VOLUME 36 NUMBER 4 AUGUST 1976

OKLAHOMA GEOLOGY NOTES

OKLAHOMA GEOLOGICAL SURVEY

Cover Picture

Glomar Challenger, Drill Ship for DSDP's Leg 48

The *Glomar Challenger,* Global Marine's drill ship contracted for the Deep Sea Drilling Project (DSDP), is shown here in dry dock in Brest, France, just before starting Leg 48 of the project. DSDP is an organization within Scripps Institution of Oceanography that operates through the support of Joint Oceanographic Institutions Deep Earth Sampling (JOIDES), a consortium of 14 oceanographic institutions in the United States, France, Great Britain, Japan, the U.S.S.R., and Germany.

The *Glomar Challenger* has a length of 400 feet, a beam of 65 feet, and a draft of 20 feet. She can remain working at sea for 90 days at a time. On site, she is capable of handling drill strings of up to 7,619 metres.

Leg 48 of DSDP, which started May 12, 1976, in Brest and ended July 13, 1976, in Aberdeen, Scotland, involved the drilling of 10 holes at sites in the Bay of Biscay and along the Rockall Plateau. Thomas L. Thompson, professor in the School of Geology and Geophysics at The University of Oklahoma, and I, from the Oklahoma Geological Survey, were among the 14 shipboard scientists who participated in Leg 48.

DSDP, which has entered the international phase of offshore drilling, is directed toward a better understanding of the oceanic crust, passive and active continental margins, and the paleoenvironment of the world's oceans. The purpose of Leg 48 was to obtain a record of the pre-rift sediments in two starved, passive margins.

—*William E. Harrison*

Editorial staff: William D. Rose, Rosemary Croy, Elizabeth A. Ham

Oklahoma Geology Notes is published bimonthly by the Oklahoma Geological Survey. It contains short technical articles, mineral-industry and petroleum news and statistics, an annual bibliography of Oklahoma geology, reviews, and announcements of general pertinence to Oklahoma geology. Single copies, seventy-five cents; yearly subscription, $3.00. All subscription orders should be sent to the address on the front cover.

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

This publication, printed by the Transcript Press, Norman, Oklahoma, is issued by the Oklahoma Geological Survey as authorized by Title 70, Oklahoma Statutes 1971, Section 3310, and Title 74, Oklahoma Statutes 1971, Sections 231-238. 1,500 copies have been prepared for distribution at a cost to the taxpayers of the State of Oklahoma of $2,268.00

Recent Field Studies of Felt Earthquakes in Oklahoma

Jim Lawson[1] and Robert L. DuBois[2]

Descriptive studies of the effects of earthquakes on people and buildings were the earliest semi-quantitative investigations of earthquakes. These studies remain important today because they are one direct approach to obtaining knowledge of the correlation between magnitude of earthquakes and expected damage. Such information is limited even today. The correlation between earthquake magnitude and damage is becoming extremely critical for highly active seismic areas, such as parts of California, because in such areas it is becoming possible to make some predictions of the expected magnitude and time of occurrence of earthquakes. For different reasons, this correlation is increasingly important in areas of lower seismicity, such as Oklahoma. The damage expected from earthquakes occurring in Oklahoma must be carefully assessed in order to plan the siting and construction of critical major structures. Field studies of felt and observed effects yield useful information on epicentral location and depth, which supplements that currently available from our multicomponent observatory (The University of Oklahoma Earth Sciences Observatory at Leonard, Oklahoma) and from out-of-State data. The data from seismographs outside of Oklahoma are degraded by (1) a distance factor, (2) the noisy location of some of them, and (3) the frequency passband response of seismographs used, which are primarily designed to record distant earthquakes.

Felt and observed effects of earthquakes are generally given values according to the modified Mercalli intensity scale, which assigns a Roman numeral to each of 12 levels described by effects on humans, man-made construction, or natural features. For example, MM III (modified Mercalli intensity III) is defined as "felt quite noticeably indoors, especially on upper floors of buildings, but many people do not recognize it as an earthquake. Standing motorcars may rock slightly. Vibration like passing of a truck. Duration estimated" (Coffman and von Hake, 1973).

When an earthquake is felt by many people over a large area, an effective way of mapping the large-scale variations in MM intensity is to send questionnaires to every postmaster in the area. The U.S. Coast and Geodetic Survey made such a map (Murphy and Cloud, 1954) for the April 9, 1952, earthquake at El Reno, Canadian County, Oklahoma, which was felt in all or parts of seven states. The map, which gives zones

[1]Geophysicist, The University of Oklahoma Earth Sciences Observatory, Leonard, Oklahoma.

[2]Kerr-McGee Professor of Geophysics, School of Geology and Geophysics, The University of Oklahoma, Norman, and director, The University of Oklahoma Earth Sciences Observatory, Leonard, Oklahoma.

of intensity, revealed a highly elongate felt area that appeared to follow the trend of the Nemaha uplift and Midcontinent gravity high.

Smaller Oklahoma earthquakes can be mapped to some extent in terms of intensities when they occur in an urban area. Such an earthquake, of magnitude m_{3HZ} 2.6, occurred at Moore, Cleveland County, Oklahoma, December 16, 1974. Magnitudes in this article are stated in terms of one of two scales developed by Otto Nuttli, m_{3HZ} (Stauder, 1975), and m_bLg (Nuttli, 1973). The value m_{3HZ} is calculated from the amplitude of 3 HZ waves typically observed from earthquakes up to 200 km from the Observatory, and m_bLg is calculated from 1 HZ waves that predominate on seismograms from more distant earthquakes. Earthquakes in less urbanized areas, such as the m_bLg 3.4 earthquake near Wilson, Carter County, Oklahoma, September 13, 1975, which became known at least to one local police department, are not necessarily reported to the press. In terms of the usual postmaster-questionnaire canvass, as used by governmental reporting groups, most small earthquakes in rural Oklahoma appear to be unfelt.

When the Wilson earthquake was located by vertical- and horizontal-component seismograms at the Earth Sciences Observatory, a limited telephone canvass located the felt area. After the press was notified, Tack Cornelius of *The Daily Ardmoreite* interviewed a number of area residents by phone and kindly sent his original interview notes to the Observatory (some of his data were published in *The Daily Ardmoreite* [Cornelius, 1975]). Mr. Cornelius' data were converted to MM intensities and displayed on a map. The map provided much more detail about the area affected by the earthquake than could have been obtained if only police departments and postmasters were canvassed.

When a larger earthquake, m_bLg 3.6, was recorded and located by the Observatory in Garvin County near Foster on November 29, 1975, a telephone canvass of nearly 20 post offices and police departments in the area did not produce one felt report. The telephone canvass was extended to random selections of individuals with results that located two clusters of felt effects. Because the felt-report clusters were 20 km apart, it was considered possible that a large area might be involved. Field studies in the area located 70 persons in 20 households who felt the earthquake, and 60 households in which the residents were at home during the time of the earthquake but felt nothing. The "not-felt" reports are important in delineating felt areas. Two freshly cracked foundations were observed at the center of the largest cluster of felt reports. The MM-intensity map (fig. 1) reveals a pattern of clusters of felt reports surrounded by locations where the earthquake was not felt. It suggests a correlation with local geology, as most of the felt locations are on alluvial flood plains. Such an association is logical, as alluvium is known to amplify seismic waves (Borcherdt and Gibbs, 1976).

The Wilson and Foster earthquakes gave a sharp contrast in felt effects. At Wilson, people described high-frequency phenomena such as

dishes rattling and sounds like sonic booms. At Foster, dishes did not rattle, but foundations cracked and people heard low-frequency rumbles that were described as "like a sonic boom but somehow different, more like the sound of a load of rock being dumped." These low-frequency effects suggest that the Foster earthquake focus was deeper than the Wilson focus. Such relative-depth information is often not calculable from seismograms, or from records from closely spaced seismographs.

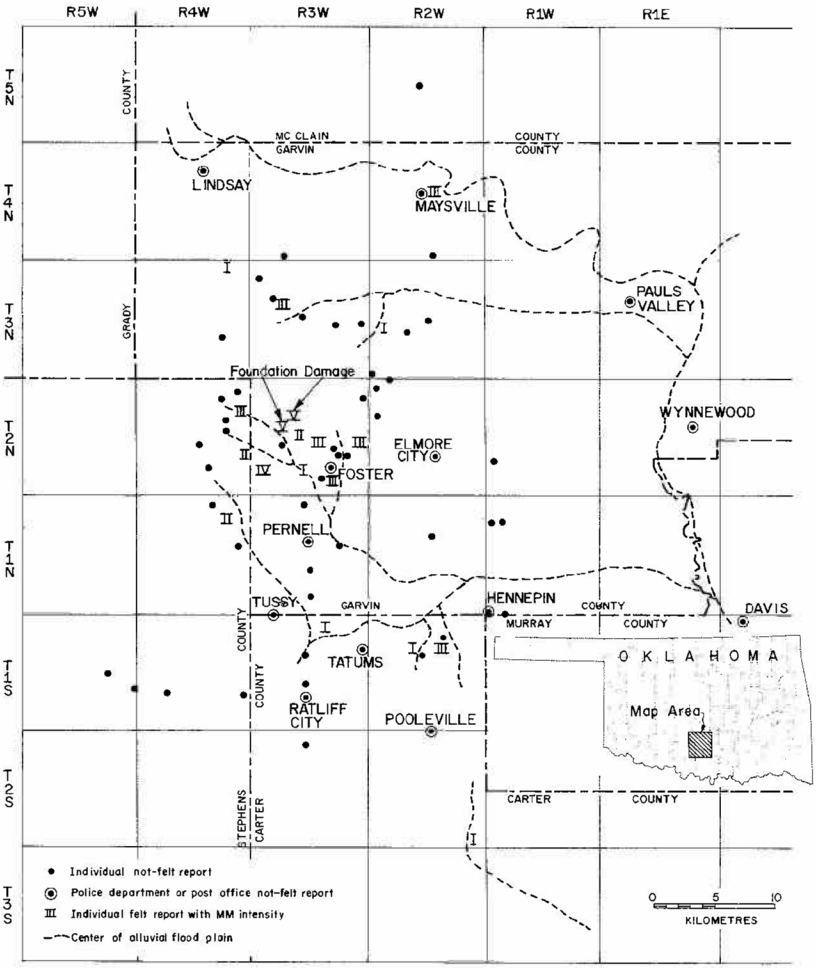


Figure 1. Map of Foster, Oklahoma, earthquake area. Earthquake occurred November 29, 1975, with magnitude of 3.6 (m_bLg).

On March 16, 1976, the Observatory located an earthquake of M_bLg 2.3 between Eufaula and Stidham, in McIntosh County, Oklahoma. Reports from a detailed telephone canvass and field study allowed us to push the accepted magnitude of the smallest earthquake perceptible to humans, m_bLg 2.6 (Nuttli and Zollweg, 1974), down to M_bLg 2.3. An April 17, 1976, earthquake of m_bLg 2.4, felt near Wilson, confirms this new limit. Eufaula has a population of more than 2,000, of which barely 2 percent felt the m_bLg 2.3 shock. The 2-percent figure was based on the response of about 600 local public-school students.

A March 30, 1976, 2.7-m_bLg earthquake near Boise City, in Cimarron County, in the Oklahoma Panhandle, gave a striking and unexplained contrast of effects between different towns. In Boise City, sounds like sonic booms were heard, and dishes rattled and even fell to the floor. In Keyes, about 25 km to the northeast, several people awoke to find objects such as candlesticks and lamps "mysteriously" moved, without overturning.

When two earthquakes (m_bLg 3.4, April 16, 1976; m_bLg 3.5, April 18, 1976) occurred near Durham, Roger Mills County, Oklahoma, the schools in the surrounding Oklahoma and Texas areas were asked by phone to print and distribute simple questionnaires to all their students and mail the completed forms to the Observatory. Along with a vigorous telephone canvass of individual households, the forms from the schools have given 531 reports that included location and responses concerning a "home-but-not-felt" report or a detailed description of the felt effects. Of the respondents, 23 felt the first earthquake, and 83 felt the second. The 531 reports, which exclude those reports in which the respondent did not clearly identify his or her exact location at the time of the earthquakes, are currently being plotted. In these studies, we initially had some concern that people might inject some imagination into their replies, but analysis of the data does not suggest such results.

Information obtained about the Durham earthquakes of April 1976 illustrates the value of canvassing individuals as a source of information supplementary to seismographic data. In addition to the OU Observatory, three stations, in New Mexico, Texas, and Colorado, had clear seismic-wave arrivals. Using the various arrival times, the U.S. Geological Survey, by computer, placed the first earthquake near Durham but the second some 100 km to the south. Negative felt reports from south of the area, and nearly identical felt patterns of both shocks, strongly indicate to us that the epicenters for both earthquakes were at the same location. Several repeated computations with various restraints have not changed the USGS epicenter-location results.

With a grant from the Nuclear Regulatory Commission, and supporting and coordinating efforts by the Oklahoma Geological Survey, the Observatory will soon be operating a network of seismographs across the State to study more thoroughly the seismicity in Oklahoma. The frequency of occurrence of earthquakes will be carefully studied, and their

epicenters accurately located by the network. The macroseismic (felt) field studies will be continued and a portable earthquake-detection system used to give supplementary data necessary for the understanding of the magnitude and location of seismicity in Oklahoma.

References Cited

Borcherdt, R. D., and **Gibbs, J. F.,** 1976, Effects of local geological conditions in the San Francisco Bay region on ground motions and the intensities of the 1906 earthquake: Seismological Society of America Bulletin, v. 66, p. 467-500.

Coffman, J. L., and **von Hake, C. A.,** 1973, Earthquake history of the United States: U.S. Department of Commerce, NOAA, EDS Publication 41-1, 207 p.

Cornelius, Tack, 1975, Earthquake felt south of Wilson [Oklahoma]: Ardmore Oklahoma, The Daily Ardmoreite, Sept. 14, 1975, p. 1.

Murphy, L. M., and **Cloud, W. K.,** 1954, United States earthquakes, 1952: U.S. Department of Commerce, Coast and Geodetic Survey, serial no. 773, 112 p.

Nuttli, O. W., 1973, Seismic wave attenuation and magnitude relations for eastern North America: Journal of Geophysical Research, v. 78, p. 876-885.

Nuttli, O. W., and **Zollweg, J. E.,** 1974, The relation between felt area and magnitude for central United States earthquakes: Seismological Society of America Bulletin, v. 64, p. 73-85.

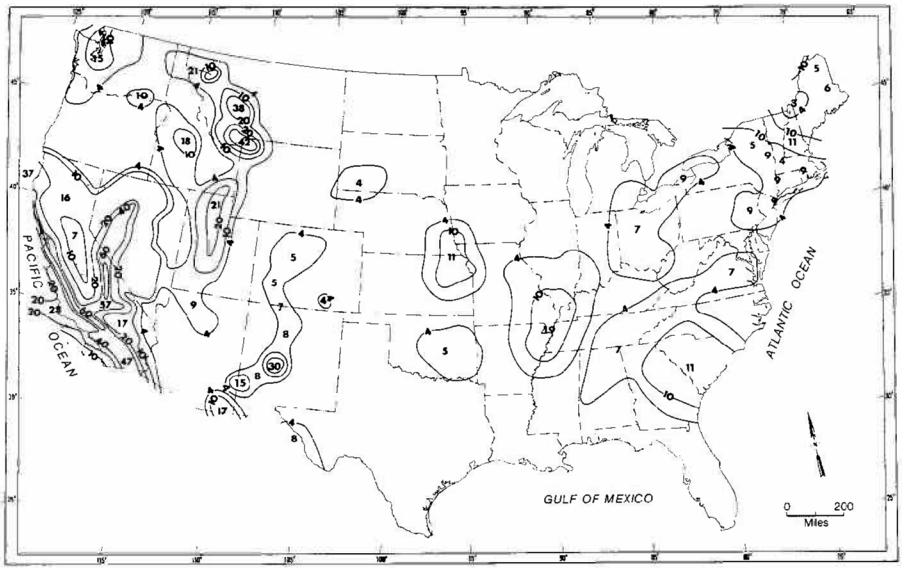
Stauder, Rev. William, S. J., 1975, Southeast Missouri regional seismic network final technical report: U.S. Geological Survey contract no. 14-08-0001-13698, 26 p.

USGS Prepares Earthquake-Hazard Report and Map of U.S.

A new report and map for the conterminous (48) United States appraising the potential ground shaking produced by earthquakes have been prepared by the U.S. Geological Survey. The map represents a first attempt to show expectable levels of shaking hazards from Oklahoma on a national basis.

Levels of ground shaking for different regions of the country are shown on the map by contour lines that express, in percentages of the force of gravity, the maximum amount of horizontal acceleration (shaking) likely to occur at least once in a 50-year period. Contours at 4, 10, 20, 40, and 60 percent of gravity are shown on the map, which is published at a scale of 1:7,500,000 (1 inch = 120 miles). All contours are expressed at the 90-percent-probability level. For Oklahoma, as an example, the map indicates a 90-percent certainty that ground shaking will be limited to 5 percent or less of the force of gravity.

The authors of the report and map emphasize that accelerations on the map are those estimated to occur on solid rock. Thus, because the



Map shows expectable levels of shaking hazards from earthquakes. Levels of ground shaking for different regions are shown by contour lines that express, in percentages of the force of gravity, the maximum amount of shaking likely to occur at least once in a 50-year period.

surface materials in many areas of the United States are not solid rock, the maximum acceleration at a particular location may be quite different from that shown on the map. For example, depending on surface geologic materials, the acceleration may be two or three times larger, or in a few cases even slightly lower, than the values shown on the map.

The report points out that exposure to damage from seismic shaking is steadily increasing because of continuing urbanization in earthquake-prone regions and because of the increasing complexity of power, water, transportation, and communication systems. Thus, the data presented are considered helpful in assessing earthquake hazards, in developing methods such as earthquake-resistant design to reduce such hazards, and in insurance studies as an aid in estimating potential earthquake losses.

Copies of the preliminary report and map, *A Probabilistic Estimate of Maximum Acceleration in Rock in the Contiguous United States,* by S. T. Algermissen and D. M. Perkins, and printed as USGS Open-File Report No. 76-416, are available for public inspection at various USGS libraries and offices throughout the country. Those closest to Oklahoma are the Federal Center, Denver, Colorado, and the Federal Building, 1100 Commerce Street, Dallas, Texas.

New U.S. Geological Survey Publications

Geohydrology of Oklahoma Panhandle

Geohydrology of the Oklahoma Panhandle, Beaver, Cimarron, and Texas Counties, is the title of a new publication by D. L. Hart, Jr., G. L. Hoffman, and R. L. Goemaat, of the U.S. Geological Survey's Water Resources Division. The 62-page report, which contains 10 plates of maps and sections in a pocket, was prepared in cooperation with the Oklahoma Water Resources Board.

The report concentrates on the Ogallala Formation of Tertiary age and rocks of Pleistocene age, which form the principal aquifer being developed for irrigating this semi-arid region. Other aquifers are the Dakota Sandstone and the Cheyenne Sandstone Member of the Purgatoire Formation, both early Cretaceous in age.

The authors point out that although the use of ground water from the Ogallala has been beneficial, continued development of this aquifer could bring ultimate depletion. During the last several years, water levels have declined as much as 40 feet, indicating that recharge is not keeping pace with withdrawal.

The report, issued as Water-Resources Investigation 25-75, can be ordered from National Technical Information Service (NTIS), 5285 Port Royal Road, Springfield, Virginia 22151 (order no. PB-254028). Paperbound copies are available for $6.00, and microform copies for $2.25.

Copper Deposits

A report by E. B. Tourtelot and J. D. Vine, entitled *Copper Deposits in Sedimentary and Volcanogenic Rocks,* has been released as Professional Paper 907-C. The authors discuss the geologic distribution of stratabound copper deposits and describe different types of deposits with reference to modern concepts of ore genesis and plate tectonics. The 34-page report can be ordered for $1.05 from the Branch of Distribution, U.S. Geological Survey, 1200 South Eads Street, Arlington, Virginia 22202.

Earth Science in Land-Use Planning

Circular 721, *Earth-Science Information in Land-Use Planning—Guidelines for Earth Scientists and Planners,* is the work of William Spangle and Associates, F. B. Leighton and Associates, and Baxter, McDonald and Co. The 28-page report is a set of general guidelines for utilizing earth-science information in land-use planning. It is expected to be useful to planners in acquainting them with available earth-science information. The report should be useful to earth scientists also in defining the needs of planners and how earth-science information can be made more

useful to them. The circular can be obtained without charge by writing the USGS Branch of Distribution at the address given previously.

Reclamation of Mined Areas

A Guide to State Programs for the Reclamation of Surface Mined Areas, by E. A. Imhoff, T. O. Friz, and J. R. LaFevers, is available as Circular 731. It surveys the status, content, and general trend of programs for the reclamation of surface-mined areas in the 50 states. Detailed information is presented in a table. A primer on surface-mining methods and a glossary are included for the use of planners. A directory of state agencies provides access to additional information. The 33-page circular is free of charge and can be obtained from the Branch of Distribution at the address given previously.

Pennsylvanian Paleotectonics

A publication by E. D. McKee, E. J. Crosby, and others should be of wide interest. Entitled *Paleotectonic Investigations of the Pennsylvanian System in the United States,* it has been issued as Professional Paper 853. It is in three parts: part I contains an introduction and regional analyses of the Pennsylvanian (349 p.); part II presents an interpretive summary and discusses special features of the Pennsylvanian (192 p.); and part III consists of 17 plates in a pocket. The whole set sells for $41 and can be obtained from the Branch of Distribution at the address given previously.

Uranium-Bearing Rocks

Unevaluated Preliminary Geologic Cross Section of Uranium-Bearing Upper Triassic Rocks Extending from Ute Reservoir, New Mexico, to Palo Duro Canyon, Texas is the title of Open-File Report 76-205 by W. I. Finch, J. C. Wright, and B. O. Davis. The cross section is available for public inspection at various federal depositories throughout the country. The closest one to Norman is the Public Inquiries Office, Room IC45, Federal Building, 1100 Commerce Street, Dallas, Texas 75202; reproductions of the section are also available from this office at the requestor's expense.

AAPG to Offer Seminars and Schools

Field Seminars

The 1976 Continuing Education Program of The American Association of Petroleum Geologists will include four field seminars in sedimentology scheduled for early fall.

The first study, September 5-11, will involve aerial and ground investigations of "Modern Clastic Depositional Environments" in the South

Carolina coastal plain. The group will be led by Miles O. Hayes, of the Coastal Research Division, Department of Geology, University of South Carolina.

A September 12-18 course will be over "Ancient Clastic Depositional Environments" in southwestern West Virgina and eastern Kentucky. Instructors will be John Ferm and John Horne, also of the Department of Geology of the University of South Carolina.

"Modern Carbonate Sediments and their Diagenesis" in the Great Bahama Bank, the world's finest natural laboratory for the study of carbonate deposition, will be the subject of a September 25 – October 1 seminar, with Conrad Gebelein, of the Department of Geological Sciences, University of California at Santa Barbara, as leader. Aerial study will be provided by chartered plane flights, and the *Goldenrod,* the Institute of Marine Sciences research vessel, will serve as a laboratory.

The final seminar of the series will be offered October 2-8 under Clyde H. Moore, of the Department of Geology of Louisiana State University, over "Ancient Carbonate Rock Sequences and Their Diagenesis" in Lower Cretaceous outcrops in central Texas.

AAPG plans to extend this field-seminar program, expanding it later to include regional structural styles and regional geology of major petroleum provinces.

Petroleum Exploration Schools

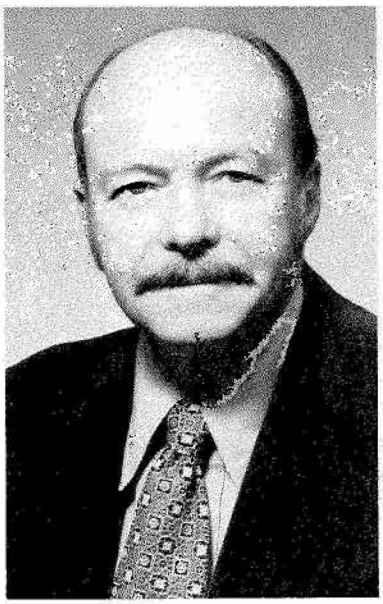
AAPG, in co-sponsorship with the Society of Exploration Geophysicists (SEG), has announced the continuation of its Petroleum Exploration Schools through varied courses to be offered September 27-October 8 in Dallas, January 17-28 in New Orleans, and April 18-29 in Houston.

More vital than ever because of the intensified need for energy exploration is the concomitant need for the dissemination of information on the most effective and up-to-date methods of technology, and these courses should be of value to both highly experienced and neophyte geologists and geophysicists. Broader aspects of sedimentology, stratigraphy, geochemistry, and structural geology in their applications to petroleum exploration are included as well, and instructors are eminently qualified personnel from both industrial and academic backgrounds.

The AAPG Continuing Education Program was first instituted in 1966 and has presented hundreds of courses since that time, from which thousands of geologists and geophysicists have derived benefit in expanding their knowledge and horizons. Charles J. Mankin, director of the Oklahoma Geological Survey and of The University of Oklahoma's School of Geology and Geophysics, is a member of the Continuing Education Committee and has been instrumental in the planning stages of courses offered.

Information on the seminars and exploration schools, including costs, can be obtained from Judy Golasinski, Lecture Coordinator, The American Association of Petroleum Geologists, P.O. Box 979, Tulsa, Oklahoma 74101.

New AAPG Executive Committee Installed



John D. Moody, AAPG president

John W. Shelton, AAPG editor

John D. Moody, New York City consultant, assumed the office of president of The American Association of Petroleum Geologists on July 1, succeeding John E. Kilkenny. Edd R. Turner, of Getty Oil Co. in Houston, was named president-elect, and Ralph L. Miller, senior geologist with the U.S. Geological Survey in Reston, Virginia, is the new vice-president. George S. Galbraith, independent geologist, Abilene, Texas, has begun a 2-year term as treasurer.

The new officers were announced at the annual meeting of the association in New Orleans in May.

Other officers will complete their 2-year terms this coming year, including editor John W. Shelton, of the Department of Geology at Oklahoma State University, and secretary Robey H. Clark, vice-president of Diamond Shamrock Corp. in Amarillo.

The Tulsa-based association (founded in 1916 on The University of Oklahoma's Norman campus) continues to grow. As the world's largest geological organization, it now counts some 18,000 members from all 50 states and 80 foreign countries.

North American Oil and Gas Fields
A Review

SUZANNE TAKKEN[1]

North American Oil and Gas Fields, edited by Jules Braunstein. The American Association of Petroleum Geologists, 1976, 360 p. Memoir 24. $22 ($18 to AAPG and SEPM members).

There are 17 field papers and a bibliography in this collection. Mid-continent geologists will find nothing in their territory, but that is the only disappointment. The editor's criteria for the selection of fields were the relative importance of the fields and the lack of an adequate description of them in readily available literature.

Because each paper is a separate entity, unrelated to the others, it seems appropriate to note a few pertinent facts about each field and some of the particular problems or unusual characteristics that exist so the reader will get some insight about the contents.

1. *Middle Ground Shoal Oil Field, Alaska,* by R. F. Boss, R. B. Lennon, and B. W. Wilson.

Not only is the field described in appropriate detail, but there is a good overview of the structural and stratigraphic geology of the upper Cook Inlet basin and the related tectonic and depositional history. For the uninitiated in Alaskan geology, the overview is interesting. For the more knowledgeable, the first section can be skipped. Oklahomans will note that the structural shape of this field is highly reminiscent of our Carter-Knox field, except that the steep limb in Alaska is on the west rather than the east.

2. *Permo-Triassic Reservoirs of Prudhoe Bay Field, North Slope, Alaska,* by H. P. Jones and R. G. Speers.

A large section of this paper is given over to detailed description of the stratigraphy, followed by a brief discussion of the post-Lisburne (post-Pennsylvanian) structural history. An interesting section on the origin, migration, and distribution of hydrocarbons concludes the material. Now that over 100 wells have been drilled in the area, it is possible to put together a comprehensive report, and this paper will undoubtedly be the definitive work for some time to come.

[1]Consulting Geologist, Oklahoma City, Oklahoma.

3. *Taglu Gas Field, Beaufort Basin, Northwest Territories,* by T. J. Hawkings, W. G. Hatlelid, J. N. Bowerman, and R. C. Coffman.

Two papers have been combined under a general title but are presented separately as "Regional Setting of Taglu Field," by Hawkings and Hatlelid, and "Geology of Taglu Field," by Bowerman and Coffman. The field was discovered in 1971, and three confirmation wells have been drilled, plus one dry hole. The productive area covers about 12 square miles, and reserves are probably greater than 3 Tcf. The rocks are probably Eocene and consist of delta-front sediments 1,700 feet (518 m) thick. Permafrost problems, overpressure, and sodium bicarbonate formation waters are some of the interesting aspects of the Taglu field.

4. *Mitsue Oil Field, Alberta—A Rich Stratigraphic Trap,* by Hal H. Christie.

Devonian sandstone deposited in deltaic conditions forms the reservoir for the Mitsue field, which is expected ultimately to produce an estimated 134 million barrels of primary oil. An interesting aspect is that the Gilwood sandstone had been thought for years to be either tight or water bearing and therefore not a valid exploration objective. The paper is concise and well written.

5. *Kaybob Oil Field, Alberta, Canada,* by N. H. Schultheis.

Another Devonian reservoir is described, but this time it's a reef in the Swan Hills Formation. Estimated recoverable oil is 126 million barrels, both primary and secondary. Four major facies are recognized and are described in some detail: organic reef, backreef, forereef, and offreef. The reef rests on Swan Hills platform limestone and is enclosed and sealed by the shales of the Waterways Formation.

6. *Big Piney—La Barge Producing Complex, Sublette and Lincoln Counties, Wyoming,* by Robert E. McDonald.

The word "complex" in the title is appropriate, because this area has production ranging from Triassic to Paleocene and occurrence ranging from purely stratigraphic to combination traps. There are 10 important fields mentioned. Ultimate reserves for the complex are estimated to be 2.5 Tcfg and 75 million bo. The presentation of this paper is excellent, with a type log, structural and stratigraphic cross-sections, and paleogeographic maps; the latter are a trademark of Rocky Mountain geologists.

7. *Altamont-Bluebell—A Major, Naturally Fractured Stratigraphic Trap, Uinta Basin, Utah,* by Peter T. Lucas and James M. Drexler.

The major accumulation here is unique because of (1) very low porosity enhanced by fractures, (2) overpressured thin producing zones, and (3) undersaturated waxy crude with pour points over 100°F. The trap is purely stratigraphic, and ultimate recovery could be 250 million bo or

more. The reservoir rocks are Tertiary lacustrine sandstones. This is indeed a fascinating and unique producing area, well described in this paper.

8. *Wattenberg Field, Denver Basin, Colorado,* by R. A. Matuszczak.

This gas field is in the "J" sandstone in a delta-front environment. It is a stratigraphic trap with relatively poor reservoir characteristics, but artificial fracturing enhances production. Estimated reserves are 1.1 Tcfg. The field has future-development possibilities, but they are dependent on the price of gas.

9. *Big Wells Field, Dimmit and Zavala Counties, Texas,* by R. L. Layden.

One of the largest fields found in Texas in the last 10 years, the Big Wells field produces from two sandstones of the San Miguel Formation (Upper Cretaceous) that are interpreted as offshore bars. Ultimate recovery is estimated to be 50 million bo and 64 Bcfg. A rather detailed history of the development of the field is included, and the point is made that massive fracture treatments have significantly enhanced production.

10. *Geology of Fairway Field, East Texas,* by Robert T. Terriere.

Lower Cretaceous reefs, combined with a contemporaneously growing structure, form this trap. The field is located along the axis of the East Texas basin in Henderson and Anderson Counties. Five rock types are recognized and are described in detail with accompanying photographs. The field is expected to produce 200 million bo.

11. *Upper Smackover Reservoirs, Walker Creek Field Area, Lafayette and Columbia Counties, Arkansas,* by Calvin A. Chimene.

The two main producing reservoirs are Jurassic oolitic limestones separated by a sandstone zone that is mappable and significant in the interpretation of local depositional history. The field is expected ultimately to produce some 30 million bo and 100 Bcfg.

12. *East Cameron Block 270, Offshore Louisiana: A Pleistocene Field,* by D. S. Holland, Clarke E. Sutley, R. E. Berlitz, and J. A. Gilreath.

The structure at Block 270 is the result of contemporaneous growth of a regional fault bounding the field on the east. Production is from numerous Pleistocene sandstones in channel-like and distributary-front patterns. Carefully designed logging programs were important in the efficient development of the field.

13. *Grand Isle Block 16 Field, Offshore Louisiana,* by Richard J. Steiner.

Here is an excellent example of perseverance being rewarded. Six years after the discovery well was drilled there was still only minor production established. It was the 18th well that found the major oil reserves, on the south flank of the salt dome. Ultimate recovery is now estimated to be 277 million bo. Some 26 separate sandstones are productive in various fault segments around the dome. Most are of Miocene age. The paper is clear and concise.

14. *Tinsley Oil Field, Yazoo County, Mississippi,* by M. F. Shelton, Jr.

Discovered in 1939, this was the first commercial oil field in Mississippi. Nearly 500 wells are expected ultimately to produce over 200 million barrels from several Cretaceous sandstones in a faulted anticline. The Woodruff sandstone has produced over 80 percent of the oil; 6 wells have produced over 2 million barrels each, while 27 wells have produced over 1 million each. The structure is over a deep-seated piercement salt dome. This paper is comprehensive and includes more than the usual number of reservoir characteristics and production statistics in several tables.

15. *Citronelle Oil Field, Mobile County, Alabama,* by Everett Eaves.

The Citronelle structure is described as residual, because it results from downwarping of a salt basin on the east, north, and west. There is no faulting, major truncation, nor facies change associated with the structure, but the 52 producing zones occur in a complicated meander-belt pattern, resulting in 330 separate reservoirs. The field was a disappointment during primary production, but unitization and excellent stratigraphic interpretation resulted in a successful secondary-recovery program. A tertiary program is being considered.

16. *Jay Field, Florida—A Jurassic Stratigraphic Trap,* by R. D. Ottmann, P. L. Keyes, and M. A. Ziegler.

Recoverable reserves of 346 million bo and 350 Bcfg make this the most significant discovery in the United States since Prudhoe Bay. Production is from dolomitized Smackover on a structural nose, with the updip trap formed by a porosity pinchout. The oil contains 9-percent H_2S, so special processing facilities are required. Development of the field has cost $132 million so far.

17. *Sunoco-Felda Field, Hendry and Collier Counties, Florida,* by A. N. Tyler and W. L. Erwin.

The Sunniland Limestone of Cretaceous age is the producing formation, in a stratigraphic trap formed by two localized reef pods on a regional carbonate bank. Ultimate production is expected to be 31 million bo, and the authors believe that more fields of this type will be found along the trend with the careful use of subsurface geology and sophisticated geophysical programs.

18. *Bibliography of North American Oil and Gas Fields from AAPG Publications,* by E. M. Tidwell.

The usefulness of this particular bibliography lies in its grouping, in one place, all or almost all of the field papers published by AAPG. Thus one does not need to consult the four published AAPG Comprehensive Indexes, which only go to 1970 anyway. The bibliography is in two parts. First, there is an alphabetical listing of the fields. The second part is a grouping of the same fields by country, state or province, and county or parish.

Earth-Science Editors to Meet in Albuquerque

The Sheraton–Old Town Inn in Albuquerque, New Mexico, will be the locale for the 10th annual meeting of the Association of Earth Science Editors on October 17-20. The hosts for the meeting will be the New Mexico Bureau of Mines and Mineral Resources and the University of New Mexico.

The meeting should be of interest not only to editors and publishers but also to librarians, cartographers, and others in related fields. Five principal sessions are planned, as follows:

"Scientific Illustrations": This session will focus on various aspects of the production of black and white and color illustrations, including editorial selection of material, color separations and corrections, printing technology, and usability.

"Improving Scientific Communications": Panel discussions are planned on aspects of the scientific-communication process, including a look at science in the news—the public's view, the scientist's view, misunderstandings, and how to improve communication—and how layout and design of scientific publications can enhance communication and reduce costs.

"Micropublication": Invited speakers will present facts and figures from the user's point of view on the kinds of geoscience information that are suited to micropublication and storage and on developments in microform production.

"Common Concerns of State Survey Editors" (concurrent session): This workshop session is planned to give editors of state and provincial geological surveys a chance to exchange ideas and "helpful hints."

"Editing and Publishing Scientific Journals" (concurrent session): Presentations are planned to stimulate discussion on problems of mutual concern to editors and publishers, including such topics as economics, metrication, graphics, and circulation.

Among the invited speakers are Robert F. Lundin, of Arizona State University, co-editor of the *Journal of Paleontology;* William Betterley, Eastman Kodak Co.; Jan V. White, author of the acclaimed book for editors and designers, *Editing by Design;* and Thomas J. Devlin, a microform specialist with Exxon Production Research Co.

A unique field trip is planned for the meeting. Tuesday evening, participants will study the geology of the Sandia Mountains by means of a tram ride (breathtaking!) and a walking tour on top of Sandia Peak.

Planning to attend the meeting from the Oklahoma Geological Survey are Bill Rose, editor; Rosemary Croy, associate editor; and Betty Ham, assistant editor. Bill is a member of the program committee and will explain his role in compiling a news-release handbook for The American Association of Petroleum Geologists in the session on "Improving Scientific Communications." Rosemary has been chairman of the nominating committee and will introduce the association's new officers at the meeting.

For futher information about the meeting, contact Robert W. Kelley, New Mexico Bureau of Mines and Mineral Resources, Socorro, New Mexico 87801 (phone, 505—835-5218).

New Mexico Geological Society Schedules Field Trip

Vermejo Park, in northern New Mexico, will be the target of the 27th annual field conference of the New Mexico Geological Society September 30—October 2.

The park, a geologically rich and beautiful locality seldom open to the public, will be approached in a first-day route from Las Vegas, New Mexico, to Raton, along the eastern front of the Sangre de Cristo Mountains over faulted highlands, volcanic plateaus, and basin and plains topography. The second and third days of the trip will cover the park itself.

Investigations will encompass the Raton coal field, the York Canyon mine, Mesozoic sediments, mid-Tertiary volcanics, geomorphic expressions, and the structure of the Vermejo anticline. The Trinidad coal field will also be covered, and there will be stops to consider oil and gas exploration and the hydrocarbon potential of northeastern New Mexico. On the final day, participants will travel through Van Bremmer Canyon to the termination point at Cimarron.

Enrollment is limited through necessity imposed by logistics of the confined areas of the park, and registration should be sought early. For information, contact Dan Sowle, 2816 Camino Principe, Santa Fe, New Mexico 87501 (phone 505—471-5260).

The New Mexico trips are always outstanding, as are the guidebooks, and this year's excursion should uphold the NMGS' reputation for excellence.

Short Course in Coal Geology to Be Offered

A 3-day short course in the basic concepts of coal geology and their applications will be offered at the Oklahoma Center for Continuing Education (OCCE) at The University of Oklahoma on October 25-27 under the leadership of S. A. Friedman, coal geologist with the Oklahoma Geological Survey and adjunct professor in the School of Geology and Geophysics. John Boardman, director of management-development programs at The University of Oklahoma, is the coordinator of the course for administrative and logistical purposes. The 1976 course, sponsored jointly by the Oklahoma Geological Survey and the Business and Industrial Services of OCCE, will be the third annual offering of "Coal Geology Fundamentals." With the growing interest in coal as a vital source of energy, a large attendance is anticipated.

The course is directed toward geologists, engineers, mineral-oriented executives, and government officials who are interested in or presently involved in this resource but are not formally trained in the principles or practice of coal geology. Lectures will be offered on the origin, occurrence,

and geographic distribution of coal; the resources of principal coal regions of the United States and exploration for further resources; types of mining, trends, and economics of coal production; and environmental considerations of mining itself and of sulfur content of coals.

The special lecturers for the short course will reflect a broad spectrum of expertise in geologic principles, technology, and economics related to this mineral resource. They are: P. A. Hacquebard, coal geologist with the Geological Survey of Canada; E. C. Beaumont, consulting geologist from Albuquerque, New Mexico; M. Deul, supervisory geologist with the U.S. Bureau of Mines at Pittsburgh, Pennsylvania; C. G. Groat, acting director of the Texas Bureau of Economic Geology; and J. A. Pederson, of the U.S. Geological Survey's Conservation Division at Denver, Colorado. Friedman will give most of the lectures and lead an optional field trip.

Lecture sessions will be in the Forum Building at OCCE, and lodging can be booked at the Ramada Inn in Norman. The registration fee of $150 includes a 100-page syllabus, and the optional field trip on October 28 will cost an additional $75.

For further information and registration forms, contact John Boardman, Director, Management Development Programs, The University of Oklahoma, 1700 Asp Avenue, Norman, Oklahoma 73037.

OGS Issues Coal-Activity Map

Reflecting the growing interest in coal as a source of energy for the State and for the nation, a map just released by the Oklahoma Geological Survey provides current information on the expanding status of coal-mining activity in Oklahoma.

Compiled by S. A. Friedman, OGS coal geologist, *Map of Eastern Oklahoma Showing Active Coal Mines (January 1, 1976)* contains data on annual production, sulfur content, and the thickness of coal beds and of overburden for 33 surface mines and 1 subsurface mine in 9 counties of eastern Oklahoma. It also designates the company operating each mine and plant in the area, the type of operation employed, and the coal beds mined.

The map is on one sheet and is at a scale of 1:500,000, or approximately 1 inch = 8 miles. Symbols indicate the scope of production from each mine, the location of preparation plants, and the nature of the mine—whether surface or subsurface. The area of known coal resources is delineated in color.

Information obtained from Sam's investigations shows that coal-mining activity almost doubled in Oklahoma during 1975.

The coal-mine map is available from the Oklahoma Geological Survey at the address shown on the front cover. The price is $2.00.

OGS Director Presides at State Geologists Meeting

The annual meeting of the Association of American State Geologists (AASG) was held in Vail, Colorado, June 20-24. The Colorado Geological Survey hosted the meeting, and they did it magnificently; special thanks are due John W. Rold, state geologist, and Richard H. Pearl, meeting coordinator.

The meeting was divided into several program sessions, punctuated by two all-day field trips—one to the famous molybdenite mine of Climax Molybdenum Co. at Climax, south of Vail on the continental divide, and the other to the oil-shale deposits and operations in the Green River Formation near Rifle, in western Colorado.

Conducting the meeting as AASG president was Charles J. Mankin, director of the Oklahoma Geological Survey. Two members of the OGS staff, geologist Kenneth S. Johnson and editor William D. Rose, also attended.

The first part of the meeting was set aside for reports by personnel of several cooperating federal agencies, who were guests of the association.

Speaking for the U.S. Geological Survey were director Vincent E. McKelvey; James R. Balsley, Jr., head of the Land Information and Analysis Office; chief geologist Richard P. Sheldon; J. S. Cragwall, Jr., chief of the Water Resources Division; and Robert H. Lyddan, chief of the Topographic Division. Mr. Lyddan told the group to "think metric." He explained that the Topographic Division wants to introduce metric maps of 7½-minute quadrangles as quickly as they are acceptable to the various states, although maps with English units will continue to be produced where mapping programs are nearing completion, as in Oklahoma. He also said that the division had planned to standardize the mapping scale at 1:25,000, rather than 1:24,000 as at present. But he assured the state representatives that the USGS would be flexible and use the type of scale and system that would be locally appropriate.

Assistant Secretary of the Interior William L. Fisher spoke of pending congressional legislation on environmental and energy-related matters. He stated that surface mining is a highly emotional issue in the U.S. Congress and mentioned the advantage of placing stress on strong reclamation programs.

Thomas V. Falkie, director of the U.S. Bureau of Mines, explained the bureau's programs and told of plans to expand its information systems, which would include computerized printing of the annual Minerals Yearbook.

Neil Steuer, of the U.S. Nuclear Regulatory Commission, explained his agency's concern with problems of seismicity, especially with regard to the site selection for nuclear power plants. Three main areas of concern east of the Rocky Mountains are New England, the area centering on New Madrid in southeastern Missouri, and the Nemaha uplift in the Midcontinent (see related article beginning on p. 135 of this issue). A fourth area of concern is Charleston, South Carolina; this area is being investigated by the U.S. Geological Survey.

Others who spoke before the group were Samuel Tuthill, Federal Energy Administration; Carl W. Kuhlman, of the U.S. Energy Research and Development Administration's waste-management program; Clayton Nichols, of ERDA's Division of Geothermal Energy; Allen Agnew, Congressional Research Service, Library of Congress; Sheldon Wimpfen, U.S. Bureau of Mines; Wilson Laird, American Petroleum Institute; and Fred S. Honkala, executive director of the American Geological Institute.

In addition to these presentations, displays were set up and a series of evening workshops were conducted by several of the cooperating federal agencies. The USGS covered urban studies, topographic mapping, and geologic data files. Other evening sessions included ERDA workshops on its National Uranium Resource Evaluation (NURE) Program and on radioactive-waste disposal.

Reports of AASG standing committees were an important part of the meeting, as usual.

Arthur Socolow of Pennsylvania reported on the liaison committee's work during the past year. The committee's basic function is liaison with federal agencies and other organizations with which the state surveys work cooperatively and otherwise need to maintain close contact. In Washington, D.C., last April, the liaison committee met with various agencies and units of both the executive and legislative branches of the federal government. The committee was welcomed and cordially received at each Washington area office visited. The committee summarized its overall feeling about this series of meetings as follows:

- The general climate among the agencies visited is one of severe budget restraints and manpower limitations.

- The subject of energy is still foremost.

- Among the agencies contacted, there is widespread respect for the professional capabilities and integrity of the USGS and the USBM, but there is also widespread concern as to their ability to respond promptly to current pressing problems.

- During the past year all federal agencies, especially Interior, have suffered from turmoil and changing leadership.

- Despite repeated offers over the years by the liaison committee and by the individual states to provide testimony, support, or data to various federal agencies at critical times, these offers have seldom been taken up.

- The Office of Management and Budget wields tremendous power in its decisions on what programs to fund and to what degree.

- There is a continuing need for state surveys, individually and collectively, to take the initiative in contacting federal agencies (1) to communicate state approval or disapproval of federal programs, (2) to make federal agencies aware of what has been done and what data exist at the state agencies, and (3) to act as the grass-roots voice of the public and to give advice on the needs and problems of the country.

Robert R. Jordan of Delaware, in discussing reciprocity among the several states with laws requiring registration of geologists, concluded that total reciprocity was a legal impossibility.

Donald T. McMillan of Utah recommended that state surveys increase their emphasis on basic geologic mapping and mineral-resources investigations.

A motion was passed authorizing AASG to establish a national committee and several regional committees to monitor and analyze ERDA's waste-disposal operations.

Among the several resolutions adopted by the association was one commending president Mankin for outstanding performance during his term of office.

New incoming officers are Duncan J. McGregor, South Dakota, president; Arthur A. Socolow, Pennsylvania, president-elect; and Robert B. Erwin, West Virginia, vice-president. Continuing office holders are Daniel N. Miller, Jr., Wyoming, secretary-treasurer; Charles G. Doll, Vermont, historian; Edwin A. Noble, North Dakota, editor; and Robert R. Jordan, Delaware, statistician.

Next year the association will meet in Newark, Delaware, June 5-9, with Bob Jordan and the Delaware Geological Survey acting as hosts. One participant seemed to express the sentiment of the group when he said, "After Vail, the only thing we can do is start at sea level and work our way back up."

Oceanic-Resource Conference Set

Sessions designed to offer an opportunity for exchange of information and thought on harvesting the energy and food resources of the sea while counterbalancing the effect on the environment will meet at Texas A&M University October 5-8. The conference, "The Second International Marine Technology Assessment Conference," is sponsored by the International Society for Technology Assessment, the European Oceanic Association, and Sea Grant, a nationwide program directed by the National Oceanic and Atmospheric Administration. At Texas A&M, Sea Grant is administered by the Center for Marine Resources.

The multidisciplinary program will provide a base for working toward harmony and coordination of private and public programs in the development of oceanic resources for the social benefit of present and future generations. Discussion will include technological methods, action programs, and consideration of past and potential programs.

For information, contact Daniel M. Bragg, Conference Chairman, Industrial Economics Research Division, Box 83 FM, Texas A&M University, College Station, Texas 77843; or Miller Spangler, Program Chairman, Nuclear Regulatory Commission, Washington, D.C. 20555.

Water-Quality Study Initiated in Northeastern Oklahoma

Kenneth V. Luza[1]

The Oklahoma Geological Survey, the Water Resources Division of the U.S. Geological Survey, and the Northeast Counties of Oklahoma Development Association have initiated a cooperative study to determine what use or uses can be made of the water in the abandoned zinc mines of the Picher mining field. The field, which is part of the Tri-State zinc and lead mining district, covers the northern part of Ottawa County, Oklahoma, and the southernmost part of Cherokee County, Kansas (fig. 1). Deposits of lead and zinc are found in several stratigraphic units within the Boone Formation (Mississippian). The mines are generally 100 to 300 feet below land surface, with a few as deep as 480 feet.

Ore was first discovered in 1901 near Commerce, Oklahoma. Increased demand for lead and zinc during World War I stimulated extensive development in the area. By 1958 production had greatly diminished, and by the late 1960's activity had virtually ceased, thus allowing the abandoned mines to fill with water. The original water level was approximately 50 feet below land surface. Access to the ore-bearing strata required extensive pumping, which created a large cone of depression. Since cessation of mining activities and pumping, the water level has risen to a depth of approximately 150 feet below the land surface.

The increased demand for water for domestic and industrial use in the Miami, Oklahoma, area has led to a search for alternate water supplies. One potential source of water is contained in the abandoned zinc mines. This source may represent an easily obtainable reservoir of approximately 90,000 acre-feet of water with an estimated recharge of 22 cubic feet per second. Since very little information is available on the quality of the water in the abandoned mines, an organized program of study was initiated to gather basic chemical-quality data.

The program of study will be conducted in three phases. Phase I will describe the system and its present water quality. This phase is essentially an intensive reconnaissance of the area. Profiles for pH, conductivity, and temperature are being taken at seven abandoned mine shafts (fig. 1). The number of samples to be taken at each shaft is based on an inspection of the water level, the conductivity-pH profiles, and a determination of the thickness of the mine from available mine maps. The number of samples to be taken vertically varies from 1 to 4. The suite of chemical constituents to be determined for three possible water-use cate-

[1]Geologist, Oklahoma Geological Survey.

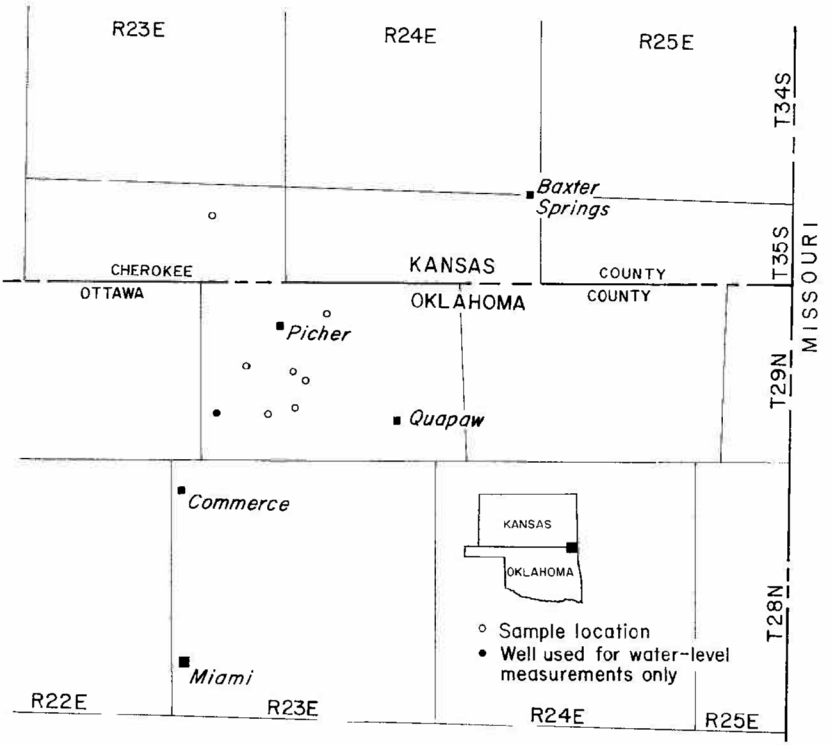


Figure 1. Index map of Picher mining field, northeastern Oklahoma and southeastern Kansas.

gories—industrial cooling, irrigation, and public water supply—is included in table 1.

Phase II will describe the annual variations in the mine waters. It is suspected that some variation in quality may occur from direct inflow during periods of precipitation. The number of shafts and the number of samples in the vertical for each selected shaft will be determined from a study of the information gathered in phase I. Present plans call for 4 to 6 shafts to be sampled on a bimonthly basis for 1 year. In addition, vertical profiles for conductivity, temperature, and pH also will be taken at the time of sampling. The suite of chemical constituents will be the same as for phase I, except for those constituents determined in phase I to be of such low concentration as to be insignificant. However, the full suite of

Table 1.—Water-Quality Constituents To Be Determined in Phase I of Study

COMMON CONSTITUENTS	DISSOLVED METALS
Bicarbonate	Aluminum — dissolved
Acidity	Arsenic — dissolved
Chloride	Barium — dissolved
Calcium — dissolved	Boron — dissolved
Fluoride — dissolved	Cadmium — dissolved
Hardness — total	Chromium — dissolved
Magnesium — dissolved	Cobalt — dissolved
Sodium — dissolved	Copper — dissolved
Sulfate	Iron — dissolved
Residue — dissolved at 180°C	Lead — dissolved
Residue — suspended at 110°C	Lithium — dissolved
Silica	Manganese — dissolved
Turbidity	Mercury — dissolved
Potassium — dissolved	Molybdenum — dissolved
Sodium adsorption ratio	Nickel — dissolved
	Selenium — dissolved
	Vanadium — dissolved
	Zinc — dissolved

ORGANICS AND NITROGEN SPECIES
Ammonia
Nitrate (NO_2 + NO_3) − dissolved
Nitrate
Nitrite
Total organic carbon
Detergents

chemical constituents will be determined twice during the year to ensure that the presumed insignificant constituents are not developing in significant concentrations.

Phase III will seek to determine long-term trends in water quality in the mines and will extend beyond phase II for approximately 4 years. During this phase, dependent upon information gathered in phases I and II, approximately four shafts will be sampled and profiled twice each year. The suite of chemical constituents will be the same as analyzed in phase II. The water-quality data will be treated statistically. The analyses will be used to determine if the water is suitable for use for industrial cooling, for irrigation, and (or) for public water supply. The study is expected to be completed by the end of 1981.

Board on Mineral Resources Studies Unconventional Natural-Gas Sources

Natural-gas production has been on the decline for some time from what traditionally have been considered normal geologic sources. Even with increased and increasingly expensive exploration programs, reserves have not kept pace with consumption. As a result of this long-term trend, the Board on Mineral Resources of the National Research Council's Commission on Natural Resources called a forum meeting in January 1976 to consider the possibilities of unconventional geologic sources for future natural-gas supplies.

At the sessions, 13 speakers presented papers on 4 such sources, focusing on: (1) methane-saturated deep geopressured zones, such as those in the Gulf Coast; (2) the low-porosity, "tight" sands of the Uinta, Piceance Creek, Green River, San Juan, Denver-Julesburg, and other western basins; (3) the carbonaceous brown shales of the Appalachian and other Devonian-Mississippian basins; and (4) the methane associated everywhere with coal seams, most of which has heretofore been dissipated as quickly as possible as a lethal mining hazard.

The 13 papers presented at the forum are contained in a 245-page publication, *Natural Gas from Unconventional Geologic Sources,* issued as Publication FE-2271-1 by the National Technical Information Service. It can be obtained from NTIS, 5285 Port Royal Road, Springfield, Virginia 22161, for $9.00 in paper and $2.45 in microfiche.

Conclusions are not offered by the authors of this publication, but many informative, down-to-earth data are presented from which the reader can form his own conclusions.

Charles J. Mankin, director of the Oklahoma Geological Survey, is a member of the Board on Mineral Resources and participated in the January forum.

ERDA Issues New Uranium-Resource-Evaluation Reports

National Assessment

A 2-part, 135-page report issued recently by the U.S. Energy Research and Development Administration (ERDA) shows probable resources of uranium oxide of 1,060,000 tons, possible resources of 1,270,000 tons, and 590,000 tons in the speculative category. Resource estimates are evaluated at production-cost cutoffs of $10, $15, and $30 per pound of uranium oxide

(U_3O_8), the standard measure. On the other hand, *reserves* in all these categories are estimated at 640,000 tons, with additional uranium recoverable as a byproduct of phosphate and copper production estimated at 140,000 tons through the period 1976-2000. The report represents the initial phase of ERDA's National Uranium Resource Evaluation (NURE) Program.

The Colorado Plateau, the Wyoming Basins, and the Texas Coastal Plain, the major producing regions in the country, contain 94 percent of the $30 reserves. These regions are estimated to contain 80 percent of the probable, 66 percent of the possible, and 28 percent of the speculative potential resources. All deposits in these regions are in stratiform or roll-front deposits. The report predicts increases in these estimates and the conversion of potential resources to the reserve category through continued exploration. It also urges prompt and vigorous action in both exploration and development. In addition, it points out the probability of discovery of uranium in other types of deposits.

The report also describes the geology of 13 broad geologic regions of the United States that have potential for containing uranium resources. Two maps are included that show locations of potential-resource areas and additional areas with possibilities of containing uranium in recoverable quantities.

National Uranium Resource Evaluation, Preliminary Report, issued by ERDA as GJO-111(76), can be obtained for $2.00 from the Technical Library, Grand Junction Office, Bendix Field Engineering Corp., P.O. Box 1569, Grand Junction, Colorado 81501.

Oklahoma Pennsylvanian and Permian

A report describing structure, stratigraphy, paleoenvironment, petrology, and petrography of Pennsylvanian-Permian units in Oklahoma identifies five possible settings for the location of uranium in the State. The 156-page report, *Summary of the Stratigraphy, Sedimentology, and Mineralogy of Pennsylvanian and Permian Rocks of Oklahoma in Relation to Uranium-Resource Potential,* was authored by John W. Shelton and Zuhair Al-Shaieb of the Department of Geology at Oklahoma State University and has been issued by ERDA as GJBX-20(76). Five large maps are included.

This study is also part of ERDA's National Uranium Resource Evaluation (NURE) Program.

A copy has been placed on file for public inspection at the Oklahoma Geological Survey. Copies can be obtained at the expense of the requestor from Colorado Copy Center, Suite T-8, Valley Federal Plaza, Grand Junction, Colorado 81501; from Quahada Engineering, 307 South 12th Street, Grand Junction, Colorado 81501; or from Sir Speedy Instant Printing Center, Engineering Section, 912 North Avenue, Grand Junction, Colorado 81501.

Red River Region

Another ERDA uranium report on deposit with the OGS, and also available as above, encompasses airborne and surface investigations of 11 counties of northern Texas and southern Oklahoma.

Issued as GJBX-13(76), *Report on Airborne Radioactivity Surveys and the Uranium Deposits in the Red River Region of Texas and Oklahoma* is a 16-page report based on surveys conducted by the U.S. Atomic Energy Commission in 1955-56.

Texas–New Mexico–Oklahoma Survey

In line with the preceding report is a contract for a radiometric and magnetic survey over eight quadrangles (1°×2°, scale 1:250,000) in eastern New Mexico, northern Texas, and central and western Oklahoma. Geodata International, Inc., of Dallas, Texas, will conduct the survey for the Grand Junction office of ERDA, using a scintillation gamma-ray detection system, multichannel analyzers, a magnetometer, and ancillary electronic equipment. The firm will survey approximately 23,000 line miles on 3.1-mile (5-km) spacing oriented east-west, with 18.75-mile (30-km) spacing on north-south tie lines. Nominal ground clearance will be 400 feet.

Williston Basin

Four reports on Cretaceous and Tertiary sedimentary uranium resources of the Williston basin have been placed on open file by the ERDA Grand Junction office. The reports, prepared by personnel of the Department of Geology of the University of North Dakota, were published simultaneously by the North Dakota Geological Survey. They are available as previously described for inspection (including the OGS office, Norman) and reproduction, and they are listed below.

Geology of the Fox Hills Formation (Late Cretaceous) in the Williston Basin of North Dakota, with Reference to Uranium Potential, by A. M. Cvancara, issued as GJBX-21(76), 16 pages, 4 plates.

The Stratigraphy and Environments of Deposition of the Cretaceous Hell Creek Formation (Reconnaissance) and the Paleocene Ludlow Formation (Detailed), Southwestern North Dakota, by Walter L. Moore, issued as GJBX-22(76), 40 pages, 10 plates.

Geology of the Cannonball Formation (Paleocene) in the Williston Basin, with Reference to Uranium Potential, by A. M. Cvancara, issued as GJBX-23(76), 22 pages, 4 plates.

Geology of the Upper Part of the Fort Union Group (Paleocene), Williston Basin, with Reference to Uranium, by Arthur F. Jacob, issued as GJBX-24(76), 49 pages, 3 plates.

The North Dakota studies are also part of ERDA's NURE program.

The Inadunate Crinoid Genus *Mooreocrinus* in Oklahoma

Harrell L. Strimple[1]

INTRODUCTION

The general thought expressed by various crinoid specialists in regard to evolutionary progression in crinoids is that the cup changed from a high cone shape to a flattened-based cup to a bowl shape with a basal invagination (Moore and Plummer, 1940; Moore and Laudon, 1943; Moore and Strimple, 1973). The procession of evolutionary modification of the arms was usually from simple uniserial to biserial, sometimes accompanied by multiple branching. Axillary brachials usually migrated proximalward; i.e., in stratigraphically older representatives the first bifurcation in a particular lineage might have occurred in the fourth or fifth primibrach, moving progressively downward until in stratigraphically younger forms the first primibrach became axillary. Very primitive forms have no pinnules, but, as they evolved, most inadunate crinoids produced pinnules, usually one pinnule to a brachial on alternate sides. They might have, however, become hyperpinnulated (having more than one pinnule for each brachial). Anal plates in the posterior interradius usually numbered three by mid-Paleozoic time, evolving thereafter, by elimination or absorption, to two, one, or none (Strimple 1960).

Although it has not been commonly noted, there may have been a moderate reversal of any of the above-described evolutionary changes; I have considered this reversal as regression. An example of this is the typically invaginated base of *Phanocrinus*, which regressed to become a planate base in *P. planus* Strimple and Moore (1973) from the Fraileys Formation (Mississippian, Chesterian) of the Eastern Interior basin. It is my thought that the lineage represented by *P. planus* probably continued into the Pennsylvanian, where one branch is represented by *Contocrinus* Knapp (1969). In *Contocrinus* there are 10 uniserial arms; the number of anal plates is reduced to one, and typically the genus has a planate-cup base, although the tendency in some species in the Upper Pennsylvanian is toward an invaginated, or concave, base.

The normal evolutionary trend toward increased basal invagination of the cup and toward biserial arms in the phanocrinid lineage is well demonstrated by *Bronaughocrinus* Strimple (1951) of late Chesterian age and by the normal *Delocrinus* Miller and Gurley (1890) of Pennsylvanian-Permian age. *Delocrinus* generally also has the anal plates reduced to one element.

[1]Curator and research investigator, Department of Geology, The University of Iowa, Iowa City, Iowa.

The Missourian specimen considered in this paper has many characters of the Chesterian *Phanocrinus planus* Strimple and Moore (1973), i.e., a low, bowl-shaped cup with a planate base and 10 uniserial arms branching on the first primibrachs. Differences lie in enlargement of the radianal accompanied by loss of RX from the cup and addition of vermicular ornamentation together with scattered median nodes on the arms. The cup of the Missourian crinoid is so similar to that of *Parulocrinus beedei* Moore and Plummer (1940) that assignment to the species is made with little hesitation. The arms of *Parulocrinus*, however, have been demonstrated by Strimple and Moore (1971, p. 26, 27) to be at least 14 in number and biserial in structure, and the 10 uniserial arms of the hypotype of *P. beedei* prevent assignment to *Parulocrinus*, suggesting instead relationship with *Mooreocrinus,* a genus typically Moscovian (Pennsylvanian, late Atokan or early Desmoinesian) in age. *Mooreocrinus* typically has 10 uniserial arms. The

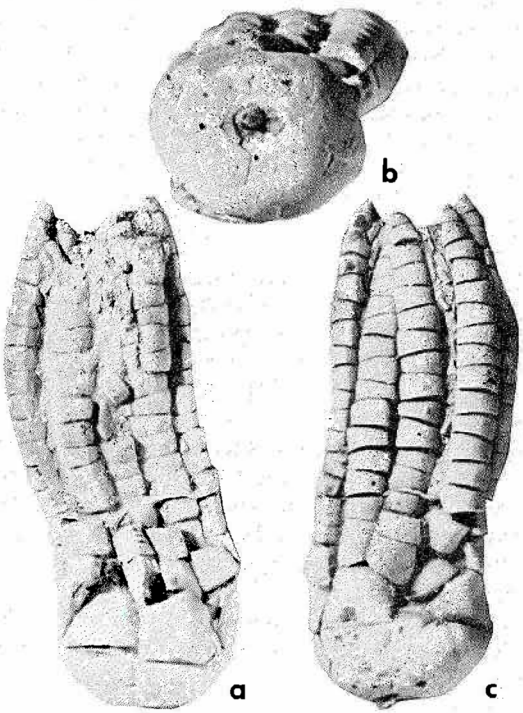


Figure 1. *Mooreocrinus beedei* (Moore and Plummer) from the Missourian of northeastern Oklahoma. Hypotype crown (USNM S-5701), viewed from anterior (*a*), base (*b*), and posterior (*c*), ×2.

brachials, however, are broad and short, and the cup is almost box shaped with long forefacets extending beyond the outer ligament facets on the radials. *Mooreocrinus* also has a strongly granular surface. *M. mendesi* (Lane, 1964) from the Tapajos Formation (Desmoinesian) of Brazil has more of a bowl-shaped cup, an unornamented cup surface, and narrow uniserial arms with more elongated brachials than are found in *M. geminatus* (Trautschold, 1867). *M. mendesi* has three anal plates, which is typical of the genus and could indicate this species to be the progenitor of *M. beedei*. I recognize that both *M. mendesi* and *M. beedei* might not be bona fide species of *Mooreocrinus,* but the matter may never be resolved unless specimens are found with the anal sacs (or anal tubes) preserved. It is possible that with such information these species might be found to be aligned with the phanocrinids rather than the cromyocrinids. *Cromyocrinus simplex* is known to have a rather short anal tube; some specimens have a coprophagous snail attached to the posterior interradius of the cup, which indicates that the anal tube is short and that the anus is on the posterior side of the tube (see Yakovlev, 1964, fig. 45). Conversely, *Phanocrinus* commonly has a long slender anal tube with a thin, elongated spike at the distal summit, and the anus is on the anterior side of the tube. The latter condition is also found in *Delocrinus*.

SYSTEMATIC DESCRIPTION

Suborder POTERIOCRININA Jaekel, 1918

Superfamily CROMYOCRINACEA Bather, 1890

Family CROMYOCRINIDAE Bather, 1890

Genus **Mooreocrinus** Wright and Strimple, 1945

Mooreocrinus beedei (Moore and Plummer, 1940)

Description.—Cup low, bowl shaped, with broad, flat base and slightly constricted summit. Infrabasal disc, at center of flattened base, is pentagonal and is a little smaller than one basal. Basals are strongly curved in longitudinal direction, with only distal extremities visible in side view of cup. Radials are pentagonal and much wider than long. Two anal plates in cup; elongated anal X and very large radianal.

Discussion.—The holotype (monotype) of *M. beedei* is from the Palo Pinto Limestone, Canyon Group (Pennsylvanian, Missourian Series); Moore and Plummer (1940) locality 181-T-1, about 3.5 miles west of Strawn, Palo Pinto County, Texas. The hypotype under consideration in this paper is a well-preserved crown, which is designated as conspecific with *M. beedei* because of the nearly identical cup. Two anal plates are present, the largest being the radianal. The hypotype is slightly smaller; i.e., cup height is 5.0 mm as compared to 7.0 mm, and cup width is 12.0 mm, compared to 14.5 mm for the holotype.

The 10 arms of the hypotype are narrow but not delicate, are uniserial, and are pinnulate; they branch on the first primibrach in all rays and

occupy about four-fifths of the total length of the crown. Outer surfaces of the arms are gently convex and are covered with a fine shagreen ornamentation. Scattered small nodes in the median portion of each brachial simulate a weak keel. Displaced lower secundibrachs show pronounced horizontal depressions along the flattened lateral sides, demonstrating a tongue and groove arrangement for interlocking adjacent arms (see fig. 1a). Distal and proximal surfaces of the brachials are marked by fine crenulations. Such crenulations are also found in the *Phanocrinus formosus* group of Chesterian age (D. W. Burdick, personal communication, January 5, 1974).

Relationship with *Mooreocrinus mendesi* has been suggested in the introduction. However, there is also a possibility of relationship with *Phanocrinus? insolitus* Webster and Lane (1967) from the Lower Permian of Nevada. *P.? insolitus* has 10 uniserial arms, a bowl-shaped cup with a basal invagination (normal evolution is from planate base to a basal concavity, as outlined in the introduction), and 3 anal plates. *Phanocrinus* (s.s.) has never been recognized in the Pennsylvanian or Permian, but it is possible that in the lineage suggested in this paper the radianal was reduced in size and the RX (or right tube plate) migrated back into the cup.

Two or three small, deep borings can be seen in the base of the cup of the hypotype. These do not resemble the large, shallow borings commonly found on Pennsylvanian crinoids, and they were probably caused by predator snails.

Hypotype.—USNM S-5701, collected by H. L. Strimple, reposited in National Musuem of Natural History, Washington, D.C.

Occurrence.—Barnsdall Formation, Pennsylvanian, Missourian; northeast of Copan, Washington County, Oklahoma, NW¼NW¼ sec. 10, T. 28 N., R. 13 E.

References Cited

Knapp, W. D., 1969, Declinida, a new order of late Paleozoic inadunate crinoids: Journal of Paleontology, v. 43, p. 340-391, pls. 61, 62.

Lane, N. G., 1964, Inadunate crinoids from the Pennsylvanian of Brazil: Journal of Paleontology, v. 38, p. 362-366, pl. 57.

Miller, S. A., and **Gurley, W. F. E.,** 1890, Description of some new genera and species of Echinodermata from the Coal Measures of Indiana, Missouri and Iowa: Journal of the Cincinnati Society of Natural History, v. 13, 59 p.

Moore, R. C., and **Laudon, L. R.,** 1943, Evolution and classification of Paleozoic crinoids: Geological Society of America Special Paper 46, 153 p., 14 pls.

Moore, R. C., and **Plummer, F. B.,** 1940, Crinoids from the Upper Carboniferous and Permian strata in Texas, *part 1 of* Contributions to geology, 1939: University of Texas Publication 3945, p. 9-468, 21 pls.

Moore, R. C., and **Strimple, H. L.,** 1973, Lower Pennsylvanian (Morrowan) crinoids from Arkansas, Oklahoma, and Texas: University of Kansas Paleontological Contributions, Article 60 (Echinodermata 12), 84 p., 23 pls.

Strimple, H. L., 1951, New Carboniferous crinoids: Journal of Paleontology, v. 25, p. 669-676, pls. 98, 99.

———1960, The posterior interradius of Carboniferous inadunate crinoids of Oklahoma: Oklahoma Geology Notes, v. 20, p. 247-253, 3 text-figs.

Strimple, H. L., and **Moore, R. C.,** 1971, Crinoids of the LaSalle Limestone (Pennsylvanian) of Illinois: University of Kansas Paleontological Contributions, Article 55 (Echinodermata 11), 48 p., 23 pls.

_____1973, Notes on the inadunate crinoid genus *Phanocrinus, in* Strimple, H. L., and Moore, R. C. (editors), Fossil crinoid studies: University of Kansas Paleontological Contributions, Paper 66, p. 2-7, figs. 1-6.

Trautschold, H., 1867, Einige Crinoideen und andere Tierreste des jüngeren Bergkalkes in Governement Moskau: Soc. imp. Nat. Moskau Bull., v. 40, pt. 2, 49 p., 4 pls.

Webster, G. D., and **Lane, N. G.,** 1967, Additional Permian crinoids from southern Nevada: University of Kansas Paleontological Contributions, Paper 27, 32 p., 8 pls.

Wright, James, and **Strimple, H. L.,** 1945, *Mooreocrinus* and *Ureocrinus* gen. nov., with notes on the family Cromyocrinidae: Geological Magazine, v. 82, p. 221-229, pl. 9.

Yakovlev, N. N., 1964, Organizm i sreda. Stati po paleoekologii Bespozvonochnykh 1913-1960 gg [Organisms and environment. Writings of palaeoecology of invertebrates 1913-1960]: Akadamie Nauk SSSR Paleont. Inst. Izdatel'stvo 2, 148 p.

IHRDC Presents Five Short Courses

Five short courses in petroleum exploration, petroleum geology, and reservoir technology will be offered in Houston this fall by the International Human Resources Development Corp. (IHRDC). The focus is toward persons active in the petroleum industry. Faculty for the courses is made up of highly experienced professionals, and their courses are structured to offer up-to-date information in both theory and practical applications.

"A First Course in Geophysical Exploration and Interpretation" is timed for October 11-15 and will be taught by Robert E. Sheriff, senior vice-president of Seiscom Delta, Inc., Houston, who is also a lecturer at the University of Houston and associate editor of *Geophysics.*

"Recognition of Petroleum Exploration Targets: A Modern Course in Petroleum Geology" will be offered October 18-22 and will have as instructor Frank B. Conselman, professor of geosciences and director of the International Center for Arid and Semi-Arid Land Studies at Texas Tech University.

Other courses are as follows. On October 25-29, Emil J. Burcick, professor of petroleum and natural-gas engineering at The Pennsylvania State University, will present lectures on "Reservoir Engineering Fundamentals and Reserves Estimation"; on November 1-5, Nigel Anstey, past president of the European Association of Exploration Geophysicists, will offer a course on "The New Seismic Interpreter"; and also on November 1-5, D. A. T. Donohue, founder and president of IHRDC, will lead sessions on "Reservoir Mechanics and Well Testing."

Further information about the courses, including costs, can be obtained from IHRDC, 35 Newbury Street, Boston, Massachusetts 02116 (phone, 617—536-0202).

October Energy Meeting to Be Held at Rolla

"Energy Crisis—An Evaluation of our Resource Potential" is the theme of a conference to be sponsored jointly by the University of Missouri at Rolla and the Missouri Energy Council of the Missouri Department of Natural Resources. It will be held October 12-14 on the university's campus at Rolla, Missouri. Cooperating organizations include The American Association of Petroleum Geologists and The American Geophysical Union. This is the third annual UMR-MEC Conference on Energy, and, as before, presentations will focus on the resources potential for meeting the nation's energy needs.

This year's conference will provide an interdisciplinary forum, however, taking into consideration not only petroleum and other mineral deposits but also chemical, solar, economic, financial, educational, and human resources. It will involve social scientists in varied fields, as well as physical scientists and engineers, both offering the results of their most recent research relating to energy resources and connected problems. It should be of interest to local governments, industry, and the general public in addition to those instrumental in providing energy.

For information on the technical aspects of the conference, contact Dr. J. Derald Morgan, Conference Director, Department of Electrical Engineering, University of Missouri at Rolla, Rolla, Missouri 65401.

Registration is $35 prior to October 1 and is $50 thereafter. For further information, contact Norma Fleming, Conference Coordinator, Extension Division, University of Missouri at Rolla, Rolla, Missouri 65401.

AAPG Updates Film Index

A new *Index to Films Related to Geology and Energy Exploration* was released earlier this year by The American Association of Petroleum Geologists. Compiled by a subcommittee of the association's Public Information Committee chaired by Robert W. Grayson, the index updates one issued in 1974. The 74-page index, or catalog, should be of value to anyone interested in selecting appropriate audio-visual aids pertaining to the earth sciences and exploration geology.

Films are grouped by principal subject, under which they are given an alphabetical, annotated listing by title. Also indicated is the running time of each film and whether the film is in black and white, color, and (or) sound. Suppliers of the indexed films are listed at the back.

The film index can be ordered from AAPG headquarters, P.O. Box 979, Tulsa, Oklahoma 74101, for $3.50 each. It is in loose-leaf form, ready for insertion in a three-ring binder.

GSA Issues Environmental Reports

The Geological Society of America's Committee on Environmental and Public Policy has published two concise, well-illustrated reports that deserve widespread distribution and recognition.

The first, *Geologic Constraints in the Urban Environment,* was prepared by a panel convened in February 1975 and chaired by Wallace R. Hansen of the U.S. Geological Survey in Denver, Colorado. The 12-page report covers these topics: water, solid waste, building foundations, landslides, construction materials, earthquake hazards, geologic constraints and open space, and ultimate responsibility of the community.

The second report is *Impact of Barrier-Island Development—Geologic Problems and Practical Solutions.* It was also prepared by a panel, which was convened in August 1975 and was chaired by Robert A. Morton of the Texas Bureau of Economic Geology in Austin, Texas. The 8-page report focuses on the coastal zones of the Gulf of Mexico and the Atlantic Ocean northward to Connecticut. Topics discussed include beach and barrier-island dynamics, important environmental considerations, impact of human activities, and alternatives to coastal problems.

Limited copies of both reports are available without charge from The Geological Society of America, 3300 Penrose Place, Boulder, Colorado 80301.

International Stratigraphic Guide Published

The following item was gleaned from the July issue of *Geology* (v. 4, no. 7, p. 419; The Geological Society of America, Boulder, Colorado):

The complete edition of *International Stratigraphic Guide* has been published by John Wiley & Sons, Inc. Edited by Hollis D. Hedberg, chairman of the International Subcommission on Stratigraphic Classification, this edition consolidates many previously published circulars and preliminary reports of the subcommission into a "more coherent and comprehensive whole" to be used as a reference by geologists.

This book, the result of 20 years of work by the subcommission, presents an internationally sponsored guide to principles, terminology, and procedure in stratigraphic classification. It sets forth recommendations for procedures in classifying rock strata into units according to various rock properties and attempts to provide a common language of stratigraphy. Illustrations of principles of stratigraphic classification and an extensive bibliography of some 1,500 entries are included.

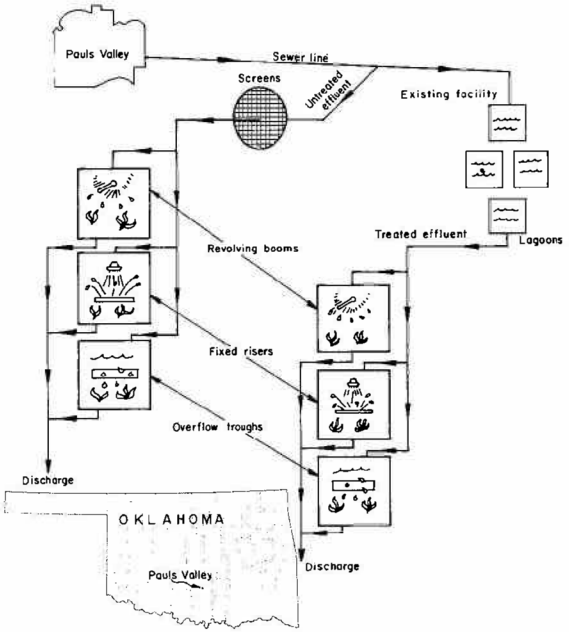
The guide can be obtained from John Wiley & Sons, Inc., 605 Third Avenue, New York, New York 10016, for $9.50.

Pauls Valley Waste-Treatment Project Dedicated

A project near Pauls Valley, in Garvin County, south-central Oklahoma, designed to evaluate treatment of municipal waste water by spray runoff, was dedicated officially on May 14, 1976, by the Honorable Henry Bellmon, U.S. Senator from Oklahoma. The research project is a joint effort by federal, State, county, and city government to determine an economical, alternative way of meeting future water-quality-discharge requirements for small communities.

Ground-breaking for the Pauls Valley project took place in June 1975. Completion of the project was made possible through funding by State and federal agencies, personnel contributions by the Garvin County Health Department, engineering and construction assistance from the City of Pauls Valley, and a land contribution by the Department of Institutions, Social and Rehabilitative Services, Pauls Valley State School. The State Department of Health oversees the entire operation.

Two parallel treatment systems are used in the project. The first utilizes untreated municipal waste water after the solids are filtered out. The waste water is applied to a series of sloping, rectangular plots by a variety of dissemination methods: (1) a spray nozzle on a rotating boom, (2) a spray nozzle on a fixed riser that sprays in one direction, and (3) an overflow trough. The second system uses treated effluent from the exist-



Simplified flow chart of parallel treatment systems utilized in Pauls Valley project.

Series of fixed risers spraying effluent on small plot of Bermuda grass.

ing lagoon, and the waste water is applied in a similar manner. Thus all 3 application techniques and the 2 parallel systems are evaluated to determine which ones are the most efficient.

After the water is applied to the experimental plots, the runoff trickles downslope and is channeled into a collecting pond for subsequent use as irrigation water or is discharged as treated effluent. The small plots are planted with warm- and cool-season cover crops, which are harvested as part of the waste-water-treatment program.

Potential advantages to spray-runoff systems are evident. Such systems may prove less expensive than other treatment systems, since they require less land and capital investment and offer the potential of an economic return from harvesting the cover crop. If operated properly, the system is expected to produce effluent that meets water-quality goals for 1983 (best available treatment).

For additional information on land-application methods, contact the Water Quality Service, Oklahoma State Department of Health, P.O. Box 53551 (NE 10th and Stonewall), Oklahoma City, Oklahoma 73105.

—*Kenneth V. Luza*

Geological Highway Map of Northeastern Region Released

Geological Highway Map of the Northeastern Region is number 10 in the series of such maps covering various regions of the United States, published by The American Association of Petroleum Geologists in cooperation with the U.S. Geological Survey. It is fitting that this edition, covering as it does such places of cherished historical connotation as Boston, Philadelphia, Princeton, Trenton, Ticonderoga, and Titusville should be issued as the National Bicentennial Edition.

The map was compiled by Allan P. Bennison, a Tulsa geological consultant, and contributions were made by personnel of the U.S. Geological Survey and by those of the state geological surveys and several universities in the Northeastern region. The region embraces the states of Pennsylvania, New York, New Jersey, Connecticut, Rhode Island, Massachusetts, Vermont, New Hampshire, and Maine. Publication of the map leaves only two regions of the country without coverage by the series, the Great Lakes and the Northern Great Plains.

It is hard to imagine a highway-map format so packed with pertinent, easy-to-use geological information. Included, in addition to the principal geologic map (at a scale of 1 inch = 30 miles), are columnar sections; cross sections; a physiographic map; a tectonic map; a map denoting fossil and gemstone localities; a map of parks, museums, and other points of geological interest; a map showing glacial deposits; a series of paleogeographic maps; a section on geologic history by John Rodgers; and a section on geology and the American Revolution.

The map of the Northeastern region can be obtained from AAPG headquarters, P.O. Box 979, Tulsa, Oklahoma 74101. Folded copies are $3.00 each, plus $0.50 handling charge, and rolled copies are $3.00 each, plus $1.00 handling charge. Folded copies can also be obtained from the Oklahoma Geological Survey for $3.00 each by writing to the address on the front cover.

New Theses Added to OU Geology Library

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

Carbonate Petrology and Lithostratigraphy of the Lecompton Member (Pawhuska Formation), Jennings-Shamrock Area, Oklahoma, by Suzanne Barrere Mistretta.

An Experimental Investigation of Magnetic Susceptibility in Weak Fields of Different Frequencies, by David Curtis Bradshaw.

Geology of the Lower Ordovician Rocks of the Choctaw Anticlinorium, Southeastern Oklahoma, by Joseph F. Dunagan, Jr.

Nannofossils of the Ozan Formation (Cretaceous), McCurtain County, Oklahoma, by Anthony Edward Krancer.

Quantitative Geophysical Study of the Cleveland Sand Reservoir (Pennsylvanian) in Eastern Part of Logan County, Oklahoma, by Dimitrios Kousparis.

The Stratigraphy of the Lower Gobbler Formation, Sacramento Mountains, New Mexico, by Robert E. Benne.

Structural Analysis of Asymmetrical Folds Using the Finite Element Method, by James Michael Anthony.

The Structure of the Eastern Part of the Mill Creek Syncline, by Robert Franklin Luke.

Subsurface Stratigraphic and Structural Analysis, Cherokee Group, Pottawatomie County, Oklahoma, by David Michael Pulling.

A Vertical Intensity Magnetic Study of the Western Part of the Arbuckle Mountains, by Patrick Joseph Ryan.

Field Trip to Study Arbuckles and Ouachitas

A field trip in conjunction with a meeting to be held in Shreveport, Louisiana, will focus on the Arbuckle and Ouachita Mountains in southern Oklahoma October 15-17. Robert O. Fay, of the Oklahoma Geological Survey, will be one of the field-trip leaders. George G. Huffman, of The University of Oklahoma's School of Geology and Geophysics, and L. R. Wilson, of the Survey and the School, will contribute articles to the guidebook. Max G. Hare, of Arkla Exploration Co., is serving as field-trip chairman. The itinerary is essentially a repetition of a trip conducted through the same region 3½ years ago (see February 1973 issue of *Oklahoma Geology Notes,* v. 33, no. 1, p. 27).

Preceding the field trip, beginning October 13, the annual meeting of the Gulf Coast Association of Geological Societies will be held in Shreveport in cooperation with the Society of Economic Paleontologists and Mineralogists. An SEPM field trip will study Tertiary units in Natchitoches and Sabine Parishes, Louisiana.

For further information about the meeting and the field trips, contact Leonard E. Jordan, P.O. Box 865, Shreveport, Louisiana 71162.

OKLAHOMA GEOLOGY NOTES

Volume 36 August 1976 Number 4