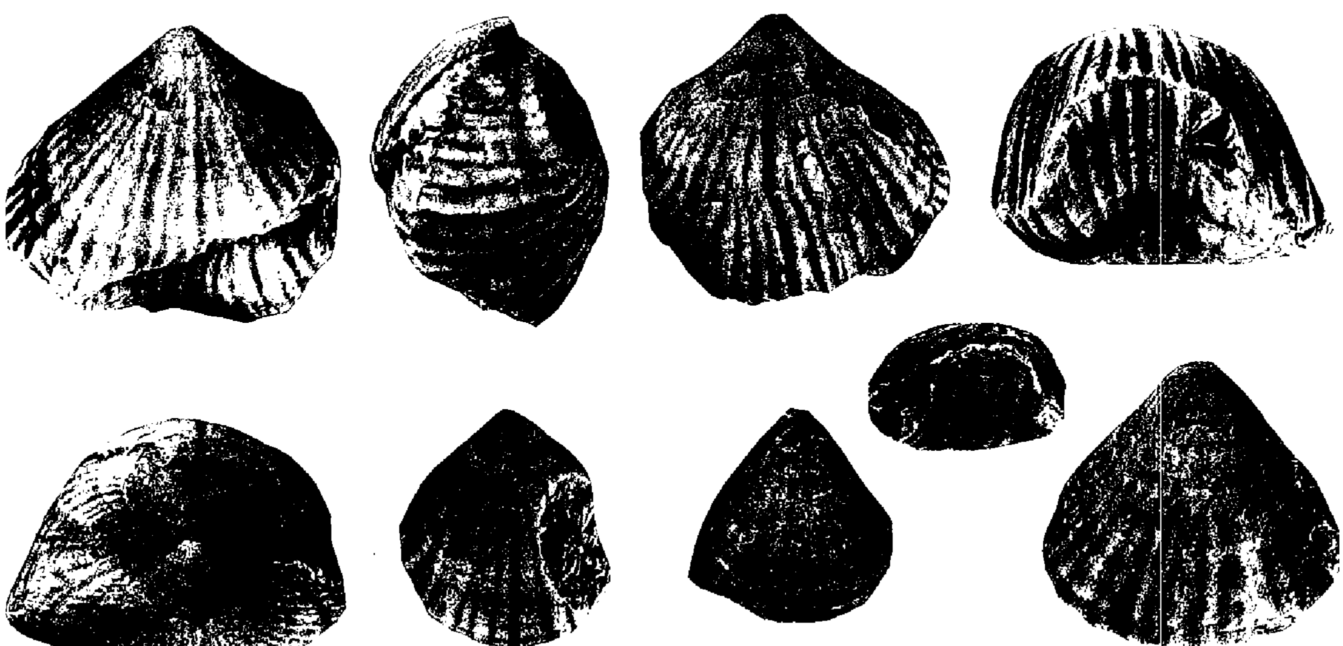
Oklahoma Geology Notes

OKLAHOMA GEOLOGICAL SURVEY/VOL. 45, NO. 2—APRIL 1985



On the cover—

Newly Described Brachiopods from the Turkey Creek Limestone

These views of *Havlicekella wilsoni* Amsden, new genus and new species, constitute figure 8 of an OGS bulletin (no. 138), authored by Thomas W. Amsden, which is being issued this month. Illustrated are pedicle, lateral, brachial, anterior, and posterior views. Specimens are shown at a magnification of 2 times except for the one at the lower right, which is 3 times actual size.

The brachiopods were collected from the Turkey Creek limestone, an informally named stratigraphic unit of Early Devonian age that crops out in a small area of Marshall County, central southern Oklahoma. This unit is part of a Paleozoic inlier surrounded by Cretaceous strata that lies along Turkey Creek.

Other new taxa described in the 19-page report include *Havlicekella miticonvexa, Plancella turkiensis,* and *Homoeospirella? subcircularis*.

Bulletin 138 can be obtained from the Oklahoma Geological Survey at the address given inside the front cover of this issue or by calling (405) 325-3031. Hardbound copies sell for $8 each, and softbound copies for $4 each.

Oklahoma Geology Notes

Editor: Connie Smith
Contributing Editors: Elizabeth A. Ham, William D. Rose
Editorial Assistant: Christie Cooper

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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. 45, NO. 2—APRIL 1985

Contents

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 for distribution at a cost of $2,508 to the taxpayers of the State of Oklahoma.

OKLAHOMA EARTHQUAKES, 1984

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, 524 earthquakes have been located in Oklahoma (Lawson and others, 1979; Lawson and Luza, 1980, 1981, 1982, 1983, 1984).

Thirty-six earthquakes were located in Oklahoma in 1984. Six earthquakes were known to be felt.

Instrumentation

A statewide network of 13 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). Nine semipermanent volunteer-operated seismograph stations and three radio-telemetry seismograph stations complete the Oklahoma Geological Survey's seismic network. The operation and maintenance of 12 of the remote stations is partially supported by the U.S. Nuclear Regulatory Commission (Luza, 1978).

Each of the nine volunteer-operated seismograph stations consists of a Geotech S-13, short-period, vertical seismometer; a Sprengnether MEQ-800-

[1]Geophysicist, Oklahoma Geophysical Observatory, Leonard.
[2]Geologist, Oklahoma Geological Survey, Norman.

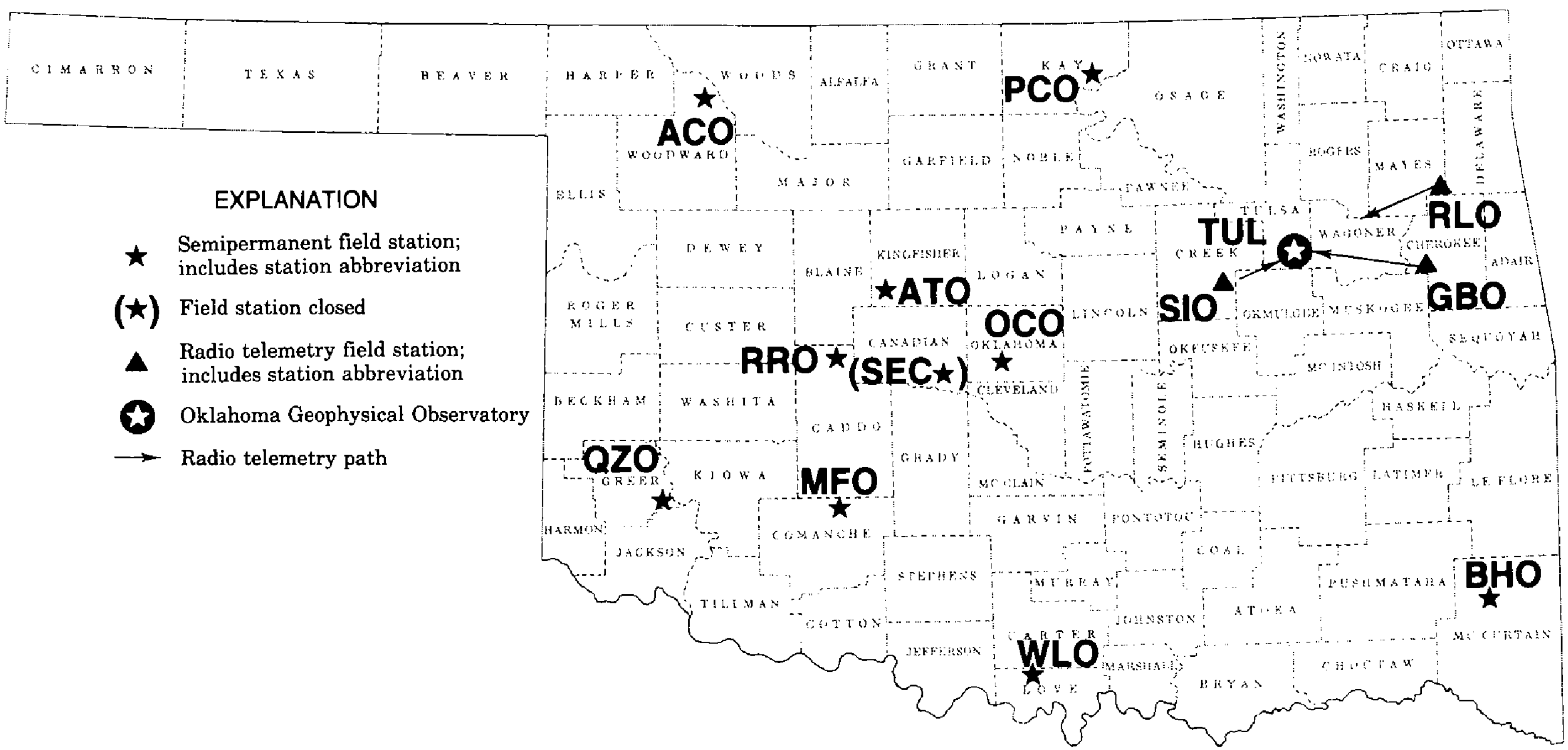

Figure 1. Active seismographs in Oklahoma.

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.

Station MFO was installed in Comanche County, southwestern Oklahoma, on April 20, 1984. Although this station was positioned near the Meers Fault to monitor possible microseismic activity, it has proved to be an excellent detector of Oklahoma earthquakes as well.

Station OCO, which contains equipment similar to the volunteer-operated stations, is located at the Omniplex museum in Oklahoma City. Omniplex staff members change the seismic records daily as well as maintain the equipment. Oklahoma Geophysical Observatory staff help interpret the seismic data and archive the seismograms with all other Oklahoma network seismograms.

A triggered-digital recording station, SCE, which was installed in December 1980 as part of a five-station array in Canadian and Grady Counties (Lawson and Luza, 1982), was closed in November 1983. The site became too noisy because of an increase in oil-field-related activities.

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 1984, 36 Oklahoma earthquakes were located (fig. 2; table 1). Six of these earthquakes were reported felt (table 2). 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 3).

The felt areas for most of those earthquakes listed in table 2 are probably restricted to a few tens of square kilometers away from the epicentral locations. No damage was reported from any of the felt earthquakes. On January 6, a magnitude-2.5 (m3Hz) earthquake, intensity MM V, occurred near Inola in northeastern Oklahoma. The last felt earthquake reported for this region occurred in March 1960. In late January, an intensity–MM V earthquake, event number 492, was reported felt 7 km east of Holdenville in Hughes County. On February 3, intensity–MM V effects were reported 13 km north of Elmore City. The same earthquake produced intensity–MM II–IV effects in the Elmore City, Maysville, and Pauls Valley areas. A magnitude-2.4 (m3Hz) earthquake was located in Love County on February 10. Intensity–MM IV effects were experienced 1 km north of station WLO. Intensity–MM V effects were reported in Okemah and Castle, Okfuskee County, on March 3. A magnitude-3.1 (m3Hz) earthquake occurred in Garvin County on November 20. This earthquake produced intensities of MM IV at Antioch and MM III at Elmore City, and was felt at Paoli.

Magnitude values range from a low of 1.1 (m3Hz) in Tulsa County to a high of 3.1 (m3Hz) in Hughes and Garvin Counties. The greatest concentration of earthquakes, 11, occurred in McClain and Garvin Counties. This region has been one of the most active since 1979. The Canadian County area, which has been the site of numerous earthquakes since 1908, contained no locatable earthquakes in 1984. Except for the February 10 earthquake, event no. 494, the Wilson area was conspicuously quiet. The Arkoma Basin region experienced a modest number of earthquakes in 1984. The first known earthquake for Harper County occurred on December 8.

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 for-

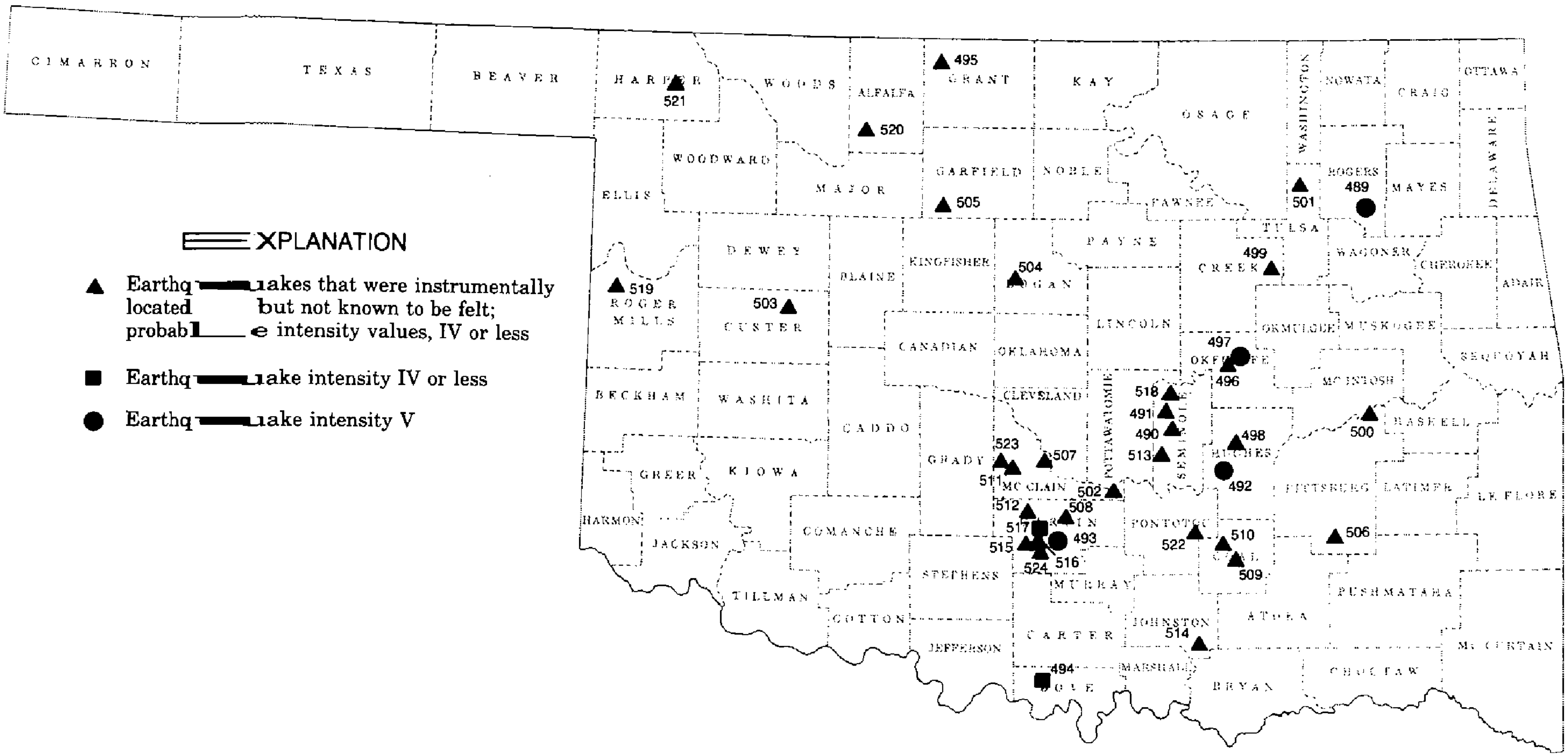

Figure 2. Distribu[redacted]tion of Oklahoma earthquakes for 1984. Numbers correspond to event numbers in table 1.

TABLE 1.—OKLAHOMA EARTHQUAKE CATALOG FOR 1984

Event Number	Date (UTC)	Origin and Time	County	Int MM	Magnitudes 3Hz	bLg	DUR	Latitude °N	Longitude °W	Depth (km)[1]
489	JAN 6	171449.81	ROGERS	V	2.5		2.5	36.161	95.582	5.0R
490	JAN 23	103704.30	SEMINOLE		1.5		1.7	35.207	96.674	5.0R
491	JAN 23	110156.21	SEMINOLE		2.2		2.1	35.234	96.690	5.0R
492	JAN 24	153409.63	HUGHES	V	3.1	2.8	2.7	35.033	96.366	5.0R
493	FEB 3	043828.04	GARVIN	V		3.2	3.1	34.665	97.356	5.0R
494	FEB 10	183913.56	LOVE	IV	2.4		2.2	34.049	97.415	5.0R
495	FEB 20	014722.00	GRANT		2.1		2.0	36.870	98.087	5.0R
496	FEB 20	114849.51	OKFUSKEE		2.3		2.1	35.485	96.358	5.0R
497	MAR 3	114202.36	OKFUSKEE	V	2.7	2.6	2.7	35.514	96.301	5.0R
498	MAR 16	171330.18	HUGHES		2.5	2.1	2.3	35.117	96.315	5.0R
499	APR 18	083637.22	CREEK		1.2		1.5	35.922	96.074	5.0R
500	APR 21	053802.16	PITTSBURG		1.9	1.5	1.8	35.233	95.563	5.0R
501	APR 28	225540.71	TULSA		1.1		1.2	36.297	95.921	5.0R
502	MAY 27	121327.31	MC CLAIN		2.1	1.7	2.0	34.889	96.965	5.0R
503	MAY 31	023658.32	CUSTER		1.5		2.0	35.735	98.903	5.0R
504	JUN 3	081413.11	LOGAN		2.0		2.2	35.895	97.593	5.0R
505	JUN 11	050845.67	GARFIELD		1.5		1.8	36.196	97.979	5.0R
506	JUL 9	030603.73	PITTSBURG		1.9	2.2	2.4	34.629	95.834	5.0R
507	JUL 13	165612.35	MC CLAIN				2.2	35.020	97.358	5.0R
508	AUG 17	180401.85	GARVIN		2.7	2.5	2.4	34.767	97.326	5.0R
509	AUG 18	040421.63	COAL		1.8	1.7	1.9	34.553	96.336	5.0R
510	SEP 8	033225.39	COAL		2.1	1.8	1.9	34.625	96.393	5.0R
511	SEP 17	095910.06	MC CLAIN		1.9	2.0	2.2	35.009	97.600	5.0R
512	OCT 4	122509.29	GARVIN		2.5	2.6	2.5	34.741	97.502	5.0R
513	NOV 4	070122.88	SEMINOLE		1.5		1.7	34.965	96.745	5.0R
514	NOV 4	083739.76	JOHNSTON		2.2	2.0	2.1	34.144	96.518	5.0R
515	NOV 16	115004.51	GARVIN		2.1		2.0	34.641	97.487	5.0R
516	NOV 18	131409.89	GARVIN		2.4	2.1	2.1	34.644	97.440	5.0R
517	NOV 20	105731.98	GARVIN	IV	3.1	3.1	2.7	34.707	97.410	5.0R
518	NOV 25	033635.64	SEMINOLE		1.9		2.1	35.340	96.635	5.0R
519	NOV 27	020847.88	ROGER MILLS		1.5		1.9	35.786	99.837	5.0R
520	NOV 30	132607.92	ALFALFA		2.1		2.2	36.580	98.466	5.0R
521	DEC 8	050442.02	HARPER		2.0		2.1	36.777	99.591	5.0R
522	DEC 11	062124.18	PONTOTOC		1.8		1.9	34.658	96.520	5.0R
523	DEC 29	034446.80	MC CLAIN		1.6	1.7	1.9	35.027	97.648	5.0R
524	DEC 29	043059.23	GARVIN		2.1	1.9	2.1	34.609	97.437	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.

TABLE 2.—EARTHQUAKES THAT WERE REPORTED FELT IN OKLAHOMA, 1984

Event no.	Date and origin time (UTC)[1]		Nearest city	County	Intensity (MM)[2]
489	Jan 6	171449.81	W Inola	Rogers	V
492	Jan 24	153409.93	S Holdenville	Hughes	V
493	Feb 3	043828.04	NE Elmore City	Garvin	V
494	Feb 10	183913.56	N Leon	Love	IV
497	Mar 3	114202.36	N Okemah	Okfuskee	V
517	Nov 20	105731.98	NE Elmore City	Garvin	IV

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

[2]Modified Mercalli (MM) earthquake-intensity scale (see table 3).

TABLE 3.—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.

mat. Table 1 contains 1984 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 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:

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

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 sec in converting the formulas for our use. The resulting equations are:

(epicenter 10 to 100 km from a seismograph)

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

(epicenter 100 to 200 km from a seismograph)

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

(epicenter 200 to 400 km from seismograph)

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

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:

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

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:

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

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 database 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 for better design of 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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1956 OKLAHOMA "EARTHQUAKE" PROBABLY WASN'T AN EARTHQUAKE

An event felt and heard over at least 13,000 km^2 of Oklahoma on February 16, 1956, has, since that date, been listed as one of the State's larger earthquakes. New evidence uncovered by James E. Lawson, Jr., geophysicist at the Oklahoma Geological Survey's Geophysical Observatory, indicates that the event was not an earthquake at all but probably sonic booms caused by military aircraft in the area at the time.

Lawson recently authored a paper in the October–December 1984 issue of *Earthquake Notes* (v. 54, no. 4, p. 5–9), published by the Eastern Section of the Seismological Society of America, giving his findings and listing the discoveries that led him to believe that the so-called earthquake was mistakenly labeled.

In 1956 the event was given a modified Mercalli intensity of VI in Edmond, Oklahoma, where there were reports of broken windows and cracked plaster, and tremors that were felt by many residents. An intensity of MM V was assigned in Guthrie, Oklahoma City, and Pawnee, with lesser intensities given to Big Cabin, Chickasha, Cushing, Duncan, Shawnee, and Stillwater. The MM V intensities in the smaller towns were assigned on the basis of information collected from questionnaires sent to local postmasters. These questionnaires have since disappeared from U.S. Geological Survey files. Some of the early accounts included reports of "a crackling noise followed by two loud booms," "an airplane exploding in the air," and sound "like distant jet at beginning of earthquake."

Associated Press reports at the time refer to three large sonic booms and said the event was not recorded on seismographs at St. Louis University or at the University of California, Berkeley. Air Force officials confirmed that aircraft capable of supersonic flight did land at Tinker Air Force Base, near Oklahoma City, at the time. Although the pilots denied exceeding the sound barrier, an Air Force spokesman said they could have "cracked through without noticing it." The official also acknowledged that the reported "crackling" sound heard as the explosion built up might have, in fact, been the sound of low-flying aircraft.

United Press reports also mention sonic booms as a possibility but quote an unnamed Oklahoma City "geologist and earthquake expert" as saying that the tremor resulted "from a shift in a fault line." The report continued to state that other unnamed experts revealed that the event was an "earth shift," not a "full-fledged earthquake." UP also reports that Nicholas Reeff, of the seismological department at Washington University in St. Louis, Missouri, said there was "a mild disturbance on the seismological instruments at 5:32 p.m." on the date of the event.

None of the newspaper accounts carried reports of broken windows, cracked plaster, or other damage.

Examination of seismograms from Lawrence, Kansas, showed no traces of an earthquake, nor did the St. Louis University recordings supposedly verified by Nicholas Reeff, a seismologist/technician there at the time, Lawson said. Another examined seismogram from Little Rock, Arkansas, also revealed no sign of the event.

Lawson personally examined seismograms from near Fayetteville, Arkansas, at that time the closest recording station to the presumed earthquake. Fayetteville seismograms recorded from 1952 to 1979 are now archived at the Oklahoma Geophysical Observatory. From these files Lawson has determined that although there was no seismogram evidence of such an event, even if the 1956 event had been an earthquake, it could not have had a magnitude exceeding 3. Lawson notes that an earthquake of magnitude 3 would have at best a felt area of only 100 km^2, while news reports at the time clearly indicated a felt area estimated to be 12,950 km^2.

The event has been removed from Observatory files and from the USGS list of United States earthquakes, and should, Lawson feels, be removed from all other earthquake catalogs and listings.

EARTHQUAKE EVALUATION ISSUED FOR ARCADIA DAM SITE

Results of a study undertaken at the request of the U.S. Army Corps of Engineers to evaluate earthquake possibilities at the site of the proposed Arcadia Dam, which would be located northeast of Oklahoma City on the Deep Fork of the Canadian River, is the subject of a recent OGS publication. Investigations were conducted at the Oklahoma Geophysical Observatory, a seismic facility operated by OGS at Leonard, Oklahoma, near Tulsa.

The report, *Expected Ground-Motion Parameters at the Arcadia, Oklahoma, Dam Site*, was issued as OGS Special Publication 85–1. The study was prepared by James E. Lawson, Jr., chief geophysicist for the Observatory.

To evaluate earthquake risk at the site, Lawson assembled a new database that includes information on horizontal ground velocity, horizontal ground acceleration, and magnitude, as well as location and date for each of 428 historical earthquakes "that could possibly have an effect on any site within the State of Oklahoma." A 10-page table incorporated as an appendix to the publication presents these data.

The parameters have been evaluated for periods of 100, 200, 500, 1,000, and 2,000 years to determine the largest earthquake, and its distance from the dam site, that could be expected in each of the time periods.

The information contained in this report should prove of value to design engineers involved in construction of the proposed dam or other projects of similar scope.

OGS Special Publication 85–1 can be obtained from the Oklahoma Geological Survey at the address given inside the front cover of this issue. The price for the 41-page volume is $3.

Paul H. Foster

Paul Henderson Foster
1909–1985

Paul H. Foster was born in Montrose, Colorado. He graduated from Central High School in Muskogee, Oklahoma. While studying electrical engineering at Oklahoma State University he worked summers as a water jack, a chain carrier, and in other capacities for the Oklahoma Pipeline Co. He received a bachelor of science degree in electrical engineering from OSU in 1931. Over a period of several years, he took graduate courses from OSU and the University of Tulsa.

After graduating, he worked for a year in a supply business owned by his father. During this time he married Alice Withrow, who was born in Petersburg, Virginia, but who also graduated from Muskogee's Central High.

Paul next worked for the Kay County Electric Corp., part of the Blackwell, Oklahoma, Rural Electric Administration. He was later supervisor of the Lindsay, Oklahoma, REA transmission system.

In 1942, Paul was employed in Wichita, Kansas, by Carter Oil Co., which transferred him later to its Tulsa research center. Paul was placed in top-secret work Carter was doing for the U.S. Navy. His work was so important that the Navy refused his application for enlistment in the uniformed services. On December 10, 1945, Foster was decorated by the Navy "in appreciation of exceptional service to Naval ordnance development." When the secrecy of World War II was relaxed, Paul's friends learned that he had had a pivotal role in the development of the proximity fuse.

After the war, Paul worked in seismic-exploration research with Carter Oil Co., which later merged into Jersey Production Research and later into Exxon. He was granted three U.S. patents related to seismic exploration. He spent some time in Denmark teaching the use of some of his patented equipment. It is believed that he may have had other patents, but such records are missing.

On November 7, 1961, Paul was transferred to the Jersey Earth Sciences Observatory near Leonard, Oklahoma, 15 mi south of Tulsa. In 1968, when this facility was given to The University of Oklahoma, Paul transferred with it, becoming superintendent in 1970. During the next few years he helped to transform the Leonard facility into one of the most comprehensive geophysical observatories in the world. He also helped to establish a statewide network of 12 seismograph stations, which has located nearly four hundred Oklahoma earthquakes. The Observatory itself has helped to locate and calculate the magnitudes of more than 20,000 worldwide earthquakes, and is one of only 10 magnetic observatories in the United States. In 1978, the Observatory was made part of the Oklahoma Geological Survey, at which time it was renamed the Oklahoma Geophysical Observatory.

In 1980, owing to a severe heart attack, Paul began working half-time at the Observatory. On January 4, 1985, he put in his usual half day troubleshooting field seismograph electronics. Late that afternoon he went briefly back to the Observatory to see that all Observatory equipment was operating properly. He then returned to his home, which since 1976 had been on the Observatory property. At 6:30 p.m. he died of a sudden heart attack. He is survived by his wife, three children, and six grandchildren.

Because of Paul's desire to join the Navy, and his exemplary civilian service to the Navy, it seems appropriate that the Observatory keeps a daily log like a ship. The first log entry by Paul H. Foster was on November 7, 1961. There are daily time marks (usually two) that are relayed to all Observatory records. Paul made his first time mark at 2030 Greenwich Time, November 13, 1961. A simple entry in the log on January 4, 1985, notes when Paul died. The staff decided to carry the nautical analogy further, as in the ringing of eight bells for a lost seaman, when on January 22 the Observatory staff made eight time marks, the first having been switched by the person who had worked longest with Paul, and successive marks switched by others in order of decreasing seniority.

The Oklahoma Geophysical Observatory will continue to operate, and various people already working, and perhaps others yet to be hired, will do much of the work that Paul did for 23 years. However, in the hearts of his family, in the hearts of his co-workers, and in the operation of the Observatory, Paul will never be replaced.

James E. Lawson, Jr.

A NEW ORDOVICIAN CONULARIID FROM OKLAHOMA?

Loren E. Babcock[1]

The study of problematic fossils such as conulariids involves several pitfalls. Because of superficial similarities, especially a conical shape, many unrelated forms have been grouped with conulariids. This problem has existed since the first conulariid genus, *Conularia*, was erected by Miller (*in* Sowerby, 1820, p. 107). Sowerby placed two species in Miller's genus, *C. quadrisulcata* and *C. teres*. *Conularia teres* is now regarded as an orthoconic nautiloid (Barrande, 1867, p. 1; Sinclair, 1940, p. 72). Other organisms that have been mistakenly identified as conulariids include hyoliths (Foerste, 1920, p. 212), medusoid cnidarians (Oliver, 1984), a trilobite (Sinclair and Richardson, 1954, p. 128), worms (Mason and Yochelson, 1985), and bivalved mollusks (a specimen figured by Willard, 1966, pl. 36, fig. 1 is *Pinna*?, not *Conularia*).

Once each fossil group is studied in detail, errors involving misidentification are likely to be corrected. However, errors involving mislabeling of specimens are not as likely to be discovered, and may in fact lead to inappropriate conclusions on the geologic history of certain "Problematica." This note concerns an instance of possible mislabeling of a conulariid specimen, a case which potentially could have extended the known range of one conulariid genus back 100 million years from its presently recognized first record.

In an unpublished doctoral thesis on the biology of conulariids, the late G. Winston Sinclair (1948) described a number of conulariid species presumably new to science. A specimen of one such form (fig. 1A, 1B) is in the United States National Museum of Natural History (USNM 111943). In addition to a USNM label, a label from The University of Oklahoma accompanies the specimen. This label identifies the specimen as OU A8951, but the number does not appear on the fossil itself. According to both the USNM and OU labels, the specimen was collected from near the middle of the Viola Limestone (Middle Ordovician), along Henryhouse Creek, Arbuckle Mountains, Oklahoma.

The specimen in question (fig. 1) is preserved in three dimensions in a tan colored limestone. It is slightly curved, but this is probably a compressional feature. Each face is marked by strong, sharp ridges that run transversely across; two adjacent rods on a face meet at an adapically concave angle at the midline and proceed away from the midline along lines

[1]Department of Geology, Kent State University, Kent, OH.

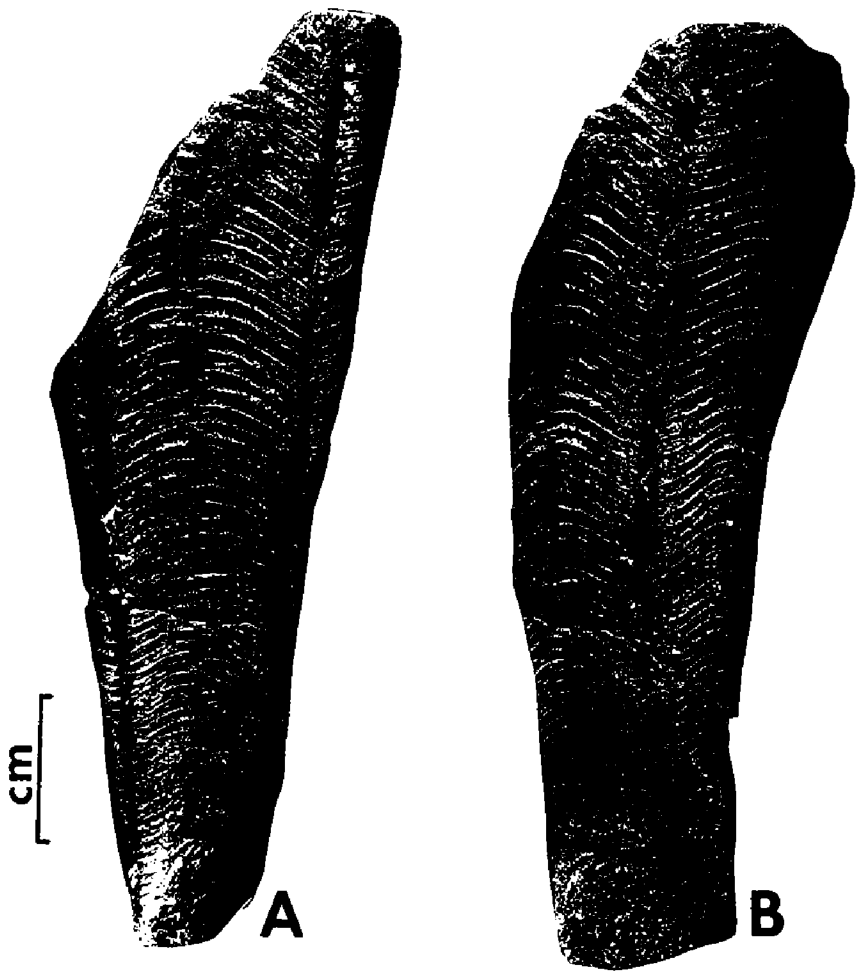

Figure 1. *Paraconularia* cf. *P. missouriensis* (Swallow) (USNM 111943). Location unknown, probably Mississippian in age. A, view of a minor face; B, corner view.

subtly curved except in the vicinity of the facial margins, where they turn gently adaperturally. There are 8–13 ridges per centimeter. The ridges alternate at the midlines and possess a single, faint row of closely spaced nodes. The midline of each face is marked by a faint, discontinuous, raised line. An apical angle, or the angle measured between two adjacent corner grooves, on one of the wider faces is about 12°, and on a narrower face, 10°.

Specimen USNM 111943 is sufficiently different from all described Ordovician conulariids to be worthy of a new species name. Such features as strong, nodose ridges that cross at an indistinct midline, and abrupt deflection of the ridges near the corner grooves, characterize the genus *Paraconularia* Sinclair, 1940. The *Treatise* (Moore and Harrington, 1956, p. F65) lists this genus as occurring in Middle Silurian through Early Carboniferous rocks, yet species from Early Mississippian through Permian strata are given as examples. Aside from this unsubstantiated, and possibly erroneous, indication of Silurian specimens, no examples of *Paraconularia* have been cited in the literature from rocks older than the Early Mississippian. On the basis of more than 2,000 museum specimens that I have examined and about 120 additional specimens that I have collected, the genus *Paraconularia* seems to range from the Late Devonian (Famennian) to the Permian. I have been unable to find any pre-Devonian forms in the collections that I have examined.

Likewise, I have been unsuccessful in locating other examples of *Paraconularia* from the Ordovician of Oklahoma. Apparently, no additional specimens of *Paraconularia* from these rocks are reposited at The University of Oklahoma (T. W. Amsden and P. K. Sutherland, personal communication, 1984). To date, the only species of conulariids reported from the Viola Limestone are *Conularia papillata* Hall (Decker, 1933, table IV), *C. trentonensis* Hall (Decker, 1933, table IV), and *Climaconus bromidus* Sinclair (Sinclair, 1942, p. 230).

The sum of morphologic characters on the present specimen indicates an impressive similarity to *Paraconularia missouriensis* (Swallow), a particularly widespread species in North America during the Early and perhaps middle Mississippian (Babcock and Feldmann, 1984). Compare Sinclair's specimen

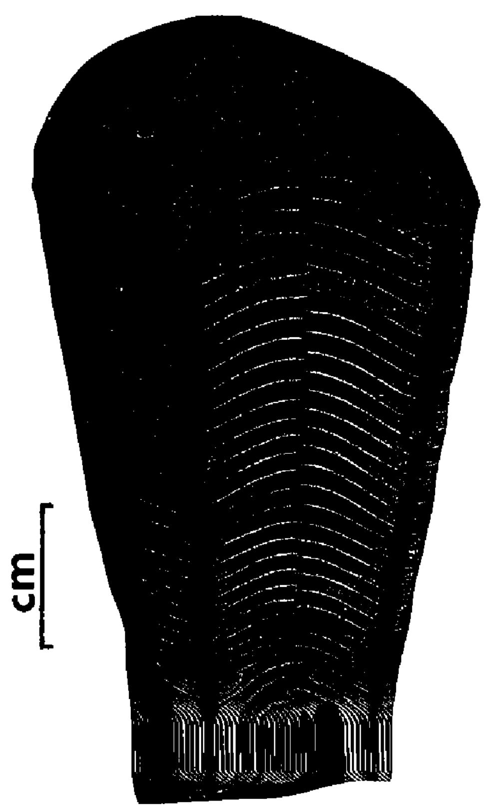

Figure 2. *Paraconularia missouriensis* (Swallow). Flattened specimen from the Cuyahoga Formation (Early Mississippian) of Richfield, Summit Co., Ohio (NYSM 3491). Both facial and corner views are exposed on this position. Original of James Hall's "*Conularia newberryi* Winchell" (Hall, 1879, pl. 34A, fig. 12).

(fig. 1) with that in figure 2, a fine example of *P. missouriensis* from Ohio, now housed in the New York State Museum (NYSM 3491).

The fact that USNM 111943 does not have a University of Oklahoma specimen number written on it leads me to wonder if the specimen and the label associated with it may have been accidently mixed. Such a simple mistake is understandable, since the matrix of the specimen is similar in color and texture to that of the Viola Limestone. The alternative is that if the specimen and label have been properly associated, this record of a *Paraconularia* near the base of the conulariids' known stratigraphic record represents a significant occurrence.

As a graduate student trying to add important information to our knowledge of conulariids, I was tempted to write a quick note extending the stratigraphic range of *Paraconularia*. Had I not examined a large number of specimens, I would have accepted the information provided by the OU and USNM labels without question. Perhaps the general message is that one should examine a large number of specimens, if possible, before making taxonomic decisions. Also, one should be cautious about specimens he or she has not collected personally, or has not collected in place. Meanwhile, additional information on conulariids from the Ordovician of Oklahoma is needed to help resolve whether or not Ordovician examples of *Paraconularia* exist.

Acknowledgments.—Mr. Frederick J. Collier, United States National Museum of Natural History, kindly permitted me to study Sinclair's conulariid. Drs. Thomas W. Amsden and Patrick K. Sutherland, Oklahoma Geological Survey and The University of Oklahoma, provided valuable information on conulariid specimens at The University of Oklahoma. Dr. Ed Landing, New York State Museum and Science Service, lent specimens for study from the James Hall collection. Dr. Rodney M. Feldmann, Kent State University, Dr. Ellis L. Yochelson, United States Geological Survey, and Mr. Jon Mortin, University College of Swansea, have read and improved on the manuscript.

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SHORT COURSE PLANNED ON INTRODUCTION TO MICROCOMPUTERS

Basic microcomputer concepts and terminology will be taught in the upcoming "Introduction to Microcomputers" short course to be conducted May 11–12, 1985, preceding the American Mining Congress Coal Convention in Pittsburgh, Pennsylvania.

The short course, sponsored by the Society of Mining Engineers of AIME, is intended for minerals professionals and managers who wish to understand microcomputers and their use in minerals organizations. No previous background in computers or data processing is required. In addition to a textbook and a class notebook, each registrant will be provided with a Commodore 64 computer for continuing self-study after the course.

Course instructors will be L. Michael Kaas and Jon P. Stone. Kaas is a mining engineer with more than 20 years of experience in the application of computers to minerals problems in industry and government. Stone is a geologist with extensive experience in minerals-information system design and development on mainframe, minicomputers, and microcomputers.

For further information and registration, contact the Meetings Dept., SME, Caller No. D, Littleton, CO 80127; telephone, (303) 973-9550.

AIPG'S OKLAHOMA SECTION PRESENTS GIFT TO SURVEY

The Oklahoma Section of the American Institute of Professional Geologists (AIPG) has announced that it will match, dollar for dollar up to $1,000, contributions by AIPG members to a publication fund for the Oklahoma Geological Survey.

The fund was established last summer to accelerate the publication program of the Survey. An initial gift of $5,000 was presented to the Survey at that time by Conoco, Inc., to start the fund.

In announcing AIPG's matching-funds support for the Survey's publication program, Oklahoma Section president Robert A. Northcutt underlined the section's commitment to further the timely publication of results of research on the geology of Oklahoma, including assessments of potentially important mineral resources.

The American Institute of Professional Geologists is a nationwide organization that operates largely through its state sections and is dedicated to maintaining high standards in the professional practice of geology by its members and the consequent protection of the public from unscrupulous or incompetent practitioners.

On hearing of the $1,000 matching gift of AIPG's Oklahoma Section, Charles J. Mankin, director of the Oklahoma Geological Survey, said, "It is particularly gratifying that an Oklahoma-based professional group in the geological sciences has recognized the importance of helping to make the results of our research available in a timely manner, and I deeply appreciate this commitment."

Donations can be made to the Oklahoma Geological Survey's publication fund through The University of Oklahoma Foundation. Gifts should be sent to 830 Van Vleet Oval, Room 163, Norman, OK 73019.

OKLAHOMA SECTION OF AIPG ANNOUNCES EXECUTIVE COMMITTEE

The officers elected by the Oklahoma Section of the American Institute of Professional Geologists (AIPG) for 1985 are as follows: president, Robert A. Northcutt, independent, Oklahoma City; first vice-president and president-elect, John A. Blair, Northern Natural Gas Co., Tulsa; second vice-president, Joseph L. Thacker, Jr., consultant, Norman; and secretary-treasurer, Robert J. Reed, Cities Service Co., Tulsa.

Rounding out the executive committee are the representative for the Oklahoma City area, Kenneth V. Luza, Oklahoma Geological Survey; the representative for the Tulsa area, Frederick N. Murray, consultant; the representative-at-large, Jerome M. Westheimer, Ardmore; and the section's past president, James E. O'Brien, consultant, Mannford.

HARRISON LEAVES SURVEY TO JOIN ATLANTIC-RICHFIELD CORP.

William E. Harrison, a petroleum geologist with the Oklahoma Geological Survey for the past 9 years, left the OGS early in 1985 to accept a position with Atlantic-Richfield Corp. in Plano, Texas. Harrison is heading up a team involved in petroleum geochemistry and said he will spend the first few months "getting back to 'state of the art' status in this discipline."

Harrison said that he will miss the university community atmosphere of OU and the Survey—an atmosphere he says is well suited to his lifestyle—as well as his colleagues at the OGS and his association with academics. He also said he would miss the great variety of projects at the Survey and the latitude given to staff members to pursue projects on their own.

"One of the most gratifying things I was involved with at the Survey was the better understanding we gained of the hydrocarbon potential of the Ouachita Mountains," he said. "Before we did that work everyone waved his hand over that area and said that potential hydrocarbon source rocks had been so hot that industry need not waste its time looking there for hydrocarbons."

But work undertaken by the OGS and the OU School of Geology and Geophysics demonstrated that certain areas had not been heated that much and were in the ideal temperature range for hydrocarbon generation, he said.

"As bad as things are in the petroleum industry, people are still leasing land in the Ouachitas," he said. "We like to think we had a part in that. We may have helped reshape the thinking for exploration potential in this region."

When asked what projects he would like most to work on if he were staying with the Survey for the next 5 years, one of the things he mentioned was continuing work on a pyrolysis technique that the University is currently trying to patent. Harrison said he would like to firm up the technique and see if the same relationship holds in different hydrocarbon-productive basins.

"If this one works out, we can go back into areas drilled 15–20 years ago, and the samples taken then will provide as much information for this approach as would samples taken last year."

Harrison said that the industry slowdown is providing researchers time for addressing projects that would have been nice to do but that had been impossible in recent years because of limited man-hours. Projects he mentioned included creating a set of standard "type" logs for every county to identify lithologic units, mapping of subsurface areas in oil- and gas-producing regions, and a thermal-maturation study of the Arkoma Basin—was it heated too much or was there simply never a chance for liquid petroleum to form there?

Harrison also said that he would have liked to work on a number of stratigraphic units in Oklahoma that might be petroleum source rocks.

"But when we were up to our eyeballs in tar sands and geothermal work, there just wasn't enough time for everything we wanted to do," he said.

While at the Survey, Harrison found time in his busy schedule to impart some of his knowledge to the new generation of geologists through an appointment at OU as a Klabzuba professor of geology and geophysics.

He was active in a number of scientific and professional organizations, serving as vice chairman of the Society of Economic Paleontologists and Mineralogists' National Research Committee in 1984–85 and chairing the SEPM research group on organic geochemistry for 2 years. Harrison was one of 33 geologists who served with the American Association of Petroleum Geologists' Visiting Petroleum Geologist program, which was designed to provide an exchange of ideas among the petroleum industry, students, and faculty. He also served as president of the Oklahoma Section of the American Institute of Professional Geologists, representing the State on the AIPG Advisory Board.

He was appointed by Gov. George Nigh to serve on the Interstate Oil Compact Commission, a cooperative advisory body that is made up of representatives from 36 oil-producing states, and works to conserve oil and gas by preventing physical waste. He also received, along with OGS geologist Joy Hampton, a distinguished-service citation from the Oklahoma Corporation Commission's Oil and Gas Division for work on the State's Emergency Contingency Plan Industry Advisory Committee, which developed guidelines industry would use in the event of petroleum-emergency situations.

One of Harrison's most recent projects at the OGS was a joint OGS-Technical University of Berlin study, funded by the German Research Council, to help Third World countries develop their natural resources. Harrison made a number of trips to Egypt to investigate oil shales that are a by-product of phosphate mining. If extracting the oil from the shale proves to be economical, the shale might then be suitable for making cement, a product in great demand in that area, he said, thereby gaining two benefits from a resource that is currently a by-product of mining.

Harrison was the author or co-author of a number of OGS publications and journal articles while at OU. His OGS publications include the following titles: *Reservoir and Fluid Characteristics of Selected Oil Fields in Oklahoma; Evaluation of Heavy-Oil Potential of Northeastern Craig and Northwestern Ottawa Counties, Oklahoma; An Evaluation of Water Resources for Enhanced Oil Recovery Operations, Cement Field, Caddo and Grady Counties;* and *Geothermal Resources and Temperature Gradients of Oklahoma.*

Those of us at the Survey will miss Bill as an internationally recognized expert on petroleum geochemistry. Even more, we will miss him as a valued colleague and friend.

OKLAHOMA AND ARKANSAS JOIN USGS TO MAP OUACHITA MOUNTAINS AREA

The Oklahoma Geological Survey will join with the Arkansas Geological Commission and the U.S. Geological Survey to map the Ouachita Mountains area of southeastern Oklahoma and west-central Arkansas—an area important because of its geologic history, its potential hydrocarbon resources, and its exposed geologic formations that are part of the Ouachita–Marathon tectonic belt.

"This tectonic belt extends from Mississippi through Arkansas and southeastern Oklahoma and is buried again in Texas, where it is present under the Dallas–Ft. Worth area, Waco, and San Antonio before being exposed again in southwest Texas, where it turns southward into Mexico," Charles J. Mankin, OGS director, said.

"This structural belt represents a period of geologic time when there was significant separation of major plates of the earth's crust," Mankin said. "Gaining a better understanding of the Ouachita system will give us a better understanding of geologic events during this period of the Earth's history.

"As a major exposure, the Ouachita Mountains give us the opportunity to interpret the occurrence of the rocks in the subsurface. Economically, the area has the potential of being a major source of hydrocarbons, and several important discoveries already have been made," he added.

Representatives from the U.S., Oklahoma, and Arkansas geological agencies met recently at the OGS to begin planning for the project, which will involve preparing surface and subsurface geologic maps and conducting geophysical studies over a 5-year period. Each of the organizations will provide matching resources.

The project is being sponsored through the USGS Cooperative Geologic Mapping Program, which grew out of concern by the national and state geological surveys over the decline in the rate the United States is being mapped geologically. The USGS solicited proposals from state surveys to help identify areas in critical need of geologic and geophysical mapping and to accelerate this much-needed mapping program.

The Ouachita mapping project could result eventually in the area being the target for future deep drilling under the National Academy of Sciences Deep Observation Earth Sampling Commission. The commission is investigating the need for a large-scale continental scientific drilling program to gather data that may be unavailable from other sources.

Geologists who attended the planning meeting at OU included Norman F. (Bill) Williams, Arkansas state geologist and an OU graduate whose father taught on the OU faculty, and Charles G. Stone, also of the Arkansas Geological Commission. In addition, Boyd R. Haley, retired from the U.S. Geological Survey, and consulting geologists Kaspar Arbenz of Boulder, Colorado, and Rodger E. Denison of Dallas are assisting with the project.

Representing the U.S. Geological Survey were Juergen Reinhardt, deputy chief for program development in the Office of Regional Geology in Reston, Virginia; and from Denver, Lindrith Cordell of the Branch of Regional Geophysics; Dudley D. Rice, John Grow, and Joseph R. Hatch, all of the Branch of Oil and Gas Resources; and Harry A. Tourtelot of the Central Region, Geologic Division.

Mankin was joined by Robert O. Fay, Michelle J. Summers, Kenneth V. Luza, Margaret R. Burchfield, Brian J. Cardott, Thomas W. Amsden, James R. Chaplin, and Kenneth S. Johnson, all from the Oklahoma Geological Survey, and by Patrick K. Sutherland, a professor in OU's School of Geology and Geophysics and part-time OGS research associate.

PECK SEEKS MORE COOPERATION BETWEEN MINING INDUSTRY, USGS

The minerals industry, government, and universities need to increase cooperative efforts to solve the serious challenges facing the mining industry today, Dallas L. Peck, director of the U.S. Geological Survey, said recently.

Peck told a USGS-sponsored minerals symposium in Denver that the principal challenges facing the mining industry today are not scientific or technical, but economic and political.

"The minerals industry is facing perhaps its most difficult test, and its very nature is changing," Peck said in remarks prepared for the McKelvey Forum on Mineral Resources at the Regency Hotel in Denver. Several hundred officials from government, industry, and academia attended the February forum named after former USGS director Vincent E. McKelvey.

"Economic and political factors have conspired to make mining one of the least profitable industries in the United States," Peck said. "The economic and political factors are not likely to change soon. Relief must come in finding ways to make exploration, mining, and extractive metallurgy more efficient and environmentally acceptable."

In a new step toward more cooperation, Peck announced a program under which scientists and other specialists from private industry, universities, and elsewhere outside the federal government will be invited to conduct earth-science and other research at the USGS in collaboration with survey scientists.

The USGS director said basic costs of this Industrial Research Associate Program will be paid by the employers or other sponsors of the researchers, and the USGS will provide the use of its extensive laboratory facilities, scientific consultation, and other technical assistance.

Peck said the program was designed primarily for private-industry scientists, especially those engaged in exploring for new mineral or energy resources, but that scientists and other specialists from schools, state and local governments, and other sectors of society are also welcome to apply.

"A recent legislative change now allows the USGS to accept money from private sources for participation in cooperative research programs," Peck added. "This legislation may also allow us to participate in projects for which internal funding cannot be developed," he said.

OU'S PETROLEUM DATA SYSTEM SELLS COPIES OF INFORMATION TAPES

Recent sales of data compiled by The University of Oklahoma's Petroleum Data System (PDS) should result both in improved access to the information for industry and reversal of a recent cash-flow shortfall for the organization, Charles J. Mankin, executive director of OU's Energy Resources Institute (ERI) and director of the Oklahoma Geological Survey, said recently. PDS is one product of Information Systems Programs (ISP), which is a branch of ERI.

There has been some confusion, Mankin said, because recent news reports seemed to indicate that the PDS system itself had been sold, rather than the copies of computer tapes which were purchased by Dwight's Energydata, Inc., and Petroleum Information, Inc., two private-industry organizations, Mankin said. The tapes consist of a machine-retrievable database of information on oil and gas fields in the United States. Each field record contains information about the location of the field, date of discovery, producing formations, annual and cumulative production, current state of production, geological and reservoir-engineering parameters, and chemistry of the oil or natural gas.

Mankin said he hopes that the competition created by this sale to independent companies might lead to some improvements in the system that would be of benefit to its users. The companies are now responsible for additions to the information on the tapes. Since the sale, the file at ERI has not been updated and has become a historical file, Mankin said.

"The system at OU could be revived at any moment through an endowment or another source of funding and be maintained for research purposes," he added.

Mankin explained that the PDS cash-flow problem had developed after U.S. Geological Survey (USGS) and U.S. Department of Energy (DOE) funding for PDS was cut abruptly. Consequently, there was insufficient time to allow PDS to develop private-sector funding and a more aggressive marketing program to replace the phased-out government funds. For many years, federal funding had provided only a part of the total revenue to build and maintain the system.

In the 12 months prior to the tape sale, PDS had developed a cash-flow deficit of almost $200,000, Mankin said. Although PDS had begun to turn the corner with an expanded marketing program to the private sector, it would have been quite some time before that deficit was made up. ERI officials, the OU administration, and the OU Board of Regents then decided that, given the current financial situation at the University, it would be best to sell copies of the tapes to raise funds to erase the deficit and terminate the program.

After much discussion with people in industry, a selling price of a quarter of a million dollars was set per copy of the tape, which was to be made available on a non-exclusive basis.

The PDS project was begun in 1968 with a grant from the USGS to examine the feasibility of establishing a machine-retrievable database of all publically available information on oil and gas fields in the United States. From that beginning developed the concept of an information system.

Over the years, with annual grants from USGS, PDS began to build the file. Support from the American Association of Petroleum Geologists helped establish a program to evaluate the quality of information in the database by having volunteers from all over the country evaluate the information.

Mankin emphasized that ISP, the parent organization of PDS, is still a functioning unit of ERI.

"ISP's largest activities are still there," he said. "The unit has more than $2.5 million a year in contract work alone. PDS brought in almost half a million dollars a year; thus it was an important activity, but in terms of dollars it was only part of the total."

ISP's largest project is contract DOE work on estimates of reserves of petroleum, natural gas, and natural-gas liquids. This project totals about $2 million per year. ISP also is involved in the National Uranium Resource Evaluation (NURE) project for DOE, and a well-history file for the state of Pennsylvania.

Along with ISP, ERI's other branches are Research Development Programs, which provides the faculty with seed grants for initiating new energy-related research projects, and the Oklahoma Mining and Minerals Resources Research Institute, which also provides faculty support and student scholarships in the fields of mineral science and mineral engineering.

PRECAMBRIAN ROCKS IN THE CENTRAL INTERIOR

Geology and Geochronology of Precambrian Rocks in the Central Interior Region of the United States, by Rodger E. Denison, E. G. Lidiak, M. E. Bickford, and Eva B. Kisvarsanyi, 1984, 20 p., U.S. Geological Survey Professional Paper 1241–C.

The authors present a synoptic discussion of the lithology, distribution, correlation, and isotope ages of the Precambrian terrane between the Appalachians and the Rocky Mountains. This paper builds upon the work that W. R. Muehlberger, S. S. Goldich, and their co-workers did in the late 1960's. Because most of the Precambrian terrane in this region is concealed, much of the interpretation is based on drill-hole samples and gravity and magnetic surveys.

For discussion purposes, the Central Interior region is subdivided into five geographic areas. Area I embraces North and South Dakota; Area II, Nebraska, Iowa, northern Missouri, northern Kansas, and eastern Colorado; Area III, southern Missouri, southern Kansas, Oklahoma, and northwestern Arkansas; Area IV, Texas and eastern New Mexico; and Area

V, the eastern Midcontinent (from the Appalachians to the Mississippi River and from southern Michigan to northern Alabama).

Each area contains a discussion on the Precambrian rock types as well as a sketch map at a scale of about 1 in. equals 150 km that shows the distribution of basement rocks. In the pocket of the publication the authors provide a correlation chart, compiled in 1980, for Precambrian rocks of the Central Interior region.

The paper concludes with a brief section on the metallogenic significance of the Precambrian basement for this region.

This report is part of a series of papers entitled "Correlation of Precambrian Rocks of the United States and Mexico," which is edited by Jack E. Harrison and Zell E. Peterman.

This publication is available by mail from Eastern Distribution Branch, Text Products Section, U.S. Geological Survey, 604 South Pickett St., Alexandria, VA 22304. The price is $2, which includes the cost of domestic surface transportation.

Kenneth V. Luza

NOTES ON NEW PUBLICATIONS

Field Geologist's Training Guide: An Introduction to Oilfield Geology, Mud Logging and Formation Evaluation

Written for oil-industry professionals, this handbook by Exlog presents a basic overview of and introduction to petroleum geology, oil-field terminology, and formation-evaluation procedures. Designed primarily for beginning logging geologists, this 304-page reference provides a resource for all newcomers to the petroleum-exploration field. Petroleum geology, oil-field fluids, rig types and their components, wellsite equipment, and the environment in which field geologists work are presented in detail. Drilling and completing a well and formation-evaluation procedures are examined from a logging geologist's perspective. The appendixes contain such information as general abbreviations, a glossary, and bit classification.

Order from: IHRDC Publications, 137 Newbury St., Boston, MA 02116. The price is $34; add $2 (Canadian orders add $3) for postage and handling.

New Bibliographies Published

The Geological Information Library of Dallas (GILD) has announced publication of the following series of bibliographies:

Annotated Bibliography of the Fort Worth Basin Area, Texas. Revised 1983. Price: $25.

Annotated Bibliography of the Arkoma Basin Area, Arkansas–Oklahoma. 1981 with 1983 supplement. Price: $35.

Annotated Bibliography of the Palo Duro Basin Area, Oklahoma–Texas–New Mexico. 1981 with 1983 supplement. Price: $25.

Annotated Bibliography of the Ardmore and Marietta Basins Area, Oklahoma. 1982. Price: $25.

Annotated Bibliography of the Black Warrior Basin Area, Alabama–Mississippi. 1983. Price: $35.

Annotated Bibliography of the Anadarko Basin Area, Kansas–Oklahoma–Texas. 1984. Price: $35.

Annotated Bibliography of the Southern Appalachian Area. 1984. Price: $35.

Selected Bibliography of the China Area. Circular no. 2. 1983. Price: $10.

Selected Bibliography of Ground-Water in the United States. Includes a reprint of GILD Publication no. 1. Circular no. 1. 1984. Price: $25.

Order from: Geological Information Library of Dallas, Suite 100, One Energy Square, 4925 Greenville Ave., Dallas, TX 75206. Texas residents include 6-percent sales tax. For foreign orders, add $2.

Linking U.S. Oil and Gas Reserve Estimates

This latest volume in a series of Rand reports on energy resources of the United States compares and adjusts two sometimes conflicting reports on oil- and gas-reserve estimates.

One source of data used in the comparison is the annual reports of the Committee on Reserves of the American Petroleum Institute (API) and those of the Committee on Natural Gas Reserves of the American Gas Association (AGA), published together in what is called informally the "Blue Book" for the years up to and including 1979. The other is the series of annual reports on reserves of the Energy Information Administration (EIA) of the U.S. Department of Energy.

The study says that in percentage terms, the differences in total reserve estimates aren't great, but they are large enough to suggest different directions for trends in these reserves during the late 1970's.

The 190-page report will be of primary interest to analysts of domestic petroleum supply who use the published series of reserve data. It is also designed as a basic reference work on recent estimates of domestic crude and natural-gas reserves.

Order from: Rand Corp., Publications Dept., P.O. Box 2138, Santa Monica, CA 90406. The price is $15, plus 6.5-percent sales tax for California residents.

Numerical Simulation of the High Plains Regional Aquifer, Northwestern Oklahoma

J. S. Havens and S. C. Christenson's new USGS publication contains 27 pages and eight oversized sheets at a scale of 1:250,000.

Order WRI 83-4269 from: Open-File Services Section, Western Distribution Branch, U.S. Geological Survey, Box 25425, Federal Center, Denver, CO 80225. The price is $7.50 for microfiche, $18 for a paper copy.