tasks as the primary resource center. While some specialized software may not be available at a satellite center, arrangements will be made to transmit the results of specialized work to that center.

The second satellite center is planned for Arkansas (at a site yet to be determined) during the third year of the program. (Efforts are being made to accelerate that schedule to provide operators in Arkansas with capabilities similar to those available to Oklahoma operators now.) Unfortunately, the data files in Arkansas are not computerized to the same degree as those in Oklahoma, which will limit the capability of a satellite center to respond to operator needs. A major task for this region is to find ways to make Arkansas and Oklahoma data compatible so operators can use information from both states in a seamless fashion. Such a capability would greatly enhance the oil and gas development of the region.

Other planned activities for the region include the development of both a newsletter and an electronic bulletin board to provide information on activities and technical developments of interest to operators. The program goals for the National PTTC Program include Internet links to permit high-speed interchange of electronic data and analytical results among the regional resource centers as well as the rest of the world.

Accessing the Resource Center

Public access to the primary resource center located at the office of the Oklahoma Geological Survey will begin in February 1995, either in person or by phone. The offices of the OGS are in the basement of the Sarkeys Energy Center in Room N-131 (northeast corner of the building). Individuals who wish to come to the center should be advised that parking may be a problem. Limited parking space for visitors is available in the Sarkeys Energy Center lot located east of the building.

The receptionist in the main office of the OGS is responsible for obtaining the services of one of the assigned staff to respond to requests for information and/or technical assistance from the primary resource center of the PTTC Program. When the Geosystems Extension Laboratory opens in April 1995, technical assistance will be available to guide the experienced computer user through the system. Training sessions on the use of the system will be offered to the novice computer user, but some computer capability will be necessary to receive full benefit from these training sessions.

Phone requests will be directed by the OGS to the assigned staff for response. Access by phone can be either through the OGS regular number (405) 325-3031, by FAX (405) 325-7069, or through the new toll-free number (800) 330-3996 (for those that live outside the local calling area and within Oklahoma or one of the surrounding states).

Details for modem access to the electronic bulletin board through the computer-user laboratory have not been developed. That information will be available when the laboratory opens for public use in April.

Public Commitment

The Petroleum Technology Transfer Council Program is becoming a reality. Success of the first step of the program depends upon the willingness of operators to participate actively in identifying information and technology needs for the domestic industry. Without that participation and a successful first step, the entire effort is bound to fail. The second step, and "proof of the pudding," is the response to these identified needs by the regional lead organizations. The Oklahoma Geological Survey and its companion organizations are committed to fulfilling that second step, and we look forward to working with operators and other interested parties in the realization of the goals of the PTTC Program.

GUIDEBOOK 29. ***Geology and Resources of the Eastern Ouachita Mountains Frontal Belt and Southeastern Arkoma Basin, Oklahoma,*** edited by Neil H. Suneson and LeRoy A. Hemish. 294 pages. Price: $16.

From the editors' preface:

This guidebook provides an introduction to new research on the geology and mineral resources of the southern part of the Arkoma basin and the northern part of the Ouachita Mountains in southeastern Oklahoma and adjacent Arkansas. The guidebook is divided into two parts: a road log for a two-day field trip that begins and ends at the Robert S. Kerr Conference Center in Poteau, Oklahoma, and contributed research papers. The focus of the field trip is the area within the perimeter marked by Poteau, Red Oak, Talihina, and the Talimena Drive in Oklahoma. The structure and stratigraphy of Carboniferous strata within the area, as well as energy resources in the region, are emphasized. Contributed papers by industry, academic, and government geologists represent the variety of important new research that is being done in the Arkoma basin and Ouachita Mountains.

This guidebook includes several of the region's historical and archaeological aspects. They are included because we believe that most geologists are curious about the landscape and its history, whether that history goes back 100 years or 100 million years.

Most of the field-trip area has been mapped recently at a scale of 1:24,000 by the Oklahoma Geological Survey (OGS). The mapping was funded by the OGS and the U.S. Geological Survey (USGS) as part of the USGS COGEOMAP (Cooperative Geologic Mapping) program that involved the OGS, USGS, and the Arkansas Geological Commission. More recently, the mapping was completed as part of the USGS STATEMAP program.

CIRCULAR 96. ***Geohydrology and Water Quality of the Roubidoux Aquifer, Northeastern Oklahoma,*** by Scott C. Christenson, David L. Parkhurst, and Roy W. Fairchild. 70 pages. Price: $4.

From the authors' abstract:

The Roubidoux aquifer is an important source of fresh water for public supplies, commerce, industry, and rural water districts in northeastern Oklahoma. Ground-water withdrawals from the aquifer in 1981 were estimated to be 4.8 million gal/day, of which ~90% was withdrawn in Ottawa County. Wells drilled at the beginning of the 20th century originally flowed at the land surface, but in 1981 water levels ranged 22–471 ft below land surface. A large cone of depression has formed as a result of ground-water withdrawals near Miami. Wells completed in the Roubidoux aquifer have yields that range from ~100 to >1,000 gal/min.

Analyses of water samples collected between 1980 and 1983 as part of this study and of water-quality data from earlier work indicate that a large areal change in major-ion chemistry occurs in ground water in the Roubidoux aquifer in northeastern Oklahoma. The ground water in the easternmost part of the study unit has relatively small dissolved-solids concentrations (<200 mg/L), with calcium, magnesium, and bicarbonate as the major ions. Ground water in the westernmost part of the study unit has relatively large dissolved-solids concentrations (>800 mg/L), with sodium and chloride as the major ions. A transition zone of intermediate sodium, chloride, and dissolved-solids concentrations exists between the easternmost and westernmost parts of the study unit.

Three water-quality problems are apparent in the Roubidoux aquifer in northeastern Oklahoma: (1) contamination by mine water, (2) large concentrations of sodium and chloride, and (3) large radium-226 concentrations.

SPECIAL PUBLICATION 94-3. ***Coal Geology of Okmulgee County and Eastern Okfuskee County, Oklahoma***, by LeRoy A. Hemish (with an underground coal mine map by Samuel A. Friedman). 86 pages, 8 oversized plates. Price: $14.

Author's abstract:

Okmulgee and Okfuskee Counties are located in the west-central part of the coal belt of northeastern Oklahoma. About 836 mi^2 of the 986 mi^2 underlain by coal-bearing strata of Desmoinesian and Missourian (Pennsylvanian) age in the two counties are in the shelf area. About 150 mi^2 are in the Arkoma basin. Remaining resources of coal in the two-county area total 496,088,000 tons (all tonnage figures are in short tons), and reserves total 15,707,000 tons. Methods used to classify and calculate resources and reserves are adaptations of standard methods used by the U.S. Bureau of Mines and the U.S. Geological Survey, as modified by Friedman (1974).

Four coal beds in Okmulgee and Okfuskee Counties are of minable thickness. They are (in stratigraphically ascending order): Mineral (Morris) coal, with reserves of 5,056,000 tons; Croweburg (Henryetta) coal, 10,185,000 tons; Dawson coal, 387,000 tons; and Tulsa coal, 79,000 tons.

Coals of the area are predominantly of high-volatile A bituminous (hvAb) and high-volatile B bituminous (hvBb) in rank. The Croweburg coal has the greatest potential for utilization because of its superior quality and greater bed thickness. More than 100 analyses indicate that the Croweberg coal averages 8.8% ash and 2.6% sulfur on an as-received basis. On the moist, mineral-matter-free basis, the Croweburg coal averages 13,753 Btu/lb. The other coals all have higher ash and sulfur contents, and lower heat values.

The Oklahoma Department of Mines has recorded a total of 32,664,742 tons taken from underground mines and strip mines in Okmulgee County since the first production of coal was reported in 1908. No production of coal has ever been reported officially from Okfuskee County, although there are old, abandoned mines in the southeastern part of the country. Production of coal from Okmulgee County for the year 1989 was only 45,497 tons, from one small stripping operation and a new underground mine in the Croweberg coal that opened late in the year.

Guidebook 29, Circular 96, and SP 94-3 can be purchased over the counter or by mail from the Survey at 100 E. Boyd, Room N-131, Norman, OK 73019; phone (405) 325-3031 or (800) 330-3996; fax 405-325-7069. Add 10% to the cost of publication(s) for mail orders, with a minimum of 50¢ per order.

UPCOMING *Meetings*

Impact of Hazardous Air Pollutants on Mineral Producers and Coal-Burning Plants, Regional Conference, March 19–21, 1995, Lexington, Kentucky. Information: Mary Lou Johnson, Kentucky Geological Survey, 228 Mining and Mineral Resources Bldg., University of Kentucky, Lexington, KY 40506; (606) 257-2846.

National Fossil Exposition XVII, April 7–9, 1995, Macomb, Illinois. Information: Gilbert Norris, 2623 34th Ave. Ct., Rock Island, IL 61201; (309) 786-6505.

American Institute of Professional Geologists/Oklahoma Geological Survey, Joint Conference, April 21–23, 1995, Norman, Oklahoma. Information: Michelle Summers,Oklahoma Geological Survey, 100 E. Boyd, Room N-131, Norman, OK 73019; (800) 330-3996, fax 405-325-7069

Water in the 21st Century Symposium, April 23–26, 1995, Salt Lake City, Utah. Information: American Water Resources Association, 5410 Grosvenor Lane, Suite 220, Bethesda, MD 20814; (301) 493-8600, fax 301-493-5844.

Application of Geophysics to Engineering and Environmental Problems, 8th Annual Symposium, April 23–27, 1995, Orlando, Florida. Information: EEGS, Mark Cramer, P.O. Box 4475, Englewood, CO 80155; (303) 771-6101.

Geology of Industrial Minerals, 31st Forum," April 23–29, 1995, El Paso, Texas. Information: Gretchen Hoffman, New Mexico Bureau of Mines and Mineral Resources, Campus Station, Socorro, NM 87801; (505) 835-5640, fax 505-835-6333.

Pipeline Conference, April 24–26, 1995, Dallas, Texas. Information: American Petroleum Institute, 700 N. Pearl St., Suite 1840, Dallas, TX 75201; (214) 953-1101.

In-Situ and On-Site Bioreclamation, 3rd International Symposium, April 24–27, 1995, San Diego, California. Information: Betty Weaver, Symposium Coordinator, The Conference Group, 1989 W. Fifth Ave., Suite 5, Columbus, OH 43212; 1-800-783-6338, fax 614-488-5747.

SEPM Permian Basin Section, Annual Field Trip, "The San Andres Formation in Outcrop and Subsurface," April 28–30, 1995, Sacramento and Guadalupe Mountains, New Mexico. Information: Debbie Osborne, Texaco, P.O. Box 3109, Midland, TX 79702; (915) 688-2958.

International High-Level Radioactive Waste Management Conference, May 1–5, 1995, Las Vegas, Nevada. Information: American Nuclear Society, 555 N. Kensington Ave., La Grange Park, IL 60525.

Water Resources at Risk, May 14–18, 1995, Denver, Colorado. Information: Helen Klose, American Institute of Hydrology, 3416 University Ave., S.E., Minneapolis, MN 55414; (612) 379-1030.

Basement Tectonics, 12th International Conference, May 21–26, 1995, Norman, Oklahoma. Information: M. C. Gilbert, School of Geology and Geophysics, 810 Sarkeys Energy Center, University of Oklahoma, Norman, OK 73019; (405) 325-3253, fax 405-325-3140.

Ames Structure and Similar Features — A Workshop
Norman, Oklahoma, March 28–29, 1995

A workshop on the "Ames Structure and Similar Features," co-sponsored by the Oklahoma Geological Survey and the Bartlesville Project Office of the U.S. Department of Energy, will be held March 28–29, 1995, at the University of Oklahoma in Norman.

The Ames structure, located on the Anadarko basin shelf in northwestern Oklahoma, is a prolific source of oil and gas (>50 producing wells). Discovered in 1991, the Ames structure has generated much exploration and geologic interest. Ames is a circular-shaped structure, buried beneath >9,000 ft of sediments. It is 6–10 mi in diameter, and has a structural relief of ~600 ft. The structure has been interpreted as a meteorite-impact crater, a volcanic caldera, or a solution/collapse feature. The event occurred in Early Ordovician time (upper Arbuckle Group or lower Simpson Group) and influenced structure and sedimentation throughout the remaining Paleozoic Era, and possibly through Recent geologic time.

The final program and speakers are listed below:

March 28, Tuesday

The Ames Astrobleme, by Bruce N. Carpenter, Log Experts, Edmond, Oklahoma

Extraterrestrial Impact Craters: A Review, by Paul D. Lowman, Jr., Goddard Space Flight Center, Greenbelt, Maryland

Terrestrial Impact Structures: Basic Characteristics and Economic Potential, by Richard A. F. Grieve, Geological Survey of Canada, Ottawa, Ontario

Impact Cratering: The Mineralogical and Geochemical Evidence, by Christian Koeberl, University of Vienna, Austria

Global Hydrocarbon Potential of Impact Structures, by David B. Buthman, Unocal, Sugar Land, Texas

Source Rock Potential of Impact Craters, by John R. Castaño, DGSI, The Woodlands, Texas; James H. Clement, Consultant, Houston, Texas; Michael D. Kuykendall, Solid Rock Resources, Tulsa, Oklahoma; and Virgil Sharpton, Lunar and Planetary Institute, Houston, Texas

Prospecting for Buried Impact Craters Using Landsat and Radar Imagery, by P. Jan Cannon, Planetary Data, Tecumseh, Oklahoma

The Ames Crater Reservoirs and 3-D Seismic Development, by Robert W. Sandridge and Ken Ainsworth, Continental Resources, Inc., Enid, Oklahoma

The Ames Structural Depression: One of 15 Endogenic Cryptoexplosion Features Located Along a Zone of Transcontinental Transverse Shear, by Paul Denney, Global Exploration Consulting, Inc., Denver, Colorado; and John Coughlon, Tower Energy Corp., Denver, Colorado

Ames Depression, Oklahoma: Domal Collapse and Solution, by Dan Bridges, Aurora, Colorado

The Chestnut 18-4 Core: A Sample of Part of a Classic Impact Structure, by Fritz Fischer, Fischer Petrologic, Denver, Colorado; and Glenn Izett, Georgetown, Virginia

March 29, Wednesday

The Chicxulub Impact Basin, Yucatán, Mexico, by V. L. Sharpton, Lunar and Planetary Institute, Houston, Texas; and L. E. Marín, Universidad National Autonoma de Mexico, Mexico City, Mexico

The Wells Creek Structure: From Heaven or Hell?, by Herbert A. Tiedemann, U.S. Department of Energy, Bartlesville, Oklahoma

The Marquez Structure in Leon County, Texas, by Alan Wong, Jonathan Sadow, Arch Reid, and Stuart A. Hall, University of Houston, Texas; and Virgil L. Sharpton, Lunar and Plantary Institute, Houston, Texas

A Large 3,000-Year-Old Crater in Loess of Central Nebraska, by Wakefield Dort, Jr., Edward J. Zeller, and Larry D. Martin, University of Kansas, Lawrence, Kansas

"Haswell Hole," A Previously Unknown Impact Structure in Southeast Colorado, by S. Parker Gay, Applied Geophysics, Inc., Salt Lake City, Utah

Trapping Mechanisms in the Arbuckle Group Sediments of Eastern Major County, Oklahoma, by Jeffrey Heyer, Cross Timbers Production Co., Fort Worth, Texas

Satellite Data Use and Season/Sensor/Image Comparisons, Ames Hole, Oklahoma, by Dave Koger, Koger Remote Sensing Image Analysis, Fort Worth, Texas; and Mike Wiley, The Consulting Operation, Farmer's Branch, Texas

The Historical Development and Production of the Arbuckle and Exotic Lithologies at Ames, by Jim Evans, Ward Petroleum Corp., Enid, Oklahoma

Petrology, Mineralogy, Geochemistry, and Age of the Ames Structure, by Christian Koeberl, University of Vienna, Austria; W. U. Reimold, University of Witwatersrand, Johannesburg, South Africa; and Robert A. Powell, Universal Resources, Oklahoma City, Oklahoma

Reservoir Characterization of a Complex Impact Crater: "Ames Crater," Northern Shelf, Anadarko Basin, by M. D. Kuykendall, Solid Rock Resources, Tulsa, Oklahoma; C. L. Johnson, Petra Technologies, Tulsa, Oklahoma; and R. A. Carlson, DLB Oil and Gas, Oklahoma City, Oklahoma

Oil Creek–Arbuckle(!) Petroleum System, Major County, Oklahoma, by David K. Curtiss and David A. Wavrek, University of South Carolina–ESRI, Columbia, South Carolina

Organic Geochemical Characteristics of Oils and Possible Source Rocks from the Ames Impact Crater, by Paul Philp and Jon Allen, University of Oklahoma; and Jane Weber, Oklahoma Geological Survey, Norman, Oklahoma

The Hydrocarbon Potential of Precambrian Astroblemes, by Richard R. Donofrio, AGR, Inc., Danbury, Connecticut

Poster Session, March 28

Impact Structure or Volcanic Structure: The Results of Gravity and Magnetic Modeling of the Ames Structure, by Jud Ahern, University of Oklahoma, Norman, Oklahoma

Ames Crater Reservoirs and 3-D Seismic Development, by Robert W. Sandridge and Ken Ainsworth, Continental Resources, Inc., Enid, Oklahoma

A Core Workshop: The Chestnut 18-4 Core, by Fritz Fischer, Fischer Petrologic, Denver, Colorado; and Glenn Izett, Georgetown, Virginia

Petrographic, X-Ray Diffraction, and Electron-Microprobe Investigations of the Chestnut 18-4 Drill Core, 9014′–9037′ Interval, from the Ames Structural Anomaly, Major County, Oklahoma, by Clifford P. Ambers and M. Charles Gilbert, University of Oklahoma, Norman, Oklahoma

Experimental Constraints on Shock-Induced Microstructures in the Impact Deposits of the Ames Crater, by Alan R. Huffman, Exxon Exploration Co., Houston, Texas

Ames Hole Production and Structural Features Identified by Surface Geochemical Techniques, by Jim Tucker, Daniel Hitzman, and Brooks Rountree, Geo-Microbial Technologies, Inc., Ochelata, Oklahoma

Arcuate Growth Faults Help to "Relax" and Explain the Ames Structure, by Richard Banks, Scientific Computer Applications, Tulsa, Oklahoma; and Mike Kuykendall, Solid Rock Resources, Tulsa, Oklahoma

Oil and Gas Production and Drilling Developments in the Ames Area, Major County, Oklahoma, by Robert A. Northcutt, Oklahoma City, Oklahoma; and David Brown, University of Oklahoma, Norman, Oklahoma

Phyllocarid Crustaceans from the Oil Creek Shale, Lower Ordovician, Within the Ames Structure, by J. T. Hannibal, Cleveland Museum of Natural History, Cleveland, Ohio; and R. M. Feldmann, Kent State University, Kent, Ohio

Origin and Potential Regional Significance of a Distinctive Gamma-Ray Marker Interval in Lower Ordovician (West Spring Creek Formation) Dolomite of the Wilburton Area, Latimer County, Oklahoma, by Paul K. Mescher, Consulting Geologist, Plano, Texas; and Douglas J. Schultz, ARCO International, Plano, Texas

The Big Basin Impact Craters of Western Kansas, by P. Jan Cannon, Planetary Data, Tecumseh, Oklahoma

The Calvin Impact Crater, Cass County, Michigan: Identification and Analysis of a Subsurface Ordovician Astrobleme, by Randall L. Milstein, Oregon State University, Corvallis, Oregon

Structure of the Kentland Dome, Northwest Indiana, by Mark A. Keys, Purdue University, West Lafayette, Indiana

Wells Creek Structure—Technical Data, by Herbert A. Tiedemann, U.S. Department of Energy, Bartlesville, Oklahoma

Red Creek Impact (Precambrian), Eastern Uinta Mountains, Northeast Utah: 125 Years of Mistaken Identity, by Howard R. Ritzma, Consulting Geologist, Salt Lake City, Utah

Ames Structure Reflected in Overlying Permian Strata, by Kenneth S. Johnson and Dorothy Smith, Oklahoma Geological Survey, Norman, Oklahoma

Advance registration (prior to March 3) is $50, which includes two lunches and a copy of the proceedings. Late and on-site registration will be $65 per person. Lodging will be available on the Ou campus or at local motels.

For more information, contact Kenneth S. Johnson or Jock A. Campbell, General Chairs, Oklahoma Geological Survey, University of Oklahoma, 100 E. Boyd, Room N-131, Norman, OK 73019; phone (405) 325-3031 or (800) 330-3996, fax 405-325-7069. To request registration forms, contact Linda Nero or Tammie Creel at the same location and numbers.

GSA South-Central and North-Central Sections Joint Annual Meeting
Lincoln, Nebraska ◆ April 27–28, 1995

The South-Central and North-Central sections of the Geological Society of America will meet in the Nebraska Center for Continuing Education and the East Campus Student Union at the University of Nebraska, Lincoln. The meeting will be hosted by the Conservation and Survey Division (Nebraska Geological Survey), the Department of Geology, and the University of Nebraska State Museum of the University of Nebraska, Lincoln; the Geography and Geology Department of the University of Nebraska, Omaha; the Nebraska Geological Society; the Omaha office of Woodward-Clyde Consultants; and the Department of Geology, Kansas State University. Societies that will meet in conjunction with the combined section meeting include the Pander Society; North-Central and South-Central sections of the Paleontological Society; Texas, Mid-Continent, and North-Central sections of the National Association of Geology Teachers; and Great Lakes and Midcontinent sections of the Society for Sedimentary Geology.

The following agenda is planned:

Symposia

Cyclic Sedimentation in Carboniferous and Permian Strata of North America: Sequence Stratigraphy, Biostratigraphy, and Paleoecology
Geoarchaeological Research in Fluvial and Eolian Depositional Environments
Quaternary Eolian Deposits of the Midcontinent: Loess, Sand, and Ash
Remote Sensing and GIS for Water-Quality Assessment
Perspectives on Urban Geology: Principles, Educational Needs, and Case Studies
College-Related Earth Science Educational Activities for K–12 Schools
Ogallala Group and Younger Neogene Geology
Chemical Dispersions in Hydrologic Systems
Geology of the Garbage Heap: Waste Sites and Waste Siting
Modern and Ancient Lake Environments of the Great Plains
Great Plains Neogene Tectonism
Occurrence, Transport, and Transformation of Pesticides and Nutrients in Surface and Ground Waters
Genesis and Morphology of Paleosols
Cretaceous Rocks of the Midcontinent
Environmental Regulations and the Regulated Community: Impacts and Responses
Catastrophic Floods
Antarctic Paleoclimates and Paleoenvironments
Depositional Environments, Lithostratigraphy, and Biostratigraphy of the White River and Arikaree Groups
Interpreting Animal Behavior from the Fossil Record

Short Course

Field and Laboratory Techniques for Vertebrate Fossils: A Primer for Geologists

Field Trips

Late Pennsylvanian and Early Permian Biostratigraphy and Paleoecology in Richardson and Pawnee Counties, Nebraska
Late Quaternary Fluvial and Eolian Sediments: Loup River Basin and the Sand Hills of Nebraska
Quaternary Geology of Eastern Nebraska
Revision of White River Group Stratigraphy, Nebraska and South Dakota
Geology and Paleontology of Ashfall Fossil Beds (Miocene) of Northeastern Nebraska
Geology of the Ogallala/High Plains Regional Aquifer System in Nebraska
Late Quaternary Landscape Evolution in Eastern Nebraska
Environmental Geology of Douglas and Sarpy Counties (Omaha), Nebraska
Upper Pennsylvanian Paleosols, Lower Platte and Weeping Water Valleys, Southeastern Nebraska
Permian Strata in the Manhattan, Kansas, Area: Implications for Climatic and Eustatic Controls
The Crow Creek Member, Pierre Shale (Upper Cretaceous) of Southeastern South Dakota and Northeastern Nebraska: Impact Tsunamite or Basal Transgressive Deposit?

For further information about the meeting, contact R. F. Diffendal, Jr., Nebraska Geological Survey, 113 Nebraska Hall, University of Nebraska, Lincoln, NE 68588; (402) 472-7546. *The preregistration deadline is March 24.*

Industry Supports OU Programs

• **Conoco, Inc. of Houston**, contributor of $93,000 to support programs at the University of Oklahoma, was recognized during a special ceremony on OU's Norman campus. The DuPont subsidiary contributed the funds to 10 OU programs, including chemistry, biochemistry, engineering, and accounting. Since 1970, Conoco and DuPont have given more than $2.7 million to OU.

• **Phillips Petroleum Foundation Inc. of Bartlesville** has pledged a $5,000 challenge grant to the Youngblood Library. Claren Kidd, geology librarian and an associate professor of bibliography, is working with individuals and corporations to match the Phillips grant for a total of $10,000 in library acquisitions. The Phillips Foundation also donated $10,000 to the Oklahoma Museum of Natural History to help the museum expand its traveling exhibits program. During the 1994–95 academic year, Phillips has donated more than $84,000 to OU programs ranging from fine arts to engineering.

• **Exxon USA** has contributed $35,000 to OU to provide additional funding for special programs and equipment for the colleges of engineering, business administration, and geosciences.

AAPG Annual Convention
Houston, Texas, March 5–8, 1995

Welcome Spring in Houston! Join us for the AAPG Annual Convention, March 5–8, 1995. Make your plans now to attend and see for yourself the unexpected pleasures of Houston in March.

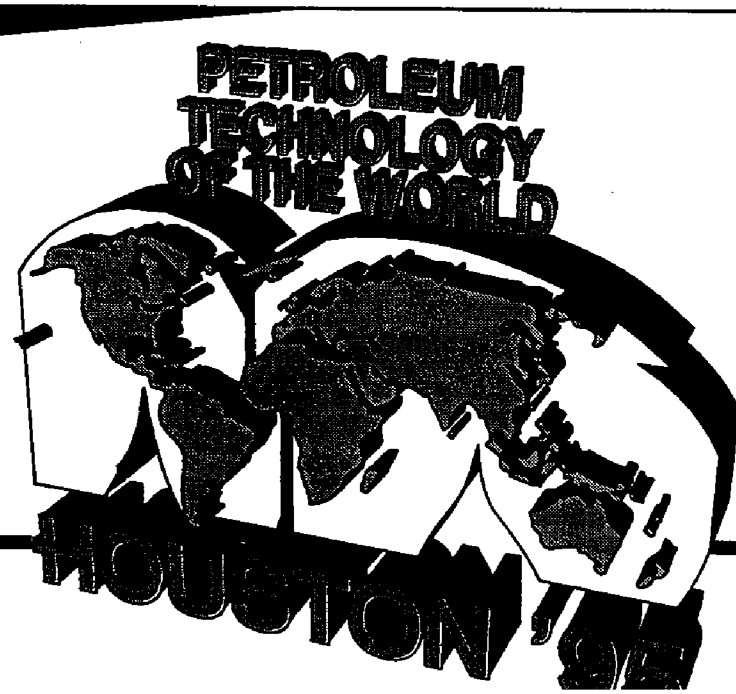
Strong technical sessions are scheduled, focusing on the international aspects of petroleum exploration. A morning and afternoon "World of Petroleum" session will be held each day of the convention, covering petroleum exploration and development in Africa, Central and South America, North America, the North Sea, the Middle East, the Asia Pacific region, and the former Soviet Union. Other technical sessions will cover 3-D seismic, U.S. salt tectonics, international salt tectonics, sequence stratigraphy, and the geologic character of hydrocarbon systems. A total of 42 oral technical sessions and 40 poster sessions will be presented covering these and other topics. Short courses and field trips will also be interesting and rewarding to attendees.

Denver started the International Pavilion, Prospect Gallery, and Deal Room, and those who visited these areas found them rewarding. Houston will continue this tradition by presenting opportunities for small independents with an interest in domestic and international petroleum exploration.

The Houston Geological Society invites you to come to Houston in March 1995 for professionally rewarding opportunities, renewed acquaintances, and plenty of entertainment.

James O. Lewis
General Chairman

Chuck Noll
General Vice Chairman



AAPG Annual Convention Agenda

Technical Program

Monday, March 6

AAPG Integrated Technology for Reservoir Quality Assessment and Prediction
AAPG Field Compartmentalization
AAPG World of Petroleum: Commonwealth of Independent States
AAPG Tectonics of the Gulf of Mexico
AAPG/SEPM Controls on Stratal Architecture in Tectonic Basins: Quantifying the Relative Roles of Sea Level, Climate, and Tectonics
DEG Spills and Leaks: Prevention and Clean Up
SEPM Using Depositional Facies Models to Better Define Hydrogeologic Systems
Our Industry: Past, Present, and Future *(film presentations)*
AAPG World of Petroleum: North Sea
AAPG Select Academic Research Topics (Student Session)
AAPG/APGE Surface Exploration for Oil and Gas
AAPG/SEPM High-Frequency Eustatic Cycles, Control on Depositional Processes
DEG Exploration, Production, and Injection Wells—Environmental Issues
SEPM The Positive Impact of Biostratigraphy: Resource Exploration and Exploitation
SEPM/AAPG Non-Marine Sequence Stratigraphy, Fluvial Response to Base-Level Change
The Mystery of 3-D Seismic *(film presentations)*

Tuesday, March 7

SEPM Basinwide Fluid-Flow Controls on Diagenetic Patterns
AAPG 3-D Techniques and Applications
AAPG World of Petroleum: Africa and the Middle East
AAPG/SEPM Exploration and Development of Carbonate Reservoirs
DEG Environmental Technology
DPA Reducing Dry Hole Risk (Maximizing Investments in Oil and Gas)
SEPM Research Symposia Part I: Stratal Architecture, Relative Sea Level and Exploration/Exploitation Significance
Exploration Geology/Geophysics *(film presentations)*
AAPG Geologic Character of Hydrocarbon Systems
AAPG World of Petroleum: Far East
AAPG/SEPM Deep-Water Sedimentation, Improved Models for Reservoir Prediction
EMD Exploration Results and Environmental Monitoring from Remote Sensing Systems
SEPM Research Symposia Part II: Sequence Stratigraphic Applications to Integrated Reservoir Management and Development
SEPM Organic Geochemistry—Solving Field Development, Surveillance, and Redevelopment Problems
That Amazing Salt *(film presentation)*
Environmental Issues *(film presentations)*

Wednesday, March 8

AAPG Abnormal Pressures
AAPG World of Salt Tectonics: USA
AAPG World of Petroleum: Central and South America
SEPM Effect of Eustatic Cycles on Diagenesis
SEPM Modeling Pore Fluid/Rock Interactions
SEPM/AAPG High-Resolution Sequence Stratigraphy of Modern Clastic Shelves and Slopes
SEPM/AAPG Carbonate and Evaporite Depositional Systems
Basin Development and Hydrocarbon Generation *(film presentations)*
AAPG Production from Deep-Water Reservoirs
AAPG Computers in Basin Modeling
AAPG Geology of Cuba
EMD World of Coal and Coalbed Methane
SEPM Hydrocarbon and Non-Hydrocarbon Natural Gas
SEPM Recent Advances in Paleontology, Paleoceanography, and Paleoecology
AAPG World of Salt Tectonics: International
AAPG/SEPM New, Innovative, and Unconventional Plays
Earth, Sea, and Sky *(film presentations)*

Short Courses

HGS Introduction to the 3-D Workstation, *March 4, 9, or 10*
HGS Buying Production—An Opportunity for Geologists, *March 4*
HGS Applications, Design, and Interpretation of 3-D Seismic for Geologists, *March 4*
HGS Low-Resistivity, Low-Contrast Productive Sands, *March 5*
HGS 3-D for Onshore Exploration and Production Enhancement, *March 5*
HGS Introduction to Cartography for Geoscientists, *March 9*
HGS Geologic Framework and Facies Architecture of the Mississippi River Delta Plain and Incised Valley, *March 9*
HGS Using Presentation Graphics—Visuals Make Your Presentation Come Alive!, *March 9*
AAPG Interaction Between Sedimentation and Salt Tectonics: An Application Workshop, *March 4–5*
AAPG Sequence Biostratigraphy Workshop, *March 4–5*
AAPG Application of Sequence Stratigraphy to Hydrocarbon Systems, *March 4–5*
AAPG Multidisciplinary Teams: How and Why They Make You Money, *March 9*
DEG Fundamentals of Federal Environmental Regulations—Impact on the Petroleum Industry, *March 2–3*
DEG Eight-Hour Health and Safety Refresher Course, *March 3*
DEG Fundamentals of Project Management for Environmental Professionals, *March 4–5*
DEG Geoscience in the Courtroom—A Joint Seminar for Earth Scientists and Attorneys, *March 4*
DPA Risk Analysis and Economics of Oil and Gas Prospects: An Overview, *March 4*
DPA Guiding Your Career as a Professional Geologist, *March 5*
EMD Detection of Subtle Basement Structures and Related Hydrocarbon Plays, *March 4*

EMD/GEOSAT Workshop: Exploration Applications of Remote Sensing, *March 5*
SEPM Clastic Facies and Sequence Stratigraphy for Graduate Students, *March 4–5*
SEPM Workshop on Hydrocarbon Reservoir Characterization—Geologic Framework and Flow Unit Modeling, *March 4–5*
SEPM Turbidites and Associated Deep-Water Facies, *March 5*
AAPG (Student Chapter) Introduction to 3-D Workstation Interpretation, *March 5*
SEG Environmental Geophysics, *March 5*

Field Trips

HGS Platform Carbonate Cycles and Third-Order Sequences, Lower Ordovician El Paso Group, El Paso, Texas, *March 3–4*
HGS United Salt Corporation's Hockley Salt Mine, Hockley, Texas, *March 4*
HGS Paleogene Sequence Stratigraphy and Sedimentology of the Brazos River Valley, Texas, *March 4*
HGS Overview of Freshwater Wetlands, *March 4*
HGS Walking Tour of Downtown Houston Building Stones, *March 5*
HGS Environmental Cruise Along the Houston Industrial Ship Channel, *March 5*
HGS Structural Styles and Evolution of the Marathon–Big Bend Region, West Texas, *March 8–12*
HGS Avery Island Salt Mine and Avery and Jefferson Islands, Louisiana, *March 8–9*
HGS Permian Reef Geology Trail, McKittrick Canyon Guadalupe Mountains: Facies, Depositional Models, and Sequence Stratigraphy, *March 8–11*
HGS Sequence Stratigraphy and Structural Geology of the Sierra Madre Oriental Foldbelt, Northeast Mexico, *March 9–12*
HGS Controls on Sequence Stacking and Fluvial to Marine Architecture in a Foreland Basin, Central Utah, *March 9–12*
HGS NPL Superfund Sites of Harris County, Texas, *March 10*
HGS Environmental and Engineering Geology of the Houston–Lower Trinity River Area, Texas, *March 11*
EMD Lignite Mines and Power Plants and Kaolinitic Sandstone Mining in East Texas, *March 9*
SEPM Recent Clastics Sedimentation and Applications to Sequence Stratigraphy in the Upper Texas Gulf Coast, *March 2–4*
GCS/SEPM Geology of the Llano Uplift, Central Texas, *March 3–5*
GCS/SEPM Holocene Coastal and Inner Shelf Deposits of the Upper Texas Gulf Coast—A Traveling Core Workshop, *March 9*
AAPG (Student Chapter) State-of-the-Art 3-D Seismic Methods and Drilling Technology: Western Geophysical Technological Laboratory, Alvin, Texas, and Chevron Services Company Drilling Technology Center, Humble, Texas, *March 4*

For further information about the annual meeting, contact AAPG Convention Dept., P.O. Box 979, Tulsa, OK 74101-0979; (918) 584-2555, fax 918-584-2274. The preregistration deadline is *January 23, 1995.*

Geologic Radon Potential of EPA Region 6; Arkansas, Louisiana, New Mexico, Oklahoma, and Texas

Prepared in cooperation with the U.S. Environmental Protection Agency, this 160-page USGS open-file report, edited by R. R. Schumann, assesses radon potential in each of the five states in EPA Region 6. The preliminary geologic radon potential assessment of Oklahoma is authored by J. K. Otton.

Order OF 93-0292-F from: U.S. Geological Survey, Earth Science Information Center, Open-File Report Section, Box 25286, MS 517, Federal Center, Denver, CO 80225. The price is $4 for microfiche and $24.50 for a paper copy; add 25% to the price for foreign shipment.

Water Resources Data—Oklahoma, Water Year 1993

Records on both surface water and ground water in Oklahoma are contained in this three-volume annual report by R. L. Blazs, D. M. Walters, T. E. Coffey, D. K. White, D. L. Boyle, and J. F. Kerestes. Specifically, it includes (1) discharge records for 135 streamflow-gaging stations and 23 partial-record or miscellaneous streamflow stations, (2) stage and content records for 30 lakes or reservoirs, (3) water-quality records for 58 streamflow-gaging stations, and (4) water-level records for 28 observation wells. Also included are lists of discontinued surface-water discharge and water-quality sites. Data for the Arkansas River basin are given in volume 1 (526 pages), and data for the Red River basin are given in volume 2 (235 pages). Volume 3 (available in the near future) will contain statewide miscellaneous water-quality data for water years 1991–93.

Order Water-Data Report OK-93-2 from: U.S. Geological Survey, Water Resources Division, 202 N.W. 66th St., Bldg. 7, Oklahoma City, OK 73116; phone (405) 231-4256, fax 405-843-7712. A limited number of copies are available free of charge.

Effects of Municipal Ground-Water Withdrawals on the Arbuckle-Simpson Aquifer, Pontotoc County, Oklahoma

The results of a study to evaluate the effects of municipal ground-water withdrawal from the Arbuckle-Simpson aquifer are presented in this 37-page USGS water-resources investigations report by Mark E. Savoca and DeRoy L. Bergman. The study was conducted by the U.S. Geological Survey in cooperation with the City of Ada and the Oklahoma Water Resources Board. A hydrogeologic map of the study area is included.

Order WRI 93-4230 from: U.S. Geological Survey, Water Resources Division, 202 N.W. 66th St., Bldg. 7, Oklahoma City, OK 73116; phone (405) 231-4256, fax 405-843-7712. A limited number of copies are available free of charge.

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

Post-Orogenic Denudation along the Ouachita Trend: Magnitude and Timing Constraints

JEFF CORRIGAN, PHILLIP CERVENY, and *STEVE BERGMAN*,
ARCO Exploration and Production Technology, Plano, TX 75075;
and *RAY DONELICK*, Donelick Analytical, Katy, TX 77084

Cretaceous and younger strata (Zuni and Tejas sequences) form a gulfward thickening veneer over a low relief erosional surface that caps much of the Ouachita orogen and parts of adjacent foreland areas. The sub-Zuni unconformity is in turn truncated by the present-day erosional surface inboard of the limit of Cretaceous exposures. We combine stratigraphic constraints imposed by these two regional erosional surfaces with cooling history information derived from new (Marathon, Llano, and Arbuckle uplifts) and previously published (Benton Hills uplift) apatite fission track data collected along exposed structural highs of the Ouachita trend to estimate the magnitude and timing of post-orogenic denudation.

Significant differences in the magnitude and timing of pre-middle Cretaceous unroofing are documented for areas analyzed. Localities within the Ouachita deformation zone (Marathon uplift, Benton Hills uplift) cooled from temperatures of 120±10°C at about 200±20 Ma to temperatures of approximately 30±10°C by Albian time (~115 Ma) for the Marathon area and by mid-Cenomanian time (~95 Ma) for the Benton Hills area. Cooling rates of 0.7–1.7°C/Ma during Jurassic to mid-Cretaceous time are estimated for both areas, corresponding to unroofing rates of 20–70 m/m.y. Data from the foreland localities (Llano and Arbuckle uplifts) imply deposition of ~800–1800 m of syn- to post-orogenic strata that was subsequently eroded prior to Albian time. Both foreland areas experienced late Permian(?) to Albian cooling and erosion rates on the order of 0.3–0.5°C/Ma and 10–20 m/m.y., respectively. Differences in the magnitude and rate of pre-middle Cretaceous denudation are consistent with position of sample localities relative to the deformation front and flexural rebound of foreland crust in response to orogen unroofing.

With the possible exception of the northern Benton Hills area, projection of the regional sub-Zuni unconformity over sample localities establishes that rocks now at the surface were within 0–500 m of the surface prior to Cretaceous deposition. Track length distributions from all samples require residence at temperatures of ~50°C after development of the sub-Zuni erosional surface, implying that ~1 km of Upper Cretaceous–Paleogene(?) strata was deposited across the entire Ouachita frontal trend and subsequently removed during later Tertiary time. Evidence that the southern mid-continent craton experienced denudation of a similar magnitude implies that this latter erosional episode is unrelated to flexural upwarping in response to loading of the passive margin.

Reprinted as published in the Geological Society of America, *1994 Abstracts with Programs*, v. 26, no. 7, p. A-72.

Progressive Changes in Siliciclastic Depositional Styles, Middle and Upper Pennsylvanian Cyclothems, Midcontinent, U.S.A.

ROBERT L. BRENNER, Dept. of Geology, University of Iowa, Iowa City, IA 52242

Middle through Upper Pennsylvanian strata in the Midcontinent record changes in sedimentary styles from terrigenous to marine process dominance. During the middle Pennsylvanian (e.g., Desmoinesian Cherokee Group) deltaic complexes were fluvially dominated with only minor effects of marine waves or tidal processes. Later in the Pennsylvanian, fluvial processes weakened in relation to marine processes, perhaps due to climatic changes affecting fluvial discharge. Upper Pennsylvanian cycles (e.g., Missourian Kansas City Group), contain intervals of laminated siltstone, shale, and flaser-bedded sandstones, suggesting that tidal processes became more dominant. Tidal influence continued to increase through the Late Pennsylvanian to the extent that estuarine deposits comprise much of siliciclastic deposits (e.g., upper Missourian–lower Virgillian Douglas Group).

Maximum regressive was generally marked by scoured surfaces formed as sea level dropped below regional base levels. Subsequent rise in sea levels, caused back-filing of scours with fluvial sands and conglomerates. Reduced flow rates within fluvial channels caused by sea level rise, resulted in lower sediment transportation rates, lower gradients, and abandonment of some channels. Coastal water tables rose as marine transgression progressed allowing the formation of laterally extensive peat bogs represented by coals that cap siliciclastic intervals. In some intervals, such as the Chanute Shale (Missourian Kansas City Group), an argillaceous, crinoidal limestone bed occurs at the coal horizon, with coal having developed on topographic highs over underlying fluvial-deltaic complexes, while limestone formed in marine waters that covered adjacent low-lying areas. Shallow marine muds were deposited over coals as marine waters inundated coastal peat bogs.

Reprinted as published in the American Association of Petroleum Geologists, *1994 Annual Convention Official Program*, p. 110.

Development of Coalbed Methane in the United States

MICHAEL J. McGUIRE, McGuire Geological Consultants, 899 S. Cole Dr., Lakewood, CO 80228

Methane has been produced from coalbeds in the United States since the early 1900s, however the significance of this resource has only been recognized during the past decade. Coalbed methane production has developed as an economic source of pipeline quality gas in several areas within the United States. Production of methane directly from coalbeds developed rapidly after the special tax credit for nonconventional gas resources was passed in 1980. In Section 29 of the 1980 Crude Oil Windfall Profits Tax Act, a tax credit was applicable to wells drilled after December 31, 1979, and before January 1, 1990. The qualification period was extended twice, for one year in the 1988 Technical and Miscellaneous Revenue Act, and for two years in the 1990 Budget Reconciliation Act. Wells drilled by the end of 1992 now receive the tax credit through the end of 2002. Commercial production of coalbed methane has been established in the San Juan, Black Warrior, Powder River, and Piceance basins. Important new drilling and potential commercial production are underway in the Central Appalachian basin, and the Arkoma and Cherokee basins. The natural gas present in coalbeds represent a substantial addition to the United States energy resource base. To maintain their current position and show future growth the coalbed methane industry will need to continue to improve production technology while controlling development costs.

Reprinted as published in the American Association of Petroleum Geologists, *1994 Annual Convention Official Program*, p. 211.

Scientific Value of Core-Drilling by the Oklahoma Geological Survey in Pennsylvanian Strata of Northeastern Oklahoma

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

The Oklahoma Geological Survey's (OGS) capabilities for collecting geologic data were enhanced by the acquisition of a core-drilling rig in 1981. Cores recovered from strata that underlie the surface of the Earth are invaluable to the geologist in that they provide another dimension for viewing the rocks.

Drilling research in northeastern Oklahoma has focused mainly on coal exploration. The principal purpose of the core-drilling is to gather data concerning the distribution, thickness, characteristics, and areal extent of coal deposits in the commercial coal belt of the State. Core-drilling data are incorporated in coal geology reports published by the OGS. The reports include maps, stratigraphic and structural data, information on coal resources reserves, and analytical data dealing with coal quality (cored coal samples are analyzed by the OGS Chemistry Laboratory). Other goals of the drilling projects are to provide control for establishing stratigraphic positions of various lithologic units in areas that are poorly known or incorrectly mapped and to recover, store, and make available to the public cores for scientific research.

Additional research applications of core-drilling in Oklahoma's Pennsylvanian strata have included a geothermal-gradient study in the Arkoma basin; establishment of reference wells in type areas of selected stratigraphic markers; recovery of cores for biostratigraphic studies; attempts to identify critical chronostratigraphic boundaries; and obtaining >2,300 ft of continuous, overlapping core from the lower part of the Missourian Series downward into the upper part of the Atokan Series in the shelf area of northeastern Oklahoma.

Reprinted as published in the Geological Society of America, *1994 Abstracts with Programs*, v. 26, no. 1, p. 8.

Burial Depth, Missing Stratigraphic Section, and Geothermics in the Cherokee Basin of the Midcontinent

ANDREA FÖRSTER, GeoForschungsZentrum Potsdam, Potsdam, Germany; and *D. F. MERRIAM*, Kansas Geological Survey, University of Kansas, Lawrence, KS 66047

The Cherokee basin, a northern shelf extension of the Arkoma basin located farther south in Oklahoma, contains a stratigraphic section consisting mostly of Permian–Pennsylvanian alternating clastics and carbonates overlying a carbonate section of Cambrian–Ordovician units on a Precambrian crystalline basement. It is estimated that about 88% of post-Precambrian time is not recorded in the basin. A major structural event in the late Mississippian–early Pennsylvanian formed the Cherokee basin and associated features. Subsequently, the Permian–Pennsylvanian sequence was deposited and buried up to 6,000 ft in Chautauqua County. Based on burial history models for different maximum depths and erosional amounts, the nonsteady state geothermal conditions during the deposition of sediments were calculated. The one-dimensional heat-transfer modeling is based on the numerical solution of the heat conduction equation by a finite-difference method. It can be assumed that since the last erosional event at the end of the Cretaceous, the paleotemperatures in the basin equal present-day formation temperatures known from thermal logging in boreholes. From temperatures patterns determined by BHTs/DSTs, fluid circulation through the system can be outlined. The circulating fluids, mainly through the Cambrian–Ordovician and Mississippian carbonates, are warm brines migrating northward out of the Arkoma basin and mingle with cooler fresh waters from the recharge area in the Ozarks. Vitrinite reflectance values were calculated for the different history models. It is postulated that the location and time of emplacement of oil and gas and mineral deposits were controlled by a combination of burial history, structural development, geothermics, and geohydrology.

Reprinted as published in the American Association of Petroleum Geologists, *1994 Annual Convention Official Program*, p. 150–151.

Nd Isotopes Link Ouachita Turbidites to Appalachian Sources

JAMES D. GLEASON, P. JONATHAN PATCHETT, WILLIAM R. DICKINSON, and *JOAQUIN RUIZ*, Dept. of Geosciences, University of Arizona, Tucson, AZ 85721

New Nd isotopic data suggest that Paleozoic turbidites in the Ouachita fold belt (Arkansas and Oklahoma) had a dominantly Appalachian provenance after Middle Ordovician time. We infer a long-lived sedimentary dispersal system of isotopically homogeneous detritus linked to Appalachian tectonics. By Carboniferous time, both the continental surface and the closing Ouachita trough were apparently flooded with sediment derived from the Appalachian collisional orogen.

Reprinted as published in *Geology*, v. 22, p. 347, April 1994.

Geochemistry of Mississippian Tuffs from the Ouachita Mountains, and Implications for the Tectonics of the Ouachita Orogen, Oklahoma and Arkansas

JENNIFER LOOMIS, BARRY WEAVER, and *HARVEY BLATT*, School of Geology and Geophysics, University of Oklahoma, Norman OK 73019

The Ouachita orogeny was the result of plate convergence at the southern margin of the North American continent, although the nature of the converging southern plate and the direction of subduction remain uncertain. The presence of areally extensive tuff layers interbedded with shale in the Mississippian Stanley Group of the Ouachita Mountains, Oklahoma and Arkansas, provides the potential to define the tectonic environment of volcanism from the geochemistry of the tuffs and thereby delimit the subduction configuration. The tuffs contain relic primary magmatic quartz, plagioclase, and alkali feldspar and range from crystal- to vitric-rich. Mineralogical sorting and diagenetic effects have caused chemical variability within individual tuff units, but overall the tuffs have retained their primary igneous geochemical characteristics. The Beavers Bend and Hatton tuffs are geochemically very similar and are more evolved (higher SiO_2, Rb, Th, REE; lower Sr, Ba) than the Mud Creek tuff. The stratigraphically equiva-

lent Sabine Rhyolite is geochemically distinct from the tuffs, having less fractionated rare earth element (REE) patterns and different trace element ratios. Both the Ouachita tuffs and Sabine Rhyolite have the geochemical characteristics of subduction-related magmas (for example, strong depletion of Nb and Ta relative to other incompatible trace elements). Consideration of trace element systematics in the tuffs compared to those of modern high-silica volcanic rocks from different subduction-related tectonic settings suggests a continental arc origin and implies southward subduction beneath a southern continent during Carboniferous ocean basin closure.

Reprinted as published in the Geological Society of America *Bulletin*, v. 106, p. 1158, September 1994.

Effects of Chamosite on Porosity in the Spiro Sandstone of the Wilburton, Red Oak, and Kinta Fields, Arkoma Basin, Oklahoma

FORREST B. HESS, School of Geology, Oklahoma State University, Stillwater, OK 74078

The lower Atokan Spiro Sandstone was deposited in a shallow marine setting. It is a productive reservoir in the Arkoma basin of Eastern Oklahoma and Western Arkansas. The Spiro is found below 15,000 feet in the southern part of the basin and approximately 4,000 feet on the northern flank. Outcrops are located along the Choctaw Fault as a result of the thrust faulting. The Spiro Sandstone is predominately a fine-grained to medium-grained quartz arenite with interbedded calcareous zones and some fossiliferous limestones. Many repeats of the Spiro are encountered during drilling due to the numerous thrust faults. Chamosite, an iron-rich chlorite, is often found in the subthrusted nits and occurs as an early diagenetic clay. In the Spiro Sandstone, chamosite is observed as a syndepositional coating of grains and as pellets formed at the site of deposition. The presence of allogenic chamositic coatings on quartz grains in the Spiro Sandstone is believed to be an important factor in the preservation of primary porosity. Chamosite grain coatings prevent the stress-induced pressure solution of quartz and the subsequent formation of quartz overgrowths. Formation of dolomite at the expense of chamosite was also observed in thin section. With the replacement of chamosite by dolomite, calcite cement precipitates and the porosity is subsequently destroyed. When chamosite coatings are absent, pressure solution of quartz grains is common and quartz overgrowths become very common. Therefore, the chamosite-rich zones in the Spiro Sandstone are the productive reservoirs, and when chamosite is absent the Spiro reservoirs are tightly cemented and non-productive.

Reprinted as published in the American Association of Petroleum Geologists, *1994 Annual Convention Official Program*, p. 170.

Reservoir Distribution and Exploration Potential of the Spiro Formation in the Choctaw Trend, Arkoma Basin, Oklahoma and Arkansas

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In the Arkoma basin, the distribution of reservoir quality sandstones in the Spiro Formation can be explained by integrating three technologies: (1) well log correlations using sequence stratigraphic principles; (2) a thermal-maturation study using surface and subsurface vitrinite reflectance values in a regional three dimensional data set; and (3) petrographic analysis of the reservoir. Parasequence stacking patterns on logs, isopach maps, and results from core studies were integrated to interpret depositional environments. In Pittsburg and Latimer counties, Oklahoma, along the Choctaw Fault Trend, the thrusted Spiro is predominantly a barrier island deposit composed of reservoir-quality, progradational and aggradational sandstones. However, to the east from Le Flore County, Oklahoma, through Yell County, Arkansas, along the structural trend, the Spiro is composed predominantly of tight, non-productive retrogradational sandstones. Petrographic observations of the progradational Spiro show that sands in the west are medium to fine grained, but in the east they are very fine grained. Chlorite coats, which inhibit quartz cementation, are present only in the west. To examine the relationship between thermal maturity and porosity, vitrinite reflectance data were calibrated to commercial gas production and petrographic data, and a thermal basement was established. The vitrinite data indicate that the Spiro in the west is within the gas window (approx. 1.5% R_0), but in the east, it is overmature (>2.5% R_0). The term overmature applies to reservoirs that have insufficient porosity for commercial production due to destructive diagenesis caused by thermal stress. The simultaneous multidisciplinary approach is economically significant because exploration analysis cycle time is decreased, and decisions can be made with more reliability.

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Three Dimensional Seismic Interpretation from the Triangle Zone Between the Ouachita Mountains and Arkoma Basin, Hartshorne, OK

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The boundary between the frontal Ouachitas fold and thrustbelt and the foreland Arkoma basin has been interpreted as a triangle zone. 3-D seismic reflection data from this triangle zone show details not recognized in conventional 2-D seismic data. The data indicates that the frontal Kiowa syncline in the Arkoma basin has been passively uplifted by blind thrusting at deeper levels. Blind thrusting takes place at two levels: the Morrowan Wapanucka Formation and the Silurian Hunton Formation. Detachments for the thrusting in the Wapanucka Formation are in the Springer Shale and the Woodford Formation. The thrusts offsetting the Hunton Formation have detachments in the Simpson Group and possibly in the Arbuckle Group or even deeper. Horizontal shortening in the Wapanucka Formation ranges from tens of meters to a few kilometers, and in the Hunton Formation from tens of meters to a few hundred of meters.

Four reflectors were interpreted: a reflector in the lower Atoka Formation, two repeated Wapanucka limestone sections and the Hunton Formation. All of the surfaces exhibit the same geometry with their fold axis plunging to the southwest. The surface geometry and fold axis data suggest that the first thrusting was in the Wapanucka Formation and later in the Hunton Formation. Faulting in the Hunton Formation has been traditionally interpreted as normal, although basement-involved reverse faults, such as the Carbon fault, have been mapped. The interpretation of some individual in lines or crosslines may also show normal faults, but the interpretation of the whole 3-D survey support the proposed compression in the older sequence.

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Enhanced Interpretations of Thermal Maturity Using Rotational Reflectance of Dispersed Vitrinite, Overmature Strata of the Arkoma Basin and Ouachita Thrust Belt

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Rotational reflectance of dispersed vitrinite, measured photometrically using automated polarized rotation, can provide objective and direct measurement of reflectance anisotropy on individual particles of dispersed vitrinite on which otherwise only random reflectance can be determined. Using this method to analyze of Paleozoic shale samples provides data that characterize the thermal maturity of the Arkoma-Ouachita region as anchizonal through incipient greenschist metamorphic. Measured vitrinite reflectance extends to >5% R_{rot} (rotational reflectance), which corresponds to >6% R'_{max} (apparent maximum reflectance). Significantly, commercial natural gas production extends to (approx.) 4% R_{rot}, and the prolific nature of production from strata at this thermal maturity level contradicts the concept of an abrupt deadline for commercial natural gas occurrence.

The use of rotational reflectance dat also can enable the interpretation of relative timing between thermal maximum and thrust faulting. In the Arkoma basin of Oklahoma, a zone of bed-parallel decollement is suggested in one well by an interval of samples containing biaxial vitrinite amidst a sequence of samples containing uniaxial vitrinite. In the Ouachita frontal thrust belt of Oklahoma, the predominance of uniaxial vitrinite in a complexly thrusted area suggests that the thermal maximum post-dated thrusting. In contrast, a similar structural setting in Arkansas yielded a predominance of biaxial vitrinite at comparable levels of thermal maturity, suggesting that the thermal maximum and thrusting overlapped in time. The inferred differences in timing between thermal and structural events corresponds to deterioration of economic natural gas production, suggesting that the rotational reflectance technique may help to explain the distribution of economic natural gas resources on a regional scale.

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Debris Flow/Slump Emplacement of a Classic "Turbidite" Sequence, Pennsylvanian Jackfork Group, Ouachita Mountains (Arkansas and Oklahoma)

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Conventionally, the Pennsylvanian Jackfork Group in the Ouachita Mountains of Arkansas and Oklahoma has been considered a classic example of a turbidite sequence deposited in a submarine-fan setting. However, the apparent "Bouma Turbidite sequences" in these strata, which were used as evidence for single event turbidity current deposition, are in reality composed of multiple events, emplaced as debris flows and slumps, and commonly reworked by bottom currents. Normal size grading and Bouma sequences are essentially absent in these sandstones. Most sandstone beds appear "massive" (i.e., structureless) in outcrop; but when slabbed and examined reveal diagnostic internal features. These beds exhibit sharp upper bedding contacts, inverse size grading, floating mudstone clasts, planar clast fabric, contorted layers, fluid escape

structures, and moderate to high matrix content. all these features are indicative of sand emplacement by debris flows (mass flows) or slumps. The dominance of slump/debris-flow deposits (nearly 70% at DeGray Spillway section) and bottom-current reworked deposits (40% at Kiamichi Mountain section), and the lack of turbidites in the Jackfork have led us to propose a slope-dominated setting. Conventional submarine-fan models, designed for turbidite systems, are not applicable to the debris-flow emplaced and bottom-current reworked sandstones of the Jackfork Group. This has direct implication for sand-body geometry and continuity because deposits of fluidal (suspension) turbidity currents are laterally more continuous than those of plastic (en masse) debris flows.

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Deep-Water Sandstones of the Pennsylvanian Jackfork Group, Ouachita Mountains: A Slope-Dominated System

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Conventionally, the Pennsylvanian Jackfork Group in the Ouachita Mountains of Arkansas and Oklahoma has been considered a classic example of a turbidite sequence deposited in a submarine-fan setting. However, the apparent "Bouma turbidite sequences" in these strata, which were used as evidence for single-event turbidity current deposition, are in reality composed of multiple events emplaced by debris flows and slumps, and commonly reworked by bottom currents. Normal size grading and Bouma sequences are essentially absent in these sandstones. Most sandstone beds appear "massive" (i.e., structureless) in outcrop, but when slabbed and examined reveal diagnostic internal features. These beds exhibit sharp upper bedding contacts, inverse size grading, floating mudstone clasts, planar clast fabric, contorted layers, fluid escape structures, and moderate to high matrix content. All these features are indicative of sand emplacement by debris flows (mass flows) or slumps. The dominance of debris-flow deposits (nearly 70% at DeGray Spillway section) and bottom-current reworked deposits (40% at Kiamichi Mountain section), and the lack of turbidites in the Jackfork have led us to propose a slope-dominated system. Conventional submarine fan models, designed for turbidite systems, are not applicable to the debris-flow emplaced and bottom-current reworked sandstones of the Jackfork Group. This unconventional model has direct implication for sand-body geometry and continuity because deposits of fluidal (suspension) turbidity currents are laterally more continuous than those of plastic (en masse) debris flows.

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Stratigraphic Responses to Geologic Processes: Late Pennsylvanian Eustasy and Tectonics in the Pedregosa and Orogrande Basins, Ancestral Rocky Mountains

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The primary factors that influence stratigraphy are tectonics, eustasy, and sediment supply. Because a change in any of these factors produces a concomitant change in relative base level or accommodation space, the link between a given process and its stratigraphic response is nonunique. Despite this ambiguity, distinguishing the origins of stratigraphic signals is theoretically possible by examining the temporal and especially the spatial scales of the signal. Correlation is a particularly critical tool for distinguishing global eustasy from regional tectonism.

Upper Pennsylvanian strata of the Pedregosa and Orogrande basins (southern Ancestral Rocky Mountains) were deposited during a time of major continental collision coincident with extensive continental glaciation, and thus they contain a composite record of significant changes in tectonism, eustasy, and sediment supply. High-frequency stratigraphic cyclicity expressed as repetitive successions of lithofacies at the 10 m scale is prevalent in all sections and displays several features that collectively imply a primarily glacioeustatic origin: (1) abrupt juxtaposition of dissimilar lithofacies, signaling rates of base-level change best attributed to glacioeustasy; (2) apparent intrabasinal, interbasinal, and (provisional) interregional correlation of high-frequency cycles across and between contrasting tectonic environments; and (3) apparent cycle frequencies that bracket the 413 k.y. periodicity typical of orbital eccentricity, the probable forcing mechanism for Pennsylvanian glaciations.

Aside from the prevalent high-frequency "cyclostratigraphy," mutltiple-cycle trends in facies and/or thicknesses define low-frequency stratigraphic patterns at the 10^2 m scale. Isolating and identifying the controlling factors for these patterns is not straightforward; nevertheless, qualitative analysis of multicyclic trends implicates distinct eustatic and tectonic processes as contributing influences. The eustatic component may derive partially from low-frequency glacioeustasy. The tectonic component almost certainly reflects Marathon-Ouachita collisional orogenesis.

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