# Oklahoma GEOLOGY Notes

OKLAHOMA GEOLOGICAL SURVEY VOL. 47, NO. 6 DECEMBER 1987

*On the cover—*

## The World's Smallest Oil Field?

The scenery of the Wichita Mountains and Slick Hills of southwestern Oklahoma is essentially a Permian inheritance which has been very lightly modified in recent times. Among the most compelling features of this exhumed Permian landscape are the fossil cave systems which perforate the Slick Hills. Most of these caves developed by selective corrosion of joint systems which cut limestones of the Arbuckle Group. As a result the caverns are long, narrow, and dominated by vertical shafts; man-sized chambers are rare, and the best exposures of cave systems are located in quarries and road cuts. Such sites have yielded an impressive array of Permian vertebrates (6 reptiles, 11 amphibians, and a single fish, according to Simpson, 1979). Most of these beasts are believed to have been swept into the cave systems after death. However, the fish and amphibians suggest that an indigenous element may have contributed to the fossil population.

The most endearing of the tiny cave systems is located in a quarry on the northern side of the Bally Mountain Range in Kiowa County. This system, which is securely dated by the reptile *Captorhinus* (a beast about twice the size of a mountain boomer), comprises numerous fissures decorated by a variety of calcitic speleothemic deposits. These include flowstone, stalactites, stalagmites, and cave popcorn; both vadose and phreatic textures are present. All of these deposits display dark zones which are rich in bitumen, both as inclusions and as coatings on calcite crystals. As the local rocks are not a likely source rock, the plumbing system involved would seem to require the upward migration of hydrocarbons from the Anadarko basin through the faults of the frontal fault zone into tectonic fractures in the Arbuckle Group (Donovan, 1986). Escaping from the fractures, these hydrocarbons then mingled with carbonate-saturated waters in the caves before being incorporated into the growing speleothems.

*(continued on p. 291)*

**OKLAHOMA GEOLOGICAL SURVEY**
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# Oklahoma GEOLOGY Notes

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# OKLAHOMA GEOLOGICAL SURVEY
# ANNUAL REPORT

## July 1, 1986–June 30, 1987

## Introduction

The precipitous decline in Oklahoma's economy that began in January 1986 continued throughout the past fiscal year. This 18-month decline, brought about by the dramatic decrease in world crude-oil prices together with a corresponding decrease in both demand and price for natural gas, is the longest and most severe since the Great Depression.

World crude-oil prices seem to have stabilized, at least temporarily, in the $18 to $20 range. However, because of the large excess production capacity in the world, there is a greater probability of future price decreases than price increases. In any event, these prices are inadequate to prevent a continuing high rate in the abandonment of marginally productive wells. In addition, that price range will not stimulate exploratory drilling and will encourage only the most attractive development opportunities. Moreover, the sales price for natural gas continues to decline, although at a somewhat lower rate than in the past fiscal year. Because there is no indication in the world market to expect an increase in crude-oil prices in the near future, and no evidence for an increase in the price for natural gas, the depressed economic conditions in the State's energy industry are likely to continue for some time.

The steep decline in value of mineral and energy production that began in calendar year 1985 continued throughout 1986 (Fig. 1). As a result, the value of that production in calendar year 1986 was $4.5 billion less than it had been in 1984 and $5 billion less than in 1982, the year of peak value. Based upon preliminary information for the first six months of 1987, the projected value for mineral and energy production for calendar year 1987 is expected to be about $5.7 billion.

This massive reduction in value of mineral and energy production since the peak year of 1982 also contributed to corresponding declines in some parts of the manufacturing and service sectors of the State's economy, which are heavily supported by the manufacture of oil-field equipment and the drilling and servicing of wells.

Other areas of State activity felt the consequences of declining mineral and energy production and value. Reductions in receipts to royalty owners, increases in unemployment, and an unprecedented number of bank failures, a seemingly endless stream of personal and corporate bankruptcies, and decreases in tax revenue at all levels of government in the State are but a few of these additional effects. Thus, the combined effects of decline in mineral and energy activity induced severe repercussions in most economic sectors and produced a prolonged recession in Oklahoma.

Fortunately, the precipitous decline in the State's economy seems to have been

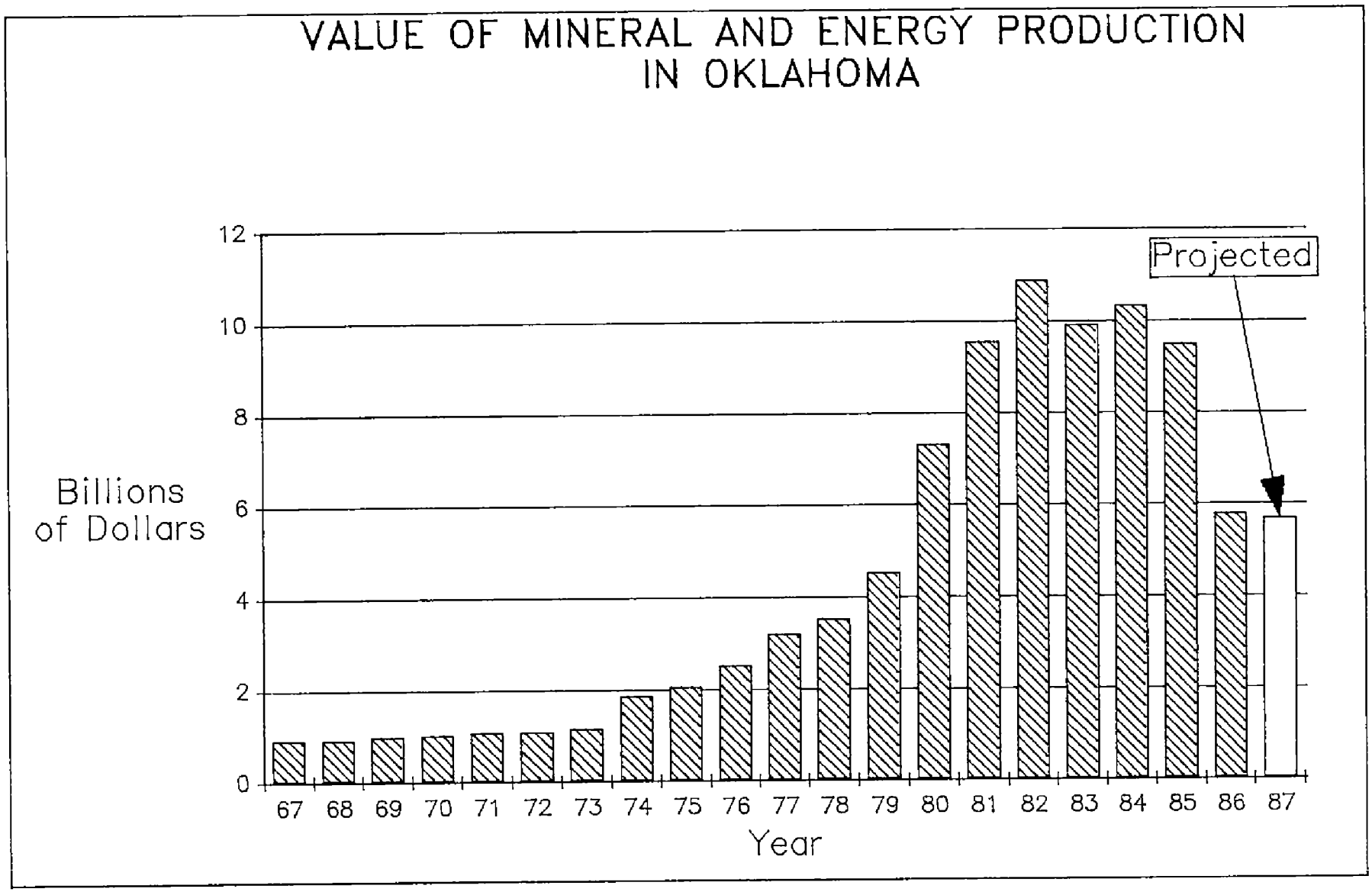


**Figure 1. Value of mineral and energy production in Oklahoma, 1967–87.**

arrested, and some indications of recovery are evident. Crude-oil prices have increased slightly and natural-gas sales are increasing. The combined effect of these factors should offset the declines in crude-oil production and market values for natural gas and should maintain the value of mineral and energy production at the calendar year 1986 level of about $5.7 billion.

The current conditions serve to emphasize the need to diversify Oklahoma's economy. Historically, the State's business activity has been characterized by the production and export of agricultural and energy raw materials. Such activity produces minimum gains for the State's economy, whereas those states using these commodities to produce consumer products are able to maximize their gains through the value-added process. Thus, the increased use of these raw materials in Oklahoma to produce consumer products should enable the State to realize those value-added benefits currently being enjoyed elsewhere in the Nation.

Information on the location, quantity, and quality of Oklahoma's natural resources together with descriptions of the State's regional geology are necessary components of a viable economic-development program. Collecting, analyzing, and disseminating such information is the charter responsibility of the Oklahoma Geological Survey. That mission was begun prior to Statehood by the Territorial Geological Survey and has been continued from 1908 to the present by this organization.

## Highlights of OGS Activities

The most significant event during the past fiscal year was the Survey's involvement in the site selection and participation in the preparation of Oklahoma's proposal for the Superconducting Super Collider (SSC). In April 1987, the U.S. Department of Energy invited states to submit proposals for siting the world's largest and most advanced particle accelerator. The SSC is designed to permit physicists to conduct high-energy particle-physics research in a facility that will consist of a 53-mi-long, elliptical concrete tunnel measuring 10 ft in diameter. The tunnel will contain ~10,000 superconducting magnets that guide two beams of protons in opposite directions at velocities approaching the speed of light. The paths intersect in experiment chambers with proton collisions approaching energy levels of 40 trillion electron volts. These collisions will modify and split individual protons, releasing particles that serve as building blocks for the protons. The study of these interactions and the particles produced during this process will further our knowledge of the relationship between energy and matter.

Governor Henry Bellmon asked the Survey to conduct an examination to determine if a satisfactory site could be found in Oklahoma for the location of the SSC. The Survey screened the State to identify those areas that should be excluded from further consideration because of adverse topography, geology, hydrology, or resource development. Engineering Enterprises assisted the Survey in evaluating the hydrologic factors. This process eliminated all but 12 areas in the State, where about 30 possible sites could be located. Each of these potential sites was examined in detail with respect to the following criteria:

- Relatively flat topography with no major drainage development
- Homogeneous geology with no folding or faulting

- Stable bedrock conditions
- Absence of ground-water aquifers
- Low seismicity
- Little or no mineral- or energy-resource development
- Minimal human disturbance

The detailed examination of the 12 areas identified two sites (Cedar Valley and Skelton Creek) that met or exceeded each of the specified criteria (Fig. 2). Of these two sites, Cedar Valley in Blaine and Kingfisher Counties had only minimal petroleum development and was chosen as the primary location.

In a parallel effort, the Benham Group conducted an environmental, cultural, and human-resource assessment of the same 12 areas. This assessment identified the Cedar Valley site as having superior characteristics with respect to the criteria established for their study.

The Cedar Valley site is superior in every respect. The topography is virtually flat, with minimal stream dissection. The bedrock is unfaulted, essentially flat-lying Permian-age mudstones. Only minimal ground water is present in the area. Limited petroleum exploration and development has occurred, primarily on the basis of 160-acre spacing units for natural gas. No subsurface problems were identified, and seismicity was determined to be inconsequential.

The Survey also participated in the preparation of the geotechnical portion of the proposal, providing information on the surface and subsurface geology, tectonics, ground-water hydrology, and resource development in the vicinity of the site.

In all, 23 staff members jointly expended 4,095 hours during an eight-week period in the development of the proposal. The remaining Survey staff also provided important support to this effort.

## Programs

The Survey has 11 separate program budgets. Eight of these budgets are concerned with the basic mission of the OGS, namely the investigation of the land, water, mineral, and energy resources of the State. The remaining three budgets provide for support services, including administration, core and sample library, and public information and assistance.

Geological Information Systems (GIS), an organization skilled in the development and management of large data bases, that was formerly a part of the University's Energy Resources Institute, has been attached to the Survey for management oversight. GIS is engaged in a major cooperative effort with the Survey in the development of a Natural Resources Information System (NRIS) for the State of Oklahoma. Current efforts are directed toward the development of data bases for petroleum and coal resources and production; nonfuel minerals and water will be included in future years.

The Survey has a full-time staff of 43 persons, including 12 geologists, one geophysicist, nine other professional staff members, and 21 classified technical support personnel. This staff is supplemented with several part-time professional staff members and a few student assistants.

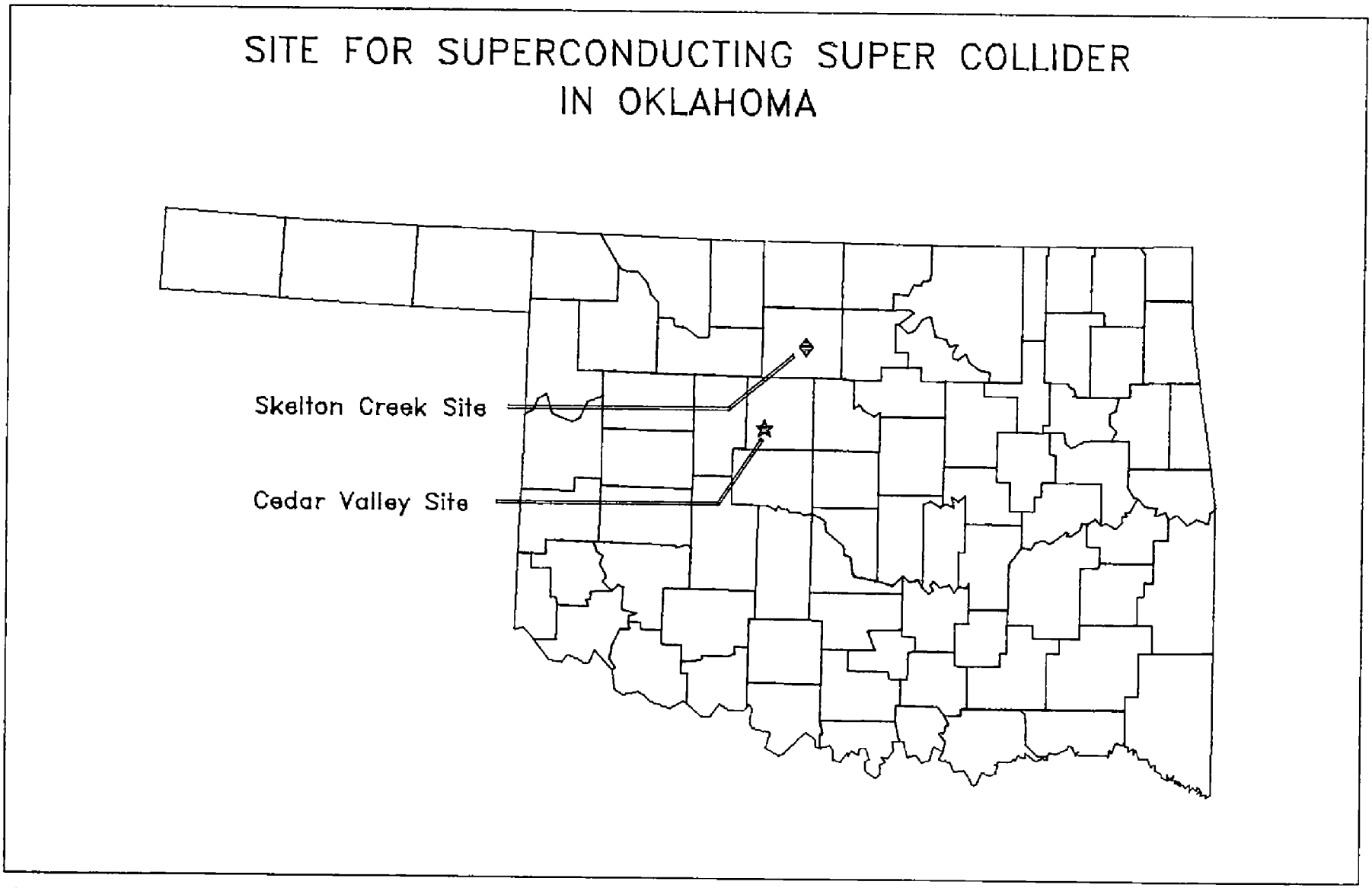


**Figure 2. Site for Superconducting Super Collider in Oklahoma.**

The Geological Information Systems staff consists of 22 personnel. Seven are professional staff engaged in the development of the system design and implementation of NRIS. Two classified staff, nine students, and four temporary personnel are engaged in data entry and other support functions.

## Basic Geologic Investigations

Fundamental to all other activities of the Survey is the need for accurate, detailed geologic-map coverage of the State. Surface geologic mapping at a scale of 1 in. = 1 mi or larger has been completed for 22 counties since 1940. The geologic map and report on Marshall County was issued in August 1987. Such mapping is in progress in three additional counties (Fig. 3). In addition, regional geologic mapping is in progress in the Ouachita Mountains, the Wichita Mountains, and in the Hollis basin.

Geologic mapping in the Ouachita Mountains is a cooperative effort with the U.S. Geological Survey and the Arkansas Geological Commission. The objective of the program is to produce detailed surface and regional subsurface geologic maps of the Ouachita Mountains to aid in understanding the geologic history of this complex terrain and to evaluate the mineral- and energy-resource potential in the region.

To date, this effort has completed geologic maps in manuscript form for the Higgins, Damon, and a portion of the Panola 7½′ Quadrangles. Anticipated in the coming fiscal year is the completion of geologic maps of the Wilburton, Baker Mountain, Tallihina Quadrangles, and the remainder of the Panola Quadrangle.

## Petroleum Investigations

Crude oil and natural gas account for ~95% of the gross value of mineral and energy production in Oklahoma (Fig. 4). Consequently, the Survey has a large portion of its effort devoted to petroleum research and information management. Included in these activities are the development of an Oil- and Gas-Field Production File, a Petroleum Well History File, a Petroleum Well-Log Library, and a Core and Sample Library (described later). Regional subsurface geologic mapping and petroleum-resource studies in several important petroleum provinces in the State are major efforts of the Survey's program in petroleum studies.

Substantial progress has been made in the development of the Oil- and Gas-Field Production File. At present, information is being compiled on the location, areal extent, and monthly production history for the years 1983–86 of each of Oklahoma's more than 3,000 fields. Other information being incorporated in the file for each of the fields includes discovery well, discovery date, producing formation(s), and consolidation history. Public release of this information will occur in early 1988.

## Coal Investigations

Oklahoma has had a long history of coal production. Mining began prior to Statehood and has continued to the present. Throughout its history, production has been small in comparison with other coal-producing states, but that activity

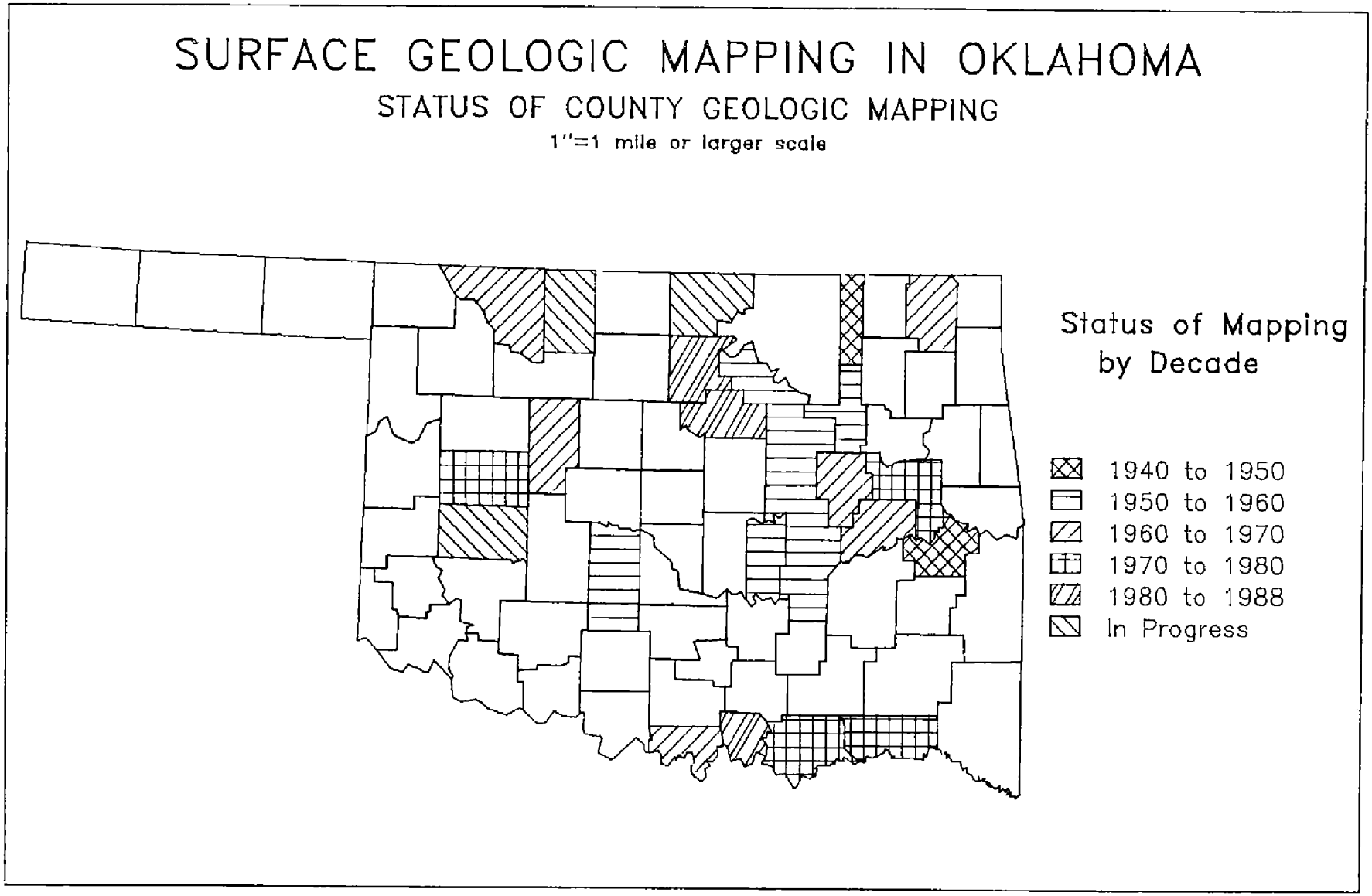


**Figure 3. Status of OGS county geologic mapping of Oklahoma.**

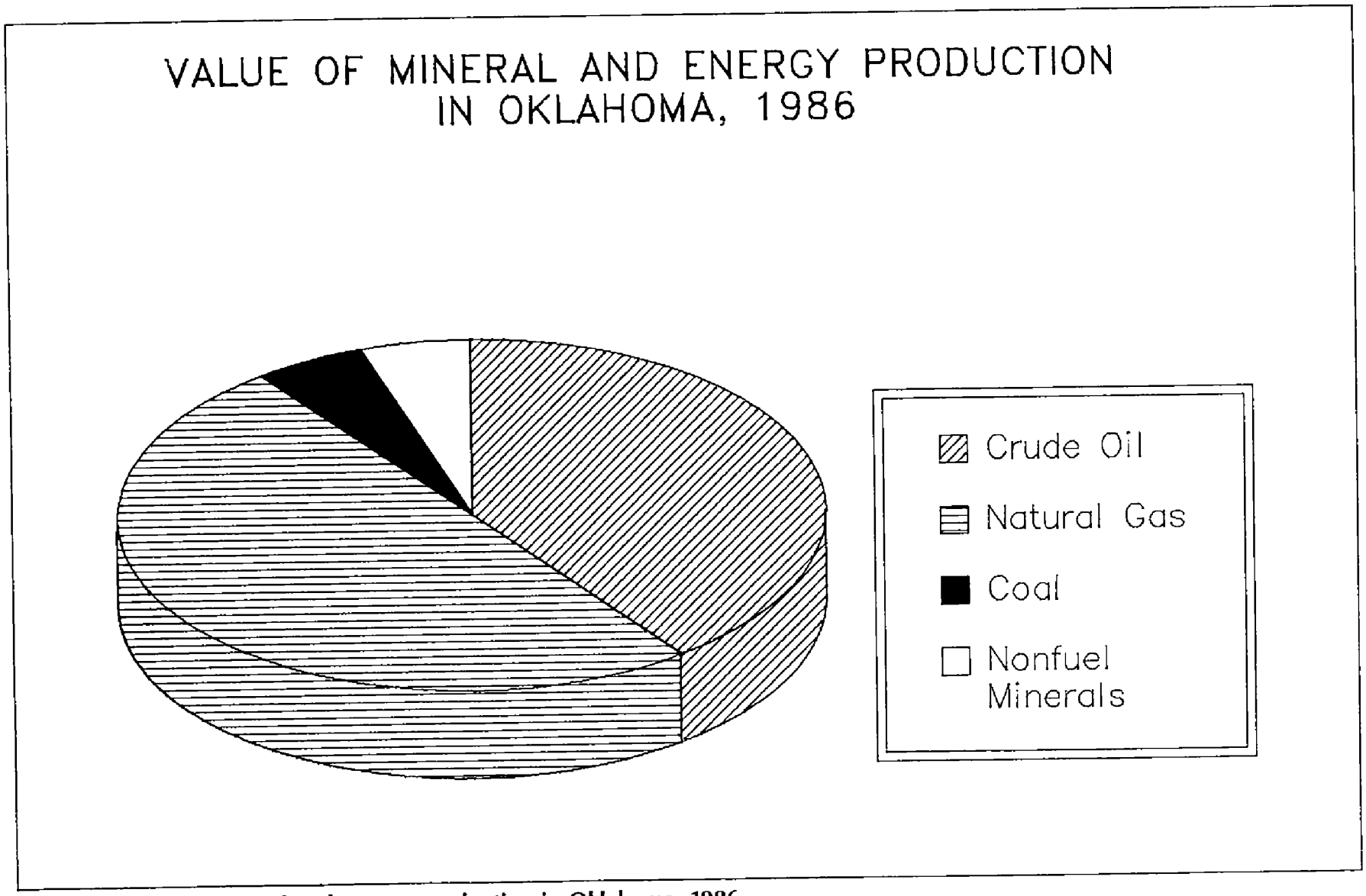


**Figure 4. Value of mineral and energy production in Oklahoma, 1986.**

continues to be an important factor in the economy of eastern Oklahoma. In 1986, the State's coal production hit an 11-year low, reflecting the large national excess productive capacity (Fig. 5). However, in 1986 more Oklahoma coal was consumed by the State's utilities than at any time in the past 20 years.

The primary thrust of the Survey's coal-investigation program consists of mapping individual coal seams and collecting point-source information on coal thickness, physical and chemical properties of the coal, overburden thickness and its physical and chemical properties, and thickness and quality of any accompanying underclay. Field mapping has been completed, and most of the analytical work is in final stages for the preparation of reports on five pairs of counties and one individual county in eastern Oklahoma. Of these reports, one on Craig and Nowata Counties was published in December 1986, three (Rogers and Mayes, Tulsa and Wagoner, Okfuskee and Okmulgee) are in editorial and cartographic preparation, and two (McIntosh and Muskogee, Le Flore) are in preparation.

The Survey's coal geologists spent a significant amount of time providing requested information to a utility to aid in completing its plans for the construction of a 300-megawatt electrical generating plant in Le Flore County. This plant will consume annually up to 1 million tons of Oklahoma coal when it becomes operational in 1991.

As part of the NRIS system, the OGS is developing a coal data base. This is a cooperative effort with the U.S. Geological Survey as part of the National Coal Resources Data System. Point-source information is being compiled on each of the coal seams throughout their areal extent. This information is obtained from coal-company records, previous studies by the Survey and other agencies, and core samples obtained by the Survey's drilling rig in areas where other information is sparse or absent. Information on 1,200 locations has been entered into the file, and information on several hundred additional locations is ready for data entry.

The Survey's program in organic petrography continues to develop information on the organic composition and fabric of each coal seam in eastern Oklahoma. This petrographic information aids in the determination of the most beneficial use(s) of each coal seam in the State.

## Industrial-Minerals Investigations

A wide variety of industrial and metallic minerals have been produced in the State at various times during its 80-year history. No metal mines are in operation at present, but industrial-mineral production is active in all parts of Oklahoma (Fig. 6). The value of these commodities was $257.8 million in 1986 (Fig. 7).

To assist present mining operations and to provide information to prospective operators, the Survey annually conducts a number of site-specific resource studies. These range from a simple estimate of the potential tonnage of a given commodity in a particular location to studies involving both field mapping and laboratory analyses. Through a cooperative agreement with the U.S. Bureau of Mines, the Survey assists in obtaining production information from operators. Because this information is supplied by the operators on a voluntary basis, the production of each operation is maintained in confidential files; only aggregated information is released for public use.

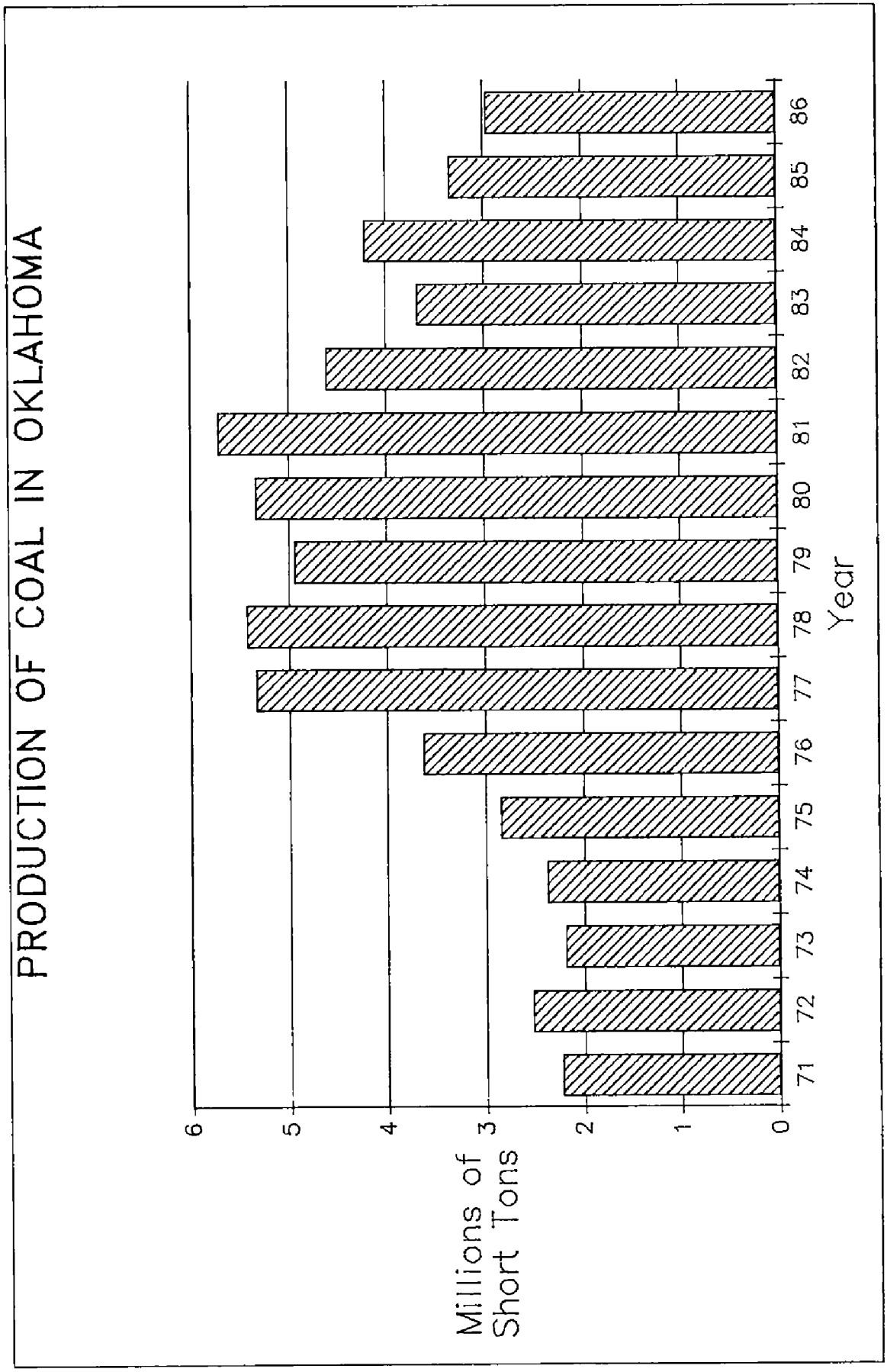


**Figure 5. Coal production in Oklahoma, 1971–86.**

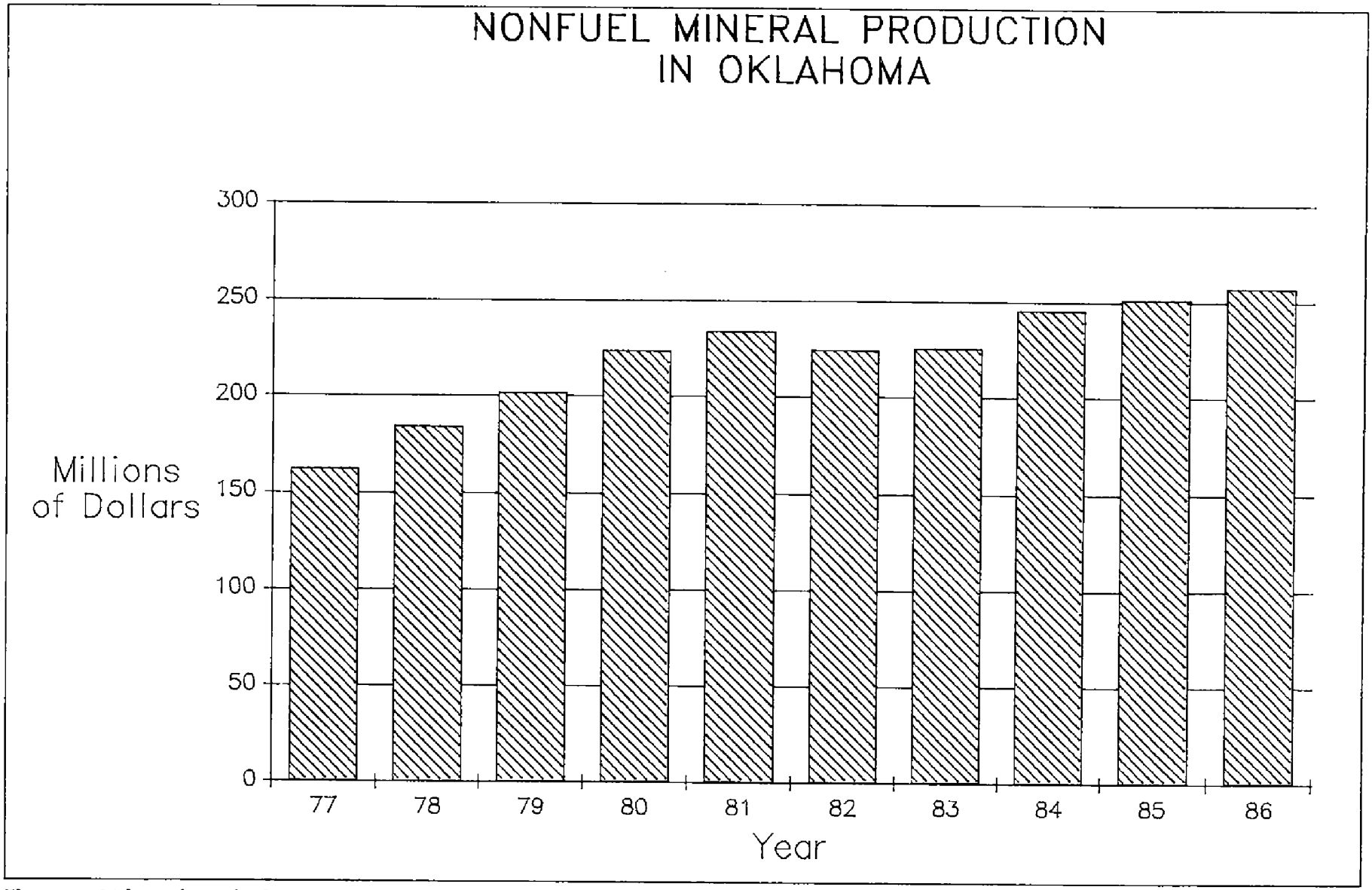


**Figure 6. Value of nonfuel mineral production in Oklahoma, 1977–86.**

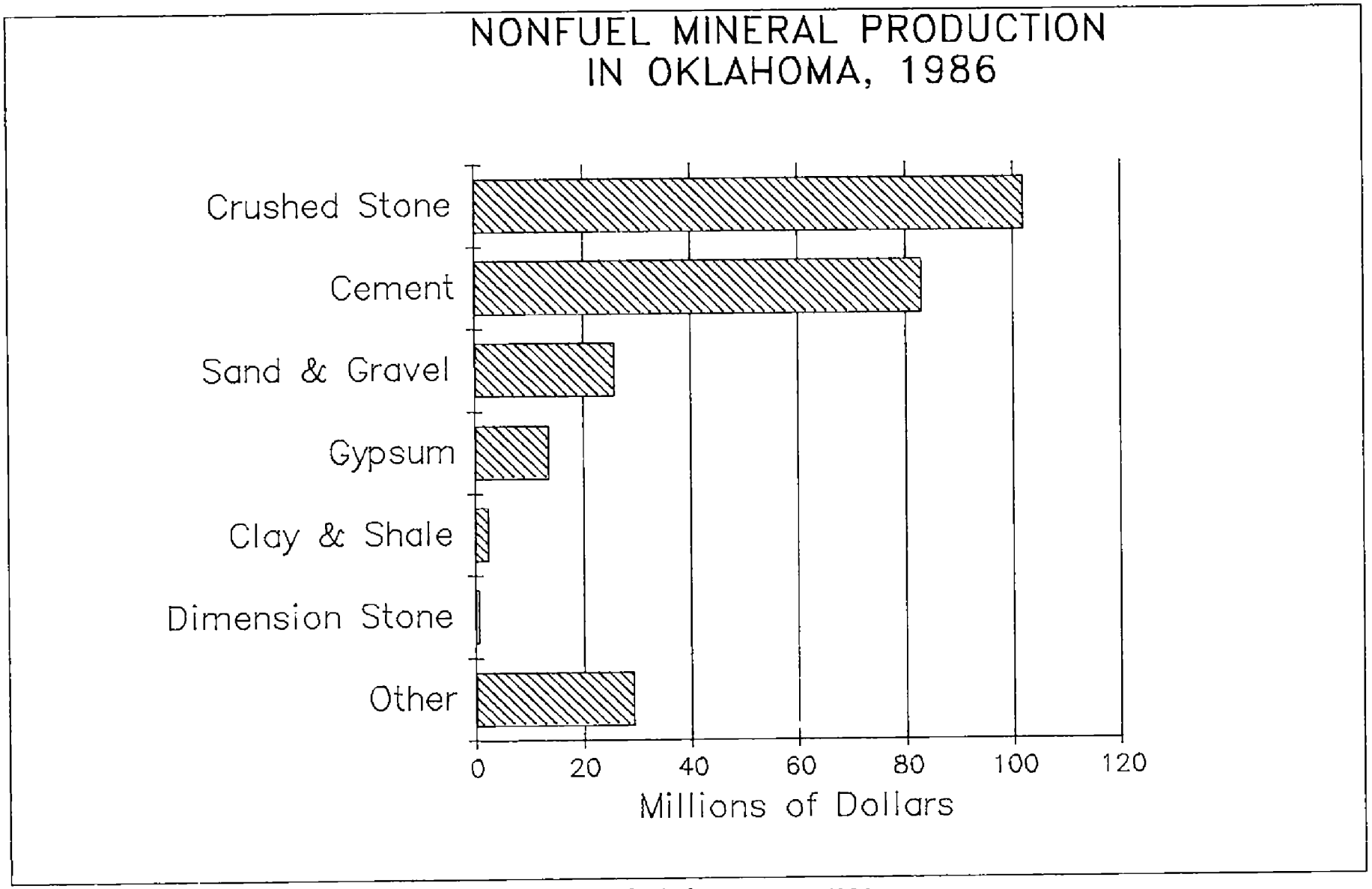


**Figure 7. Value of nonfuel mineral production in Oklahoma by industry sector, 1986.**

Inclusion in NRIS of the information on current production together with the location of nonfuel-mineral resources in the State is scheduled to begin during the next fiscal year. Although it will take several years to compile, all of the historical information and data on current mineral activities and resource potential should be an asset to those attempting to attract new industry to the State.

## Environmental Geologic Studies

Natural geologic hazards, large construction projects, and the development and utilization of natural resources give rise to the need for environmental and engineering geology studies. The Survey either undertakes studies or participates with other agencies and organizations in a broad range of such investigations.

A report recently released, *Stability Problems Associated with Abandoned Underground Mines in the Picher Field, Northeastern Oklahoma* (Circular 88), was part of a cooperative program between the U.S. Bureau of Mines and the State Geological Surveys of Oklahoma, Kansas, and Missouri. The Miami-Picher Field in Oklahoma, once the largest zinc-producing region in the world, was abandoned in the late 1960s. This study identified and described more than 1,000 shafts in the mining district, 481 identified as being open or in some stage of collapse. Suggestions for remedial action with respect to these features are included in the report.

Work is continuing on mapping the location and extent of abandoned underground coal mines in the coalfields of eastern Oklahoma. The purpose is to identify potential hazards from subsidence and other effects that may occur from these underground mines. A similar effort is under way to identify and determine the extent of reclamation, if any, of the active and abandoned surface non-coal mines throughout the State.

A cooperative project between the U.S. Geological Survey, the U.S. Nuclear Regulatory Commission, and the Oklahoma Geological Survey was initiated in March 1984 to evaluate the movement history of the Meers fault. The results of this investigation were released this past January as Special Publication 87-1 entitled *Investigation of the Meers Fault, Southwestern Oklahoma*. Field studies, trench examinations, and carbon-14 age-dates indicate the last fault movement occurred between 1,000 and 2,000 years ago. However, the trench stratigraphy indicates a lengthy recurrence interval of many thousands of years between earthquake events.

## Water-Resources Investigations

The Survey discharges its responsibility for water resources studies through a cooperative effort with the Water Resources Division of the U.S. Geological Survey. This program, in its present form, has been in effect for more than 20 years. Results to date include the publication of a statewide, regional assessment of the occurrence, quality, quantity, and uses of Oklahoma's ground-water resources. These results have been published as a series of nine hydrologic atlases that cover the State exclusive of the Panhandle. Information on the Panhandle was developed through a separate cooperative program between the U.S. Geological Survey and the Oklahoma Water Resources Board.

Circular 87, *Geohydrology of the Vamoosa–Ada Aquifer,* and Circular 89, *Effects of Brine on the Chemical Quality of Water in Parts of Creek, Lincoln, Okfuskee, Payne, Pottawatomie, and Seminole Counties,* were published during the year. These investigations are a part of a series of studies on the geohydrology and water quality of the major ground-water aquifers in the State. The study of the Vamoosa–Ada aquifer describes the geologic framework and hydrology of the system and provides a general evaluation of the chemical quality of the ground water.

The report on the effects of brine on the chemical quality of water identifies areas in the counties included in the study where water quality has been degraded and identifies potential sources of that degradation.

Special Publication 87-2, *Physical and Chemical Characteristics of Water in Coal-Mine Ponds, Eastern Oklahoma,* provides water-chemistry information on 102 sites in the 59 coal-mine ponds in eastern Oklahoma. The information was collected during 1977–81 to determine temperature, specific conductance, dissolved oxygen, pH, and dissolved sulfate, chloride, iron, and manganese in these coal-mine pond waters.

## Basic Research

The maintenance of a program in basic research is important in developing and sustaining all of the other investigative activities of the Survey. Each of these programs is, in fact, a mixture of basic and applied research. The new knowledge gained from basic studies and the stimulation provided by such investigations results in higher-quality products for all of the other applied activities. Investigations included in the program in basic research are stratigraphic studies in the Anadarko basin and a shale-geohydrology study.

The Anadarko basin studies are being conducted in cooperation with the U.S. Geological Survey and involve two aspects of the geology and hydrocarbon-resource potential of that basin. The geologic investigation is directed toward understanding the factors that control the distribution of limestone and dolomite in lower Paleozoic rocks. The presence of dolomite is, in many places, coincident with conditions favorable for accumulation of hydrocarbons.

A determination of the thermal history of the basin is being conducted through an examination of the organic-rich shales. This project is directed toward evaluating the potential of these shales as source rocks for the hydrocarbons found in the basin.

The shale-hydrogeology study is a cooperative effort with the Water Resources Division of the U.S. Geological Survey and is directed toward developing a fundamental understanding of the mechanisms involved in the migration and containment of fluids in these low-permeability rocks. Field investigations are being conducted in four locations with shale units of differing mineralogical and physical properties.

## Oklahoma Geophysical Observatory

The Observatory, located at Leonard, Oklahoma, was originally developed by Jersey Production Research Co. (now Exxon) as a facility to continuously record

several earth parameters, including the magnetic field, electric field, earth tide, and a number of atmospheric parameters; a complete array of seismic recording instruments detects and locates both regional and worldwide seismic events.

In 1965, the facility was donated to the University of Oklahoma. In 1978, the University decided to terminate operation of the facility, and it was turned over to the Survey. Since assuming responsibility for the Observatory, the Survey has expanded the facility and modernized the instrumentation. Much of this has been accomplished with cooperative support from the U.S. Nuclear Regulatory Commission and the U.S. Geological Survey. The Observatory has a staff of five persons: one geophysicist, and four technical support personnel. The central facility has seven seismometers, three of which are long-period and four are short-period recording instruments. Seven field stations containing seismometers are located at strategic positions around the State, and three radiotelemetry stations are located near Leonard. The program of monitoring earthquake activity, both in Oklahoma and around the world, is a continuing activity of the Observatory. A report cataloging all earthquake events in the State is published annually in *Oklahoma Geology Notes* (1986 catalog, *in* v. 47, p. 65–72).

The Observatory has one of the 11 geomagnetic stations located in the United States. This station is operated cooperatively with the U.S. Geological Survey; the other 10 stations in the U.S. are operated solely by the U.S. Geological Survey. The location is particularly critical because in all but one direction, the station is more than 1,000 km from another magnetic recording facility. The instrumentation measures both the total intensity of the Earth's magnetic field and its declination and inclination.

The National Oceanographic and Atmospheric Administration (NOAA) selected the Oklahoma Geophysical Observatory to be part of the National Crustal Monitoring Network. In the coming fiscal year, NOAA will determine the precise location (within 1 in.) of a point on a special triangulation station situated on the Observatory grounds. This will be accomplished by using a 16-ft-diameter dish to reference the position with 18 quasars. In subsequent years, the site will be reoccupied, and the data obtained from the Oklahoma location together with information gathered at five other North American sites will be used to determine the relative motion of the North American plate with respect to the other plates on the Earth's surface.

## Core and Sample Library

For more than 30 years the Survey has maintained a library of rock cuttings and cores from petroleum exploratory and development wells drilled in Oklahoma. These materials have been contributed by companies that recognize the need to maintain this information for future subsurface geological and reservoir engineering studies. Because of the extensive exploratory drilling that has taken place in Oklahoma, it is apparent that future production will come increasingly from the improved recovery of hydrocarbons in existing fields. The cuttings and cores maintained in the library will be important in that effort.

The library contains more than 25,000 boxes of petroleum cores taken from about 2,500 wells, and samples from about 35,000 wells. A computer file of the

core data is being developed and will be available in late 1987. This file will assist users in determining the availability of cores of any particular formation in any area of the State.

To assist in planning for future improvements, the Survey recently hosted a workshop for current and potential users of the core and sample library. The well-attended meeting provided a number of useful suggestions for improvements in our management and customer-service activities.

It should be noted that the present core storage is essentially filled to capacity with boxes of cores with little flexibility to rearrange space for more acquisitions. Unless new space is found soon, it will become necessary to restrict or even curtail receipt of new core material.

## Public Information and Assistance

The mission of the Survey is research and public service. Providing information and technical assistance to the public is essential to the proper discharge of that mission. That information and assistance is made available in a variety of ways. Technical publications on the results of scientific investigations are the foundation of this effort. An important companion activity is the translation of some technical information for the lay public where such information would be particularly useful in the formulation of public policy and in communicating information about especially interesting aspects of Oklahoma's natural environment.

The Survey also responds to a multitude of requests from within and outside the State for information about local and regional aspects of the State's geology or natural resources. These requests are received in the form of letters, phone calls, or personal visits and require about 25% of the aggregate professional staff time for response.

About 200 scientific and public lectures, field trips, conferences, and exhibits are presented annually by the staff in an effort to extend the knowledge gained from the many investigations and analytical studies that are conducted. These efforts are complemented by service on a large number of committees, boards, and task forces for which a special knowledge of geology and natural resources is useful.

## Administration

The establishment of the Survey was mandated by the State Constitution at Statehood in 1907. The First Legislature passed the necessary enabling legislation, and the Survey began operation in July 1908. At that time, the OGS was placed under the University of Oklahoma Board of Regents for fiscal and administrative control. Subsequently, with the creation of the Oklahoma State Regents for Higher Education, the Survey was placed under that body for program authority and budget.

The Survey operates with a minimum of administrative staff and support, believing that lean management is the most effective and efficient form of administration. In this manner, minimal resources are devoted to administrative overhead, allowing maximum use of available support for the mission of the organization.

## Summary

The Oklahoma Geological Survey has served the State for 79 years. During that time the results of the many field studies, collection and organization of geological and natural resource information, and basic research efforts have been presented in 143 bulletins, 89 circulars, 35 mineral reports, 24 guidebooks, 29 geologic maps, 30 special publications, 47 volumes of *Oklahoma Geology Notes* (including its predecessor, *The Hopper*), and numerous documents that have been either maintained in the open file or published in one of the numerous publications of national and international geological organizations.

The basic mission of the Survey is to provide the citizens of Oklahoma with high-quality scientific and technical information and assistance. That mission is made possible because of a dedicated and capable staff, and because of the close working relationships that have been established with other state and federal agencies, colleges and universities, scientific and technical organizations, companies, and individuals interested in the geology and the natural resources of our State.

— Charles J. Mankin, *Director*

# Appendix 1

## OGS Staff, 1986–87 Fiscal Year

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K. Jack Crawford[7]

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*Secretarial*
Betty D. Bellis
Mitzi G. Blackmon
Margarett K. Civis
Velma L. Cottrell
Judith A. Schmidt

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[1]Promoted May 1987.
[2]Appointed September 1986.
[3]Appointed July 1986.
[4]Terminated June 1987.
[5]Terminated April 1987.
[6]Terminated January 1987.
[7]Appointed February 1987.

# Appendix 2

## OGS Publications Issued, 1986–87 Fiscal Year

### New Publications

Bulletin 139—*Late Ordovician–Early Silurian strata in the central United States and the Hirnantian Stage*, by Thomas W. Amsden and James E. Barrick. 95 pages, 40 figures, 7 plates, 7 tables. Issued November 19, 1986.

Bulletin 140—*Coal geology of Craig County and eastern Nowata County, Oklahoma*, by LeRoy A. Hemish. 131 pages, 17 figures, 8 plates, 2 tables. Issued December 22, 1986.

Bulletin 141—*Conodonts and conodont biostratigraphy of the McLish and Tulip Creek Formations (Middle Ordovician) of south-central Oklahoma*, by Jeffrey A. Bauer. 58 pages, 8 text-figures, 5 plates, 2 tables. Issued February 5, 1987.

Circular 87—*Geohydrology of the Vamoosa–Ada Aquifer, east-central Oklahoma*, by Joseph J. D'Lugosz, Roger G. McClaflin, and Melvin V. Marcher. 42 pages, 3 figures, 3 plates, 7 tables. Issued August 26, 1986.

Circular 88—*Stability problems associated with abandoned underground mines in the Picher Field, northeastern Oklahoma*, by Kenneth V. Luza. 113 pages, 20 figures, 3 plates, 8 tables. Issued December 1, 1986.

Circular 89—*Effects of brine on the chemical quality of water in parts of Creek, Lincoln, Okfuskee, Payne, Pottawatomie, and Seminole Counties, Oklahoma*, by Robert B. Morton. 38 pages, 10 figures, 1 plate, 5 tables. Issued January 23, 1987.

Guidebook 23—*Petrology of the Cambrian Wichita Mountains igneous suite*, M. Charles Gilbert, editor. Guidebook for field trip no. 7, November 7–9, 1986, Geological Society of America, 99th annual national meeting. 196 pages, 176 figures, 24 tables. Issued October 24, 1986.

Guidebook 24—*The Slick Hills of southwestern Oklahoma—Fragments of an aulacogen?* R. Nowell Donovan, editor. Guidebook for field trip no. 12, November 7–9, 1986, Geological Society of America, 99th annual national meeting. 112 pages, 109 figures, 10 tables. Issued October 24, 1986.

Special Publication 86-1—*Oil-oil and oil-rock correlations: A chemist's perspective*, by Jane L. Weber. 51 pages, 5 figures. Issued August 26, 1986.

Special Publication 86-2—*Temperature-gradient information for several boreholes drilled in Oklahoma*, by William E. Harrison and Kenneth V. Luza. 42 pages, 18 figures, 7 tables. Issued October 6, 1986.

Special Publication 86-3—*Oil generation in the Anadarko basin, Oklahoma and Texas: Modeling using Lopatin's method*, by James W. Schmoker. 40 pages, 18 figures, 1 table. Issued November 17, 1986.

Special Publication 86-4—*The relationship between coal rank and present geothermal gradient in the Arkoma basin, Oklahoma*, by Brian J. Cardott, LeRoy A. Hemish, Charles R. Johnson, and Kenneth V. Luza. 65 pages, 16 figures, 2 plates, 3 tables. Issued December 12, 1986.

Special Publication 87-1—*Investigation of the Meers Fault, southwestern Oklahoma*, by Kenneth V. Luza, Richard F. Madole, and Anthony J. Crone. 75 pages,

22 figures, 2 plates, 1 table. Issued June 3, 1987.
*Oklahoma Geology Notes*—Six bimonthly issues (August 1986–June 1987), containing 261 pages.

**Publications Reprinted**

Guidebook 6—*Subsurface stratigraphic names of Oklahoma*, by Louise Jordan. 220 pages, 212 figures. Issued December 1957; sixth printing May 5, 1987.
Educational Publication 2—*Introduction, guidelines, and geologic history of Oklahoma. Book I of Guidebook for geologic field trips in Oklahoma*, by Kenneth S. Johnson. 15 pages, 16 figures, 7 photographs, 1 table. Issued January 1971; third printing June 1, 1987.

# Appendix 3

## Publications by OGS Staff, 1986–87 Fiscal Year

THOMAS W. AMSDEN

Late Ordovician–Early Silurian strata in the central United States and the Hirnantian Stage: Oklahoma Geological Survey Bulletin 139, 95 p., 1986 (with James E. Barrick).

BRIAN J. CARDOTT

The relationship between coal rank and present geothermal gradient in the Arkoma basin, Oklahoma: Oklahoma Geological Survey Special Publication 86-4, 65 p., 1986 (with LeRoy A. Hemish, Charles R. Johnson, and Kenneth V. Luza).
Folded Woodford Shale, Ouachita Mountains [cover-photo description]: Oklahoma Geology Notes, v. 46, p. 165–166, 1986.

CHARLES A. FERGUSON

Ichnofossils in the Ouachitas [cover-photo description]: Oklahoma Geology Notes, v. 47, p. 1–2, 1987.

SAMUEL A. FRIEDMAN

Oklahoma, *in* Coal seams and fields: seam analyses and descriptions of coal fields; 1986 Keystone coal industry manual: McGraw-Hill, New York, p. 531–535, 1986.
Developments in coal in 1985: American Association of Petroleum Geologists Bulletin, v. 70, p. 1643–1649, 1986 (with Richard W. Jones, Mary L. W. Jackson, and Colin G. Treworgy).

LEROY A. HEMISH

OGS hosts coal forum: Oklahoma Geology Notes, v. 46, p. 146–149, 1986.

Stratigraphy of the Lower part of the Boggy Formation (Desmoinesian) in northwestern Muskogee and southwestern Wagoner Counties, Oklahoma: Oklahoma Geology Notes, v. 46, p. 168–187, 1986.

Pennsylvanian conulariids from Okfuskee County, Oklahoma [cover-photo description]: Oklahoma Geology Notes, v. 46, p. 201–202, 1986.

The relationship between coal rank and present geothermal gradient in the Arkoma basin, Oklahoma: Oklahoma Geological Survey Special Publication 86-4, 65 p., 1986 (with Brian J. Cardott, Charles R. Johnson, and Kenneth V. Luza).

Coal geology of Craig County and eastern Nowata County, Oklahoma: Oklahoma Geological Survey Bulletin 140, 131 p., 1986.

Elements of an OGS core-drilling project: Oklahoma Geology Notes, v. 47, p. 73–77, 1987.

Names of coal beds in the northeastern Oklahoma shelf area: Oklahoma Geology Notes, v. 47, p. 96–113, 1987.

KENNETH S. JOHNSON

Oklahoma limestone quarries among largest in nation: Oklahoma Geology Notes, v. 46, p. 230, 1986.

State gypsum quarries among largest in U.S.A.: Oklahoma Geology Notes, v. 46, p. 231, 1986.

Hydrogeology and recharge of a gypsum-dolomite karst aquifer in southwestern Oklahoma, U.S.A., *in* Gunay, G.; and Johnson, I. V. (eds.), Karst water resources; Proceedings of the International Symposium on Karst Water Resources, Ankara, Turkey, July 7–19, 1985: International Association of Hydrological Sciences Publication No. 161, p. 343–357, 1986.

Development of the Wink Sink in west Texas due to salt dissolution and collapse, *in* Beck, B. F.; and Wilson, W. L. (eds.), Karst hydrogeology: engineering and environmental implications: Proceeding of the Second Multidisciplinary Conference on Sinkholes and the Environmental Impacts of Karst, Orlando, Florida, February 9–11, 1987, p. 127–136, 1987.

Oklahoma, *in* 1986 Annual review for exploration, mining, mineral processing, coal, and industrial minerals: Mining Engineering, v. 39, no. 5, p. 338, 1987.

Geology of Cleveland County, Oklahoma, *in* Soil survey of Cleveland County, Oklahoma: U.S. Dept. of Agriculture, Soil Conservation Service, Washington, D.C., p. 165–169, 1987 (with B. G. Bourlier, G. A. Sample, B. G. Swafford, and G. Douthit).

Isopach and lithofacies map of the Sauk Sequence (excluding basal clastics) in the northern Midcontinent, U.S.A.: U.S. Geological Survey Miscellaneous Field Studies Map MF 1835-D, scale 1:1,000,000, 1987 (with W. D. Pratt and others).

JAMES E. LAWSON, JR.

Oklahoma earthquakes, 1986: Oklahoma Geology Notes, v. 47, p. 65–72, 1987

(with Kenneth V. Luza).

Some aspects of seismic sealing and the strong ground motion of the eastern Missouri earthquake of January 12, 1984: Seismological Research Letters, v. 58, p. 53–58, 1987 (with Otto W. Nuttli, David S. Bowling, and Randall Wheeler).

KENNETH V. LUZA

Temperature-gradient information for several boreholes drilled in Oklahoma: Oklahoma Geological Survey Special Publication 86-2, 42 p., 1986 (with William E. Harrison).

The relationship between coal rank and present geothermal gradient in the Arkoma basin, Oklahoma: Oklahoma Geological Survey Special Publication 86-4, 65 p., 1986 (with Brian J. Cardott, LeRoy A. Hemish, and Charles R. Johnson).

Stability problems associated with abandoned underground mines in the Picher Field, northeastern Oklahoma: Oklahoma Geological Survey Circular 88, 114 p., 1986.

Holocene deformation associated with the Meers fault, southwestern Oklahoma, *in* Donovan, R. N. (ed.), The Slick Hills of southwestern Oklahoma—fragments of an aulacogen?: Oklahoma Geological Survey Guidebook 24, p. 68–74, 1986 (with Anthony J. Crone).

Characteristics of late Quaternary surface faulting on the Meers fault, Comanche County, southwestern Oklahoma [abstract]: EOS, American Geophysical Union Transactions, v. 67, no. 44, p. 1188, 1986 (with Anthony J. Crone).

Oklahoma earthquakes, 1986: Oklahoma Geology Notes, v. 47, p. 65–72, 1987 (with James E. Lawson, Jr.).

Investigation of the Meers fault, southwestern Oklahoma: Oklahoma Geological Survey Special Publication 87-1, 75 p., 1987 (with Richard F. Madole and Anthony J. Crone).

LARRY N. STOUT

Conodont biostratigraphy of the Permian Meade Peak Phosphatic Shale Member, Phosphoria Formation, southeastern Idaho: Contributions to Geology, University of Wyoming, p. 169–190, 1986 (with Fred H. Behnken and Bruce R. Wardlaw).

NEIL H. SUNESON

Flute casts in the Atoka Formation [cover-photo description]: Oklahoma Geology Notes, v. 46, p. 125–126, 1986.

Ouachita guidebooks indexed: Oklahoma Geology Notes, v. 46, p. 140–145, 1986.

Measured sections, Oklahoma Ouachita Mountains: Oklahoma Geology Notes, v. 47, p. 48–61, 1987.

Wildhorse Mountain Formation in the Ouachita Mountains [cover-photo description]: Oklahoma Geology Notes, v. 47, p. 93–94, 1987.

JANE L. WEBER

Oil-oil and oil-rock correlations: a chemist's perspective: Oklahoma Geological Survey Special Publication 86-1, 51 p., 1986.

## Appendix 4

### Papers and Talks Given by OGS Staff at Public Meetings, 1986–87 Fiscal Year

Elementary Science Teachers Workshop, Tulsa, Oklahoma, July 7, 1986.
JAMES E. LAWSON, JR.: "Earthquakes in Oklahoma."

Oklahoma Conference on Environmental Quality, "The Environment and Economic Development," Oklahoma City, Oklahoma, July 9, 1986.
CHARLES J. MANKIN: "Waste management."

Tulsa Rock and Mineral Society, lecture tour, Leonard, Oklahoma, July 21, 1986.
JAMES E. LAWSON, JR.: A lecture tour of the Oklahoma Geophysical Observatory.

Women in Energy, Oklahoma City, Oklahoma, August 8, 1986.
CHARLES J. MANKIN: "Future oil and gas production in Oklahoma."

Rotary Club, Shawnee, Oklahoma, September 2, 1986.
CHARLES J. MANKIN: "Oklahoma's natural resources."

School of Geology and Geophysics Colloquium, University of Oklahoma, Norman, Oklahoma, September 3, 1986.
CHARLES J. MANKIN: "Whatever happened to the energy crisis?"

Annual Cluster Meeting of the Central Region State Geological Surveys and the U.S. Geological Survey, Lawrence, Kansas, September 16, 1986.
KENNETH S. JOHNSON: "Geologic-mapping programs at the Oklahoma Geological Survey."

Oklahoma Science Teachers Association State Meeting, Tulsa, Oklahoma, October 16, 1986.
JAMES E. LAWSON, JR.: "Earthquakes in Oklahoma."

Tulsa Rock and Gem Show, Tulsa, Oklahoma, October 25, 1986.
JAMES E. LAWSON, JR.: "Oklahoma earthquakes."

Society of Economic Paleontologists and Mineralogists, Midcontinent Section Meeting, Ponca City, Oklahoma, October 30–November 1, 1986.

JAMES R. CHAPLIN: "A reappraisal of the lithostratigraphy of the Council Grove and Chase Groups (Permian) in north-central Oklahoma and partial equivalent rock units in Kansas and Nebraska."

KENNETH S. JOHNSON: "Nonpetroleum mineral resources of Permian rocks in Oklahoma and the Texas Panhandle" and "Principal aquifers in Permian strata of central and western Oklahoma."

Unitarian-Universalist Fellowship, Norman, Oklahoma, November 2, 1986.

CHARLES J. MANKIN: "Whatever happened to the energy crisis?"

AAPG Student Chapter, School of Geology and Geophysics, University of Oklahoma, Norman, Oklahoma, November 13, 1986.

JOCK A. CAMPBELL: "Structural and petroleum geology of the Uinta Mountain/Basin Transition Area, northern Utah."

Geological Society of America Annual Meeting, San Antonio, Texas, November 13, 1986.

CHARLES A. FERGUSON: "Structure of the Mt. Withington Cauldron, Mogollan-Datil Volcanic Field, New Mexico."

Fort Smith Geological Society Fall Meeting, Fort Smith, Arkansas, November 13, 1986.

LEROY A. HEMISH: "Coal geology of the northern part of the northeast Oklahoma shelf area."

Department of Geology Colloquium, University of Arkansas, Fayetteville, Arkansas, January 23, 1987.

BRIAN J. CARDOTT: "Organic petrology—my world and welcome to it."

Department of Geology Seminar, University of Oklahoma, Norman, Oklahoma, January 28, 1987.

CHARLES A. FERGUSON: "Structure and stratigraphy of the Mt. Withington Cauldron, south-central New Mexico."

Geology Seminar, New Mexico Institute of Mining and Technology, Socorro, New Mexico, January 29, 1987.

CHARLES A. FERGUSON: "Geology of the northern San Mateo Mountains, New Mexico."

Fort Smith Geological Society, Fort Smith, Arkansas, February 3, 1987.

CHARLES J. MANKIN: "The geopolitics of natural resources."

Texas Bureau of Economic Geology, Austin, Texas, February 4, 1987.

KENNETH V. LUZA: "The Meers fault investigation."

Second Multidisciplinary Conference on Sinkholes and the Environmental Impacts of Karst, Orlando, Florida, February 9, 1987.

KENNETH S. JOHNSON: "Development of the Wink Sink in west Texas due to salt dissolution and collapse."

Norman Cable TV program, "The Public's Business," Norman, Oklahoma, February 11, 1987.

CHARLES J. MANKIN: "Oklahoma's natural resources."

Ardmore Geological Society, Ardmore, Oklahoma, February 12, 1987.

KENNETH S. JOHNSON: "Geologic excursions through the Grand Canyon."

School of Geology and Geophysics, Terrestrial Palynology class (Geology 5643), University of Oklahoma, Norman, Oklahoma, February 24, 1987.

BRIAN J. CARDOTT: "Vitrinite reflectance analysis."

Tulsa Geological Society, lecture tour, Leonard, Oklahoma, March 1, 1987.

JAMES E. LAWSON, JR.: A lecture tour of the Oklahoma Geophysical Observatory.

Kiwanis Club, Durant, Oklahoma, March 25, 1987.

CHARLES J. MANKIN: "Whatever happened to the energy crisis?"

Mineral Owners Association of Oklahoma, State Senator Ray Giles, and others, State Capitol, Oklahoma City, Oklahoma, March 26, 1987.

JOCK A. CAMPBELL: "Major geologic characteristics of petroleum reservoir rocks and examples of gas-well behavior in Oklahoma."

Department of Geology Colloquium, Southern Illinois University, Carbondale, Illinois, March 27, 1987.

BRIAN J. CARDOTT: "Organic petrology—my world and welcome to it."

Friends of the Pleistocene, South-Central Cell field trip, near Lawton, Oklahoma, March 27, 1987.

KENNETH V. LUZA: "Holocene deformation on the Meers fault near Canyon Creek."

Ouachita Mountains COGEOMAP Workshop, Norman, Oklahoma, April 1–4, 1987.

BRIAN J. CARDOTT: "Hydrocarbon source-rock potential—status of sample collection and petrographic analysis."

CHARLES A. FERGUSON: "Paleocurrent studies in the northern Ouachita Mountains" and led field trip to Higgins and Damon 7½′ Quadrangles, frontal Ouachita Mountains (with Neil H. Suneson).

NEIL H. SUNESON: "Oklahoma mapping program" and led field trip to Higgins and Damon 7½′ Quadrangles, frontal Ouachita Mountains (with Charles A. Ferguson).

School of Geology and Geophyscis, Terrestrial Palynology class (Geology 5643), University of Oklahoma, Norman, Oklahoma, April 2, 1987.
LEROY A. HEMISH: "Pennsylvanian-age coals of Oklahoma."

American Institute of Professional Geologists, Kansas and Oklahoma Sections Joint Meeting, Ponca City, Oklahoma, April 3–4, 1987.
JAMES R. CHAPLIN: "Permian lithostratigraphy of the northern Midcontinent—a reappraisal"
CONNIE G. SMITH: "The public's view of geologists at the Oklahoma Geological Survey."

Geology Alumni Banquet, Stillwater, Oklahoma, April 4, 1987.
CHARLES J. MANKIN: "The geopolitics of natural resources."

Tulsa Junior College, geology class lecture tour, Leonard, Oklahoma, April 8, 1987.
JAMES E. LAWSON, JR.: A lecture tour of the Oklahoma Geophysical Observatory.

Department of Geology Seminar, Texas Christian University, Fort Worth, Texas, April 16, 1987.
KENNETH V. LUZA: "Holocene movement on the Meers fault."

Kansas State University Chapter of Sigma Xi, Manhattan, Kansas, April 21, 1987.
CHARLES J. MANKIN: "The future of our nation's energy economy and resources."

Oklahoma City Geological Society, Oklahoma City, Oklahoma, April 30, 1987.
KENNETH S. JOHNSON: "Grand Canyon float trip."

Southern Plains Region of the National Speleological Society Annual Technical Meeting, Oklahoma City, Oklahoma, May 2, 1987.
KENNETH S. JOHNSON: "Study of the Blaine Formation gypsum-dolomite aquifer in southwestern Oklahoma."

Oklahoma Society of Land Surveyors Annual Convention, Oklahoma City, Oklahoma, May 2, 1987.
KENNETH S. JOHNSON: "Information and services available from the Oklahoma Geological Survey."

11th Annual Forum of Western Interior Coal Basin Geologists, Columbia, Missouri, May 5–6, 1987.
BRIAN J. CARDOTT: "Petrography of coals from the Desmoinesian–Missourian boundary."
SAMUEL A. FRIEDMAN: "Coal mines, mining, markets, and coal production in Oklahoma in 1986" and "Coal specification requirements of electric-power-plant engineers, regarding trace elements in Oklahoma coal."
LEROY A. HEMISH: "The use of coal beds as markers for resolving stratigraphic problems."

Okmulgee Middle School, student lecture tour, Leonard, Oklahoma, May 15, 1987.
JAMES E. LAWSON, JR.: A lecture tour of the Oklahoma Geophysical Observatory.

American Geophysical Union, Baltimore, Maryland, May 17, 1987.
CHARLES J. MANKIN: "The role of geology in public policy."

Oklahoma Corporation Commission for the Commissioners of the State Land Office, State Capitol, Oklahoma City, Oklahoma, May 20, 1987.
JOCK A. CAMPBELL: Provided expert witness on the nature and continuity of certain parts of the Cherokee and Marmaton groups (Desmoinesian).

Lions Club, Wewoka, Oklahoma, May 26, 1987.
CHARLES J. MANKIN: "Whatever happened to the energy crisis?"

Mineral Owners Association of Oklahoma, State Senator Ray Giles, Senate Natural Resources Committee, and petroleum-industry representatives, State Capitol, Oklahoma City, Oklahoma, May 27, 1987.
JOCK A. CAMPBELL: "Behavior of selected gas wells from various depths and reservoirs in Oklahoma."

Tulsa Webster High School, earth science class lecture tour, Leonard, Oklahoma, May 27, 1987.
JAMES E. LAWSON, JR.: A lecture tour of the Oklahoma Geophysical Observatory.

Rocky Mountain Federation and American Federation Mineralogical Society National Show and Convention, Oklahoma City, Oklahoma, June 14, 1987.
KENNETH S. JOHNSON: "Geology and minerals of western Oklahoma" and "Reading and interpretation of topographic maps."

American Society of Civil Engineers, Geotechnical Engineering Division Specialty Conference, "Geotechnical Practice for Waste Disposal," Ann Arbor, Michigan, June 15–17, 1987.
CHARLES J. MANKIN: "Geological criteria for deep-well injection of hazardous wastes."

School of Geology and Geophysics and Oklahoma Geological Survey faculty and staff, University of Oklahoma, Norman, Oklahoma, June 25, 1987.
CHARLES A. FERGUSON: "Scenery and geology of Canada's arctic and Rocky Mountain regions."

Oklahoma Corporation Commission for the Commissioners of the State Land Office, State Capitol, Oklahoma City, Oklahoma, June 30, 1987.
JOCK A. CAMPBELL: Provided expert witness on the nature and continuity of certain parts of the Cherokee and Marmaton groups (Desmoinesian).

# OGS RELEASES MARSHALL COUNTY BULLETIN

*Geology and Mineral Resources of Marshall County, Oklahoma*, a comprehensive report by George G. Huffman, Kenneth F. Bridges, Robert W. Ganser, Alan M. Holtzman, Jr., and Michael L. Merritt, has recently been issued by the Oklahoma Geological Survey as Bulletin 142. The book is divided into two parts—areal geology and petroleum geology—and, in addition to 57 figures, includes oversize maps showing areal geology and subsurface structure.

Authors' abstract:

Marshall County encompasses 421 $mi^2$ in central southern Oklahoma, of which 64 $mi^2$ is covered by water. Rocks exposed at the surface range in age from early Paleozoic (Viola Group) to Late Cretaceous (Woodbine Formation). Paleozoic rocks, including the Viola Group, Hunton Group, Woodford Formation, and Sycamore Limestone, are partially exposed around Lake Oteka on the Mannsville anticline. The basal Cretaceous Antlers Formation (Trinity Group) comprises the Baum Limestone Member, a probable lagoonal deposit which lies unconformably on eroded Paleozoic rocks, and the Antlers sandstone, a nearshore deposit of a transgressive sea. The overlying Fredericksburg Group is represented by the Goodland Limestone and the Kiamichi Formation. The Washita Group includes the Caddo Formation (Duck Creek and Fort Worth Members), the Bokchito Formation (Denton Clay, Soper Limestone, Weno Clay, McNutt Limestone, and Pawpaw Sandstone Members), the Bennington Limestone, and the Grayson Marlstone. The Upper Cretaceous Woodbine Formation (Dexter Member) rests disconformably on the Lower Cretaceous beds. Three terrace levels are well developed on unconsolidated Quaternary deposits overlying Cretaceous rocks along the eastern and southern edges of the county.

Surface structure is relatively simple: a gentle SE dip is interrupted by NW-trending folds, including the Cumberland syncline, the Mannsville–Madill–Aylesworth anticline, the Kingston syncline, and the Preston anticline.

Subsurface rocks in Marshall County include the Precambrian Tishomingo Granite and the Colbert Porphyry (Carlton Rhyolite) of Middle Cambrian age. Overlying Paleozoic rocks (Arbuckle facies) include the Reagan Sandstone and Honey Creek Limestone, Arbuckle Group, Simpson Group (Joins, Oil Creek, McLish, Tulip Creek, and Bromide Formations), Viola Group, Sylvan Shale, Hunton Group, Woodford Formation, Sycamore Limestone, "Caney" Shale, "Goddard–Springer" Shale, Dornick Hills Group, Deese Group, and Hoxbar Group. The Ouachita facies includes the Mazarn Shale, Womble Shale, Bigfork Chert, and Polk Creek Shale (Ordovician); Missouri Mountain Shale and Arkansas Novaculite (Silurian–Devonian); and Stanley Shale (probably Upper Mississippian) in the subsurface of southeastern Marshall County, where these rocks have been thrust-faulted northwestward onto rocks of the Arbuckle facies. Both the Arbuckle and Ouachita facies are truncated by erosion and disconformably overlain by Cretaceous rocks.

Tectonic elements of significance to an understanding of the subsurface geology of Marshall County include, from northeast to southwest, the Ravia fault block and associated Ravia and Sand Canyon nappes, Cumberland fault, Cumberland anticline, Cumberland syncline, Mannsville–Madill–Aylesworth fault system, Mannsville anticline, Madill anticline, Aylesworth anticline, Bryan fault, Kingston fault, Kingston syncline, Preston anticline, Overbrook thrust fault, Criner fault block, and Bryan salient of the Ouachita thrust system.

Numerous oil and gas fields associated with these structures include the Cumberland, Aylesworth, Southeast Aylesworth, North Madill, Madill and East Madill,

Southeast Mannsville (abandoned), Enos, Isom Springs, Southwest Isom Springs, Kingston (abandoned), Handy and Southeast Handy (Texas), and South Powell. New discoveries in the Ouachita facies in the Isom Springs area and deep Ordovician production in the South Powell field highlight recent developments.

Nonmetallic-mineral production includes petroleum, natural gas, stone, sand, and gravel. Water is abundant, especially in surface lakes.

The geologic and tectonic history of Marshall County includes (1) faulting of the Precambrian basement and formation of the southern Oklahoma geosyncline, part of the Ouachita aulacogen; (2) filling of the southern Oklahoma geosyncline with early Paleozoic carbonates and late Paleozoic clastic rocks; (3) deposition of the Ouachita facies in the Bryan and Atoka basins (Ouachita geosyncline); (4) several episodes of tectonic activity, especially in post-Hunton, pre-Woodford time and during the Pennsylvanian (Wichita, Arbuckle, and Marathon–Ouachita orogenies); (5) post-Pennsylvanian, pre-Cretaceous erosion and peneplanation; (6) inundation by Cretaceous seas and deposition of cretaceous sediments; (7) post-Cretaceous erosion; and (8) formation of extensive Pleistocene terraces and development of modern drainage systems.

Oil and gas accumulation and entrapment in Marshall County occurred in Late Pennsylvanian time, shortly after the folds and faults of the Arbuckle and Ouachita systems had been formed. Oil and gas trapped in isolated Pennsylvanian sands enclosed in Pennsylvanian shales accumulated during Pennsylvanian time. Shallow accumulations of hydrocarbons in basal Cretaceous sands may be the result of upward leakage from underlying structures, migration having occurred along fractures and faults which cut pre-Cretaceous beds.

Bulletin 142 is available over the counter or postpaid from the Oklahoma Geological Survey at the address given inside the front cover of this issue. The price is $10 for paperbound copies, $14 for clothbound.

## GRAND CANYON FLOAT TRIP OFFERED

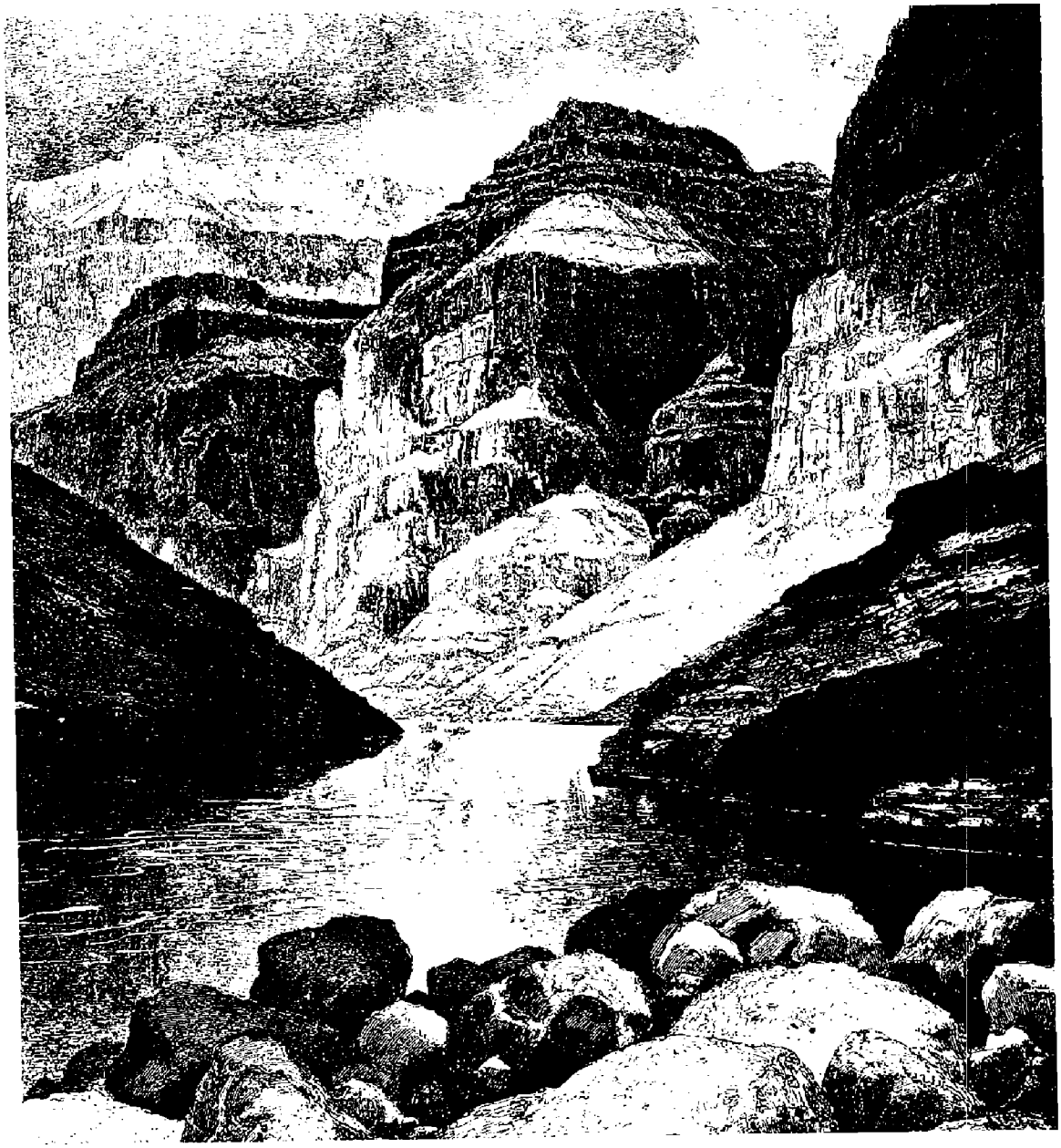
The University of Oklahoma is offering a special geological field trip down the Colorado River and through the Grand Canyon from April 23 to May 1, 1988, as part of a program of cooperation with professional geologists in central Oklahoma. The trip, offered as a non-credit course of study, is geared primarily to geologists and their spouses (or guests), and will include seven days on the river examining the geology, archaeology, Indian activity, and early-day exploration of the Colorado River. The trip will have enough technical and scientific data to stimulate scientific interests and further an understanding of basic geologic processes, but will also be fundamental enough to be of interest to a spouse or nonprofessional friends.

Total cost for the trip for each person, from the Will Rogers World Airport on Saturday morning, April 23, until return to Will Rogers World Airport on Sunday afternoon-evening, May 1, is $1,325. This price—subject to change, depending upon the price of services charged to the University—includes transportation by plane and bus, motel in Flagstaff for two nights (double occupancy), camping equipment, float-trip costs, guide service, and meals in Flagstaff and on the river. Those making their own travel plans to and from Flagstaff will pay $1,150 per person (subject to change, as noted above), to cover all expenses except airfare.

The continuing-education course and field trip is being organized and led by Dr. Kenneth S. Johnson, associate director of the Oklahoma Geological Survey and visiting professor at the University of Oklahoma. An experienced field-trip leader, Ken has made three trips down the Colorado River through the Grand Canyon, and in 1985 and 1986 he organized and led trips identical to this offering through the Grand Canyon for groups of geologists and spouses.

Enrollment for the course and field trip is open now and will continue until the program is filled. Space will be allocated on a first-come, first-served basis. A $200 deposit per person reserves space on a raft; final payment must be received by February 1, 1988.

For additional information, contact Dr. Johnson at the Oklahoma Geological Survey, University of Oklahoma, Norman, OK 73019, phone (405) 325-3031, or contact Josephine Wilke or Karen Hinkle, Energy Resources Institute, University of Oklahoma, Norman, OK 73019, phone (405) 325-2429.



# GSA SOUTH-CENTRAL SECTION MEETING
## Lawrence, Kansas, March 14–15, 1988

Sponsored by the University of Kansas Department of Geology and the Kansas Geological Survey, the 22nd Annual Meeting of the Geological Society of America South-Central Section will feature the following meetings and field trips.

## Symposia

Geology and Geophysics of the Precambrian of the Midcontinent
The Tippecanoe Sequence in the Western Interior
Geological Reconnaissance of the Trans-Mississippi West
Geology and Paleontology of the Unique Hamilton Quarry Locality
Pre-Cenozoic Aquifers of the Midcontinent
Pollution and Contamination of Shallow Aquifers in the Midcontinent
Cyclicity and Periodicity Throughout the Geologic Record

## Field Trips and Workshops

Precambrian of the Midcontinent—A Field Trip in a Room
Tippecanoe Sequence of the Subsurface
A Visit to Hamilton Quarry
Minelands Reclamation and Coal Geology in Southeastern Kansas
Lamproite in Wilson and Woodson Counties, Kansas

For further information about the meeting, contact Anthony W. Walton, Dept. of Geology, University of Kansas, Lawrence, KS 66045; (913) 864-4974. The pre-registration deadline is February 7.

# UPCOMING MEETINGS

**Association of Ground Water Scientists and Engineers, Ground Water Geochemistry Conference,** February 16–18, 1988, Denver, Colorado. Information: National Water Well Association, 6375 Riverside Dr., Dublin, OH 43017; (614) 761-1711.

**Association of Ground Water Scientists and Engineers, "Design Fundamentals for Site Characterizations and Remediations,"** February 22–23, 1988, Montgomery, Texas. Information: National Water Well Association, 6375 Riverside Dr., Dublin, OH 43017; (614) 761-1711.

**Federation of Environmental Technologists, Environment '88 Seminar and Exhibition,** March 7–8, 1988, Milwaukee, Wisconsin. Information: FET, P.O. Box 185, Milwaukee, WI 53201; (414) 251-8163.

**Association of Ground Water Scientists and Engineers, "Remote Sensing: Applications to Hydrogeology,"** March 8–10, 1988, Baltimore, Maryland; *or* August 2–4, 1988, St. Louis, Missouri. Information: National Water Well Association, 6375 Riverside Dr., Dublin, OH 43017; (614) 761-1711.

**Association of Ground Water Scientists and Engineers, Agricultural Impacts on Ground Water Conference,** March 21–23, 1988, Des Moines, Iowa. Information: National Water Well Association, 6375 Riverside Dr., Dublin, OH 43017; (614) 761-1711.

**Association of Ground Water Scientists and Engineers, "Surface Geophysical Techniques for Ground-Water-Related Investigations,"** March 29–31, 1988, Denver, Colorado; September 26–28, 1988, St. Charles, Illinois; *or* November 29–December 1, 1988, Tucson, Arizona. Information: National Water Well Association, 6375 Riverside Dr., Dublin, OH 43017; (614) 761-1711.

**Anadarko Basin Symposium,** April 5–6, 1988, Norman, Oklahoma. Information: Kenneth S. Johnson, Oklahoma Geological Survey, 830 Van Vleet Oval, Room 163, Norman, OK; (405) 325-3031.

**Society of Petroleum Engineers/U.S. Dept. of Energy, Sixth Symposium on Enhanced Oil Recovery,** April 16–21, 1988, Tulsa, Oklahoma. Information: Herbert A. Tiedemann, U.S. Dept. of Energy, Bartlesville Project Office, P.O. Box 1398, Bartlesville, OK 74005; (918) 337-4293.

**Sixth Thematic Conference on Remote Sensing for Exploration Geology,** May 16–19, 1988, Houston, Texas. Information: Environmental Research Institute of Michigan, P.O. Box 8618, Ann Arbor, MI 48107-8618; (313) 994-1200, Ext. 3234.

**Second National Outdoor Action Conference on Aquifer Restoration, Ground Water Monitoring, and Geophysical Methods,** May 23–26, 1988, Las Vegas, Nevada. Information: National Water Well Association, 6375 Riverside Dr., Dublin, OH 43017; (614) 761-1711.

**Fourth Canadian/American Conference on Hydrogeology: Fluid Flow, Heat Transfer, and Mass Transport in Fractured Rocks,** June 21–24, 1988, Banff, Alberta, Canada. Information: National Water Well Association, 6375 Riverside Dr., Dublin, OH 43017; (614) 761-1711.

**International Working Meeting on Soil Micromorphology** (meeting of Subcommission B of the International Society of Soil Science), July 10–15, 1988, San Antonio, Texas. Information: L. P. Wilding, Dept. of Soil and Crop Sciences, Texas A&M University, College Station, TX 77843-2474; (409) 845-3604.

# OIL AND GAS INFORMATION CONFERENCE HELD

The Oklahoma Geological Survey and the U.S. Department of Energy hosted the First Conference on Oil and Gas Information and Data-Base Management October 20–21 in Norman, Oklahoma. A total of 42 participants from 14 state agencies, the DOE offices in the Washington, D.C., area, and the DOE Project Office in Bartlesville, Oklahoma, attended the meeting. The group gathered to examine the current status of activities and future plans of state organizations in the collection, management, and use of state-level oil and gas information. Papers from the meeting are to be published by the OGS. The meeting was so successful that the group plans to meet yearly.

# NOTES ON NEW PUBLICATIONS

### *Hydrology of Area 40, Western Region, Interior Coal Province, Kansas, Oklahoma, and Missouri*

The USGS is providing hydrologic data through a series of reports covering the coal provinces nationwide. This report, by M. V. Marcher, J. F. Kenny, and others, broadly characterizes the hydrology of Area 40 in southeastern Kansas, southwestern Missouri, and northeastern Oklahoma. The 97-page report consists of a brief text with an accompanying map, chart, graph, or other illustration for each of a number of water-resources related topics. Topics include general geographic, geologic, and hydrologic descriptions, information on available water data, and discussion of specific hydrologic problems in the area. The summation of the topical discussions provides a description of the hydrology of the entire area, which encompasses both coal-producing and non-coal-producing regions.

Order OF 83-266 from: U.S. Geological Survey, Water Resources Division, 215 Dean A. McGee Ave., Room 621, Oklahoma City, OK 73102; (405) 231-4256. Copies of the report are available free of charge.

### *Hydrology of Area 41, Western Region, Interior Coal Province, Oklahoma and Arkansas*

This USGS report is one of a series that describes the hydrology of selected areas in coal provinces nationwide. Authors M. V. Marcher, D. L. Bergman, L. J. Slack, S. P. Blumer, and R. L. Goemaat provide a description of the hydrology of Area 41, which includes parts of eastern Oklahoma and western Arkansas. The 86-page report provides general hydrologic information by means of a brief text with accompanying map, chart, graph, or other illustration, for each of a series of topics related to water resources.

Order OF 84-129 from: U.S. Geological Survey, Water Resources Division, 215 Dean A. McGee Ave., Room 621, Oklahoma City, OK 73102; (405) 231-4256. This report is available free of charge.

# OKLAHOMA ABSTRACTS

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

## Summary and Comparisons of Three Technologies for Locating Abandoned Wells in Central Oklahoma

J. JEFFREY VAN EE, U.S. Environmental Protection Agency; LINDA ALLER, National Water Well Association; KRISTEN K. STOUT, Bionetics, Inc.; FRANK FRISCHKNECHT, U.S. Geological Survey; and DEBORAH FAIRCHILD, Environmental and Ground Water Institute

The U.S. Environmental Protection Agency evaluated three techniques for locating abandoned oil and gas wells in twenty-four sections of four townships near Oklahoma City, Oklahoma. The techniques were a traditional search of the records, a historical aerial photography search and an aerial magnetometer survey. The University of Oklahoma's Environmental and Ground Water Institute performed the records search and selected the twenty-four sections for study. The Agency's Environmental Photographic Interpretation Center used historical aerial photographs from the 1930s through 1981 to locate wells in the study areas. The United States Geological Survey determined from mathematical modeling that high resolution aerial magnetometry surveys were capable of locating abandoned wells, and conducted flights at 61-meters altitude and 100-meter spacings in Oklahoma. Approximately 95–98 percent of the probable number of oil and gas wells were located by the magnetometer survey compared with 91 percent from the photographic search.

The advantages, disadvantages, and costs of the three methods are summarized and suggestions are offered on how the methods may be applied to different areas.

Reprinted as published in the National Water Well Association, *Proceedings of the Seventh National Ground Water Quality Symposium, September 26–28, 1984, Las Vegas, Nevada*, p. 306.

## United States Earth Sciences, Status and Future: How Bad, How Good?

W. G. ERNST, Dept. of Earth and Space Sciences, Institute of Geophysics and Planetary Physics, University of California, Los Angeles, CA 90024

[Address as Retiring President of The Geological Society of America, November 1986]

The polyglot, fragmented, United States earth science community is in a state of stress, owing in part to decline of the domestic metals mining industry, severe economic downturns in the U.S. oil and gas industries, dispersal of research effort and decreasing role of the U.S. Geological Survey in production of detailed geologic maps, and apparent virtual stagnation of American geoscience education. Nevertheless, 15 research initiatives listed in this paper and several expanding applied fields provide examples of unparalleled opportunities for research and

development (R&D) in the earth sciences. Realization of these, and other, R&D goals will require coordinated efforts on the part of the earth science community to justify, promote, and sequence the various programs. Increased effectiveness in communication, education, research, and economic development can be achieved through a more unified approach, coordinated through the National Research Council Board on Earth Sciences and through the American Geological Institute. Individual basic and applied research initiatives which are considerably more promising than others cannot be identified; on the contrary, synergistic interactions among disparate subdisciplines are—and always have been—unpredictable, numerous, and fruitful in the geosciences. Acceleration of the rate of scientific advancement and economic development will require substantial increases in public and private support of the earth sciences. Enhanced R&D funding is advocated on the basis of clear scientific promise and acute relevance of the geosciences to long-term national needs, both societal and economic.

Reprinted as published in the Geological Society of America *Bulletin*, v. 99, p. 1.

## Petrologic, Paleomagnetic, and Structural Evidence of a Paleozoic Rift System in Oklahoma, New Mexico, Colorado, and Utah

[See discussion and reply in the Geological Society of America *Bulletin*, v. 99, p. 315–316.]

## Coal Depositional Models for Deltaic and Alluvial Plain Sequences

CHRISTOPHER R. FIELDING, Dept. of Geology and Mineralogy, University of Queensland, St. Lucia, Queensland 4067, Australia

Coal depositional models attempt to predict the distribution and geometry of coal beds within given sequences or provinces. To date, models proposed for coals of alluvial and deltaic origin have emphasized depositional environment as the controling variable. In this article, I propose that subsidence regime and, to a lesser extent, sediment supply are the dominant controls upon coal distribution rather than environment of accumulation. For this reason, most existing coal depositional models are likely to have limited predictive capability.

Reprinted as published in *Geology*, v. 15, p. 661.

## Geological Implications of Late Cambrian Trilobites from the Collier Shale, Jessieville Area, Arkansas

WILLIAM D. HART, JAMES H. STITT, STEVEN R. HOHENSEE, and RAYMOND L. ETHINGTON, Dept. of Geology, University of Missouri, Columbia, MO 65211

Late Cambrian shelf trilobites characteristic of the *Elvinia* and *Taenicephalus* Zones (Franconian Stage) have been recovered from seven localities in newly

recognized outcrops of the Collier Shale near Jessieville, Arkansas. Deposition of the Collier Shale spanned the Cambrian–Ordovician boundary; Late Cambrian trilobites occur in the lower part and Early Ordovician conodonts occur in the upper part of the formation. The trilobites are well known from many shallow-water shelf localities in North America, and their presence indicates that the Benton uplift is not an exotic terrane but an original part of North America. The thin, dark limestones containing the trilobites were deposited in a deep-water, outer-shelf or continental-slope location, and they establish an approximate position for the Late Cambrian shelf edge along the southern margin of North America.

Reprinted as published in *Geology*, v. 15, p. 447.

## Organic Carbon Losses During Burial and Thermal Maturation of Normal Marine Shales

ROBERT RAISWELL, Dept. of Earth Sciences, University of Leeds, Leeds, England; and ROBERT A. BERNER, Dept. of Geology and Geophysics, Yale University, New Haven, CT 06511

The percentage of organic carbon lost during the burial diagenesis of normal marine shales (those originally deposited in oxygenated bottom waters) can be estimated by using the ratio of organic carbon (C) to pyrite sulfur (S) and assuming that the mean initial burial value of C/S for such sediments has been approximately constant since the Devonian. Plots of mean C/S vs. vitrinite reflectance ($R_0$) for some sedimentary basins of Jurassic and Carboniferous age show a monotonic decrease of C/S with increasing $R_0$.

Reprinted as published in *Geology*, v. 15, p. 853.

## Crustal Subdivisions of the Eastern and Central United States and a Seismic Boundary Hypothesis for Eastern Seismicity

ROBERT D. HATCHER, JR., Dept. of Geological Sciences, University of Tennessee, Knoxville, TN 37996-1410; ISIDORE ZIETZ, 8340 Greensboro Dr., Apt. 524, McLean, VA 22102; and JOE J. LITEHISER, Bechtel Civil and Minerals, Inc., P.O. Box 3965, San Francisco, CA 94119

Potential field and surface geologic data may be used to subdivide the Precambrian and Phanerozoic crust of the eastern and central United States into several blocks. These subdivisions are made by using the trends, amplitudes, and frequencies of magnetic anomalies in conjunction with gravity and surface geologic data. Most blocks appear unrelated to historical seismicity, but between New Mexico and Georgia, the edges of several blocks may be connected to form the northern boundary of a broad zone of very low earthquake activity. We speculate that this southern zone has been decoupled from the stress regime affecting the remainder of the central and eastern United States and should

experience few, if any, large earthquakes in the future as long as the present stress configuration is maintained.

Reprinted as published in *Geology*, v. 15, p. 528.

## Sources and Management of Agricultural Nonpoint Source Pollution in Arkansas, Oklahoma, and Texas

J. NIX, D. HONNELL, and C. KUYPER, Ouachita Baptist University, Arkadelphia, AR 71923; A. SHARPLEY, S. SMITH, and J. NANEY, USDA–ARS, Water Quality and Watershed Research Laboratory, Durant, OK 74702

The impact of agricultural management on the chemical composition of surface runoff, groundwater, and reservoirs has been assessed for up to 20 years in different geologic regions of the three states. Results for 20 watersheds and 45 wells in Oklahoma and Texas show that phosphorus levels in runoff were consistently above critical levels associated with accelerated eutrophication. Nitrate and salinity levels in groundwater, however, were generally within acceptable limits for drinking and irrigational use. Soil erosion from conservation or normal farm practices was small, with the major proportion of sediment in reservoirs originating from eroding gullies and stream banks. Changes in the chemistry (nutrient, sediment, oxygen, and heavy metal content) of several southwest Arkansas reservoirs have been measured during the past 20 years. Since its inception, hypolimnetic dissolved oxygen concentrations of De Gray Lake, Arkansas, have generally increased. The long-term study of De Gray Lake has provided data establishing water quality gradients within the reservoir, which are related to geology, land-use, and nonpoint source inputs from the watershed. Measures to reduce the environmental impact of agricultural nonpoint source pollution in this region include judicious use of fertilizer and implementation of soil conservation practices.

Presented at the North American Lake Management Society Regional Symposium on Lake and Reservoir Management, Austin, Texas, July 27–28, 1987.

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Clearly, this is a scenario which is both a challenge to the academic (the problem is currently under investigation by the author and Doug Elmore and Mike Engel from the University of Oklahoma) and a lesson in eclecticism to the student of basin analysis. It is also an affront to the management of oil companies! Job termination might well result for the bright young neophyte who blithely announces that he or she can date oil migration by studying fossil reptiles in Permian cave systems.

Perhaps the most tantalizing of the cave conduits is illustrated on the cover and in the accompanying diagram. A small fissure displays an initial vadose coating around its circumference. Subsequently this conduit was plugged at a level below the present level of exposure and as a result a perched phreatic tube developed. Large calcite crystals grew upward into this tube and eventually incorporated hydrocarbons into their higher portions, thus (1) fossilizing the oil-water contact, (2) proving conclusively that oil floated on water in the Permian Period, and (3) producing a viable submission to the Guiness Book of Records as the World's Smallest Oil Field. The horizontal contact suggests that the limestones of the Slick Hills have the same structural attitude today that they had in Permian times.

## References

Donovan, R. N., 1986, Geology of the Slick Hills, *in* Donovan, R. N. (ed.), The Slick Hills of southwestern Oklahoma—fragments of an aulacogen?: Oklahoma Geological Survey Guidebook 24, p. 1–12.

Simpson, L. C., 1979, Upper Gearyan and Lower Leonardian terrestrial vertebrate faunas of Oklahoma: Oklahoma Geology Notes, v. 39, p. 3–19.

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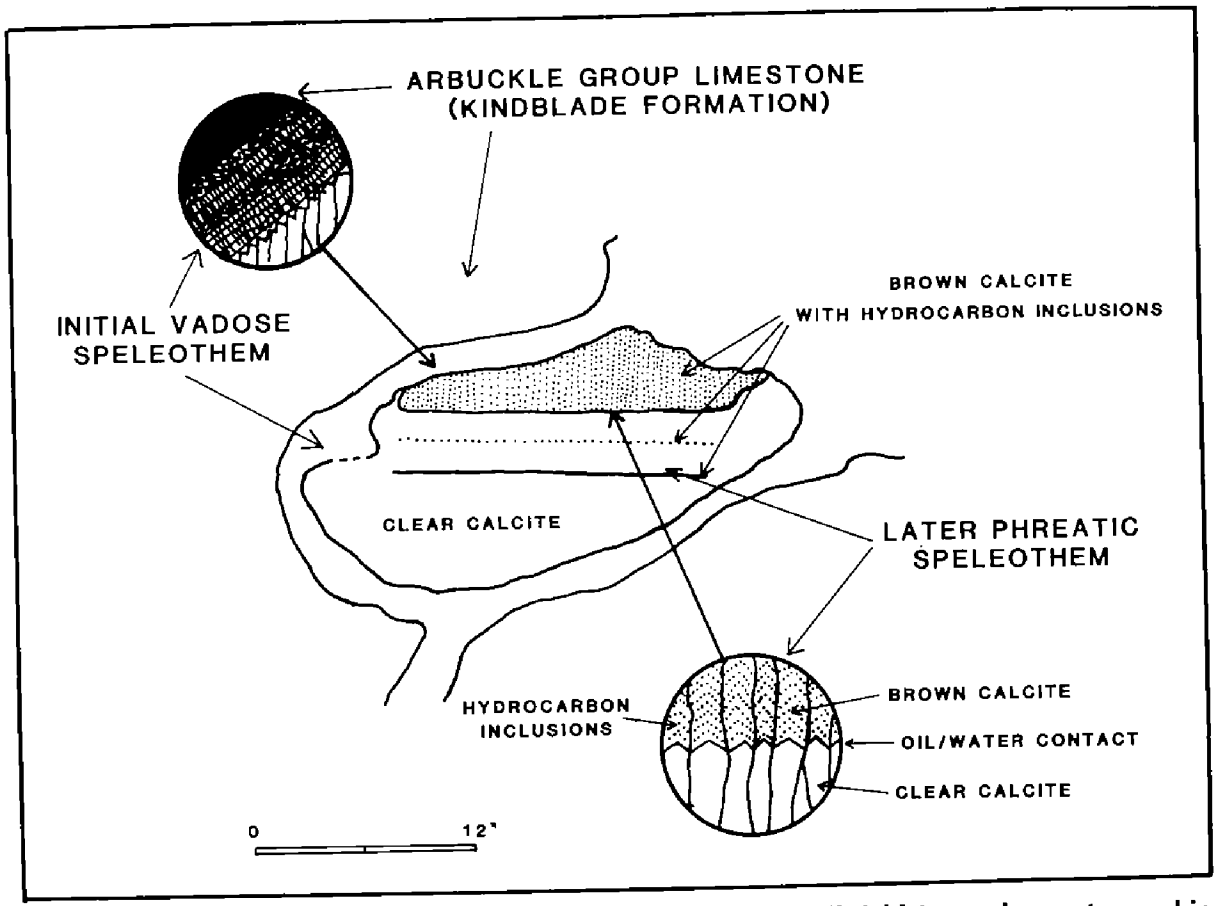


**Sketch showing fossilized oil-water contact in the World's Smallest Oil Field. Insets show petrographic details.**