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OKLAHOMA GEOLOGY NOTES

OKLAHOMA GEOLOGICAL SURVEY

Cover Picture

Ridges and Valleys of the Ouachita Mountains

Oblique aerial photograph showing folded and faulted sedimentary rocks in the Ouachita Mountains of southeastern Oklahoma. The view is looking eastward down Big Creek valley, which is flanked by Rich Mountain (right, background) and Black Fork Mountain (left, background). The community of Page is at the foot of Black Fork Mountain (left, center).

These long, sinuous ridges are capped by sandstones of the Jackfork Group of Early Pennsylvanian age, whereas the valleys comprise mostly shales of the Stanley Group of Late Mississippian age. The two groups aggregate about 20,000 feet of dark-gray shales and turbidites that were deposited in the Ouachita geosyncline.

Strata dip to the south (right) in most parts of the picture. The Jackfork-upper Stanley sequence is repeated in the two principal mountain ridges because of a major fault (the Honess fault) in Big Creek valley.

The structural features and tectonic history of this area and other parts of the central Ouachita Mountains of Oklahoma and Arkansas are the subject of a new report by Frank A. Melton (see p. 56 of this issue).

— *Kenneth S. Johnson*

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 $1,949.90.

An Unusually Large Pennsylvanian Ammonoid From Oklahoma

Royal H. Mapes[1]

INTRODUCTION

Discovery of new fossil localities and periodic recollecting of published classic sites often result in the recovery of undescribed taxa as well as larger and (or) more nearly complete specimens of described species. Study and documentation of such specimens can give greater understanding and insight into paleobiology and biostratigraphy.

In cephalopod studies, it is desirable to have mature individuals of a species in order to observe the complete ontogenetic development. This is especially critical with regard to form and sutural outline of the ammonoids. Descriptions that incorrectly assume a mature development for a species can and have led to confusion in the literature; for an example, see the generic discussion of *Eumorphoceras* by McCaleb and others (1964). Because of the significance attributed to ammonoid ontogeny, the author deems desirable the description of an exceptionally large specimen of *Eoasianites welleri* (Smith, 1903) from the Pennsylvanian of Oklahoma.

Table 1.—Ammonoid Occurrences and Maximum Diameters Known from Seminole Formation (Pennsylvanian, Missourian) at Collinsville, Oklahoma

Designation by Miller & Owen (1937)	Current Taxonomic Designation	Maximum Known Diameter (mm)
Bisatoceras primum	*Bisatoceras primum*	34
Eudissoceras collinsvillense	*Gonioglyphioceras gracile*	14
Gastrioceras clinei warei	*Eoasianites welleri*	290
Gastrioceras clinei clinei	*Eoasianites clinei*	75
Gastrioceras jonesi	*Eoasianites excelsus*	141
Gastrioceras prone	*Eoasianites prone*	12
Gastrioceras retiferum	*Owenoceras retiferum*	23
Prothalassoceras inexpectans	*Eothalassoceras inexpectans*	42
Schistoceras unicum	*Eoschistoceras unicum*	56
	Maximites cherokeensis	9

LOCALITY HISTORY

In 1934 John M. Ware discovered cephalopod-bearing concretions of Pennsylvanian (Missourian) age in overburden of a coal strip pit at Collinsville, Tulsa County, Oklahoma. This site has since become a classic

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and productive cephalopod locality. The first study of cephalopods from this locality (Miller and Owen, 1937) documented the occurrence of nine ammonoid species. Periodic recollecting has yielded one additional form (Unklesbay, 1962). Thus, a total of 10 ammonoid species are known to occur at this locality (table 1). Recently an important specimen belonging to the genus *Eoasianites* was recovered by the writer, forming the basis of this report.

SYSTEMATIC PALEONTOLOGY

Family Gastrioceratidae Hyatt, 1884

Genus **Eoasianites** Ruzhencev, 1933, p. 165

Type Species: **Eoasianites subhanieli** Ruzhencev, 1933, O. D.

Diagnosis.—The conch of *Eoasianites* ranges from subglobular to globular when mature and is highly evolute when juvenile. Sculpture is transverse with one or more ridges or beads present on the umbilical shoulder. The suture has a moderately high ventral saddle. At maturity, the first lateral saddle remains rounded; the prongs of the bifid ventral lobe and the first lateral lobe become asymmetrical and attenuate.

Discussion.—The generic complex consisting of *Eoasianites* Ruzhencev, 1933, *Glaphyrites* Ruzhencev, 1936, and *Syngastrioceras* Librovitch, 1938, remains a source of confusion among American Paleozoic cephalopod workers; and indeed some authors have regarded the latter two genera as synonyms of *Eoasianites* (Miller and Furnish, 1940, 1957). However, Ruzhencev (1962) and Gordon (1964) remain convinced of generic separation based on ornament, whorl section, and suture. McCaleb (1968), in his intensive study of this problem, followed Miller and Furnish in the suppression of *Glaphyrites;* however, he maintained that separation of *Syngastrioceras* is possible because of its more attenuated elements: an asymmetric first lateral saddle and a drawn-out first lateral lobe at maturity. Of these two criteria, only the prior has validity in that the mature specimen described in the present report has a drawn-out first lateral lobe (fig. 1) that is virtually identical to those reported by McCaleb. Also, the extremely attenuated prongs of the ventral lobe give the suture of this specimen a more attenuated appearance than any of those illustrated by McCaleb.

Undoubtedly this generic complex deserves additional work in order to clarify and redefine generic limits. However, for the purposes of this report, the genus *Eoasianites* is used with reservation.

Occurrence.—According to Ruzhencev (1962), the genus *Eoasianites* occurs in Middle Pennsylvanian to Lower Permian units in the Urals, North America, and Timor.

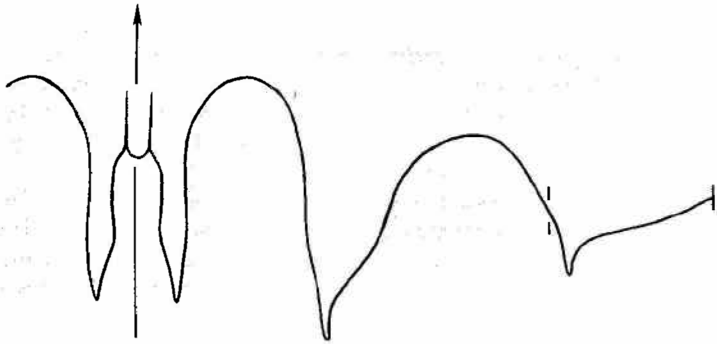

Figure 1. Sutural outline of *Eoasianites welleri,* where D = 225 mm, H = 63 mm, W = 75 mm. From Seminole Formation (Pennsylvanian, Missourian), Collinsville, Tulsa County, Oklahoma; SUI 39466, × 3/5.

Eoasianites welleri (Smith, 1903)

Gastrioceras welleri SMITH, 1903, p. 98; pl. 24, figs. 13-20.

Gastrioceras clinei warei MILLER and OWEN, 1937, p. 410-413, text-fig. 2, table 1; pl. 51, figs. 6-9, 12-13.

Eoasianites angulatus UNKLESBAY, 1962, p. 78.

Glaphyrites welleri GORDON, 1965, p. 219.

Description.—The original description of *E. welleri* (Smith, 1903) was based on several specimens collected from an unknown Middle Pennsylvanian locality in Carroll County, Missouri. Specimens originally designated *E. clinei warei* were described from a locality near Collinsville, Oklahoma (Miller and Owen, 1937). Two years later Miller and Owen (1939) indicated this subspecies as being virtually identical to *E. welleri* but did not suppress the taxon. Descriptions by these authors are considered adequate for specimens up to a diameter of 60 mm, but subsequent discoveries reveal that significant differences appear in larger specimens. Fully mature forms were unknown or at least unrecognized from the Collinsville locality previously, and large fragments of body chambers were all assigned to *E. excelsus* (Meek) on the basis of size.

Large specimens of *E. welleri* have a semiglobular conch with a large open umbilicus. The largest known specimen (fig. 2) attained an estimated conch diameter of 290 mm, a whorl height of about 80 mm, a width of approximately 180 mm, and a maximum umbilical diameter across the umbilical shoulders of about 170 mm.

In cross section, the venter is somewhat flattened, with moderately rounded ventrolateral areas and an abrupt but smoothly rounded umbilical shoulder forming an acute angle with the umbilical wall. The umbilical wall is slightly convex and at the terminal suture is about 35 mm long. The acute angle of the umbilical shoulder is variable on the body chamber of the specimen and gradually changes to an obtuse angle, which is more gently rounded at the terminal orad end of the body chamber. The type of ornament and the degree of shape modification of the umbilical shoulder by the missing shell are unknown.

The suture pattern is distinctive and forms a large bifid ventral lobe with narrow, slightly asymmetrical attenuate prongs, a rounded ventrolateral saddle, and an attenuated lateral lobe that has a recurved tip. The umbilical lobe is approximately one-fifth of the umbilical wall distance from the umbilical shoulder.

Remarks.—This specimen is probably the largest *Eoasianites* recovered from Oklahoma. It is unfortunate that because of the preservational condition of this large specimen it is impossible to examine sutures on the inner whorls of the phragmocone and make direct comparisons with described specimens. Unklesbay (1962) described a large partial phragmocone from the same locality with an estimated diameter of 110 mm and assigned it to *E. excelsus* (Meek). Comparison of the two specimens reveals that the general dimensions are similar; however, the narrow, slightly asymmetrical,

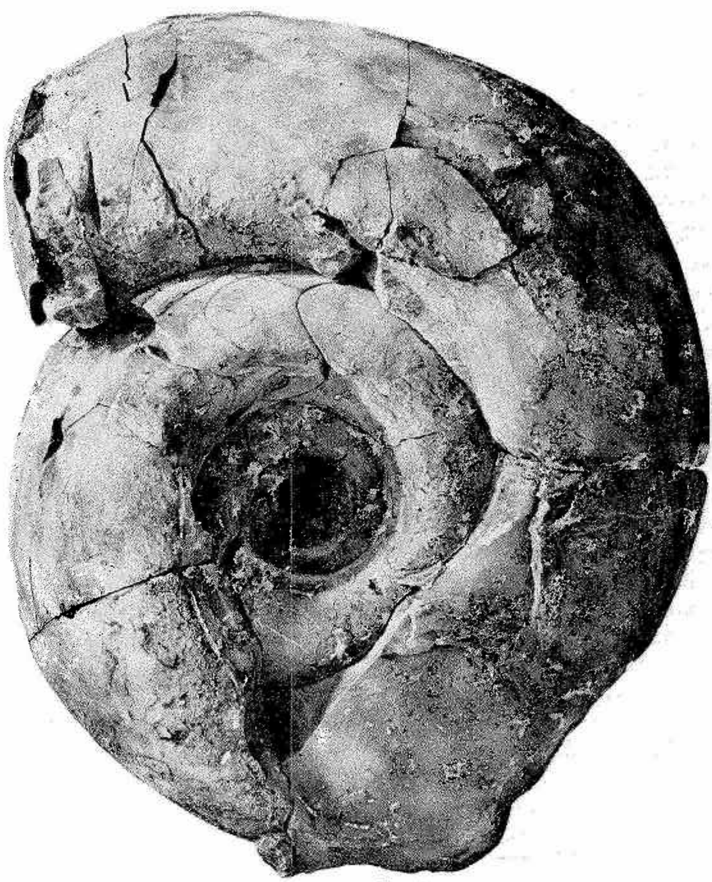

Figure 2. *Eoasianites welleri* (Smith, 1903), a mature individual from Seminole Formation (Pennsylvanian, Missourian) at strip pits south of Collinsville, Tulsa County, Oklahoma; SUI 39466, × 2/5.

attenuated prongs of the ventral lobe are distinctly different from the moderately wide, more asymmetrical prongs of *E. excelsus* reported by Unklesbay. Because of this sutural difference it seems reasonable to assign, provisionally, the recently recovered extremely large specimen to *E. welleri*, which is the only other large umbilicate *Eoasianites* known to occur at the Collinsville locality.

Occurrence.—The large specimen of *E. welleri* was recovered from spoil banks consisting largely of shale of the Seminole Formation (basal Missourian) at the south end of the strip pits 1 mile south of Collinsville, Tulsa County, Oklahoma (S½ sec. 32, T. 22 N., R. 14 E.). Most of the cephalopods from this locality have been recovered from black limy concretions in a black shale that overlies the Dawson coal; however, the large cephalopod described in this report represented an entire concretion with essentially no matrix.

Repository.—The large specimen of this report is reposited in the Department of Geology Repository, The University of Iowa, Iowa City, catalog no. SUI 39466.

ACKNOWLEDGMENTS

Brian F. Glenister, W. M. Furnish, and H. L. Strimple, Department of Geology, The University of Iowa, provided encouragement and constructive suggestions concerning this report.

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Three Field Conferences Are Scheduled

Tri-State Region

The Tulsa Geological Society will sponsor a field trip April 30-May 1 on "Coal and Oil Potential of the Tri-State Region." The trip, after leaving the meeting point at Tulsa, will visit 12 localities in northeastern Oklahoma, southeastern Kansas, and southwestern Missouri. Stops will be made to inspect six coal mines, a sandstone containing heavy oil and a heavy-oil-recovery project, an outcrop of the Bluejacket (Bartlesville) Sandstone, the Empire district electric-power plant, and the Bartlesville office of the U.S. Energy Research and Development Administration (ERDA).

S. A. Friedman, coal geologist with the Oklahoma Geological Survey, will discuss the coal geology and the mining at Peabody's No. 1 mine near Chelsea, Oklahoma, and Peabody's No. 2 mine near Vinita, Oklahoma. He is also a contributor to the guidebook for the trip.

A paper by Leonard R. Wilson, George Lynn Cross Research Professor in The University of Oklahoma School of Geology and Geophysics and a geologist with the OGS, "Palynological Stratigraphy of the Desmoinesian Series Coals in Oklahoma," will be included in the guidebook. Dr. Wilson will also lecture at six coal-mine stops.

For information on the TGS trip and the guidebook, contact Frederick N. Murray, 3734 East 81st Place, Tulsa, Oklahoma 74136 (phone, 918—584-4471).

Central Texas

The Permian Basin Section of the Society of Economic Paleontologists and Mineralogists, in Midland, Texas, will offer a 3-day field conference April 29-May 1 over the north-central Texas region. Emphasis will be on fluvial and deltaic sandstone and mudstone facies of Middle and Upper Pennsylvanian rocks and limestone-bank facies of Middle Pennsylvanian rocks. Leaders will be L. F. Brown, Jr., A. W. Cleaves, and E. G. Wermund, all of The University of Texas Bureau of Economic Geology. Headquarters will be at the Holiday Inn, Mineral Wells, Texas. The cost is $65.00, $40.00 for students.

For information, contact Craig Thompson, P.O. Box 1595, Midland, Texas 79701 (phone, 915—683-6301).

Colorado Ground-Water Conference and Field Trip

"Impact of Mining and Energy Development on Ground-Water Resources" is the title adopted for a Rocky Mountain ground-water conference to be held May 12-14 in Denver, Colorado.

Emphasis at the conference will be on oil shale, uranium, coal, and geothermal energy. Keynote speeches and panel discussions will cover exploration for these energy sources, mining and development, legal controls over their development, and environmental considerations.

A 2-day pre-meeting field trip will cover water resources and oil shale in the Piceance Creek basin, geothermal resources at Glenwood Springs, Colorado, water problems associated with resort developments in Vail, Colorado, transmountain water-diversion projects for Denver and Denver County, and the structure and stratigraphy of the Denver basin as related to ground-water resources.

For information, contact Richard H. Pearl, Room 254, 1845 Sherman Street, Denver, Colorado 80203 (phone, 303—892-2611).

GSA Rocky Mountain Section to Meet in Albuquerque

The University of New Mexico and the New Mexico Geological Society will co-sponsor the 29th annual meeting of The Geological Society of America's Rocky Mountain Section in Albuquerque May 20-21. Technical sessions will be held on the campus of the University of New Mexico.

In addition to papers scheduled for the sessions, four symposia will be offered, covering the origin of basalt, the Rio Grande rift, ash-flow tuffs, and tectonics and mineral resources of southwestern North America. Two pre-meeting field trips will cover the Jemez volcanic field and the Grants uranium belt; post-meeting trips will be over the Rio Grande rift and the Mogollon-Datil volcanic field.

For meeting information, contact Lee A. Woodward, Department of Geology, University of New Mexico, Albuquerque, New Mexico 87131. Housing will be handled by Viki Pedroncelli, Division of Continuing Education, University of New Mexico, Albuquerque, New Mexico 87131.

Symposium on Rocky Mountain Coal Announced

The Colorado Geological Survey and the Colorado School of Mines are sponsoring the 1976 Symposium on the Geology of Rocky Mountain Coal, to be held at the Green Center, Colorado School of Mines, Golden, on April 26 and 27. This timely 2-day meeting, the first of its kind to be held in recent years, is designed primarily for the geologist exploring for and developing the coal resources of the Rocky Mountain region, from Montana to New Mexico.

Presentations will include studies of basic coal geology and geochemistry (both general and topical), exploration methods and tools (including coal analysis, geophysical surveys, and well-log interpretation), and various aspects of coal mining and utilization (such as mined-land reclamation, mine design and engineering, and computer applications). Ample time for discussion of the papers presented will be scheduled for each day.

For further information on the meeting, contact D. Keith Murray, Colorado Geological Survey, 254 Columbine Building, 1845 Sherman Street, Denver, Colorado 80203 (phone, 303—892-2611).

ERDA Issues Uranium Reports, Maps, Bibliography

Uranium-Assessment Reports

Two reports on uranium potential were recently placed on open file by the U.S. Energy Research and Development Administration (ERDA). One of these publications, GJO-1642-1, *Potential Uranium Host Rocks and Structures in the Central Great Plains,* containing 8 fold-out maps, has been deposited for inspection at the Oklahoma Geological Survey.

Authored by E. J. Zeller, G. Dreschhoff, E. Angino, K. Holdoway, W. Hakes, G. Jayaprakash, and K. Crisler, of the Radiation Physics Laboratory, Space Technology Center, The University of Kansas, and by D. F. Saunders, of Texas Instruments, Inc., the 66-page report covers an area extending from longitude 99° to 104° W. between the North Platte River and the Canadian River. Data were derived from a literature search for known uranium occurrences and potential uraniferous rocks, supplemented by a geomorphic-lineament study derived from satellite imagery plus field traverses. Gamma-ray well logs used for the survey in Kansas outlined possible uraniferous provinces in the subsurface in that area and led to acceptance by the authors of well-log data as a useful tool in finding potential deposits in any well-explored petroleum region.

The other ERDA open-file uranium report is an assessment of such resources in New Mexico. Based on a survey of expectations of 36 geologists, an estimate of undiscovered resources was reached in the amount of 226+ million tons of material containing 455,480 tons of U_3O_8. Detailed estimates are presented for the entire state and for each of 62 subdivisions, including the San Juan basin, which is estimated to contain 92 percent of the undiscovered uranium. This report, *A Subjective Probability Appraisal of Uranium Resources in the State of New Mexico,* was issued as GJO-110(76), and the nearest repository where it can be examined is The University of Texas Bureau of Economic Geology at Austin, Texas.

Both these open-file reports can be copied at the requestor's expense. For information on this service, contact Quahada Engineering, 307 South 12th Street; Sir Speedy Instant Printing Center, Engineering Section, 912 North Avenue; or Colorado Copy Center, Suite T-8, Valley Federal Plaza; all at Grand Junction, Colorado 81501.

Preliminary Maps of Wyoming, Arizona, and New Mexico

Four maps of features of three western states have been placed on open-file by the Grand Junction office of ERDA:

Preliminary Map 21 is an electric-log cross section showing the lithology of the Wasatch and Fort Union Formations, Sheridan to Wyodak, Powder River Basin, Wyoming.

Preliminary Map 22 shows the distribution of known uranium occurrences in New Mexico.

Preliminary Map 23 shows mine locations in the Carrizo Mountains uranium area, Apache County, Arizona, and San Juan County, New Mexico.

Preliminary Map 24 consists of nine sheets of electric-log cross sections showing the lithology of the Wasatch and Fort Union Formations, Powder River Basin, Wyoming.

The nearest repositories for these maps are the U.S. Geological Survey Library, in Building 25 of the Denver Federal Center at Lakewood, Colorado, and the Government Publications Section, Zimmerman Library, University of New Mexico, Albuquerque, New Mexico. Copies will be made at the requestor's expense by Quahada Engineering and Sir Speedy at the addresses given previously.

Nuclear-Materials Bibliography

Nuclear Raw Materials—A Selected Bibliography, published by ERDA as TID-3357, contains a cross-indexed listing of 273 open-file reports issued by the Grand Junction office between 1955 and 1974. The bibliography is for sale at the National Technical Information Service (NTIS), U.S. Department of Commerce, Springfield, Virginia 22161. The price for United States orders is $4.00 for paper, $2.25 for microfiche.

Many of the reports included are available from NTIS. They can be inspected at the Grand Junction office.

ERDA Plans Symposium on Nuclear-Waste Management

The U.S. Energy Research and Development Administration (ERDA) will sponsor an International Symposium on the Management of Wastes from the nuclear-fuel cycle in Denver, Colorado, July 11-16.

Representatives from ERDA laboratories, industry, and academic institutions will present results of several months of planning and evaluation for an ERDA research and demonstration program on radioactive-waste management and isolation. International representatives also will participate in the meeting. Participants will assess technology developed in the United States and abroad that has been proposed for handling radioactive wastes produced by the commercial nuclear-power industry.

Further information about the meeting can be obtained by writing Floyd L. Culler, Oak Ridge National Laboratory, P.O. Box 10, Oak Ridge, Tennessee 37830; or Carl W. Kuhlman, Division of Nuclear Fuel Cycle and Production, Energy Research and Development Administration, Washington, D.C. 20545.

New Publication Covers Oklahoma's Reservoir Resources

Oklahoma Reservoir Resources, a collection of 18 papers given at a symposium of the Oklahoma Academy of Science (OAS) held in November 1974 at Durant, Oklahoma, has been issued as the fifth in the academy's Annals series. The 151-page volume, containing diverse scientific information about the State's surface-water reservoirs, was published in March by the Oklahoma Geological Survey.

The publication not only provides information on surface-water resources but also embodies the growing realization that scientific investigations must cut across disciplinary boundaries. The multidisciplinary nature of this issue of the OAS annals is evident in the variety of subjects dealt with, ranging from reservoir management and planning, water quality, and economic and environmental impact to recreational uses of reservoirs and the effects of impoundment on fish and waterfowl.

Papers were authored by biologists, ecologists and environmentalists, engineers, economists, a geographer, and fish and wildlife specialists. The involvement of personnel of Oklahoma State University in the symposium is represented by 9 of the 18 papers. The publication was edited by Loren G. Hill, associate professor of zoology at The University of Oklahoma and director of the Oklahoma Biological Station, and by Robert C. Summerfelt of the Cooperative Fishery Research Unit at OSU. A foreword is given by Norman N. Durham, 1974 president of OAS, who is dean of the graduate college and professor of microbiology at OSU.

Oklahoma Reservoir Resources can be obtained from the Oklahoma Geological Survey by writing to the address on the front cover. The price is $6.00.

Map Sheet on Ouachita Mountains Issued by OGS

Stereoscopic and Mosaic Aerial-Photograph Study of the Structure of the Central Ouachita Mountains in Oklahoma and Arkansas, by Frank A. Melton, has just been published by the Oklahoma Geological Survey as Map GM-18. Dr. Melton is a professor emeritus in the School of Geology and Geophysics at The University of Oklahoma and, having been a pioneer in the field of aerial-photograph interpretation, has long been recognized as an accomplished specialist in this field. The investigation represents years of study by the author in delineating structural features and trends from aerial photos in the Ouachita Mountain region.

GM-18 consists of one 4-color map sheet, approximately 46 by 39 inches, that has been folded in an envelope. Shown on the sheet is a text on the structure and structural history of the central Ouachita Mountains, plus three maps at scales of 1:250,000, 1:125,000, and 1:62,500. The smallest scale map (1:250,000) covers an east-west region extending for about 175 miles, from Talihina, Oklahoma, to beyond Little Rock, Arkansas. The two larger scale maps concentrate mainly on the central Ouachitas of Oklahoma and show the structures of this area in detail. Also on the sheet is a cross section through Big Cedar fault zone in Arkansas, plus a series of schematic sections showing progressive development of the Ouachita geosyncline and the Ouachita Mountains.

Survey cartographer David M. Deering did the scribing and other preparation of the final copy. Dr. Melton also acknowledged the significant contributions of Survey geologist Kenneth S. Johnson.

Dr. Melton feels that his study is of unique value in recognizing local and regional structures by means of stereoscopic examination of aerial photos. This is so, he explains, because many of the features in the Ouachita province are obscure when studied in the field. In his text he points out that his approach "in no way belittles or ignores the great amount of important field examination that has been carried out by others; the many stratigraphic and structural maps now available are indispensable in any study of the Ouachita system."

GM-18 can be obtained for $5.00 by writing to the address on the front cover.

Three OGS Publications Reprinted

Popular demand has exhausted the supply and necessitated the reprinting of Oklahoma Geological Survey Circular 23, Guide Book 14, and Educational Publication 2. These publications were all reprinted on the Survey's small offset press.

Barite Circular

The sand-barite rosette, Oklahoma's official State rock, found in exposures of the Permian-age Garber Sandstone in 10 central counties, represents the most popular expression of the mineral barite. Barite, however, occurs in Oklahoma in diverse types of deposits; and although not in sufficient concentration to be of commercial value under present conditions, the deposits have always been of geologic interest.

Requests for information about these barite occurrences have resulted in reissue of an OGS circular written in 1944 by the late William E. Ham, OGS geologist for thirty years, and Clifford A. Merritt, now professor emeritus of The University of Oklahoma School of Geology and Geophysics. Circular 23, *Barite in Oklahoma,* contains both general and specific information on the deposits, as well as illustrations and maps and a discussion of barite origin in Oklahoma's Permian sedimentary rocks.

The price of the circular is $1.00.

Well-Log Guide

The Composite Interpretive Method of Logging Drill Cuttings, by USGS geologist John C. Maher, first issued in 1959 as Oklahoma Geological Survey Guide Book 8, revised and reissued in 1964 as Guide Book 14, gives detailed instruction for the preparation and application of composite interpretive logs, logs developed by synthesizing drillers logs, electric logs, and radioactivity logs. Demand for the book has been constant from its first printing.

The reprinted Guide Book 14 is available for $2.00.

Field-Trip Instruction Guide

OGS Educational Publication 2, *Introduction, Guidelines, and Geologic History of Oklahoma,* by Kenneth S. Johnson, geologist with the Survey, issued in 1971 as Book 1 of *Guidebook for Geologic Field Trips in Oklahoma,* contains step-by-step instructions on the planning of a field trip, pointers to be followed in leading a group in the field, and safety measures during a trip. Included also are a 7-page condensed geologic history of the State and a list of general references on the geology of Oklahoma.

This educational guidebook was prepared with the cooperation of the National Science Foundation, the Oklahoma Curriculum Improvement Commission, and the Curriculum Section of the Oklahoma Department of Education. It is the first of a projected series of regional guidebooks designed for use by secondary-level teachers of earth science and was issued as a "preliminary version" in order to take advantage of recommendations by users. Book 2 of this series, *Northwest Oklahoma,* also authored by Johnson, was issued as OGS Educational Publication 3 in 1972.

Introductions, Guidelines, and Geologic History can be obtained from the Oklahoma Geological Survey for $1.00; *Northwest Oklahoma* is available for $0.50.

Orders for all these publications should be sent to the address on the front cover.

New Topographic Map of Oklahoma Available

A new wall-sized topographic map of Oklahoma at a scale of 1:500,000 (approximately 1 inch = 8 miles) was issued recently by the U.S. Geological Survey. (The date of the edition is 1972, although the map was released in late 1975.) In addition to standard base information, shown in black, topographic contours (200-foot interval) are overprinted in brown, highways in purple, county lines and national forests in green, water features in blue, and national parks and recreation areas in pink.

The map has been printed on a good grade of heavy stock. The western part of the Panhandle has been detached and printed below the eastern part to reduce the size of the map sheet, which measures 35 by 54 inches.

The topographic map of Oklahoma can be ordered from the U.S. Geological Survey, Denver, Colorado 80225, or Reston, Virginia 22092. It can be ordered also from the Oklahoma Geological Survey by writing to the address on the front cover. The price is $2.00.

CRIB Data File Now Available to Public

The Computerized Resources Information Bank (CRIB), a national mineral-resources data bank established in mid-1972 by the U.S. Geological Survey (see *Oklahoma Geology Notes,* v. 33, p. 199), is now available to the public as a result of a modification to a contract between the USGS and The University of Oklahoma. The CRIB file consists of records on mineral deposits and commodities of the United States and foreign countries and is expected to be of increasing importance in view of the nation's growing dependence on outside sources for mineral needs.

Since February 1974, OU has been under contract with the USGS to provide automatic-data-processing services, materials, and supplies for keyboarding data for utilization in OU's Generalized Information Processing System (GIPSY) and building the data base in computer-readable form through the use of GIPSY programming modules. (The GIPSY format is also used in the Petroleum Data System, another joint USGS-OU project.)

The CRIB file contains approximately 50,000 records, of which 31,000 are presently available in the master file; the remainder are in various holding areas undergoing editing and will be added to the master file shortly. New records are expected to be added at the rate of 500 to 1,000 a month.

Requests for data from the CRIB file should be made to Director, Information Systems Programs, The University of Oklahoma, 1808 Newton Drive, Room 116, Norman, Oklahoma 73069. Charges are made on a cost-reimbursement basis.

GSA Publishes Paper on St. Francois Mountains

The age of the Precambrian rocks of the St. Francois Mountains, in southeastern Missouri, is the subject of a 48-page special paper published recently by The Geological Society of America. Authors M. E. Bickford and D. G. Mose describe the U-Pb and Rb-Sr methods used for age determinations for these rocks, which indicate ages in the 1,300-1,500-m.y. range. Their analytical data and sample localities are given in four appendix tables.

The St. Francois Mountains are notable in constituting the most extensive exposure of Precambrian rocks in the Midcontinent region. These rocks are part of a Precambrian terrane extending from central Wisconsin and northern Ohio to the Texas Panhandle. (By contrast, the rocks of the Wichita Mountains of southwestern Oklahoma, which also lie within the Precambrian terrane, have been considered much younger, about 550 m.y. [Cambrian], although recent work indicates a Precambrian age for some of the mafic rocks of the Wichita Complex.)

Special Paper 165, *Geochronology of Precambrian Rocks in the St. Francois Mountains, Southeastern Missouri,* can be ordered from The Geological Society of America, Publication Sales Department, 3300 Penrose Place, Boulder, Colorado 80301, for $7.00 a copy.

Tommy Thompson to Teach at OU

The University of Oklahoma's School of Geology and Geophysics has been fortunate in receiving the acceptance of Thomas L. ("Tommy") Thompson to a faculty appointment as Visiting Professor in Petroleum Geology.

One of the most respected men in his field, Dr. Thompson has pursued a broad and varied career in all phases of petroleum exploration and evaluation, in uranium and other mineral exploration, in oceanographic research, in petroleum geochemistry, and in field mapping. An ongoing interest has been the geology of continental margins of the world, particularly in reference to plate tectonics, and in 1973 this interest led to his being named a Distinguished Lecturer for The American Association of Petroleum Geologists. His paper, "Plate Tectonics in Oil and Gas Exploration of Continental Margins," a scholarly and lucid presentation of the subject, was heard by 50 geological groups in North America. Thompson later delivered this lecture in whole or in part at meetings in such far-flung places as Hawaii, Egypt, Portugal, Angola, Pakistan, Thailand, Taiwan, and Japan.

Dr. Thompson has worked with Phillips Petroleum Company, Alex McCoy Associates, Inc., and the Stanford Research Institute. Since 1962 he has been with Amoco Production Company, where his work was in the areas of oil and gas exploration in the Midcontinent region of the United States and in the Rocky Mountains. While with Amoco he was also involved in mineral exploration in Alaska, in oceanographic research and the investigation of oceanic resources, and in the study of continental-margin geology.

In addition to the paper that formed the basis of his AAPG lecture tour, Tommy has numerous publications to his credit, including studies in structure, stratigraphy, tectonics, general geology, gravity measurements, mineral and petroleum prospecting, economic geology, suboceanic geologic mapping, and the significance to petroleum exploration of information recovered from JOIDES (Joint Oceanographic Institute Deep Earth Sampling).

His current membership in professional societies includes the Society of the Sigma Xi, American Geophysical Union, The American Association of Petroleum Geologists, The Geological Society of America, Tulsa Geological Society, and American Institute of Professional Geologists (now the Association of Professional Geological Scientists). Last year he served as president of the Oklahoma Section of what was then AIPG and was a member of the national executive committee of that organization. He has also served on committees for AAPG and as editor for the Tulsa Geological Society.

Tommy Thompson's academic education was received at the University of Colorado, where he received his B.A. degree in geology in 1950, and at Stanford University, where he earned a Ph.D., also in geology, in 1962. He has also participated in several special courses and seminars. He has had teaching experience at both Colorado and Stanford, and at San Jose State University.

Thomas L. Thompson (left), new Visiting Professor in Petroleum Geology in the School of Geology and Geophysics at The University of Oklahoma, talks with Hugh Thralls, chairman of the School's Alumni Advisory Council. (Photograph by Gilbert Jain.)

It may be worthy of note to mention here that Tommy's father, Warren O. Thompson, also received his B.A. at Colorado and his Ph.D. at Stanford in geology. Warren Thompson, known to many as a distinguished geologist, was on the geology faculty at Colorado for over 40 years, serving as chairman of the department from 1949 to 1961.

It was not only an interest in earth processes that Tommy Thompson grew with in the Middle Rockies. He also, you might say, was "exposed" to the outdoors in that very appropriate place and became involved in mountain climbing, fishing, hunting, and white-water boating. Also skiing. In 1951 he was in the Olympic ski tryouts, and for 22 months of a 3-year stint in the U.S. Air Force he conducted tests of aircraft skis for arctic operations. One of his publications, written for the Air Force, was on "Snow As It Affects Aircraft Ski Performance."

Dr. Thompson is married and is the father of seven (!) children. We welcome him and his family to the School and to the University community, and to Norman. All of them.

"Don't Miss the Boat"

The 1976 annual meetings of The American Association of Petroleum Geologists and the Society of Economic Paleontologists and Mineralogists will be held in New Orleans May 23-26. The New Orleans Geological Society, host for the convention, anticipates the "most momentous annual meeting in AAPG history." As an organization that has been working for the past 2 years to make it just that, the NOGS is prepared to back up its optimism with a multitude of technical sessions, short courses, symposia, colloquia, seminars, exhibits, and field trips; plus a myriad of social offerings, including cocktail parties, luncheons, a banquet, guided tours into the history and the modernity of a fascinating city and its environs, and a dance on a riverboat. The NOGS urges everyone to "be in that number."

For those connected now or in the past with The University of Oklahoma, a highlight of the social events will be the OU alumni luncheon, to be held May 25 at the Delta Towers.

Energy will be in the foreground at the meeting in the opening address on "Energy Sources," to be delivered by Philip Abelson, president of the Carnegie Institution and editor of *Science,* and in the keynote address on "The Timing Factor in Energy Exploration," to be given by AAPG president John E. Kilkenny.

Short courses will be offered May 22 and 23 on the continental slope, plate tectonics and hydrocarbon accumulation, and sedimentary environments and hydrocarbons. Research symposia and colloquia will be held on each of the four days of the meeting, and pre- and post-convention field trips will cover the Jackson-Vicksburg-Natchez area, the Weeks Island salt dome, the Black Warrior basin, carbonates of the Yucatán Peninsula, and the geology and archeology of Guatemala.

An innovation for AAPG at this year's meeting will be "poster sessions," during which the author of a paper will be presented for discussion and consultation for a specified 1½-hour period at a booth containing illustrative material from his paper. A cash award is offered for the best poster presentation.

Attending from OU and the Oklahoma Geological Survey will be Charles J. Mankin, director of the School of Geology and Geophysics and of the Survey; Kenneth S. Johnson, geologist with the Survey; Edward C. Stoever, Jr., professor of geology and geophysics; and William E. Harrison, petroleum geologist with the Survey.

Dr. Mankin will be involved in meetings as a member of AAPG's Committee on Academic Liaison, Continuing Education Committee, Research Committee, and Grants-in-Aid Committee. Stoever and Mankin are both members of the governing board of the American Geological Institute, which will hold a meeting May 27 in connection with the AAPG-SEPM annual meetings. Johnson will attend a meeting of AAPG's Committee on Environmental Geology and will participate in a pre-convention field trip to an underground salt mine in the Weeks Island salt dome.

OKLAHOMA ABSTRACTS

AAPG Regional Meeting, Southwest Section
Wichita Falls, Texas, February 29-March 2, 1976

The following abstracts are reprinted from the February 1976 issue, v. 60, of the *Bulletin* of The American Association of Petroleum Geologists. Page numbers are given in brackets below the abstracts. Permission of the authors and of Gary Howell, AAPG managing editor, to reproduce the abstracts is gratefully acknowledged.

Geotectonic Evolution of Wichita Aulacogen, Oklahoma

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

The paired uplifts and depositional basins of the Wichita lineament which trends northwest across southern Oklahoma were recognized by the Soviet geologist, Shatski, as the most obvious North American example of an aulacogen. These long-lived, deeply subsiding, and often fault-bounded features result from thermal doming of continental lithosphere, produced by plume-generated uplifts, which rupture the crust in three rifts at angles of about 120° to one another. Two of the rifts open by plate accretion to form an ocean basin while the third, extending at high angles from the newly rifted margin far into the plate interior, becomes inactive as a "failed arm" or aulacogen.

These features, of which the Afar region linking the Red Sea, Gulf of Aden, and the Ethiopian rift system is a modern example, begin as narrow fault-bounded grabens and later become broader downwarps. Intermittent basaltic and rhyolitic volcanism often characterizes the early stages of formation and later tectonic events often produce compressional folds and faults important to the accumulation of hydrocarbons.

The Wichita aulacogen long has been known as the Southern Oklahoma geosyncline. Developed on a Precambrian granitic basement, this depositional trough received nearly 20,000 ft (6,061 m) of graywacke, bedded chert, spilitic basalt, rhyolite, and hypabyssal sills. Late Cambrian to Devonian subsidence localized deposition in the trough of as much as 9,500 ft (2,879 m) of carbonate strata, a much greater thickness than is found on the adjacent platform.

Continental collision began to affect the area in Carboniferous time, as the Afro-South America plate converged on North America to form Pangea. Compressive stresses initiated by this collision were transmitted far into the continental interior along the reactivated basement faults. Both vertical and

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

transcurrent movement on these faults gave rise to a complex system of paired uplifts and fault basins, such as the Arbuckle Mountains-Ardmore basin and the Wichita Mountains-Anadarko basin. [327-328]

Study of Carbonate Environments Using Well Cuttings

BILLY J. WRIGHT, Permian Basin Sample Laboratory, Midland, Texas

During the last 20 years, a great deal has been learned of carbonate rocks and sediments, but many petroleum geologists have not yet learned to recognize and utilize the rock types, significant allochems and textures that can be seen in well cuttings and cores.

Most biogenic banks can be divided into seven distinctive zones which, for simplicity, are called basin, "way" fore bank, fore bank, bank-core, bank flat, lagoon, and shelf. Each zone is characterized by certain rock types, allochem assemblages, and textures that can be recognized in well cuttings and cores. These diagnostic features seem to be common to many types of biogenic banks, regardless of geologic age, and they can often be identified in recrystallized or dolomitized rocks. Most biogenic bank complexes are transgressive, regressive, or cyclical, and the seven zones listed previously are found commonly in vertical succession in wells. Their correct identification coupled with an understanding of bank growth and porosity development can lead to a much improved success ratio in exploring for biogenic bank reservoirs and traps. [328]

Upper Strawn Depositional Systems (Late Desmoinesian) of North-Central Texas

ARTHUR W. CLEAVES, Bureau of Economic Geology, The University of Texas at Austin, Austin, Texas

Terrigenous clastic and carbonate facies comprising the upper half of the Strawn Group were deposited within the Fort Worth foreland basin and on the adjacent Concho platform of north-central Texas. Seven major cycles of deltaic progradation and abandonment have been identified utilizing data from 3,500 wells and surface measured sections. Four deltaic depocenters, two carbonate banks, and an embayment-strandplain complex comprise the principal depositional systems present in the area. Variations in the rate of subsidence for the foreland basin and platform and the initiation of subsidence to form the Midland basin determined the lateral distribution of these depositional systems, as well as the lithofacies geometry for individual systems.

When subsidence ended in the central part of the Fort Worth basin (middle Desmoinesian), Strawn deltas prograded across the filled foreland basin and onto the stable, gradually subsiding Concho platform. Deltaic facies deposited on the platform comprise thin (less than 150 ft thick), multilateral, lobate and elongate delta systems. Initial deltas prograded toward the western margin of the platform. Carbonate-bank deposition subsequently became established on the downdip ends of these oldest deltas. A strandplain-embayment system made up of mud flats, chenier sandstone bodies, and thin (less than 30 ft or 9 m thick) bayhead deltas developed between the two main deltaic depocenters on the platform. The Midland basin on the west was a poorly defined structural feature, for no true shelf-edge or slope facies of Desmoinesian age have been identified.

High-constructive delta systems in excess of 200 ft (61 m) thick accumulated along the northwestern margin of the Fort Worth basin during periods of active subsidence. Thicker deltaic units contain linear, multistoried sandstone bodies whose geometries resemble bar-finger sands of the modern Mississippi delta. Valley-fill fluvial deposits commonly incise the high-constructive deltaic facies. The Arbuckle and Wichita Mountains of Oklahoma were the most significant source areas for these arkosic, northern delta systems, whereas the Ouachita foldbelt supplied the chert-rich terrigenous clastic debris for the deltaic facies of the Concho platform. [324]

Evolution of Anadarko Basin

RODGER E. DENISON, Consultant, Dallas, Texas

The evolution of the Anadarko basin area can be broken into four distinct phases.

The earliest recognizable phase is in the Early and Middle Cambrian. It is characterized by diverse bimodal igneous activity localized in a tensional incipient rift complex striking about N60°W. The major igneous activity was characterized by an early phase of basaltic composition and a late acidic phase of granites and rhyolites. The latest rhyolite phase extended beyond the limits of the rift.

The early phase was followed rapidly by a transgression of Late Cambrian seas. This second phase extends through the Devonian and is characterized by passive shallow-water sedimentation of a dominantly carbonate sequence. During this period shallow-water deposition in the area underlain by Cambrian igneous rock resulted in a sequence approximately twice the thickness of the same units where they were underlain by massive Precambrian rocks. It is clear that the area underlain by Cambrian basement was "softer," and thus able to respond to loading more readily than the rigid older basement. As a consequence, the Cambrian basement areas received a much thicker sequence of sediments.

The third stage was a period characterized by very rapid, largely clastic sedimentation accompanied by locally intense deformation. The Mississippian was the first period of major clastic sedimentation in the basinal area. This sequence is at least five times thicker in the areas of Cambrian basement than where underlain by the Precambrian. The deformation began during the Early Pennsylvanian and continued (with several pulses) through the Late Pennsylvanian. The deformation was most intense in the Arbuckle Mountain-Criner Hills areas southeast and east of the Anadarko basin and along the fault system separating the Wichita Mountains from the basin. The vast majority of the structural data strongly supports a deformation caused by compression normal to the basin axis. The deformation is best defined in the Arbuckle Mountains, where it is precisely parallel with the structural grain of the Cambrian igneous activity, N60°W. The basement rocks are involved closely in the deformation, and in areas underlain by Cambrian basement the deformation is much more intense than in areas underlain by massive Precambrian rocks.

The final phase is the passive postdeformation filling of the basin in Permian time and is characterized by clastic red beds and evaporites. [325]

The following abstracts are reprinted from the Southwest Section Regional Meeting Program of The American Association of Petroleum Geologists. Permission of the authors and of Gary Howell, AAPG managing editor, to reproduce the abstracts is gratefully acknowledged.

Stratigraphic Trap Possibilities in the Arbuckle Group

LLOYD E. GATEWOOD, Consultant, Oklahoma City, Oklahoma

One of the richest oil and gas producing areas in the United States is a 200 mile wide and 850 mile long belt extending from the Central Kansas Uplift across Oklahoma, North Texas, Southwestward to the Central Basin Platform, Delaware Basin and into New Mexico. More than 90% of all oil and gas produced from Ordovician-Cambrian rocks has come from this area and from accumulations extending from the grass roots downward to depths in excess of 22,000 feet in Arbuckle-Ellenburger carbonates. This area's Arbuckle potential should eventually more than match the Simpson production history from stratigraphic traps alone, even though the deep fractured Arbuckle dolomite structural gas traps such as West Mayfield and Mills Ranch are just now emerging.

Oklahoma is in the center of this prolific region with a much thicker Arbuckle section measuring over 8,000 feet in its hydrogen sulphide rich limestone depocenter and 5,000 foot thick platform dolomites, and yet Arbuckle production has come from less than 200 fields of which nearly 150 of these fields are located in one area, the Osage uplift.

It has only been since the Arbuckle discovery at the 47 year old Healdton field in 1960 that actual serious exploration has been conducted looking for the Arbuckle production itself and that only on structures.

This 500-600 foot productive fractured dolomite was found 1,000 feet below the top of the Arbuckle. It was encased within limestone rocks. The intense fracturing and varied porosity types plus appearance of intraformational breccia in the "Brown Zone" dolomite have led to the common belief that this zone was a "Tectonic Dolomite" and the hunt has been on ever since for this type dolomite on other structures believing that this type dolomite could only be formed or deformed by tectonism instead of in an original depositional environment as laid down in the sea.

Lately, an Environmental Model of West Spring Creek time using 300 outcrop samples for a 650 square mile area of the Arbuckle Mountains and Criner Hills in the Ardmore Basin has shown four general environments were active throughout West Spring Creek time. These environments are:

(1) Lagoonal;
(2) Supratidal — or lagoonal-supratidal complex;
(3) Intertidal;
(4) Subtidal-Limestone depocenter.

It may be possible to adapt subsurface well samples to these type models for predicting depositional environments in delineating stratigraphically the diagenetic terrain dolomites, reefs, shoals and porous dolomites interbedded and capped with evaporites.

There will always be a mystery connected with the Arbuckle environment, but hopefully if both the industry and geologist can change

from structure and fault traps and adapt so as to explore the environmental stratigraphic traps there may be many happy economic surprises ahead for all of us from the Arbuckle.

Morrow-Springer-Chester Relationships in the Anadarko Basin of Oklahoma

SUZANNE TAKKEN, Consultant, Oklahoma City, Oklahoma

Recent deep drilling to the Hunton in the Anadarko Basin has provided us with new information on the Morrow-Springer-Chester section as well as some new production. It seems clear that the Springer sands are Chesterian in age and that a nearly continuous depositional history can be identified in the deep basin, from Meramec up to the Morrow. Small local unconformities can be identified within the Springer-Chester section, but only the basal Morrow unconformity seems of regional significance.

A recent Springer gas play on the northeast flank of the Anadarko Basin, in Caddo and Grady Counties, has brought new interest in Springer correlations. The very thin producing sands are significantly over-pressured, and a local rule-of-thumb assigns reserves of 1 BCF per foot of pay. These sands appear to correlate with the so-called upper Chester limes of the deeper basin. Additional, thicker sands exist basinward and should provide exploration objectives for many years to come.

GSA Annual Meeting, South-Central Section
Houston, Texas, February 26-27, 1976

The following abstracts are reprinted from the *Abstracts with Programs* of The Geological Society of America, v. 8, no. 1. Page numbers are given in brackets below the abstracts. Permission of the authors and of Jo Fogelberg, managing editor of GSA, to reproduce the abstracts is gratefully acknowledged.

Precambrian Rocks in the Eastern Arbuckle Mountains of Oklahoma

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There are four map units in the Precambrian part of the Arbuckle Mountains. The youngest is the Tishomingo Granite near the center of the outcrop area. On the west the Tishomingo intrudes the Troy Granite and an unnamed granodiorite. The Troy is slightly chilled at contacts with the granodiorite. To the east the Tishomingo intrudes the Blue River gneiss. The gross metamorphic character of the gneiss is only locally developed. In the thin section all the samples show a complete reorganization of texture. The composition of the gneiss is variable but in bulk composition it is granitic. The age relationship between the Blue River and Troy cannot be established. Isotopic ages have thus far failed to show a difference in age. All the major rock units have an age range of about 1300-1400 million years.

Diabase, microgranite, granite and rhyolite dikes cut two or more of the map units. Diabase dikes are most common and are of both Cambrian and

Precambrian age. Granite and distinctive micrograniite dikes are of Precambrian age. Rhyolite dikes cut all units and are of Cambrian age. The diabase micrograniite and rhyolite dikes show a strong preferred strike direction of N60°W, coincident with the late Paleozoic structural grain. [17]

Computer Models of Simple Shear Deformation Superposed on Symmetric Folds Applied to Deformation in the Ouachita Mountains

ROGER FEENSTRA and JOHN S. WICKHAM, School of Geology and Geophysics, The University of Oklahoma, Norman, Oklahoma

Symmetric folds were generated and altered using finite element computer models to predict fold shapes and finite strain distributions. The finite element model was formulated for linear strain triangles using incompressible, Newtonian constitutive equations. Initial, single-layer symmetric folds with limb dips of 22.5° and 45° were produced by modeling a stiff layer in a weak matrix compressed parallel to the layer. The subsequent simple shear deformation was imposed on the model boundaries by moving them parallel to the enveloping surface of the folds. Several models were computed varying the limb dips of the initial folds and the viscosity ratio of the stiff layer to matrix. As the simple shear deformation progresses, the folds become asymmetric as one limb lengthens and thins while the other limb shortens and thickens. Accumulating strain distributions in both the matrix and stiff layer change from their initially symmetric distribution about axial planes to asymmetric distributions. In the stiff layer, principal strain elongations tend to parallel the layer in the long limb, and cross the short limb at high angles. Folds in the Broken Bow Uplift of the Ouachita Mountains are asymmetric with thin, long limbs and thick, short ones. Slaty cleavage parallels the long limbs but crosses the short limbs at large angles. Assuming that slaty cleavage patterns reflect accumulated strain distributions, folds from the Broken Bow Uplift remarkably fit the computer models. The hypothesis that simple shear deformation modified earlier folds in the Ouachita Mountains is consistent with the results of the computer models. [20]

Igneous Rock Relationships of the Medicine Creek Area, Wichita Mountains, Oklahoma

JOE D. GIDDENS III, CHARLES W. GREGORY, CYNTHIA K. B. SMITH, and JOSEPH F. FISCHER, Department of Geology, The University of Texas at Arlington, Arlington, Texas

Mapping along Medicine Creek on the northern flank of the Wichita Mountains, Oklahoma, has revealed complex relationships between three main intrusive rocks. The oldest rock present is layered anorthosite of the Raggedy Mountain Gabbro Group. The anorthosite is intruded by a massive biotite gabbro informally called the Mount Sheridan Gabbro. The gabbro intrudes sill-like into the anorthosite; the lower slope of Mount Sheridan has massive biotite gabbro at the bottom and top, with a lens of anorthosite in the middle. Mount Scott Granite is younger yet, and cuts across the basic rocks; it physically overlies the other rocks, and forms the caprock of the mountains. The contact between the granite and Mount Sheridan Gabbro is

characterized by a hybrid zone of variable width, possibly as much as 200′ wide. In spite of the hybridization, a sharp contact between the rocks can be found, and highly "granitized" xenoliths of gabbro occur in the granite. [22-23]

Mineral Chemistry and Petrography of the Layered Series of the Raggedy Mountain Gabbro Group, Wichita Mountains, Oklahoma

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The Layered Series of the Raggedy Mountain Gabbro Group is a sequence of anorthosites, troctolites, and anorthositic gabbros which constitute the core of the Wichita Mountains. Samples for this study were collected from 2 traverses through the layered series which cover 65m and 50m of section respectively. All samples examined are cumulates exhibiting extensive adcumulus growth. Plagioclase (An_{66} to An_{76}) is the most abundant cumulus phase comprising from 60% to 99% of the mode. Olivine (Fo_{66} to Fo_{71}) often rimmed by orthopyroxene-magnetite coronas and clinopyroxene ($Fs_{11.0}Wo_{44.3}En_{44.7}$ to $Fs_{13.5}Wo_{45.5}En_{41.0}$) are also cumulus phases comprising from 0% to 25% and 0% to 40% of the mode respectively. Orthopyroxene ($Fs_{22.3}Wo_{1.4}En_{76.3}$ to $Fs_{36.5}Wo_{3.3}En_{60.2}$) is exclusively post cumulus and never comprises more than 5% of the mode. Petrographic evidence strongly suggests that cumulus clinopyroxene and plagioclase formed bimineralic aggregates within the magma chamber which then settled to the magma chamber floor. Mineral chemistry as determined by electron microprobe analysis reveals a slight increase in Fe/(Fe+Mg) in the ferromagnesian phases with increasing stratigraphic height in the Layered Series. Al_2O_3 and TiO_2 values of clinopyroxenes are uniformly low. The combined petrographic and chemical data indicates that the Layered Series formed by gravity settling of crystals from a differentiating basaltic magma with tholeiitic affinities. Comparison of the mineral chemistry of the Layered Series with some well studied layered intrusions suggests that the present level of exposure is approximately midway between the top and bottom of the body. [58-59]

Relation of the Layered Series to Other Rocks of the Wichita Complex, Oklahoma, and Resulting Precambrian Structural Implications

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From mineralogical, textural and phase chemical data the feldspathic cumulate rocks of the Wichita and Glen Mtns. are interpreted to represent a limited vertical exposure of a much more extensive stratiform gabbroic complex. The rocks are adcumulates and not representative of any melt composition. Petrologic constraints require the presence of mafic and ultramafic cumulates at depth and the original presence of more fractionated cumulates above the present level of exposure. The exposed rocks, called the Layered Series, are very similar to feldspathic cumulates in the Main Zone C of the Bushveld Intrusion and the Anorthosite Zone of the Stillwater Complex. By analogy some 3-4km of cumulates probably exist at depth, becoming more mafic downwards, and 2-4km have been removed from higher levels by erosion. Intrusive contacts together with mineralogical and phase compositional differences indicate that the Mt. Sheridan biotite gabbro is not a more fractionated member of the Layered Series but is of separate, genetically unrelated origin. The granitic rocks of the Wichita Complex are too abundant to represent a fractionated residuum from the Layered Series and, in any case, are intrusive into the latter, along with the Mt. Sheridan Gabbro, at a relatively low level. Available evidence collectively points to a separate genesis and older age for the Layered Series relative to other rocks of the Wichita Province, separated by an extensive period of uplift and erosion possibly comprising several hundred million years. It is possible that the Layered Series belongs to the same magmatic episode which produced the 1200 m.y. old rocks of the Swisher Gabbroic Terrane, the two collectively defining an old zone of crustal weakness which influenced the development of the Paleozoic Southern Oklahoma Aulacogen. The bimodal character of gabbroic magmatism within a long-active continental rift system may be analogous to that now recognized in the Keweenawan in Minnesota and the mid-continent gravity high. [59]

Geologic and Petrologic Interpretations of Geophysical Anomalies over the Southern Oklahoma Aulacogen

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The Southern Oklahoma Aulacogen, a 600 km long, linear tectonic belt, extends from the Ouachita Foldbelt in north Texas across southern Oklahoma into the Texas panhandle. Gravity, magnetic and seismic anomalies associated with the trend are unique to the midcontinent. Residual Bouguer gravity anomalies are consistent with models of a shallow lopolith shaped mafic pluton and basic volcanic rocks emplaced along the axis of the aulacogen. The rocks constitute a bimodal igneous complex emplaced in a cratonic rift valley in part during the middle Cambrian, as the first stage of aulacogen development. Geologic restraint on the gravity models further requires the mafic body to increase in density with depth, similar to what might be expected of a layered differentiated intrusive. Seismic arrival times indicate an anomalous crust and possibly upper mantle beneath the aulacogen similar to that of other aulacogens and cratonic rifts. Subsidence of the aulacogen in late Cambrian time formed a deep structural and sedimentary trough which persisted until the Pennsylvanian. Late Paleozoic deformation generally re-established morphologic features of the Cambrian rift valley to their original position. The deformation in the late Paleozoic was dominantly vertical and transcurrent and may be related to plate interaction that formed the Ouachita Foldbelt. Recorded earthquake epicenters show that this region is still a fundamental zone of weakness in the earth's crust. [60]

Paleomagnetism and Age of Wichita Mountain Basement

WILLIAM ROGGENTHEN and A. G. FISHER, Department of Geological and Geophysical Sciences, Princeton University, Princeton, New Jersey; and GIOVANNI NAPOLEONE, Instituto Geologico, Via Lamarmora 4, Firenze, Italy, and J. F. FISCHER, Department of Geology, The University of Texas, Arlington, Texas

At six sites investigated, mafic rocks of the Wichita Mountains (Oklahoma) basement have stable remanent magnetic vectors and yield consistent paleo-poles after AF demagnetization. Five of these pole positions fall onto Irving & Park's polar wander curve near "hairpin 30", about 1500 to 1300 million years old, and show emplacement of the Raggedy Mountain Layered Complex, followed by intrusion of the Mount Sheridan Gabbro. A sixth site, Panther Creek, falls mid-way between these Precambrian poles and the Cambrian pole position of the Mount Scott Granite, suggesting overprinting of the initial vectors in Cambrian time. We suggest that the mafic rocks of the Wichita Mountains are 1300 to 1500 million years old, and that the Late Precambrian to Cambrian ages with which they have been credited resulted from a thermal overprint by the Cambrian granites. [62]

Comparison of Thermal-Infrared Imagery with Aerial Photography as a Geologic Mapping Tool in Carbonate Terrain

KENNETH A. SARGENT, Department of Geology, Furman University, Greenville, South Carolina, and EDWARD C. LOOMIS, Department of Geology, Southern Illinois University, Carbondale, Illinois

Detailed geologic mapping of an area of folded and faulted lower Paleozoic limestones and dolostones enables a direct comparison of standard aerial photographs with thermal-infrared images as sources of structural and lithologic information. Thermal-infrared images taken in 1968 on flights over portions of the Arbuckle Mountains, Oklahoma are compared with aerial photographs taken in 1949 during a period of minimal vegetative coverage of the area and with aerial photographs taken in 1969. The 1969 flights were chosen to provide a more direct comparison of remote sensing techniques.

The 1949 photographs provide, due to minimal cover, excellent expression of both structure and lithology. The 1969 photographs are considerably less useful due to more extensive ground cover. Changing weather patterns between 1949 and 1969 have produced deeper weathering, lower outcrop relief, and thicker vegetative and soil cover. By contrast, the thermal infrared imagery provides detail that is in general better than that on the 1969 photographs and some information which is not obtainable on either set of photographs. Lineations are more clearly defined on the thermal-infrared images which permit extension of known linear features and recognition of features not previously detected. Areas of dolostone within the limestones were especially well-defined on the images. Some dolostone discernible on the images was not detected on either set of aerial photographs and was difficult to find during field reconnaissance. [63]

Anorthosite-Gabbro-Granophyre Relationships, Mount Sheridan Area, Oklahoma

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Field and laboratory investigation of an anorthosite-gabbro-granophyre occurrence in the eastern Wichita Mountains has been undertaken for the purpose of obtaining evidence of possible genetic relationships between the rock types. Field evidence has established that the anorthosite is the oldest unit while the gabbro and granophyre appear to have been emplaced at about the same time. Laboratory investigation (oxygen isotopic and microprobe analysis) suggests that the granophyre may have been derived from the lower crust or upper mantle in conjunction with the gabbro.

The specific chemical and mineralogical properties of the granophyre (e.g., alkalic nature, extremely high SiO_2 content, and presence of ferroaugite) are those common to rhyolite and granite occurring in provinces characterized by bimodal magmatic activity. It is proposed that the occurrence of gabbro and granophyre at Mount Sheridan represents a bimodal association that is related to a period of crustal extension and thinning. [68]

Anorthosite-Gabbro-Diorite Petrogenesis, Mt. Sheridan Area, Oklahoma

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Exposures in the Mt. Sheridan area include an $\simeq$600 foot section of anorthosite-gabbro-diorite capped by a thin granite sill. The anorthosite consists of plagioclase (>90%) of composition $An_{70\text{-}75}$ with minor augite, olivine and opaques. The overlying gabbro, $\simeq$400 feet thick, is composed of plagioclase, clinopyroxene, orthopyroxene and accessory biotite, hornblende, micropegmatite and opaques. The plagioclase range from $An_{39\text{-}70}$, averaging An_{64} near the gabbro-anorthosite transition gradually changing to An_{54} near the gabbro-diorite transition. This fractionation trend is also reflected in the pyroxene compositions: Fe/Mg ratios in the cpx and opx range from $0.34 \rightarrow 0.46$ and $0.38 \rightarrow 0.48$, respectively. Overlying the gabbro is a 50 foot section of diorite, mineralogically similar to the gabbro but richer in biotite, quartz, K-feldspar and micropegmatite. Extensive deuteric alteration has converted much of the biotite and pyroxene to chlorite and hornblende. Microprobe analyses of plagioclase, relict pyroxenes and primary and secondary hornblendes in the diorite show that this sequence is also fractionated: the plagioclase ranges from $An_{54} \rightarrow An_{21}$; Fe/Mg ratios in the cpx and opx range from $0.46 \rightarrow 0.51$ and $0.48 \rightarrow 0.57$, respectively; and hornblende Fe/Mg ratios range from $0.51 \rightarrow 0.72$. Present throughout the entire sequence are schlieren and pegmatitic dikes composed of quartz + K-feldspar + micropegmatite + hornblende + opaques + plagioclase ($An_{40\text{-}55}$) $\pm$ prehnite $\pm$ chlorite $\pm$ epidote.

The upward changes in mineralogy, phase chemistry and whole-rock chemistry (increasing K, Rb and Rb/K) support fractional crystallization of a gabbroic magma by crystal settling of plagioclase as the mechanism for generating the anorthosite$\rightarrow$diorite sequence. The sequence was subsequently altered by upward diffusing alkali-silica-volatile-rich residual fluids. [68-69]

Palynological Evidence for the Origin of the Atoka Formation (Pennsylvanian) Rocks in the Type Area

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The type area of the Atoka Formation (Pennsylvanian) is in the vicinity of Atoka, Atoka County, Oklahoma. There the majority of the formational rocks are dark gray shales which are difficult to distinguish from the underlying Morrowan and Chesterian shales. Contacts are obscure and the stratigraphy is complicated by folds and faults. Megafossils are rare but palynomorphs are abundant and diagnostic. A palynological investigation was undertaken to determine the nature of the formation. Results indicate that the lowest shales contain approximately 20% typical Morrowan palynomorphs, 5% Chesterian (Goddard), and 75% Atoka (Des Moinesian). Higher in the section Morrowan palynomorphs are less common (10%), Chesterian (Goddard) more abundant (35%), and Devonian (Woodford) occur for the first time (5%), Atoka (Des Moinesian) palynomorphs dominate the assemblage (50%). In the highest shales examined Atoka (Des Moinesian) palynomorphs dominate (60%) while Chesterian and Devonian palynomorphs are less common and in varying percentages. The assemblages suggest that the Atoka Formation shales in the type area are largely from recycled sediments of Morrow, Goddard, and Woodford shales all of which are lithologically quite similar and when recycled result in a shale that is difficult to distinguish in age until examined for palynomorphs. [72-73]

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The National Coal Resource Data System—New Tool for Coal-Resource Assessment

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The National Coal Resource Data System (NCRDS) is being established by the U.S. Geological Survey to meet the increasing demands for rapid retrieval of information on coal location, quantity, quality, and accessibility. An interactive conversational query system devised by the USGS retrieves information from the data bank through a standard computer terminal. Development of the system is in two phases to accommodate the availability and complexity of the data.

Phase I, which is currently available, contains published areal resource and analytical data. The primary objective of this phase is to retrieve and calculate resource data by area on a local, regional, or national scale. Factors available for retrieval are: State, county, quadrangle, township, range, section, AAPG province code, coal province, region, district, field, coal bed, formation, geologic age, source and reliability of data, and coal-bed rank, thickness, overburden, and tonnage, or any combination of variables. Analytical items include individual values for proximate and ultimate analyses, sample type, analysis type, BTU value, and other physical and chemical tests. Information will be validated and deleted or updated as needed.

Phase II of the NCRDS is being developed to store, retrieve, and manipulate observation point data. Lithologic, geochemical, and petrographic values for any area will be aggregated to produce isoline maps, calculate resources and overburden, and combine factors as desired. The goal of Phase II is to update Phase I data and to produce end-use maps for individual coal beds or entire coal basins to facilitate optimum end use according to individual bed characteristics. [149]

Diversity and Succession in a Late Pleistocene Pond Fauna, Major County, Oklahoma

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A small deposit of Quaternary freshwater sediments was trench sampled in order to analyze the total invertebrate fauna. Five bulk samples were disaggregated by the Amine 220 technique, washed, dried, and sieved into 25 individual samples.

Fossils (snails, bivalves, and ostracods) from the sieve-sample splits were counted and identified. Faunal counts were adjusted to reduce frequencies to whole numbers of individuals of a single generation. Adjusted data were programmed into standard diversity and equitability measures to reveal trends in community succession.

Diversity and equitability data along with depositional characteristics show that early stages of colonization were marked by low diversity and high dominance. These frontal environments would have been of high stress and support only a few species. As more favorable conditions were reached, diversity increased dominance decreased, and the system trended towards equilibrium. Then, as the cycle continued stress conditions increased, the more vulnerable species were biologically winnowed out, nearly the reverse of the colonization stage.

This pattern which is quite predictable is shown by use of diversity and equitability measures. Pond communities undergo succession, thus quantification of data should reflect certain aspects of the pond's wet-dry cycle. [264-265]

Earthquake-Prediction Policy Report Released by NAS

Hazardous earthquakes have not been part of human history in Oklahoma, but the State has had numerous small earthquakes and a few medium-sized ones. In fact, a seismograph study by Jim Lawson conducted at OU's Leonard Earth Sciences Observatory[1] showed an average of one quake in each 40 days of a 29-month test.

Earthquakes are much more common worldwide than is commonly believed: a seismicity map issued by the U.S. Geological Survey in 1974[2]

[1]See *Oklahoma Geology Notes,* v. 35, p. 73.

[2]See *Oklahoma Geology Notes,* v. 34, p. 154.

spots almost 23,000 earthquakes of 4.5 magnitude or greater on the Richter scale that occurred from mid-1963 through 1972 alone. Now, earthquakes are becoming not only reportable but predictable.

Earthquake prediction studies, which for some time have created a great deal of interest in the scientific community and more recently have become newsworthy, have entered the public domain through a new report issued by the National Research Council of the National Academy of Sciences.

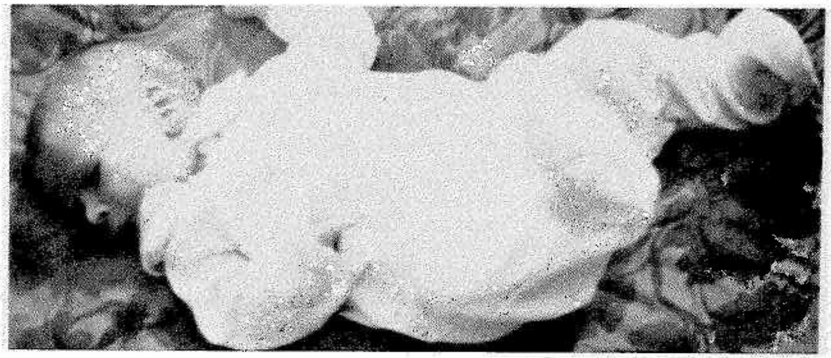
The 151-page volume, *Earthquake Prediction and Public Policy,* was formulated by the Panel on Public Policy Implications of Earthquake Prediction of the Advisory Committee on Emergency Planning of the National Research Council of the National Academy of Sciences (which may have a record for the world's longest panel title). The report offers detailed recommendations for hazard reduction and preparedness based upon consideration of the advantages and disadvantages of predictions, strategies that should be employed in their use, and the role of government in response to such predictions.

Earthquake Prediction and Public Policy is available for $6.50 from National Academy of Sciences, Printing and Publishing Office, 2102 Constitution Avenue, Washington, D.C. 20418.

It's a Boy for Croy!

The Oklahoma Geological Survey's editorial section can use all the help it can get (haven't our authors been saying that for years?), and on February 27 our associate editor, Rosemary Croy, did her bit by giving birth to a fine red-headed boy, thereby increasing the Croy household by 50 percent. Rosie and Jim's new heir, Zachary Andrew Croy (how about that monogram!), arrived in the early-morning hours of the 27th and weighed in at 7 pounds, 9 ounces—a sturdy lad indeed and the Survey's first bicentennial baby!

Mother and son are prospering—even papa Jim is holding up pretty well—and Rosie expects to be back at work by the middle of April. None too soon, either; like we said, we can use all the help we can get.



Zachary Andrew Croy

U.S. Board on Geographic Names Decisions

The U.S. Board on Geographic Names recently approved three Oklahoma place names, which were published in the October through December 1975 issue of *Decisions on Geographic Names in the United States* (Decision List 7504, p. 19-20).

Jug Motte Creek (variant: Red Fork Creek) has been adopted to identify a stream 11.3 km (7 mi) long that heads in Oklahoma at 36°57′15″ N., 99°09′49″ W., and flows northeast into Kansas to Red Fork Creek 34 km (21 mi) southeast of Coldwater; Comanche County, Kansas, and Woods County, Oklahoma; sec. 6, T. 35 S., R. 16 W., Sixth Principal Meridian (37°01′19″ N., 99°05′15″ W.).

Red Fork Creek (variant: Red Creek) has been adopted to identify a stream 19.3 km (12 mi) long that heads in Oklahoma at 36°56′40″ N., 99°06′54″ W., and flows north-northeast into Kansas to the Salt Fork of the Arkansas River 30 km (18.5 mi) southeast of Coldwater; Comanche County, Kansas, and Woods County, Oklahoma; sec. 3, T. 34 S., R. 16 W., Sixth Principal Meridian (37°06′45″ N., 99°03′05″ W.).

Tom Steed Reservoir (variants: Mountain Park Reservoir, Snyder Lake) is a statutory adoption for a reservoir formed by damming West Otter Creek 9.7 km (6 mi) north-northwest of Snyder; named by Congressional action, Public Law 94-77, August 9, 1975, for Tom Steed, Congressman from Oklahoma; 34°44′50″ N., 98°59′20″ W. (at dam).

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