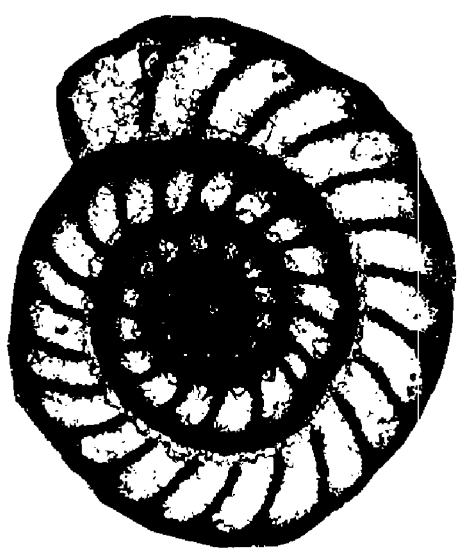
Oklahoma Geology Notes

OKLAHOMA GEOLOGICAL SURVEY / VOL. 44, NO. 2—APRIL 1984



On the cover—

Morrowan Calcareous Foraminifer

April's cover photo depicts a foraminifer tentatively identified as *Millerella marblensis* Thompson, x100, sagittal section, from the Brentwood Limestone Member of the Bloyd Formation in northwestern Arkansas. The illustration is figure 10 of plate 5 from OGS Bulletin 133, *Calcareous Foraminifers and Algae from the Type Morrowan (Lower Pennsylvanian) Region of Northeastern Oklahoma and Northwestern Arkansas,* by John R. Groves.

The author, who received his M.S. from The University of Oklahoma, recently earned a Ph.D. from the University of Iowa. Currently he is on the faculty of Oklahoma State University, Stillwater.

The bulletin represents a significant contribution to knowledge of the stratigraphy of Lower Pennsylvanian rocks in Oklahoma and Arkansas with application to other parts of North America as well. The tiny fossils Groves describes represent both the animal and plant kingdoms; the foraminifers are one-celled marine animals, and the algae are marine plant forms.

The Morrowan is of particular interest today because of problems associated with determination of the boundary between the Pennsylvanian System and the underlying Mississippian System, and also determination of the boundary between the Morrowan and overlying Atokan Series.

The 65-page bulletin contains descriptions of 44 species and 38 genera, including one new genus and one new species.

Bulletin 133 can be ordered from the Survey at the address given below. The price is $12 hardbound, $8 paperbound.

Oklahoma Geology Notes

Editor: Connie Smith
Editorial Staff: Elizabeth A. Ham, William D. Rose

Oklahoma Geology Notes, ISSN 0030-1736, is published bimonthly by the Oklahoma Geological Survey. It contains short technical articles, mineral-industry and petroleum news and statistics, reviews, and announcements of general pertinence to Oklahoma geology. Single copies, $1.50; yearly subscription, $6. All subscription orders should be sent to the Survey at 830 Van Vleet Oval, Room 163, Norman, Oklahoma 73019.

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

Oklahoma Geology Notes

OKLAHOMA GEOLOGICAL SURVEY / VOL. 44, NO. 2—April 1984

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This publication, printed by The University of Oklahoma Printing Services, Norman, Oklahoma, is issued by the Oklahoma Geological Survey as authorized by Title 70, Oklahoma Statutes, 1981, Section 3310, and Title 74, Oklahoma Statutes, 1981, Sections 231-238. 1,800 copies have been prepared and distributed at a cost to the taxpayers of the State of Oklahoma of $2,539.

OKLAHOMA EARTHQUAKES, 1983

James E. Lawson, Jr.,[1] and Kenneth V. Luza[2]

Introduction

The earliest documented earthquake in Oklahoma occurred near Jefferson, Grant County, on December 2, 1897 (Stover and others, 1981). The next oldest Oklahoma earthquake happened near Cushing in December 1900. This event was followed by two additional earthquakes in the same area in April 1901 (Wells, 1975). The largest known Oklahoma earthquake occurred near El Reno on April 9, 1952. This magnitude-5.5 (mb) earthquake was felt in Austin, Texas, as well as Des Moines, Iowa, and covered a felt area of approximately 362,000 square km (Docekal, 1970; Kalb, 1964; von Hake, 1976). From 1900 through 1982, 441 earthquakes have been located in Oklahoma (Lawson and others, 1979; Lawson and Luza, 1980, 1981, 1982, 1983).

Forty-seven earthquakes were located in Oklahoma in 1983. No earthquakes were known to be felt.

Instrumentation

A statewide network of 11 seismograph stations is recording seismological data in Oklahoma (fig. 1). The Oklahoma Geophysical Observatory (OGO) station, TUL, has been recording earthquake data since December 1961. The Observatory, located near Leonard, Oklahoma, in southern Tulsa County, operates seven seismometers, three long period and four short period, which are installed in a vault detached from the main building. The seismic responses at TUL are recorded on 14 paper-drum recorders and one digital recorder. Accurate timing is assured by a microprocessor clock that is continually locked to the National Bureau of Standards cesium-beam clocks by low-frequency radio transmissions broadcast by WWVB (Lawson, 1980). Seven semipermanent volunteer-operated seismograph stations, three radio-telemetry seismograph stations, and one volunteer-operated triggered-digital seismograph complete the Oklahoma Geological Survey's seismic network. The

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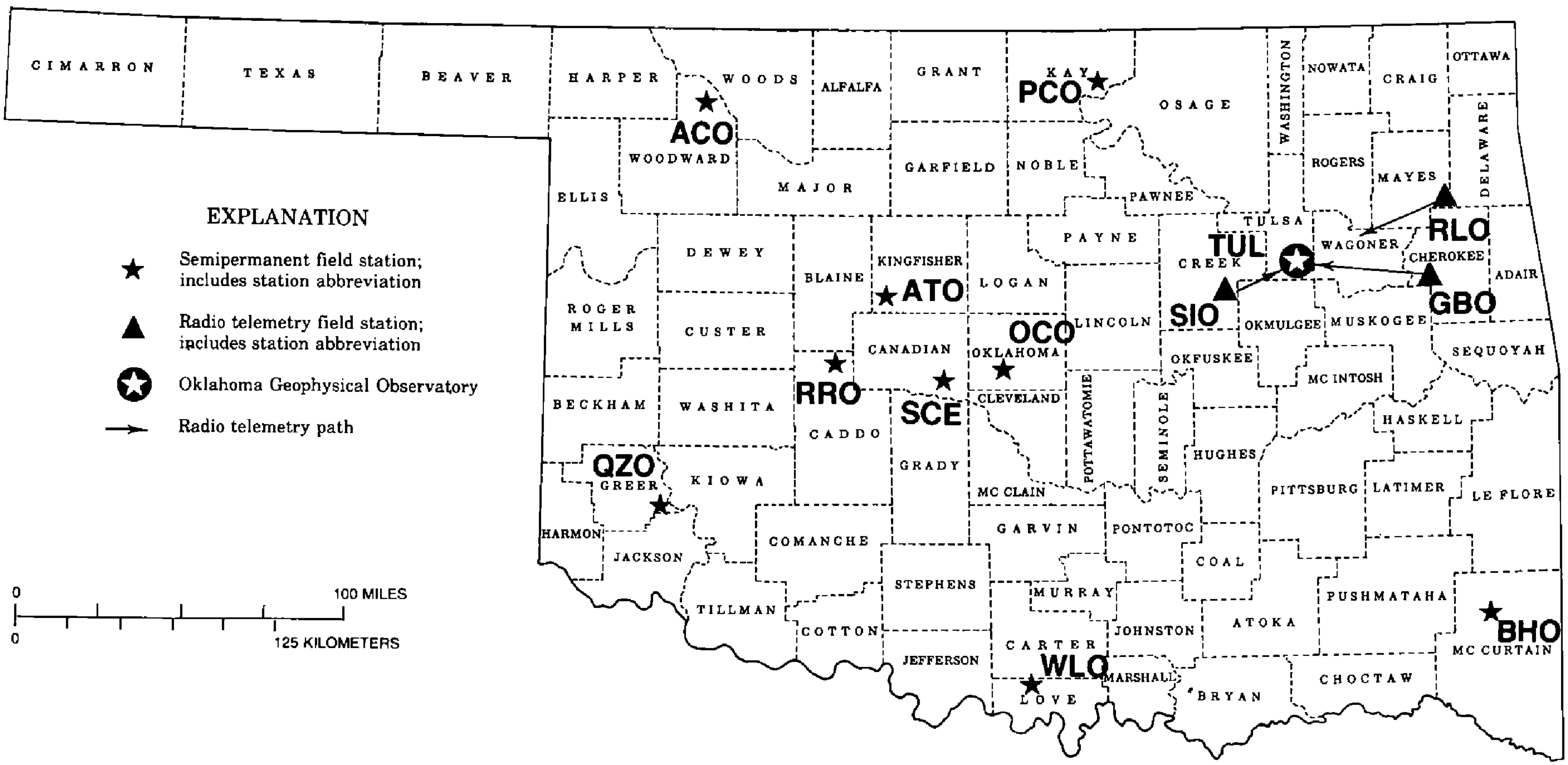

Figure 1. Active seismograph stations in Oklahoma.

operation and maintenance of 11 of the remote stations is being supported by the U.S. Nuclear Regulatory Commission (Luza, 1978).

Each of the seven volunteer-operated seismograph stations consists of a Geotech S-13, short-period, vertical seismometer; a Sprengnether MEQ-800-B unit, including amplifier, filters, ink-recording unit, and a clock; and a Kinemetrics time-signal-radio receiver for high-frequency WWV time signals. Each radio-telemetry system consists of one Geotech S-13 seismometer and one radio-telemetry unit. The telemetry unit amplifies the seismometer output and uses this output to frequency-modulate an audiotone. A 500-milliwatt, crystal-controlled transmitter limits the line-of-sight transmission to 80 km. Seismograms from the radio-telemetry stations are recorded at the Oklahoma Geophysical Observatory.

A triggered-digital recording station, SCE, was installed in December 1980 as part of a five-station array in Canadian and Grady Counties (Lawson and Luza, 1982). At SCE, a Sprengnether DR-100 unit is located in an outbuilding, where it is well grounded and connected to AC power. A WWVB antenna, which is attached to a 2-m galvanized pipe driven into the ground near the outbuilding, is connected via cable to the recorder. The cable is connected to a 4.5-Hz vertical geophone that is buried 0.3 m deep. Volunteers change the tapes weekly, and the tapes are mailed to the Observatory for processing. Station SCE continues to operate, whereas the other four temporary stations were closed in 1982.

Data Reduction and Archiving

Arrival times from all visible teleseisms (phases from distant earthquakes) at TUL, RLO, BHO, GBO, and OCO are sent to the U.S. National Earthquake Information Service and the International Seismological Centre in England. P-wave and surface-wave amplitudes from TUL, plus selected arrival times from SIO, ACO, QZO, and other stations, are also included. These reduced seismic data are sent to more specialized agencies such as the USAF Tactical Air Command, which monitors worldwide underground nuclear tests.

From station TUL, at the OGO near Leonard, five short-period vertical seismograms (with differing frequency responses) are searched exhaustively for local and regional earthquake phases. Also searched are two TUL short-period horizontal seismograms; two short-period vertical seismograms from each of RLO, SIO, and OCO; and one short-period vertical seismogram from each of the nine other stations.

Fourteen to 16 daily TUL seismograms, as well as 15 daily seismograms from the remote stations, are permanently archived at the OGO. Fourteen of the daily TUL seismograms are lent to the U.S. National Geophysical Data Center (NGDC) for microfilming. One complete set of microfilms is kept at the NGDC, which supplies on request additional copies for the world seismological community. In addition to the originals, the OGO archives also contain one complete set of microfilms of the TUL seismograms.

Earthquake Distribution

All Oklahoma earthquakes recorded on seismograms from three or more stations are located. In 1983, 47 Oklahoma earthquakes were located (fig. 2, table 1). None of these earthquakes was reported felt. The 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 constructions, or natural features (table 2).

Magnitude values range from a low of 0.9 (mbLg) in Creek and Tulsa Counties to a high of 2.9 (mbLg) in Beaver and Pontotoc Counties (table 1). Six earthquakes occurred in a 30-km-wide zone that extends 50 km southward from Norman (Cleveland County) through McClain, Grady, and northern Garvin Counties. The greatest concentration of earthquakes, 18, occurred in eastern Creek County, southwestern Tulsa County, and northern Okmulgee County (fig. 2). The first known earthquake occurred in Harmon County on May 16.

The 1983 earthquake epicentral data, when combined with previous earthquake data, continue to produce at least four seismic trends worthy of discussion.

One trend is located in north-central Oklahoma (fig. 3). The pre-1977 earthquake data (circles) and the 1977–83 earthquake data (triangles) are shown in figure 3. There appears to be a 40-km-wide and 145-km-long earthquake zone that extends northeastward from near El Reno toward Perry (Noble County). Most of the earthquakes within this zone have occurred in the vicinity of the El Reno–Mustang area, which has been the site of numerous earthquakes since 1908. One of the 1983 earthquakes plots within this zone. Prior to installation of the statewide earthquake-station network, more than one-half of the known Oklahoma earthquakes occurred in the vicinity of El Reno. However, after the El Reno earthquake of 1952, magnitude 5.5 (mb), no earthquakes were reported for this region until 1978.

The correlation of historical and recent earthquake activity to known structural features remains unclear. Some fault features that cut pre-Pennsylvanian rocks are shown in figure 3, using information compiled from Jordan (1962), Wheeler (1960), and Luza and Lawson (1981). The El Reno–Perry trend appears to cut diagonally across the Nemaha Uplift structures at about a 30° angle. The southern end of this trend appears to be more active than the middle and northern parts. The recent as well as the historical earthquake data seem to support this observation.

A second trend is situated between Norman and Pauls Valley. Six earthquakes were instrumentally located in this region. This trend closely parallels

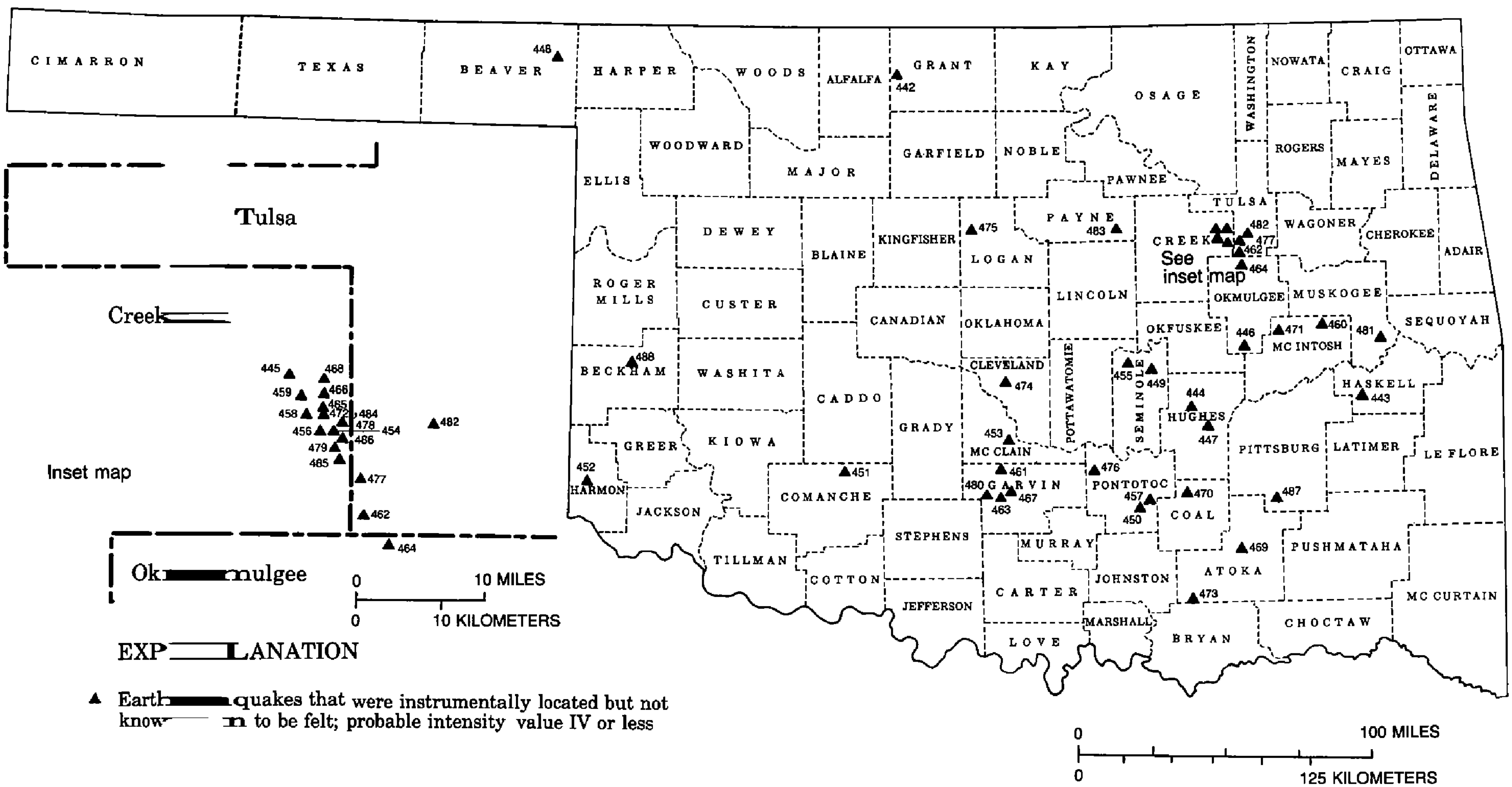

Figure 2. Distribution of Oklahoma earthquakes for 1983. Numbers correspond to event numbers in table 1.

TABLE 1.—OKLAHOMA EARTHQUAKE CATALOG FOR 1983

Event Number	Date and Origin Time (UTC)		County	Magnitudes 3Hz	bLg	DUR	Latitude (°N.)	Longitude (°W.)	Depth (km) [1]
442	JAN 10	170643.75	GRANT	2.7	2.5	2.4	36.704	98.107	3.9
443	JAN 21	000504.58	HASKELL	1.8		2.0	35.165	95.282	5.0R
444	FEB 1	071938.08	HUGHES	1.7		1.3	35.082	96.272	5.0R
445	FEB 17	195100.43	CREEK	1.7		1.9	35.862	96.067	5.0R
446	FEB 19	005932.94	OKMULGEE	1.7	1.3	1.7	35.399	95.975	5.0R
447	MAR 10	080604.14	HUGHES	2.6	2.3	2.6	35.035	96.202	12.5R
448	MAR 11	165048.26	BEAVER	2.9	2.8	2.8	36.827	100.115	5.0R
449	MAR 13	101720.85	SEMINOLE			1.9	35.309	96.557	5.0R
450	MAR 28	093224.86	PONTOTOC	2.1		1.9	34.635	96.561	5.0R
451	MAY 15	040023.58	COMANCHE	2.8	2.7	2.6	34.827	98.360	5.0R
452	MAY 16	210821.08	HARMON	2.8	2.8	2.5	34.718	99.883	5.0R
453	JUN 21	183259.87	MC CLAIN	2.6	2.9	2.5	34.959	97.405	5.0R
454	JUN 22	052952.24	CREEK	1.6		1.8	35.932	96.037	5.0R
455	JUN 22	053546.13	SEMINOLE	1.8	1.3		35.321	96.623	5.0R
456	JUN 22	091047.07	CREEK	1.3		1.3	35.932	96.043	5.0R
457	JUL 5	200225.84	PONTOTOC	2.4	2.4	2.3	34.667	96.519	5.0R
458	JUL 8	065021.36	CREEK	1.6		2.0	35.946	96.054	5.0R
459	JUL 24	215958.71	CREEK	1.0		1.6	35.950	96.054	5.0R
460	JUL 26	101056.69	MC INTOSH	1.6		1.9	35.489	95.518	5.0R
461	JUL 27	055743.45	GARVIN	2.1	1.9	2.2	34.855	97.425	5.0R
462	AUG 3	043124.2	TULSA	1.2		1.4	35.883	96.011	5.0R
463	AUG 8	040711.19	GARVIN	2.0		1.9	34.731	97.416	5.0R
464	AUG 10	010040.34	OKMULGEE	1.5		2.0	35.848	95.980	5.0R
465	AUG 10	190837.95	CREEK	1.4		1.5	35.948	96.043	5.0R
466	AUG 12	070027.81	CREEK	1.6		2.1	35.950	96.041	5.3
467	AUG 18	063816.68	GARVIN	1.7	1.7	1.8	34.741	97.404	5.0R
468	AUG 19	135205.91	CREEK	1.6		1.7	35.957	96.043	5.0R
469	AUG 20	054601.39	ATOKA	2.1	1.9	2.3	34.435	95.984	5.0R
470	AUG 20	112843.42	COAL			1.5	34.728	96.319	5.0R
471	AUG 24	101003.43	MC INTOSH			1.4	35.493	95.787	5.0R
472	AUG 30	003202.58	CREEK	1.7		2.0	35.946	96.043	5.0R
473	SEP 28	001615.35	ATOKA	1.5		1.9	34.166	96.305	5.0R
474	SEP 28	012601.33	CLEVELAND	1.9		2.2	35.250	97.367	5.0R
475	OCT 6	070925.29	LOGAN	1.7	1.4	2.2	35.985	97.537	5.0R
476	OCT 23	193446.93	PONTOTOC	2.9	2.9	2.7	34.817	96.888	5.0R
477	NOV 13	052752.82	TULSA	1.3		2.0	35.918	96.027	5.0R
478	NOV 20	080324.66	CREEK	1.0		1.3	35.936	96.031	5.0R
479	NOV 21	055320.14	CREEK	1.1		1.5	35.926	96.035	5.0R
480	NOV 23	143617.57	GARVIN	2.1	2.1	2.1	34.731	97.485	5.0R
481	NOV 27	163342.84	MUSKOGEE			1.7	35.431	95.200	5.0R
482	NOV 29	034918.14	TULSA	0.9		1.1	35.942	95.925	5.0R
483	DEC 4	053600.18	PAYNE		1.5		35.961	96.746	5.0R
484	DEC 11	050122.25	CREEK	0.9		1.3	35.946	96.043	5.0R
485	DEC 11	071344.57	CREEK	1.3		1.8	35.920	96.033	5.0R
486	DEC 11	073425.13	CREEK	1.5		2.1	35.930	96.031	5.0R
487	DEC 19	142453.32	PITTSBURG	2.0	1.7	1.9	34.682	95.774	5.0R
488	DEC 29	104644.26	BECKHAM	2.3	2.2	2.4	35.284	99.620	5.0R

[1] The hypocenter is restrained (R) at an arbitrary depth of 5.0 km, except where indicated, for purposes of computing latitude, longitude, and origin time.

the McClain County fault zone that is about 40 km wide and 60 km long. Perhaps this highly complex fault zone, containing numerous subparallel faults, is the southernmost extension of the Nemaha Uplift.

In south-central Oklahoma, earthquakes are concentrated in the Wilson area, in Carter and Love Counties. In the past this area has been the site of numerous small earthquakes. A fourth general area of earthquake activity

TABLE 2.—MODIFIED MERCALLI (MM) EARTHQUAKE-INTENSITY SCALE (ABRIDGED) (MODIFIED FROM WOOD AND NEUMANN, 1931)

I	Not felt except by a very few under especially favorable circumstances.
II	Felt only by a few persons at rest, especially on upper floors of buildings. Suspended objects may swing.
III	Felt quite noticeably indoors, especially on upper floors of buildings. Automobiles may rock slightly.
IV	During the day felt indoors by many, outdoors by few. At night some awakened. Dishes, doors, windows disturbed. Automobiles rocked noticeably.
V	Felt by nearly everyone, many awakened. Some dishes, windows, etc., broken; unstable objects overturned. Pendulum clocks may stop.
VI	Felt by all; many frightened and run outdoors.
VII	Everybody runs outdoors. Damage negligible in buildings of good design and construction. Shock noticed by persons driving automobiles.
VIII	Damage slight in specially designed structures; considerable in ordinary substantial buildings; great in poorly built structures. Fall of chimneys, stacks, columns. Persons driving automobiles disturbed.
IX	Damage considerable even in specially designed structures; well-designed frame structures thrown out of plumb. Buildings shifted off foundations. Ground cracked conspicuously.
X	Some well-built wooden structures destroyed; ground badly cracked, rails bent. Landslides and shifting of sand and mud.
XI	Few if any (masonry) structures remain standing. Broad fissures in ground.
XII	Damage total. Waves seen on ground surfaces.

lies along and north of the Ouachita front (Arkoma Basin), in southeastern Oklahoma. This fourth area experienced only limited seismicity in 1983, and that seismicity was usually concentrated in Pontotoc, Hughes, McIntosh, Haskell, Pittsburg, Coal, and Atoka Counties.

Catalog

An HP-9825T desk-top computer system is used to calculate local earthquake epicenters. A catalog containing date, origin time, county, intensity, magnitude, location, focal depth, and references is printed in page-size format. Table 1 contains 1983 Oklahoma earthquake data displayed in a modified version of the regional earthquake catalog. Each event is sequentially numbered and arranged according to date and origin time. The numbering system is compatible with the system used for the *Earthquake Map of Oklahoma* (Lawson and others, 1979).

The date and time are given in UTC. UTC refers to Coordinated Universal Time, formerly Greenwich Mean Time. The first two digits refer to the hour on a 24-hour clock. The next two digits refer to the minute, and the remaining

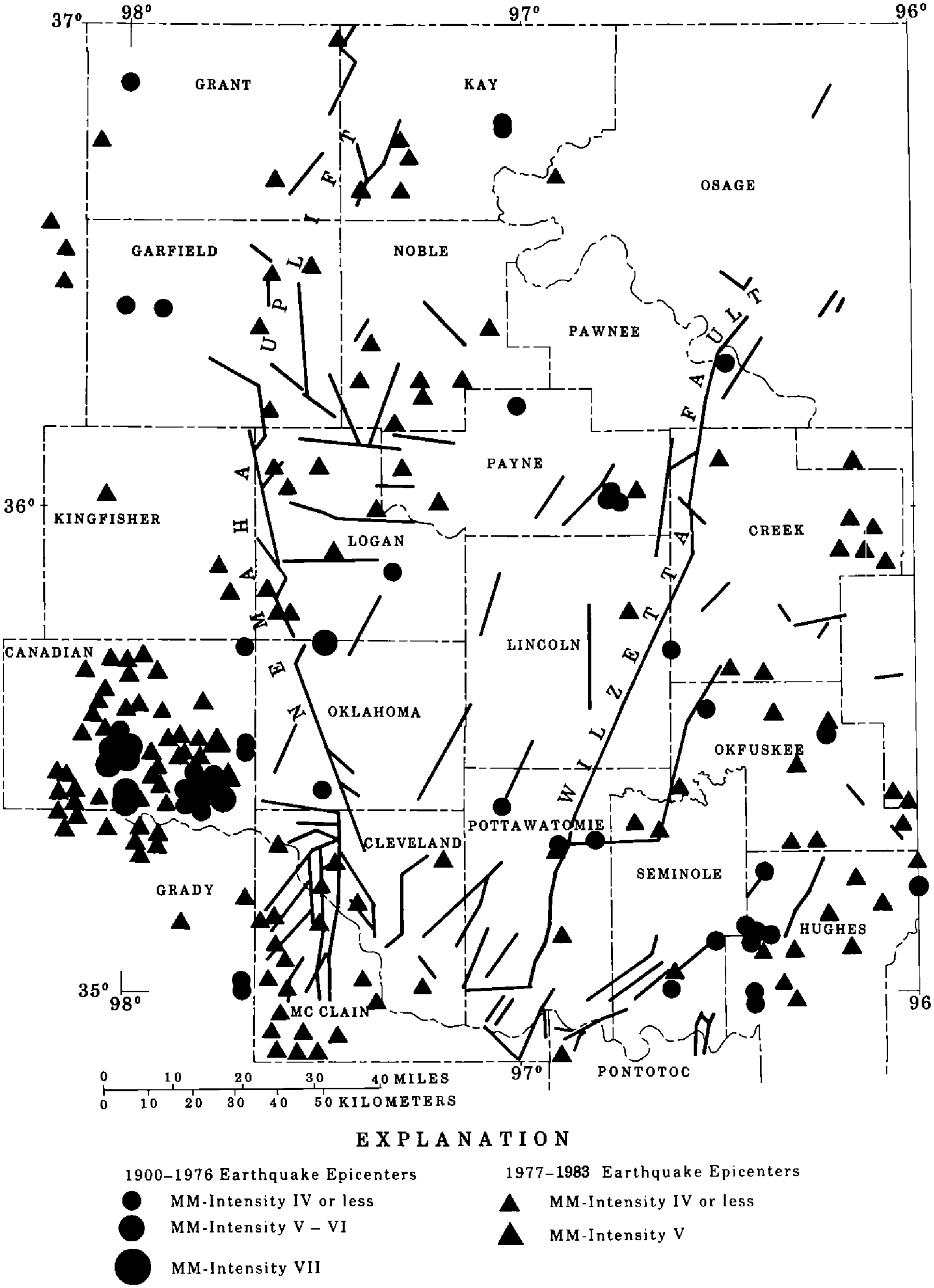

Figure 3. Distribution of faults that cut pre-Pennsylvanian strata, and earthquake epicenters for north-central Oklahoma (Wheeler, 1960; Jordan, 1962; Luza and Lawson, 1981).

digits are the seconds. To convert to local Central Standard Time, subtract 6 hours.

Earthquake magnitude is a measurement of energy and is based on data from seismograph records. There are several different scales used to report magnitude. Table 1 has three magnitude scales, which are mbLg (Nuttli), m3Hz (Nuttli), and MDUR (Lawson). Each magnitude scale was established to accommodate specific criteria, such as the distance from the epicenter, as well as the availability of certain seismic data.

For earthquake epicenters located from 11 km to 222 km from a seismograph station, Otto Nuttli developed the m3Hz magnitude scale (Zollweg, 1974). This magnitude is derived from the following expression:

$$\text{m3Hz} = \log(A/T) - 1.63 + 0.87\log(\Delta),$$

where A is the maximum center-to-peak vertical-ground-motion amplitude sustained for three or more cycles of Sg waves, near 3 hertz in frequency, measured in nanometers; T is the period of the Sg waves measured in seconds; and Δ is the great-circle distance from epicenter to station measured in kilometers.

In 1979 St. Louis University (Stauder and others, 1979) modified the formulas for m3Hz. This modification was used by the OGO beginning January 1, 1982. The modified formulas had the advantage of extending the distance range for measurement of m3Hz out to 400 km, but also had the disadvantage of increasing m3Hz by about 0.12 units compared to the previous formula. Their formulas were given in terms of log (A) but were restricted to wave periods of 0.2 sec to 0.5 sec. In order to use log (A/T), we assumed a period of 0.35 second in converting the formulas for our use. The resulting equations are:

(epicenter 10 to 100 km from a seismograph)

$$\text{m3Hz} = 0.88\log(\Delta) + \log(A/T) - 1.46$$

(epicenter 100 to 200 km from a seismograph)

$$\text{m3Hz} = 1.06\log(\Delta) + \log(A/T) - 1.82$$

(epicenter 200 to 400 km from a seismograph)

$$\text{m3Hz} = 1.29\log(\Delta) + \log(A/T) - 2.35.$$

Otto Nuttli's (1973) earthquake magnitude, mbLg, for seismograph stations located between 55.6 km and 445 km from the epicenter, is derived from the following equation:

$$\text{mbLg} = \log(A/T) - 1.09 + 0.90\log(\Delta).$$

Where seismograph stations are located between 445 km and 3,360 km from the epicenter, mbLg is defined as:

$$mbLg = \log(A/T) - 3.10 + 1.66 \log(\Delta),$$

where A is the maximum center-to-peak vertical-ground-motion amplitude sustained for three or more cycles of Sg waves, near 1 hertz in frequency, measured in nanometers; T is the period of Sg waves measured in seconds; and Δ is the great-circle distance from epicenter to station measured in kilometers.

The MDUR magnitude scale was developed by Lawson (1978) for earthquakes in Oklahoma and adjacent areas. It is defined as:

$$MDUR = 1.86 \log(DUR) - 1.49,$$

where DUR is the duration or difference, in seconds, between the Pg-wave arrival time and the time the final coda amplitude decreases to twice the background-noise amplitude. Before 1981, if the Pn wave was the first arrival, the interval between the earthquake-origin time and the decrease of the coda to twice the background-noise amplitude was measured instead. Beginning January 1, 1982, the interval from the beginning of the P wave (whether it was Pg, P*, or Pn) and the decrease of the coda to twice the background-noise amplitude was used.

The depth to the earthquake hypocenter is measured in kilometers. For most Oklahoma earthquakes the focal depth is unknown. In almost all Oklahoma events, the stations are several times farther from the epicenter than the likely depth of the event. This makes the locations indeterminate at depth, which usually requires that the hypocenter depth be restrained to an arbitrary 5 km for purposes of computing latitude, longitude, and origin time. All available evidence indicates that no Oklahoma hypocenters have been deeper than 15 to 20 km.

Earthquake detection and location accuracy have been greatly improved since the installation of the statewide network of seismograph stations. The frequency of earthquake events and the possible correlation of earthquakes to specific tectonic elements in Oklahoma are being studied. It is hoped that this information will provide a more complete data base that can be used to develop numerical estimates of earthquake risk, giving the approximate frequency of the earthquakes of any given size for different regions of Oklahoma. Numerical risk estimates could be used to better design large-scale structures, such as dams, high-rise buildings, and power plants, as well as to provide the necessary information to evaluate insurance rates.

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A Review

EDUCATING AMERICANS FOR THE 21ST CENTURY

Educating Americans for the 21st Century: A Plan of Action for Improving Mathematics, Science and Technology Education for All American Elementary and Secondary Students So That Their Achievement Is the Best in the World by 1995. (No charge for single copies; available from Commission on Precollege Education, National Science Foundation, Washington, D.C. 20550.)

Elizabeth A. Ham[1]

How is that for a title? One would think it had been formulated by a committee. But it would have to be a committee that had its goal firmly in its corporate mind and that had determined a sure way of attaining that goal.

The overlong, unobjective title aside, it actually was more than a committee that prepared this "Report to the American People and the National Science Board": it was a commission, the National Science Board Commission on Precollege Education in Mathematics, Science and Technology, composed of 20 distinguished members (academic executives, industrialists, engineers, a high-school math teacher, high-ranking educators) and co-chaired by William T. Coleman, Jr., senior partner of O'Melveny and Myers of Washington, D.C., and New York City, and Cecily Cannan Selby, former dean of academic affairs and chairman of the Board of Advisors of the North Carolina School of Science and Mathematics. An interesting name on the list is that of Bill Cosby, who not only is famous for his comedy but also uses an earned Ph.D in education to work in this field.

The commission was assisted by 14 persons who served as members of four task groups. About half these task-group people are educators, but this list contains also the names of the governor of Arizona, a DuPont official in educational aid, a Florida state senator who works in education in secondary schools, the chief education officer of the American Association for the Advancement of Science, and executives of Standard Oil Co. of Ohio, Bell Laboratories, and the Carnegie Corp. Numerous other individuals, professional societies, and corporations helped with the project in various ways.

All this expertise has been put to work to develop solutions to a problem long recognized and much in the news of late: the inadequacy of education in science offered the nation's young. The commission went beyond earlier ef-

[1]Associate editor, Oklahoma Geological Survey.

forts, some of which, in spite of extensive investigations, had really only identified the problem.

The title of this report is a shortened version of the stated basic objective of the commission. The date named for attainment of the objective was selected because it allows time for a complete education cycle (12 years) for a school child, time for retraining teachers, training new teachers, developing curricula, raising funds, and changing attitudes of parents and teachers.

In order for the mission even to get off the ground, as the commission stresses in its report, a strong national leadership is needed to direct attention to the "problems, performance and potential of elementary and secondary mathematics, science and technology education" for *all* students and to encourage a national and local commitment to "educational excellence." The commission advises that the President appoint a National Education Council to identify goals, recommend changes, and report to the President regularly and to the people periodically on the status of and progress toward achieving the new goals.

Governors' councils also should be established to develop and monitor goals on the state level, the report recommends, and local school boards should come into the picture and encourage educators, local officials, business people, labor leaders, and parents to join together to become involved in constructive changes in their local educational systems.

The report states that objective assessments should be made regularly to evaluate progress on all levels—i.e., nationally, in each state, and in local communities—and a national mechanism to make these assessments should be financed and maintained by the federal government.

"A strengthened commitment at all levels of government to ensuring quality education for all American students is required." One thing this report stresses over and again is that quality education must be made available to *all* students "wherever they live, whatever their race, gender, or economic condition, whatever their immigration status or whatever language is spoken at home by their parents, and whatever their career goals." The commission feels that incentives and opportunities should be offered for the most talented but is convinced that all students, unless turned off, can progress in science, mathematics, and technology and that it is essential to the nation's well-being that they have the opportunity to do so.

All the above is contained in the first section of the report, which, all in all, is truly an extensive, detailed piece of work.

Another section compares science education in America with that of other developed countries, particularly Japan, and finds the differences that are unfavorable to us stem not only from the cultural homogeneity in Japan, West Germany, and the U.S.S.R. but also from commitment to all children (that again), from time-on-task, from motivation, from the expectation of excellence, and from hard work. There are other significant differences, however, that are brought out, and some of these are strongly in our favor.

Among these: greater opportunities for higher education and personal advancement in this country (although a much larger percentage of Japanese students graduate from high school, admission to a university is restrictive and contingent upon a stiff examination), the flexibility and hence resilience afforded by the freedom of choice of courses of study in this country and hence a choice of careers, the opportunity to change careers at any stage to meet the needs and opportunities of our "evolving economy," and (most important, it seems to me) the encouragement given in this country to "independent thought and judgment, analytical capacity, and the maximum development of each individual's potential" in scientific disciplines, which results in leadership in theoretical and experimental science, and which has in turn led to highly significant "breakthrough technology" that has been developed in this country.

As the report states, the challenge is to match the advantages of the "monolithic," central, nationally directed educational systems of these other countries "while preserving the unique strengths of America's diverse educational system."

The remainder of the 124-page report gets down to specifics as to how to do this: recruiting, training, and retraining teachers; early and continuing stimulating exposure to mathematical and scientific concepts and processes; increased time during the academic day given to academic subjects, especially mathematics, science, and technology, plus higher requirements; improved compensation for teachers, improved surroundings, and up-to-date materials; better discipline; accessible, knowledgeable administrators who are willing to share decision making; reasonable class sizes; increased student involvement to keep students interested; education in and use of new information technologies (computers)——

There are 52 pages of what the commission calls "exhibits," one giving examples of existing programs that were reviewed; one offering suggestions for courses, curricula, content, and what should be achieved through courses; one a breakdown of costs of initiating and maintaining the suggested improvements; one a discussion of methods of improving teacher compensation; and, finally, the advantages and some of the uses of computers in the schools.

There is much to admire about this report: the obvious dedication to purpose, the emphasis on excellence without elitism, the recognition of the importance of upgrading education in disciplines other than the scientific, the acknowledgment of the good in American education as well as the deficiencies.

The commission has done a lot of worthy work, and their report is well worth reading.

However——

Is the study of the Earth and earth processes not a science? The report urges that even the youngest children acquire a "knowledge of phenomena in the natural environment" and that there be "growth in the natural curiosity of children about their physical and biological surroundings." So then are children not to learn of the land on which they live and how it got to be as it is and what is contained on and in it?

The only mention of geology in the entire report is a brief reference in "Exhibit A" to some of the educational offerings of the American Geological Institute.

This is an unfortunate, unbelievable, serious omission. How even in this listing could the commission overlook the important work done by the National Association of Geology Teachers in developing lesson modules for grades K–12 in the Crustal Evolution Education Project?

How could they overlook a lot of things? How many geological surveys, including the Oklahoma Geological Survey and the U.S. Geological Survey, issue educational publications suitable as aids to teachers? How many geological societies, including the Oklahoma City Geological Society, offer rewards of recognition to secondary-school students for outstanding accomplishments? How many universities, including The University of Oklahoma, have science fairs where high-school and younger students can exhibit results of their experiments, some of which are in the field of earth science? How many state science academies, including the Oklahoma Academy of Science, recognize excellence in teaching these young people, with some of the recipients being teachers of earth science and geography?

This is a good report as far as it goes, but it doesn't go far enough.

There are few children not fascinated by rocks, fossils, minerals, and landforms; and given even basic instruction, their fascination could be expanded into knowledge of their most basic surroundings. Earth science should be included in any program of improving science education. It is for the nation's good, not only for satisfying individual student minds. What is more basic than the Earth and its resources? Geology should be included.

I think possibly this lapse in the report may extend back into the very thing the report is decrying: deficiencies in science education. That is, it is most likely that the members of the commission themselves had no exposure to the science of geology.

There is a companion volume to this report, a 251-page publication entitled *Source Materials.* This source book contains reports from conferences on science education held for teachers, scientists, administrators, and representatives of professional societies, foundations, and industry. In this book there are many suggestions for revising curricula and for supplying trained teachers.

Also in this book there is a little hope: one of the many participants in one of the conferences was a geologist, Prof. John R. Carpenter of the Department of Geology, University of South Carolina. This book also mentions earth science as part of a super general-science course for grades 9–10 and as a course for grades 11–12 to be offered to students who want to pursue science as a career. There is no "working group," however, for geology, as there is for mathematics, biology, chemistry, physics, and engineering.

CLAREN KIDD ELECTED TO GIS OFFICE

Claren Kidd, geology librarian at The University of Oklahoma, has been elected vice-president/president-elect of the Geoscience Information Society (GIS). As such, she will plan the society's November 1984 meeting and will serve as its president in 1985.

The society was formed in 1965 as a nonprofit professional society. Its purpose is to improve the exchange of information in geoscience. Today approximately 300 geoscientists, librarians, documentalists, editors, and information scientists are members. GIS is a member society of the American Geological Institute and is an associated society of the Geological Society of America with which it concurrently meets.

GIS members are active in areas of editorship, publishing, data processing, network planning, copyright, and bibliographical control of theses, maps, and guidebooks. Perceived needs of this international membership have resulted in the formation of committees for the compilation of union lists of geologic field-trip guidebooks; study of U.S. Geological Survey Open-File Reports and Miscellaneous Field Investigations map series, now designated to be included in depository shipments to libraries; formulation of guidelines for authors and publishers of geologic field-trip guidebooks; organization and presentation of an international geoscience-information meeting; development of criteria for reviewing geoscience journals; and improvement of database searching.

Kidd has been a member of GIS since 1972, when she became OU's geology librarian. She has been active on several GIS committees concerned with guidebooks and open-file reports. She is also a member of the Special Libraries Association and has held several committee memberships in its Oklahoma chapter.

NEW THESES ADDED TO OU GEOLOGY LIBRARY

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

Statistical Analysis of Dolomite Outcrop Fracture Distributions to Evaluate Well Core Sized Samples (Sawtooth Mountains, Montana), by William Edward Todd-Brown, Jr. 165 p., 11 figs., 1983.

Structural and Geochemical Study of the South Sulphur Asphalt Deposits, Murray County, Oklahoma, by Daniel B. Williams. 163 p., 30 figs., 7 plates, 1983.

Structural Mechanisms and Oil Accumulation Along the Mountain View-Wayne Fault, South-Central Oklahoma, by Tyrrell C. Axtmann. 70 p., 17 figs., 8 plates, 1983.

Areal Geology of Cement-Cyril Area, Southeastern Caddo County, Oklahoma, by Michael R. Nelson. 64 p., 26 figs., 1 plate, 1983.

A Statistical Study of Fracture Orientation and Spacing on the East Kaibab Monocline, Arizona, by Michael E. Quillin. 87 p., 5 plates, 1983.

The Tertiary Bathymetry of the Norwegian-Greenland Sea and Eurasia Basin and the Cenozoic Environment, by Clare Ann Bernero. 193 p., 1983.

A Structural Interpretation of a Portion of the Eastern Laramie Mountain Flank, Albany, Platte, and Laramie Counties, Wyoming, by Thomas H. Butler. 69 p., 15 figs., 4 plates, 1982.

Lithostratigraphy and Depositional Environments of the Mayes Formation (Mississippian) in Adair County, Oklahoma, by Thomas J. Turmelle. 144 p., 9 figs, 10 plates, 1982.

Structural Style of the Wichita Mountains of Southern Oklahoma, by Thomas R. McLean. 94 p., 28 figs., 3 plates, 1983.

Organic Facies Variation of the Woodford Shale, in Western Oklahoma, by Karen L. Sullivan. 101 p., 33 figs., 3 tables, 1983.

WORLD ENERGY CONFERENCE TO BE HELD AT OU

The University of Oklahoma Energy Center will be the host for a world energy conference, announced OU President William S. Banowsky and officials of the United Nations Institute for Training and Research (UNITAR) in New York. The conference is expected to draw geologists, geophysicists, engineers, economists, financial specialists, policy-makers, and independent oil and gas producers from 50 countries to the OU campus July 25 through August 3.

The conference will examine the wide availability of small oil and gas accumulations and discuss their geologic occurrences. Also to be considered are problems of access to data on oil and gas resources. Related issues to be analyzed are the supply of drilling rigs, training of drillers, and the end-use of production in rural areas. Participants will have the opportunity to make field visits to producing leases and drilling companies. The conference will be technical and is designed to provide a forum for world specialists, who are invited to prepare papers for presentation.

Technical sessions will cover geology and exploration, occurrences, production and range of production costs, appropriate technology, the legal status of shallow resources, the institutional environment, development of shallow hydrocarbon resources, and financing.

The emphasis is on shallow reservoirs that could become a major low-cost energy supply, particularly in rural areas of developing countries. In many cases, these shallow, and often small, energy resources have not been developed because they normally are not profitable for large multinational companies or national energy companies to develop.

An effort will be made at the conference to delineate the conditions favorable to the development of shallow oil and gas reservoirs and to take the first steps toward promoting measures to facilitate that development.

"The existence of the Energy Center concept makes it possible for OU to attract a conference of such magnitude and importance to Oklahoma," Jay T. Edwards, executive director of the OU Energy Center, said. "Energy specialists from throughout the world will share ideas, disseminate information, and discuss problems. OU faculty, students, and energy professionals throughout Oklahoma and this region will benefit as a result."

The conference will be the eighth on energy and natural resources organized by UNITAR since 1976. It is a follow-up to the conference on small energy resources held in Los Angeles in 1981. Among the co-sponsors of the conference are the U.N. Development Program, the U.N. Department of Technical Cooperation for Development, the U.S. Department of Energy, and the Independent Petroleum Association of America.

The conference will begin at 5 p.m. July 25 at a formal opening session, to be followed by a reception. The technical program will begin the next day. A dinner for all participants will be held August 2. The conference is scheduled to close August 3.

The inclusive fee of $400 covers one set of preprints of the papers presented, invitations to receptions and the dinner, and guarantees a place on the field trip. A company paying $1,000 will be entitled to send three registrants. Authors of papers accepted for presentation will be charged a reduced fee of $200.

For further information, contact the Organizing Committee of the Conference on the Development of Shallow Oil and Gas Resources at: UNITAR, 801 United Nations Plaza, New York, NY 10017. Telephone (212) 754-8618 or 8641.

James Chaplin

Laurie Warren

REGIONAL STRATIGRAPHER, RESEARCH ASSISTANT JOIN STAFF OF OKLAHOMA GEOLOGICAL SURVEY

The Oklahoma Geological Survey has recently expanded its research capabilities through the addition of two staff members who have begun new projects that will be of great benefit to Oklahoma.

James R. Chaplin, regional stratigrapher, and Laurie A. Warren, research assistant, are beginning their respective projects, which will result in new county maps and a coal data-base for the State.

Chaplin, who has an M.S. in geology from the University of Houston and a B.S. in geology from Cornell College in Mount Vernon, Iowa, came to the OGS after 20 years of teaching geology at Morehead State University in Morehead, Kentucky. While at Morehead, Chaplin taught courses in physical and historical geology, stratigraphy and sedimentation, paleontology, marine science, field geology, and environmental geology. He was also active in directing student research and advising students in careers in geology. Chaplin also assisted in teaching a course in field methods in structural and stratigraphic interpretations of the southern Rocky Mountains for the University of Kentucky in its geology field camp at Gunnison, Colorado, in the summer of 1981. He has done areal geologic mapping in eastern Kentucky involving the preparation of 7.5-minute geologic quadrangles for the joint U.S. Geological Survey–Kentucky Geological Survey mapping project.

Chaplin is enthusiastic about the opportunity of spending more time in the field and being involved in an intensive program of mapping surface rocks.

Already hard at work, he is mapping the geology of Kay County, in northern Oklahoma.

"I began in Kay County mainly because it is in the northern part of the State, and I can work from the stable platform area into the basin areas. Also, I want to see what changes the rocks have undergone from Kansas into Oklahoma," he said.

Chaplin feels that his previous work in the Midcontinent Carboniferous areas and his experience in the Appalachian region will be helpful in his work here in Oklahoma.

Among Chaplin's professional affiliations are the American Institute of Professional Geologists, the American Association of Petroleum Geologists, the Pander Society, the Paleontological Society, and the Society of Economic Paleontologists and Mineralogists.

Warren, who recently received a B.S. in geology from OU, worked for the Survey for three years as a student assistant in the editorial section. While at OGS, she also gained experience in geology by compiling a geologic work map for interpreting coal stratigraphy and structure, by assisting in field work, by determining the rank of coal through ASTM standards, and by using the Parr formula for classifying coal.

Warren has also helped with drafting a generalized stratigraphic column, has measured polygons for determining acreages of coal beds, and has compiled tables of coal resources and reserves, in addition to performing preliminary drafting work on the correlation chart for the AAPG-USGS COSUNA project. She completed an independent study project supervised by OGS petroleum geologist William E. Harrison, and is currently enrolled in a computer-programming course at OU.

The project for which Warren was hired is being funded by the U.S. Geological Survey.

"I am excited about my participation in the NCRDS (National Coal Resources Data System) project, because it will provide me with an opportunity to be involved in coal research and to work with people for whom I hold a great deal of admiration and respect," she said. Warren explained that the developed data base will have great potential for reproducing valuable information in the form of maps, tables, or listings which should be of great use to industry, the public, and other governmental agencies.

She will be working with OGS coal geologists Samuel A. Friedman and LeRoy Hemish to acquire available coal data through the methods of literature search, requests from private industry, and surveys of both state and federal government sources before assessing the quantity and quality of the accumulated data prior to their incorporation into NCRDS. OGS geological data coordinator Michelle Summers will help with computerization of the data. Other objectives of this project include compiling data on coal stratigraphy and coal fields on a statewide basis, and updating Oklahoma's coal-resources and -reserves estimates and putting this information into the data-base.

NOTES ON NEW PUBLICATIONS

Hydrologic and Geologic Aspects of Waste Management and Disposal: A Bibliography of Publications by U.S. Geological Survey Authors, 1950 - 81

E. H. Handman's 40-page circular contains references to more than 500 reports, articles, and maps published in U.S. Geological Survey series, in journals of professional organizations, and in publications by cooperating agencies. It also includes subject and author indexes.

Order C 0907 from: Eastern Distribution Branch, Text Products Section, U.S. Geological Survey, 604 South Pickett St., Alexandria, VA 22304. The publication is distributed without charge in limited quantities.

Future Supply of Oil and Gas from the Gulf of Mexico

This 21-page professional paper by E. D. Attanasi and J. L. Haynes introduces a combined economic-engineering industry planning model and a discovery process model that forecasts costs of finding and producing future oil and gas discoveries in the Gulf of Mexico.

Order from: U.S. Geological Survey, 507 National Center, Reston, VA 22092. Price: $3.25.

Seismicity Map of the State of New Mexico

C. W. Stover, B. G. Reagor, and S. T. Algermissen are authors of this map which covers latitude about 31° to about 37°, longitude about 103° to about 109°. The map scale is 1:1,000,000 (1 inch = about 16 mi), and the sheet is 31 x 51 in.

Order MF-1660 from: Western Distribution Branch, U.S. Geological Survey, Box 25286, Federal Center, Denver, CO 80225. The price is $2.40.

Terrigenous Clastic Depositional Systems

Terrigenous Clastic Depositional Systems, by W. E. Galloway and David K. Hobday, combines practical facies reconstruction and economic geology on both local and regional scales. The 423-page volume focuses on applied three-dimensional subsurface analysis of sedimentary basins and their associated mineral-fuel deposits.

Order from: Springer-Verlag New York Inc., P.O. Box 2485, Secaucus, NJ 07094. Price: $39, clothbound.

Geraghty & Miller's Groundwater Bibliography

Geraghty & Miller's Groundwater Bibliography, by Frits van der Leeden, contains over 4,500 selected references on ground water, and has been made available by the Water Information Center, Inc.

Compiled by a hydrogeologist actively working for a major ground-water consulting firm, the 330-page volume references both "classic" works and new publications in the rapidly growing ground-water field. Included are management, protection, contamination, exploration, energy development, modelling, and the law.

The bibliography is divided into a general section containing a listing of general bibliographies, periodicals, and books, followed by a subject section that lists 29 topics.

Order from: Water Information Center, Inc., 6800 Jericho Turnpike, Syosset, NY 11791. The price is $18.

Metal Deposits in Relation to Plate Tectonics

Metal Deposits in Relation to Plate Tectonics, by Frederick J. Sawkins, surveys the geology and settings of metal deposits and their relation to specific plate-tectonic environments. Sawkins assesses such environments in terms of structure, lithology, and types of metal deposits that can be ascribed to each and gives descriptive examples of many different deposit types. He also clarifies the systematics of metal deposits and their distribution patterns in space and time in the 340-page book.

Order from: Springer-Verlag New York Inc., P.O. Box 2485, Secaucus, NJ 07094. The price is $38, clothbound.

Water-Resource Maps Published

A new set of maps, prepared under a joint project of the Oklahoma State Department of Health (OSDH) and the Oklahoma Geological Survey (OGS) and issued by OSDH, provides information on sources of ground water in Oklahoma. The set consists of two large map sheets in color, one delineating unconsolidated alluvial and terrace deposits, the other showing bedrock aquifers. Known and potential areas of recharge of these aquifers are also shown. Both maps were compiled by OGS associate director Kenneth S. Johnson. The scale of the maps is 1:500,000, or 1 in. equals approximately 8 mi.

Explanations printed on the map sheets describe each aquifer and provide information about yields, water quality, and thickness of the deposits. The maps were compiled mainly from information contained in a statewide series of hydrologic atlases that were prepared in a cooperative program between OGS and the U.S. Geological Survey. These and other pertinent references from which additional information can be obtained are listed.

Maps Showing Principal Ground-Water Resources and Recharge Areas in Oklahoma is available from the Oklahoma State Department of Health, Films and Publications Distribution, 1000 NE 10th St., Oklahoma City, OK 73152. The price is $5.

Uranium and Thorium Occurrences in New Mexico: Distribution, Geology, Production, and Resources, with Selected Bibliography

The U.S. Department of Energy has placed on open file the above three-volume report, which lists and describes more than 1,300 uranium and thorium occurrences in more than 100 stratigraphic units in New Mexico. These occurrences are indexed by county, alias, numerical order, mining district, and 1° by 2° National Topographic Map Series quadrangle; each occurrence is located on at least two maps. The report also contains district maps of the major uranium-producing areas in the state and production data from more than 200 mines. It also describes the geology, mineralization, and uranium and thorium potential of host rocks in New Mexico.

Order from: Bendix Field Engineering Corp., Technical Library, P.O. Box 1569, Grand Junction, CO 81502-1569. The microfiche price is $17. For orders outside the U.S. and Canada, add $3 per report.

Geochemistry of Sedimentary Ore Deposits

J. B. Maynard's new 305-page book provides a background for understanding sedimentary processes in ore genesis. It integrates geochemistry, petrography, and sedimentology to characterize the occurrence and origin of those ores that are formed by sedimentary processes. Each type of ore is placed in its sedimentologic context, and the chemical processes involved in its formation are discussed. This approach integrates geochemistry with the vertical profile of sedimentary characteristics for each deposit.

Order from: Springer-Verlag New York Inc., P.O. Box 2485, Secaucus, NJ 07094. Price: $29.80, clothbound.

Preliminary Appraisal of the Hydrology of the Stigler Area, Haskell County, Oklahoma

Water-Resources Investigations report WRI 82-4099 consists of 41 pages and three oversized sheets at a scale of 1:24,000 (1 in. = 2,000 ft).

Order from: USGS, Water Resources Division, 215 Dean A. McGee Ave., Room 621, Oklahoma City, OK 73102. Price: microfiche $5, paper copy $12.50

Petroleum Economic Evaluation Using Microcomputers

Reservoir engineers and others assessing the economic viability of producing petroleum reservoirs will be able to use this new software package on IBM-PC, Apple II, and other CP-M-equipped microcomputers. The disk and manual provide algorithms and techniques designed to predict the economic potential of reservoir units.

Written in PASCAL, the modules include cash flow, revenue projections, depreciation and depletion allowances, windfall-profit and other taxes, project costs, and several measures of profitability. The program source code is available, allowing users to tailor any module to fit their own needs. The package was written by Robert MacDonald and Charles Tutt, Jr., Intera Petroleum Consultants, Austin, TX.

Order from: IHRDC Publications, 137 Newbury St., Boston, MA 02116. The price is $350.

Phosphate Minerals

This 360-page reference book by Jerome O. Nriagu and Paul B. Moore provides basic information on phosphate minerals and their synthetic equivalents. The book summarizes the deterministic properties of the 300 or so known phosphate minerals and discusses the recent influence of pollution on the precipitation of phosphate minerals in soils and sediments.

Order from: Springer-Verlag New York Inc., P.O. Box 2485, Secaucus, NJ 07094. Price: $57.50, clothbound.

New Two-Map Series Available

PennWell has made available a two-map series, *Natural Gas Pipelines of Oklahoma* and *Petroleum Liquids Pipelines of Oklahoma,* drawn on a base created from the official U.S. Geological Survey 1:500,000-scale State Map series. Both maps are reproduced in seven colors.

Order from: PennWell Maps, P.O. Box 21278, Tulsa, OK 74121. Price: $55 each or $90 for both, U.S.; $72 each or $110 for both, export.

Correlation of Stratigraphic Units of North America (COSUNA) Project

These chart sets offer stratigraphic correlation of rock units in the United States, by region, to complement the stratigraphic correlation program done in Canada by the Geological Survey of Canada. The following chart sets are now available: (1) Northern Rockies/Williston Basin Region (NRW), which includes the Williston Basin, Sweetgrass Arch, Montana Folded Belt province, Central Montana Uplift, and Idaho Mountains province—size, 41 x 48 in., catalog no. 682; (2) Southwest/Southwest Mid-Continent Region (SSMC), which includes the Anadarko Basin, Permian Basin, Palo Duro Basin, Amarillo Arch, Las Animas Arch, Orogrande Basin, Pedrogosa Basin, and Basin and Range province—size, 40 x 56 in., catalog no. 683; and (3) Atlantic Coastal Plain Region (AC), which includes the Atlantic Coast Basin—size, 37 x 43 in., catalog no. 684. The entire series of charts is expected to be complete by late 1984.

Order from: AAPG Bookstore, P.O. Box 979, Tulsa, OK 74101. Price: 1–9 copies, $8 each; 10–99 copies, $6 each; over 100 copies, $5 each.

Seismic Expression of Structural Styles

This three-volume set, edited by A. W. Bally, illustrates structural geology through reflection-seismic profiles. Volume 1, in 216 pages, *The Layered Earth,* describes primary structures and focuses on relatively undisturbed stratigraphy. Volume 2, in 327 pages, *Tectonics of Extensional Provinces,* focuses on extensional tectonics in rifts, passive margins and cratonic basins, and soft-sediment tectonics occurring in structural provinces that have an extensional origin. Volume 3, in 448 pages, *Tectonics of Compressional Provinces/Strike Slip Tectonics,* deals with the tectonics of dominantly compressional provinces and the associated décollement tectonics of folded belts; a final section includes examples of wrench-fault tectonics.

Order from: AAPG Bookstore, P.O. Box 979, Tulsa, OK 74101. Price: volume 1, AAPG, $24, others, $30; volume 2, AAPG, $36, others, $42; volume 3, AAPG, $42, others, $48.

Mineral Surveys by the Geological Survey and the Bureau of Mines of Bureau of Land Management Wilderness Study Areas

In this 28-page circular, the U.S. Interior Department's Wilderness Program is described, including a wilderness review of areas by the U.S. Bureau of Land Management. After a preliminary determination of wilderness suitability has been made, mineral surveys of the areas are made by the U.S. Geological Survey and the U.S. Bureau of Mines.

Order C 0901 from: Eastern Distribution Branch, Text Products Section, U.S. Geological Survey, 604 South Pickett St., Alexandria, VA 22304. The publication is distributed without charge in limited quantities.

OKLAHOMA ABSTRACTS

AEG 26th Annual Meeting
San Diego, California, October 2–7, 1983

The following abstracts are reprinted from *Abstracts with Programs* of the Association of Engineering Geologists. Page numbers are given in brackets below the abstracts. Permission of the authors and of the AEG to reproduce the abstracts is gratefully acknowledged.

Regional Geologic and Hydrogeologic Criteria for Screening of Potential Waste-Disposal Sites

KENNETH S. JOHNSON, Oklahoma Geological Survey, Norman, OK 73019

By the fall of 1983, Oklahoma will be the second State in the nation to receive interim authorization from the U.S. Environmental Protection Agency to administer all phases of the Resource Conservation and Recovery Act (RCRA) program for disposal of hazardous industrial wastes. To facilitate State implementation of all aspects of the RCRA program, three statewide maps and reports have been prepared depicting geologic and hydrogeologic parameters that must be evaluated in screening potential sites for safe disposal of wastes. One map depicts the outcrop distribution and characteristics of each of the 35 thick shale or clay units that are generally suitable as host rocks for surface disposal of wastes. The second map shows the distribution of unconsolidated alluvium and terrace deposits, and the third map shows the distribution and hydrologic character of bedrock aquifers and their recharge areas: these latter two maps show the areas in the State where special attention must be exercised in permitting storage or disposal of waste materials that could degrade the quality of ground water. Both industry and State regulatory agencies are using these maps and reports in preliminary screening of the State to identify potential sites. The current paper deals with establishing

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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.

criteria for preparation of the three maps and reports, and with the problems and benefits reported by users from industry and regulatory agencies. [78]

Environmental Problems Associated with Abandoned Underground Mines in the Picher Field, Oklahoma and Kansas

KENNETH V. LUZA, Oklahoma Geological Survey, Norman, OK 73019

Surface subsidence and discharges of acid mine water are problems associated with abandoned underground lead–zinc mines in the Picher Field, northeastern Oklahoma and southeastern Kansas. Approximately 3,000 acres are underlain by an interconnected network of mines. Numerous examples of ground failure associated with orphan mine shafts existed or have developed since cessation of mining. Mine-workings maps and field surveys indicated that at least 1,400 shafts existed in the main part of the mining district. Some 635 shafts are either open or in some stage of collapse. Most shaft collapses began with the deterioration of the wooden cribbing near the shaft collar. Many of the cave-ins are between 20 and 60 feet in diameter. Where cave-ins extend into the underground workings, spectacular-looking surface collapses that range from 200 to 400 feet in diameter have resulted.

At 100 sites, surface collapse does not appear to be related to shafts. Two areas in Oklahoma, one west of Commerce and the other west of Cardin, contain the highest concentrations of non-shaft collapses. Ground failure appears to be related to (1) mining of multiple ore zones, (2) large stopes, and/or (3) weak roof rock.

Large volumes of water were encountered during mining operations. High-capacity sump pumps were used to maintain unsaturated conditions. At present, recharge to the mines comes from natural infiltration through fractures and solution cavities as well as from inflow to abandoned shafts, boreholes, and collapse features. In the late 1960's, mine dewatering programs were discontinued. By the late 1970's, the mines were completely full of water. Acid water charged with above-normal concentrations of iron, lead, zinc, and cadmium began to discharge to the surface through abandoned shafts and boreholes in late 1979. [84]

AAPG Southwest Section Meeting
Midland, Texas, February 5-7, 1984

The following abstract is reprinted from the *Bulletin* of the American Association of Petroleum Geologists, v. 68, no. 1. The page number is given in brackets below the abstract. Permission of the authors and of the AAPG to reproduce the abstract is gratefully acknowledged.

Ferroan Carbonates Formed at Depth Require Porosity Well-Log Corrections: Hunton Group (Upper Ordovician to Lower Devonian), Deep Anadarko Basin, Oklahoma and Texas

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Iron in the minerals calcite and dolomite of limestones and dolostones increases bulk densities and probably also decreases resistivities recorded by logging tools. Whereas dolostones alone retain porosity (intercrystalline and moldic) in the deep Anadarko basin of southwestern Oklahoma and Texas, it is particularly important to distinguish variations in the chemical compositions of dolomite (especially of iron). Bulk densities determined by measuring proportions of major minerals (X-ray diffraction) and iron content (X-ray fluorescence) permit improved estimates of true porosities and water saturations. Dolomite densities range from 2.82 g/cm^3 up to 3.02 g/cm^3 for strongly ferroan dolomite.

In the Hunton Group (Upper Ordovician to Lower Devonian) of the Anadarko basin, we have calculated more porosity and hydrocarbons than expected for select zones. Intervals with less than 4% apparent porosity before correction for iron actually have 4 to 10% porosity. Potentially productive intervals have been missed.

At depths exceeding 10,000 ft (3 km), ferroan dolomite and calcite in the Hunton Group carbonates are predictably associated with interbedded argillaceous zones and with the underlying marine Sylvan Shale. In the deepest of the 50 wells studied, well logs show high densities in the lowermost Hunton (above the Sylvan Shale) which can only be interpreted as the presence of iron-rich dolomite. Detailed fossil correlations by Amsden have established the relatively constant age of a single lithostratigraphic horizon locally present at the base of the Hunton Group conformably overlying the Sylvan Shale, leading us to conclude that increased temperature with depth is the predominant factor for dolomitization. The smectite-to-illite transition in the Sylvan Shale is suggested as a possible source of magnesium and iron. Preliminary shale analysis and stable-isotope-ratio analysis support the above conclusions. [119]