OKLAHOMA GEOLOGY NOTES

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Cover Picture

The Berwyn Conglomerate

The cover photograph shows an exposure of the Berwyn Conglomerate, just above the Berwyn coal smut at the type section, about 2 miles south of Gene Autry (formerly Berwyn), Carter County, Oklahoma (SW¼NE¼SE¼NW¼ sec. 36, T. 3 S., R. 2 E.). Here, the Berwyn lies about 200 feet above the Confederate Limestone.

The Berwyn Conglomerate was first named by Birk (1925, AAPG *Bulletin,* v. 9, p. 987). At that time, the conglomerate was thought to contain arkose and was correlated with the Pontotoc Group (now Oscar and Vanoss Groups) around the west and north edges of the Arbuckle Mountains. The type section is 74 feet thick and consists of alternating beds of greenish-gray and reddish-brown shales, tan fine-grained sandstones, and algal limestone and chert conglomerates. About 6 feet above the base is a 5-foot gray shale and siltstone containing coal smuts and yielding a lower Hoxbar (early Missourian) flora. Many of the limestone and chert pebbles are covered with algal layers as much as 2 inches thick, and in many places the Pontotoc overlies the Berwyn and contains reworked Berwyn rocks. When the Berwyn Conglomerate is traced southward and westward from the type section, the conglomeratic portions of the Berwyn disappear, indicating a northeastern origin.

—*Robert O. Fay*

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

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

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

This publication, printed by the Transcript Press, Norman, Oklahoma, is issued by the Oklahoma Geological Survey as authorized by Title 70, Oklahoma Statutes 1971, Section 3310, and Title 74, Oklahoma Statutes 1971, Sections 231-238. 1,500 copies have been prepared for distribution at a cost to the taxpayers of the State of Oklahoma of $1,941.45.

Statistics of Oklahoma's Petroleum Industry, 1973

John F. Roberts[1]

Total drilling of wells in search of oil and gas decreased slightly in 1973, from the 1972 total of 2,300 to 2,281 (table 1, fig. 1). A sizable increase in development gas wells was recorded (from 286 in 1972 to 470 in 1973), owing to a substantial price increase, particularly in intrastate contracts.

Table 1.—Drilling Activity in Oklahoma, 1973

	1973				1972
	Crude	Gas	Dry	Total	Total
All wells					
Number of completions	898	539	844	2,281	2,300
Footage				12,434,227	12,297,180
Average footage				5,451	5,347
Exploration wells					
Number of completions	35	69	248	352	416
Percentage of completions				30	20
Footage				2,279,089	2,907,925
Average footage				6,475	6,990
Development wells					
Number of completions	836	470	596	1,929	1,884
Percentage of completions				69	68
Footage				10,155,138	9,389,255
Average footage				5,264	4,984

Source: *Oil and Gas Journal,* v. 72, no. 16, April 22, 1974.

The number of oil wells did not keep up the pace, because higher oil prices arrived so late in the year that increased drilling was reflected only in the number of active locations at year's end, not in completions. Sixty-two counties were explored for new reserves (fig. 2). Woodward County was the site of the most activity—25 tries, 5 of which were successful gas discoveries. As usual, Osage County had the highest total wells, 178; Kingfisher was second with 127 tests. The statewide success ratio for development wells was 69 percent; exploratory wells, 30 percent.

Natural-gas development and exploration activities in the western and northwestern counties of the State, involving Morrow (Pennsylvanian) and Springer (Mississippian) sands and the Hunton Limestone, accounted for two sizable portions of the State's effort. Similar activity occurred with good

[1]Geologist, Oklahoma Geological Survey.

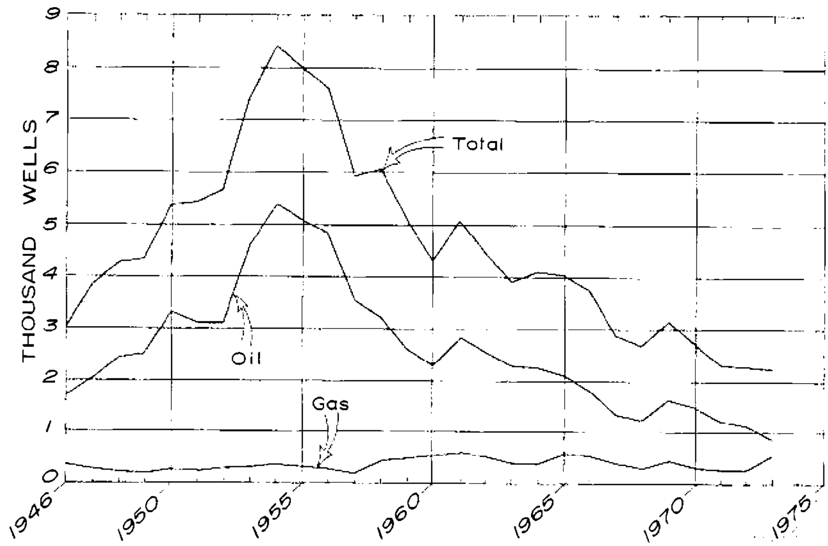

Figure 1. Graph showing total wells drilled, oil wells completed, and gas wells completed in Oklahoma, 1946-73. Source: *Oil and Gas Journal.*

results in the same formations in Canadian, Grady, and Caddo Counties, central Oklahoma. The Sycamore Limestone (Mississippian) discovery made in Stephens County during 1972, under the old Hewitt Field (Pennsylvanian production), expanded in all directions and now extends into Carter County. This one reservoir is becoming a major source of reserves within the State.

A recently received publication, *National Stripper Well Survey, January 1, 1974,* a joint project of the Interstate Oil Compact Commission and the National Stripper Well Association, indicates that at the close of 1973, Oklahoma had approximately 57,000 stripper wells, a 4.2 percent increase over 1972 figures. A stripper well, for the purpose of this survey, is a well capable of producing 10 barrels of oil per day or less during the year under consideration. In Oklahoma, stripper wells produced 74,109,932 barrels of oil during 1973, accounting for about 38 percent of the State's total liquid hydrocarbon production. There is a sensitive relationship between the increasing value of oil and rising operating expenses, and the relative changes in each have considerable impact on the amount of remaining reserves that can be recovered economically.

Table 1 summarizes drilling activity during 1973 and compares it with that of the previous year. The average total depth of all wells increased from 5,347 feet to 5,451 feet. The average total depth for exploratory drilling decreased, owing to fewer completions in the deep Anadarko basin. Several

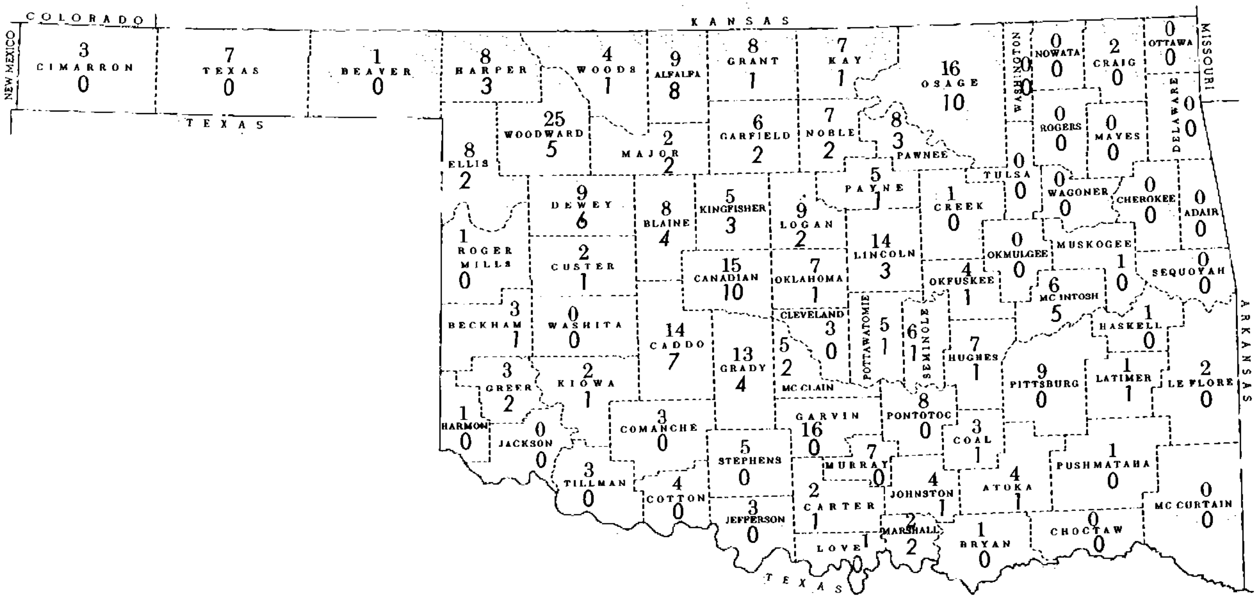

Figure 2. Exploratory drilling by counties during 1973. Upper figures give the number of exploratory wells drilled; lower figures give the number of successful completions. Source: American Petroleum Institute in cooperation with the U.S. Bureau of Mines.

wells in that area were still drilling at year's end. The average footage of development wells increased significantly, from 4,984 to 5,264.

The 21 giant fields of Oklahoma are listed in table 2. (A giant field is one that has an estimated recovery of more than 100 million barrels of oil.) These giant fields produced 41 percent of the year's total oil and accounted for 48 percent of the estimated ultimate yield and 41 percent of the remaining recoverable reserves in the State. This production came from 35 percent of the State's total number of producing wells.

TABLE 2.—GIANT OIL FIELDS OF OKLAHOMA, 1973

FIELD	1973 PRODUCTION (1000 BBLS)	CUMULATIVE PRODUCTION (1000 BBLS)	ESTIMATED RESERVES (1000 BBLS)	NUMBER OF WELLS
Allen	2,645	124,381	15,619	1,495
Avant	410	106,242	2,758	625
Bowlegs	1,750	156,827	8,173	180
Burbank	3,870	500,354	40,646	1,075
Cement	2,470	138,956	16,044	1,475
Cushing	3,245	460,217	24,783	1,715
Earlsboro	460	215,804	4,196	190
Edmond West	715	154,522	5,478	455
Eola-Robberson	4,355	104,257	35,743	485
Fitts	2,180	148,308	11,692	610
Glenn Pool	2,150	307,441	12,559	1,015
Golden Trend	9,875	393,876	106,124	1,235
Healdton	6,880	286,665	33,335	1,520
Hewitt	6,880	212,391	37,609	1,180
Little River	365	159,571	5,429	170
Oklahoma City	1,860	731,896	18,104	280
Seminole, Greater	1,190	198,446	11,554	260
Sho-Vel-Tum	33,320	968,206	181,794	8,025
Sooner Trend	11,480	189,604	60,396	2,920
St. Louis	1,185	215,045	9,955	635
Tonkawa	275	134,937	2,063	200
Totals	97,560	5,907,946	644,054	25,745

Source: *Oil and Gas Journal*, v. 72, no. 4, January 28, 1974.

Table 3 lists cumulative and yearly production and the value of all petroleum products to January 1, 1974. Table 4 compares the petroleum production of the past 2 years. Crude-oil and natural-gas production declined, while the total value of each product increased owing to increased unit prices (especially in the last quarter of the year). Production rates failed to meet market demands, even though maximum effort was made.

TABLE 3.—CUMULATIVE (THROUGH 1955) AND YEARLY (1956-1973) MARKETED PRODUCTION AND VALUE OF PETROLEUM, NATURAL GAS, NATURAL GASOLINE, AND LIQUEFIED PETROLEUM GAS IN OKLAHOMA[1]

YEAR	CRUDE PETROLEUM		NATURAL GAS		NATURAL GASOLINE AND CYCLE PRODUCTS		LIQUEFIED PETROLEUM GAS	
	VOLUME (1,000 BBLS)	VALUE ($1,000)	VOLUME (MMCF)	VALUE ($1,000)	VOLUME (1,000 GALS)	VALUE ($1,000)	VOLUME (1,000 GALS)	VALUE ($1,000)
Through 1955	7,230,010	11,443,269	12,977,332	1,378,370	14,420,482	890,729	3,673,364	120,097
1956	215,862	600,096	678,603	54,288	489,963	26,543	579,101	23,427
1957	214,661	650,423	719,794	59,743	460,644	25,329	587,140	21,824
1958	200,699	594,069	696,504	70,347	440,798	26,029	657,114	25,822
1959	198,090	578,423	811,508	81,151	448,353	29,443	675,869	27,070
1960	192,913	563,306	824,266	98,088	531,995	33,074	762,258	32,409
1961	193,081	561,866	892,697	108,016	521,237	33,358	817,082	30,141
1962	202,732	591,977	1,060,717	135,772	552,795	35,764	838,903	25,223
1963	201,962	587,709	1,233,883	160,405	555,467	35,131	810,894	28,981
1964	202,524	587,320	1,323,390	166,747	554,053	34,011	880,804	28,055
1965	203,441	587,944	1,320,995	182,297	570,129	34,561	894,665	32,208
1966	224,839	654,281	1,351,225	189,172	576,124	35,715	968,254	44,381
1967	230,749	676,095	1,412,952	202,052	568,905	35,846	1,005,633	49,276
1968	223,623	668,202	1,390,884	197,506	584,010	38,829	1,070,874	39,520
1969	224,729	701,155	1,523,715	223,128	614,082	38,931	1,146,768	34,403
1970	223,574	712,419	1,594,943	248,811	622,146	39,933	1,177,218	52,975
1971	213,312	725,610	1,684,260	273,945	595,854	40,856	1,156,680	56,732
1972	207,633	709,033	1,806,887	294,523	611,478	42,709	1,140,216	57,101
1973	193,107	753,117	1,771,626	327,751	597,660	45,550	1,187,340	65,000
Totals	10,997,541	22,946,314	35,076,181	4,452,112	24,316,175	1,522,341	20,030,177	794,645

Figures from: *Minerals Yearbook* of the U.S. Bureau of Mines. Totals for crude petroleum differ from those compiled by the U.S. Bureau of Mines and the American Petroleum Institute principally because of the exclusion from USBM and API compilations of an estimated production of 26,355,000 barrels for the years 1905-1906.

[1]Preliminary figures for 1973.

Figure 3 shows a decrease in natural-gas reserves from 14.5 trillion cubic feet to 14.1 trillion cubic feet. Extensions and revisions increased, as did discoveries, owing to the accelerated search for higher priced natural gas in all portions of the State, particularly in western Oklahoma. The remaining-reserves ratio to production was 7.9, compared to 8.25 the previous year.

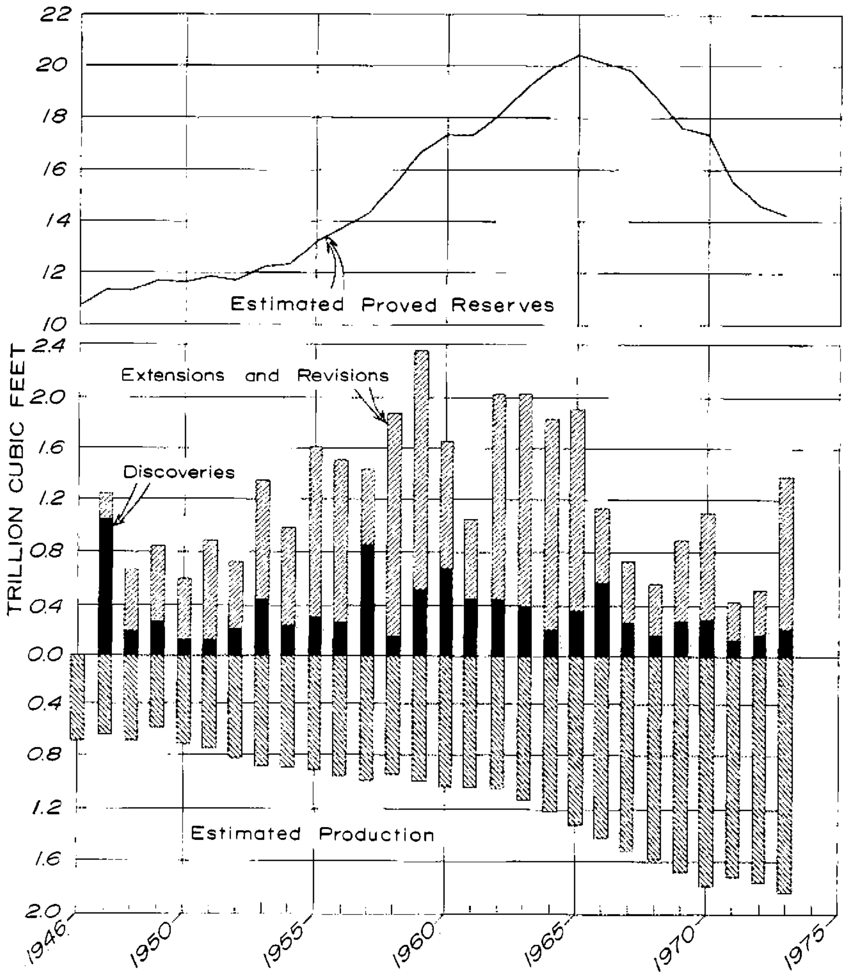

Figure 3. Graph showing statistics on estimated proved reserves of natural gas in Oklahoma, 1946-73. Source: American Gas Association, annual reports.

Figure 4 displays a slight increase in extensions and revisions of total liquid hydrocarbons. The decline of production from 240 million barrels in 1972 to 220 million barrels in 1973 accounts for the decline of remaining reserves to 1,560 million barrels, a ratio of 7.1.

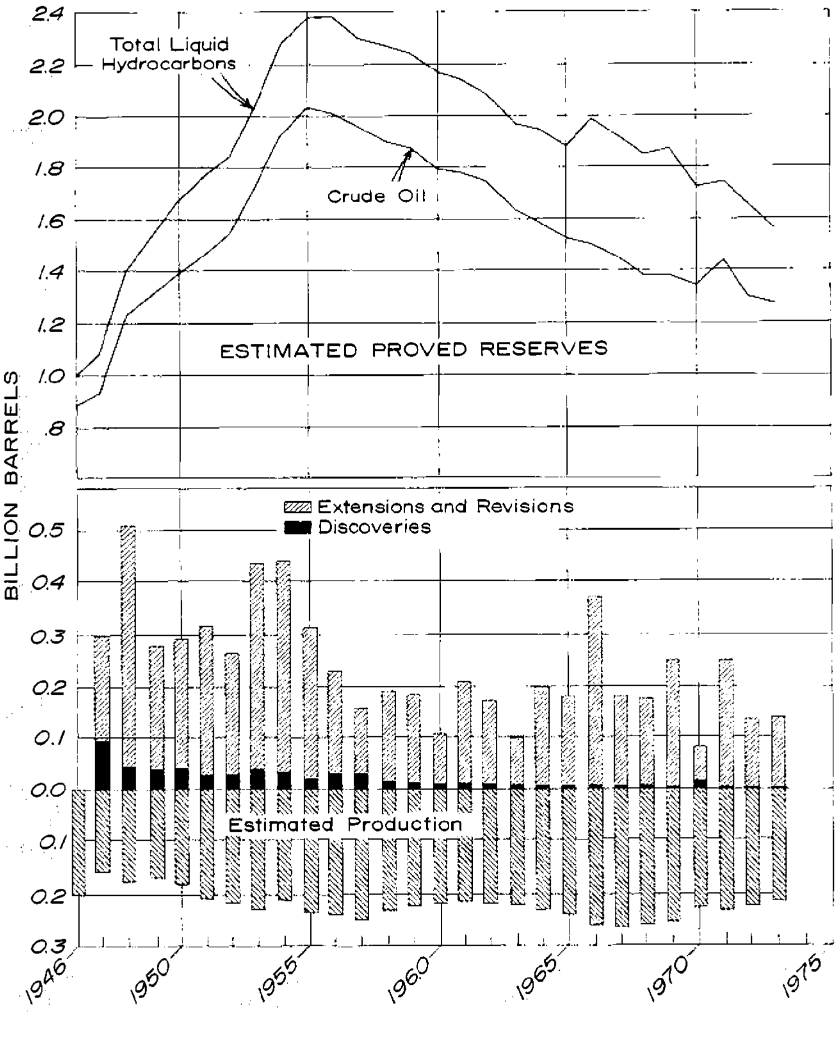

Figure 4. Graph showing statistics on estimated proved reserves of total liquid hydrocarbons in Oklahoma, 1946-73. Source: American Petroleum Institute, annual reports.

Oklahoma continues to rank third in the nation in gas production (with 7.9 percent of the total U.S. production) and fourth in crude-oil production (5.6 percent of the total). The State ranks fourth in terms of natural-gas reserves and fifth in oil reserves.

TABLE 4.—HYDROCARBON PRODUCTION IN OKLAHOMA

	1972	1973
Crude oil and lease condensate		
Total annual production (1,000 bbls)[1]	207,633	193,107
Value ($1,000)[1]	709,033	753,117
Cumulative production 1891-year (1,000 bbls)	10,804,434	10,997,541
Daily production (bbls)	567,303	529,060
Total number of producing wells[2]	73,807	73,025
Daily average per well (bbls)	7.7	7.2
Oil wells on artificial lift (estimated)[2]	69,807	69,082
Natural gas		
Total annual marketed production (MMCF)[1]	1,806,887	1,771,626
Value ($1,000)[1]	294,523	327,751
Total number of gas and gas-condensate wells[2]	8,453	8,868
Natural-gas liquids		
Total annual marketed production (1,000 bbls)[1]	41,707	42,500
Value ($1,000)[1]	99,810	110,550

[1]Item for 1972 is U.S. Bureau of Mines final figure. Item for 1973 is U.S. Bureau of Mines preliminary figure.
[2]*World Oil*, annual forecast and review issue, v. 178, no. 3, February 15, 1974.

USGS to Set Up Regional Core Libraries

An important segment of a new 5-year program instituted by the U.S. Geological Survey to develop new exploratory ideas and techniques for use by the oil and gas industry involves setting up regional well-core libraries. The program is under the direction of C. Keith Fisher of the USGS Denver office, and the first of these repositories will be developed in the Denver area to store all core material available from the Rocky Mountain states. Material is expected to come from exploration-company libraries, academic institutions, state groups, and from outfits currently drilling wells—in short, from all sources where it is in jeopardy of being lost through lack of space or facilities. Successful development will depend on cooperation and coordination from state surveys and from industry.

Future plans for the core libraries call for the USGS to phase out its supervision of the regional facilities and turn them over as self-sustaining operations supported by state survey agencies, professional societies, private companies, and individuals.

Comments on the core library project are solicited by the USGS and should be addressed to C. Keith Fisher, U.S. Geological Survey, Federal Center, Denver, Colorado 80225.

Facies and the Reconstruction of Environments

A Review

ELIZABETH A. HAM[1]

Facies and the Reconstruction of Environments, Selected Papers Reprinted from AAPG Bulletin, compiled by Jules Braunstein. The American Association of Petroleum Geologists, 1974, 223 p. AAPG Reprint Series No. 10. $5.

Emphases change, in geology as in other realms of man's search after knowledge, and it seems now as if the earth sciences are caught up in a wave of nostalgia. Geology, almost by definition, has always been concerned with the way things were, but there are more and more current releases dealing with paleoenvironments, paleogeography, tectonics, paleotemperatures, paleocurrents, paleoecology, and facies, facies, facies.

No. 10 in the AAPG Reprint Series is educational, reeducational, and, at the risk of committing a pun, timely.

This paperback publication, made up of 8 selected articles by 9 well-selected authors, reprinted from the AAPG *Bulletin,* is evolutionary in its structure of proceeding from the concept of facies to the methodology of study of the concept and then to the practical applications of the results obtained. The book is time-progressive, however, in the structure of its presentation of papers, moving from Thomas G. Payne's 73-page article, "Stratigraphical Analysis and Environmental Reconstruction," first published in the *Bulletin* in 1942, to Gary A. McDaniel's "Application of Sedimentary Directional Features and Scalar Properties to Hydrocarbon Exploration," which appeared in the September 1968 issue.

Time stops with that issue, and although the reason for terminating the reprints in 1968 is explained succinctly by Jules Braunstein in his excellent brief preface—"newer volumes are readily available to interested readers"—this reader was left with the letdown feeling experienced at the termination of an absorbing series. One hopes that some day there will be a follow-up.

In addition to the sudden ending, another unfortunate but necessary detraction from the excellence of this volume is the omission of material on carbonate rocks; as Braunstein states in the preface, the AAPG plans other reprint volumes on carbonates.

The most comprehensive paper, a refresher course in itself, is Payne's lengthy article, already mentioned. The terminology is expansive, with full descriptions of concepts leading to the choice of terms. Categories, subcategories, methods of study, methods of application, and numerous illustrated and tabular examples of processes and contributing conditions from living organisms to geographical factors to dynamism are included.

Were the volume arranged in logical progression, however (from the concept through methodology to the practical application in resource explo-

[1]Assistant Editor, Oklahoma Geological Survey.

ration), rather than chronologically, it would have begun with either J. Marvin Weller's article, "Stratigraphic Facies Differentiation and Nomenclature," or Curt Teichert's "Concepts of Facies." Weller's paper is really a beginning, a definition, and Teichert's is loaded with the history of the subject, from Steno in 1669 through modern-day sedimentologists. Both of these papers offer a plethora of valuable references, making them doubly significant.

An article by W. C. Krumbein and F. G. Nagel, "Regional Stratigraphic Analysis of 'Upper Cretaceous' Rocks of Rocky Mountain Region," is valuable for its instructions on the preparation of maps. This paper offers a good footing for the approach taken in the articles by John M. Andrichuk, Robert W. Stapp, and Gary McDaniel, all of which are concerned primarily with applying the study of facies and paleoenvironments to the recovery of fossil fuels. Charles D. Masters' short article (10 pages) with a long title, "Use of Sedimentary Structures in Determination of Depositional Environments, Mesaverde Formation, Williams Fork Mountains, Colorado," anticipates some of the recent work published by several scientists, including John Shelton, who authored Oklahoma Geological Survey Bulletin 118, which sets forth a methodology for determining sand genesis and which was published in October 1973.

Facies and the Reconstruction of Environments is nostalgic in more ways than one. It is bound to take readers back to an academic time when they studied these concepts in a classroom, perhaps under one of the authors included, perhaps even under Professor G. E. Anderson at The University of Oklahoma.

U.S. Board on Geographic Names Decisions

Ivanhoe Creek (variants: Lyanhae Creek, Manbee Creek) has been adopted by the U.S. Board on Geographic Names to identify a 26-mile-long (42 km) stream which heads in Lipscomb County, Texas, at 36°27′29″ N., 100°10′30″ W., and flows northeast into Wolf Creek 3.5 miles (5.6 km) west northwest of Shattuck in Ellis County, Oklahoma (sec. 24, T. 21 N., R. 26 W., Indian Meridian; 36°17′21″ N., 99°56′38″ W.). (U.S. Board of Geographic Names, *Decisions on Geographic Names in the United States*, Decision List 7401, January through March 1974, p. 12.)

Seneca Creek (variants: Cieneguilla Creek, Cienequilla Creek, Cienequillia Creek, Cienquilla Creek, Cienquillia Creek, Cinequillia Creek) has been adopted by the U.S Board on Geographic Names to identify a stream 50 miles (80 km) long, which heads in Union County, New Mexico, at 36° 37′10″ N., 103°38′30″ W., and flows eastward to join Corrumpa Creek to form the Beaver River 4.5 miles (7.2 km) northwest of Felt, in Cimarron County, Oklahoma (sec. 32, T. 2 N., R. 2 E., Cimarron Meridian; 36°35′52″ N., 102°52′00″ W.). (U.S. Board on Geographic Names, *Decisions on Geographic Names in the United States,* Decision List 7402, April through June 1974, p. 16.)

New Brachiopod Bulletin Released by Survey

Bulletin 119, an investigation of Late Ordovician-Early Silurian brachiopods, has just been released bv the Oklahoma Geological Survey. Written by Survey geologist Thomas W. Amsden, the report describes articulate brachiopods from the Keel Formation of the Arbuckle Mountain region of Oklahoma and from correlative units in the Edgewood Group of southwestern Illinois and eastern Missouri, in the Mississippi River valley.

The study is of special significance, because faunas of this general age (Late Ordovician and Early Silurian) have been little known, not only for the central United States but for many parts of the world. An interesting characteristic of the faunas described in this report is their similarity to the *Hirnantia* fauna of Europe.

The combined faunas of the Keel Formation and the Edgewood Group total 29 species, of which 8 are new; 27 genera are represented, of which 4 are new: *Leptoskelidion, Biparetis, Brevilamnulella,* and *Thebesia.* The 26 fossil plates included in the report illustrate silicified specimens of excellent preservation, showing exterior and interior structure in detail.

Additional illustrations comprise 2 plates of photomicrographs of Edgewood thin sections and 51 text-figures of various kinds. An appendix containing detailed descriptions of collecting localities and 13 tables of biometric data rounds out the publication.

The 154-page Bulletin 119, *Late Ordovician and Early Silurian Articulate Brachiopods from Oklahoma, Southwestern Illinois, and Eastern Missouri,* can be ordered from the address on the front cover of the *Notes.* Paperbound copies are $6.50 apiece, and hardbound copies, $8.50.

Notes Available in Microform

The Oklahoma Geological Survey has entered into an agreement with Xerox Corporation that makes *Oklahoma Geology Notes* available through the Xerox University Microfilms Serials Program. Since 1949, Xerox University Microfilms has produced microfilm and microfiche of the world's leading serials for libraries and for scholars. The collection includes approximately 7,000 periodicals, dating from 1668 to the present.

Under the terms of our agreement, current issues of the *Notes* will be sold in miniature form only to bona fide subscribers to the publication. These copies will not be distributed until the end of the volume year, at which time the entire volume will be delivered. Back issues (dating back from 1941-73) will be available in miniature form to all who request them regardless of whether they subscribed to the original edition.

For additional information about the micro-edition of the *Notes,* please contact Xerox University Microfilms, 300 North Zeeb Road, Ann Arbor, Michigan 48106 (phone: 313, 761-4700).

U.S. Bureau of Mines and State Legislative Council Sponsor Field Trip

The U.S. Bureau of Mines Liaison Office in Oklahoma, cooperating with the State Legislative Council, sponsored a field trip September 18-19 to the coal-mining area of eastern Oklahoma. Robert Arndt, USBM Liaison Officer-Oklahoma, was the principal organizer, and Senator Leon Field, Senator Bob Funston, and Representative Earnest Isch, members of the State Legislative Council's Committee on Soil and Water Resources, were in attendance, along with representatives of several State agencies, personnel from certain federal agencies, and persons from various concerned citizens groups who were invited to attend.

People sometimes overlook opportunities to influence or consult with State legislators by forgetting that these elected officials work for them even during the 7 months of the year when the Legislature is not in session. The work of the State Senate and House of Representatives is carried on during the legislative interim by committees that are organized under the auspices of the State Legislative Council. The committees are assigned to gather data on specific issues and make recommendations on what and whether legislation needs to be enacted when the State Legislature convenes.

State Senator Bob Funston, a member of the State Legislative Council's Committee on Soil and Water Resources, examines unreclaimed coal land in eastern Oklahoma. The committee chairman, Senator Leon Field, and Representative Earnest Isch also participated in the 2-day field trip.

Participants on the USBM-State Legislative Council field trip examine an area northeast of Stigler that has been surface mined and then reclaimed by Garland Coal and Mining Company. Mrs. H. H. Holman, who represented the League of Women Voters on the trip, photographs grasses growing from the shaly terrain.

The field trip to eastern Oklahoma enabled members of the Committee on Soil and Water Resources to compare, firsthand, the dramatic differences in the appearance of land mined before Oklahoma passed reclamation laws versus that reclaimed under the Reclamation Act of 1968 and the 1971 act. The legislators also talked to employees of several coal companies and to fellow trip participants about current mining practices. Pertinent aspects of surface mining for coal—including technology, geology, applied and natural reclamation, the reasons for the existence of unreclaimed land in Oklahoma and the problems caused thereby, the potential for utilization of reclaimed land, standards for environmental quality and their relationship to existing and pending national and state laws and legislation—were considered during the 2 days. Material passed out to all participants included Oklahoma Geological Survey map GM-17, *Description of Disturbed and Reclaimed Surface-Mined Coal Lands in Eastern Oklahoma,* by Kenneth S. Johnson. State Legislators, state and federal employees, mining personnel, and interested citizens had an opportunity to learn from each other, and the consensus seemed to be that more beneficial action, finer representation, and more cooperation between all parties would result if opportunities for interaction could somehow be devised for all persons involved whenever state or federal legislation is contemplated.

—Rosemary L. Croy

GSA Special Papers Deal with Ammonoids and Conodonts from Arkansas and Oklahoma

Two recent publications by The Geological Society of America are of special interest to Oklahoma geologists.

Special Paper 145, *Upper Mississippian Ammonoids from Arkansas and Oklahoma*, by W. Bruce Saunders, concerns itself with the Imo Formation of northeastern Arkansas and the Rhoda Creek Formation of south-central Oklahoma, which contain rich ammonoid assemblages of approximately equivalent age. Studies such as this one are providing refined standards for detailed regional and worldwide biostratigraphic correlations.

Special Paper 152, *Late Mississippian and Early Pennsylvanian Conodonts, Arkansas and Oklahoma*, by H. Richard Lane and Joseph J. Straka II, presents a comprehensive systematic treatment of conodonts from Late Mississippian and Early Pennsylvanian rocks exposed in the type Springerian and Morrowan regions. One important contribution of the 144-page report is that it demonstrates that the Springerian Series is not a viable time-stratigraphic subdivision of the Lower Pennsylvanian.

The 110-page Special Paper 145 sells for $6.50, and Special Paper 152 costs $12.50. Both can be ordered from The Geological Society of America, Publication Sales Department, 3300 Penrose Place, Boulder, Colorado 80301.

New Thesis and Dissertations Added to OU Geology Library

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

Evolution of Folds in the Blaylock Formation (Silurian), Ouachita Mountains, Southeastern Oklahoma, by Roger E. Feenstra.

The following Ph.D. dissertations have also been added to the library:

Brachiopod Biostratigraphy and Faunas of the Morrow Series (Lower Pennsylvanian) of Northwestern Arkansas and Northeastern Oklahoma, by Thomas Wood Henry.

The Structure of the Interlayer Water in Montmorillonite, by Garrett Louis Morrison.

Summary of October 1973 Rainstorm Enid and Vicinity, North-Central Oklahoma

U.S. Geological Survey

Heavy and intense rainfall centered over the urban area of Enid, Oklahoma, on October 10 and 11, 1973, resulting in record-breaking floods and extensive damage along many streams in north-central Oklahoma. This report shows the distribution of the intense rainfall and briefly describes the flooding and damage from that storm. The data presented are a summary of U.S. Geological Survey Water-Resources Investigations 27-74, entitled *Flood of October 1973 in Enid and Vicinity, North-Central Oklahoma,* by R. H. Bingham, D. L. Bergman, and W. O. Thomas, Jr.

The National Weather Service at Enid recorded 15.68 inches (39.83 cm) of rainfall in 13 hours, and 12 inches (30 cm) of that amount fell between 6:45 and 9:45 p.m. on October 10. The maximum amount registered for a 1-hour period was 5.3 inches (13.5 cm) between 8:00 p.m. and 9:00 p.m. Supplemental rainfall data collected by the National Weather Service and the U.S. Geological Survey were used to delineate an area of approximately 500 square miles (1,300 km^2) that received more than 10 inches (25 cm) of rainfall and an area of approximately 100 square miles (260 km^2) that received 15 to 20 inches (38 to 51 cm; fig. 1).

Rainfall during the October 1973 storm represented 54 percent of the mean annual precipitation of 29.15 inches (74.0 cm) at the Enid weather station, and it was approximately 7 times greater than the normal October rainfall of 2.27 inches (5.77 cm). The total rainfall for the 13-hour storm, 15.68 inches (39.83 cm), exceeded the State's previous 24-hour record of 12.3 inches (31.2 cm) for any October since the State first began recording weather information in 1892.

Peak discharges at one crest-stage partial-record station and at 15 miscellaneous sites were determined by indirect methods using hydraulic formulas for flow in open channels, flow over road embankments, and flow through contracted openings at bridges and culverts. Peak-unit discharge, which generally is expressed in cubic feet per second per square mile or cubic meters per second per square kilometer, is an indication of flood intensity. During the October 1973 flood, the peak-unit discharge at the indirect-discharge-measurement sites ranged from 140 cubic feet per second per square mile (1.53 cubic meters per second per square kilometer) for Osage and Pond Creeks at Jefferson to 1,660 cubic feet per second per square mile (18.09 cubic meters per second per square kilometer) for the Sand Creek tributary near Kremlin. The peak discharges for many streams within the storm area exceeded the calculated 100-year flood. The 1957 flood was larger in areal extent, and certain isolated storms have caused higher peak-unit discharges, but the October 1973 flood is documented as having the highest magnitude or peak-unit discharge over such a large area. All flood runoff from the storm drained into Keystone Lake at the confluence of the Arkansas and Cimarron Rivers about 90 miles east of Enid. The lake stage and amount of water stored during this flood was the peak of record; however, the lake had adequate capacity to store and regulate all the storm runoff and thus prevented damage downstream.

Runoff from the storm resulted in record-breaking floods on many streams in north-central Oklahoma. Long-time residents of areas where flooding was the most severe reported that stream stages during the Oc-

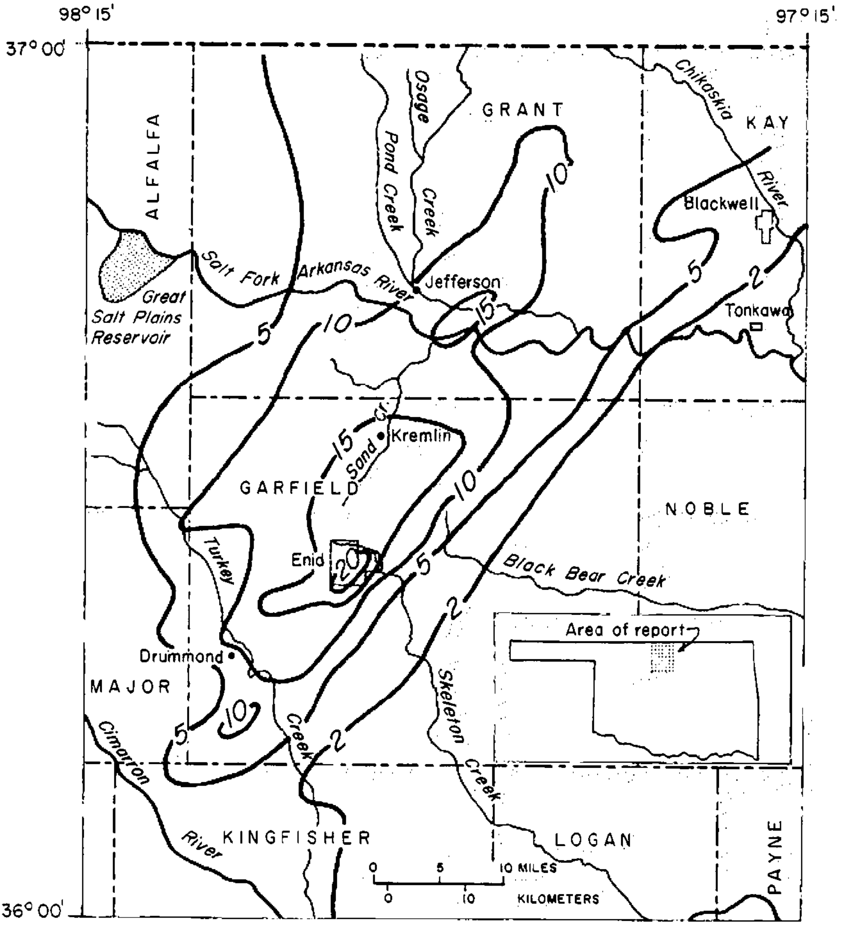

Figure 1. Rainfall map of 1973 storm, Enid and vicinity, north-central Oklahoma. Lines show areas of equal rainfall; numbers show amount of rainfall, in inches.

tober 1973 flood were higher than any previous stages since at least 1889. The long-term gaging stations on Turkey Creek near Drummond and on the Salt Fork of the Arkansas River near Tonkawa showed all-time maximum stages and discharges. The 1923 peak stage was higher than the 1973 peak stage on the Arkansas River at Ralston, about 30 miles east of the area shown in figure 2; however, the peak discharge of the October 1973 flood was greater, as a result of channel scour that developed during the intervening years. The Chikaskia River at Blackwell reached its highest recorded stage since 1923, and it caused extensive flooding in the town of Blackwell.

The October 1973 flood was memorable in terms of devastation. The rainfall centered over the large urban area of Enid, which made flood damage especially severe (figs. 2, 3). The towns of Blackwell, Dover, Jefferson, and Tonkawa were also badly damaged. Nine lives were lost in the floodwaters, 7 of the 9 within the city of Enid. In addition, highways, county roads, bridges, city streets, and railroads were damaged considerably. Thousands of acres of winter wheat and topsoil were lost by erosion. Total flood damage was estimated at $78 million by the Oklahoma State Civil Defense Agency. Because of intensive residential and agricultural damage,

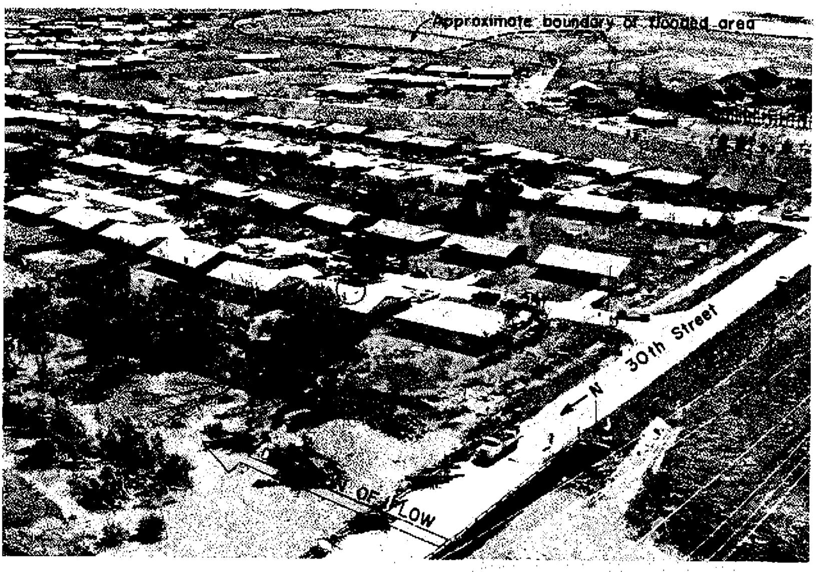

Figure 2. Area flooded by Boggy Creek at 30th Street in Enid. Note hole cut in roof of house by occupants, so they could escape fast-rising floodwaters. Photograph by Kenneth Gill, U.S. Army Corps of Engineers.

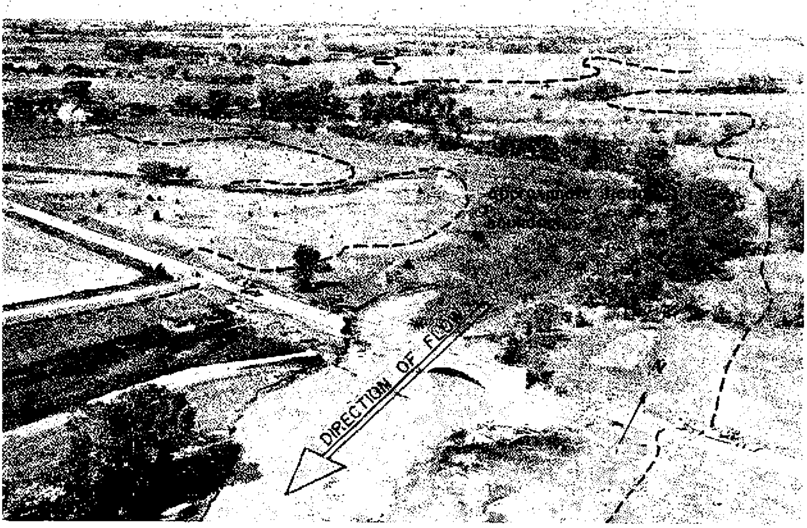

Figure 3. Flooded area and damage along Skeleton Creek in vicinity of Willow Road, near Enid. Photograph by Kenneth Gill, U.S. Army Corps of Engineers.

the President of the United States declared the City of Enid, plus Garfield, Grant, Kay, Kingfisher, and Noble Counties, disaster areas. Parts of Pawnee and Osage Counties were also declared disaster areas by the President, because there was so much agricultural damage.

Reference Cited

Bingham, R. H., Bergman, D. L., and **Thomas, W. O.,** 1974, Flood of October 1973 in Enid and vicinity, north-central Oklahoma: U.S. Geological Survey Water Resources Investigations 27-74.

AAPG Releases Film Index

The American Association of Petroleum Geologists' Public Information Committee, chaired by Gary A. McDaniel, has compiled *Index to Films Related to Geology and Energy Exploration.* The catalog was prepared to assist in locating audiovisual aids pertaining to the earth sciences. The films are listed by subject matter (178 films, classified by categories such as earthquakes, glaciology, oceanography, and outer-space geology). A brief description of each film is included, as is the source for each and information about rental charges. The price of the index is $3.50, prepaid, and it is available in loose-leaf form, ready for insertion in a 3-ring notebook.

Earth Science Editors Bask on California Beaches

Some 50 earth-science editors, including Bill Rose, Oklahoma Geological Survey editor, and Rosemary Croy, OGS associate editor, were persuaded to take a few days from their regular duties to attend the Association of Earth Science Editors eighth annual meeting October 13-16 at Asilomar Conference Grounds near Pacific Grove, California. For Bill, the sacrifice was more complete than for most of the editors, because his daughter and son-in-law live in nearby Monterey, and he was absolutely forced to take a few days of vacation time and prolong his stay.

Asilomar, a unit of the California State Park system, is situated on the tip of the Monterey Peninsula amid acres of pine trees, a breathtaking setting for any meeting. A welcoming address by James E. Slosson, California State Geologist, a seminar on "Paper," highlighted by contributions from Crown Zellerbach representatives, and panel discussions on "Innovations" and the "Impact of Rising Costs on the Future of Publications" consumed much of the daylight hours, but time was allowed before and after technical sessions for a barbecue at the ocean's edge and walks along the beach or through the forest. In addition, a field trip planned in conjunction with the meeting featured a view of the San Andreas fault, a tour of a local winery, and a hike in Point Lobos State Reserve, a 1,250-acre area along the south shore of Carmel Bay that the National Park Service has designated a Registered Natural Landmark.

The AESE Award for Outstanding Contributions in the Earth Sciences went to Marie Siegrist this year. When the *Bibliography and Index of Geology Exclusive of North America* was first initiated, in 1934 (published by The Geological Society of America with funds from the Penrose Bequest), Marie was hired as an assistant to the late John M. Nickles, although he was reported to have had grave reservations about hiring a woman. With Mr.

Nickles' death in December 1945, Marie became editor. Early volumes of the *Bibliography* contained translations of article titles and occasional explanations, but beginning about 1947 brief annotations or abstracts were added to the citations, and several volunteers, known as farmees, were recruited to assist the two staff members with the abstracting. Volumes 11-30 of the *Bibliography*, with Marie as editor, contain approximately 124,000 abstracts that have been read, edited, and proofread by her. In reporting on the award committee's selection of Marie Siegrist as the second recipient of the AESE Award, the chairman, Pete Wilshusen, commended her "ability to write a concise précis, her linguistic talents, wise observation of rules, immeasurable patience, judicious use of time . . . good humor, ingenuity, and sincere dedication."

New AESE officers introduced at the Asilomar conference were George E. Becraft, chief of the Office of Scientific Publications for the U.S. Geological Survey, president; Patricia Wood Dickerson, editor, Bell & Murphy & Associates, Houston, vice-president and president-elect; John L. Heller, chief, Denver Editorial Section, U.S. Geological Survey, secretary-treasurer; and John D. Haun, Department of Geology, Colorado School of Mines, director (John Haun is also the new president-elect of the American Institute of Professional Geologists).

Next year the Association of Earth Science Editors will hold its annual meeting November 16-19 in Hershey, Pennsylvania. Pete Wilshusen and the Pennsylvania Geological Survey will serve as hosts.

Kansas to Host Conference on Remote Sensing

The research committee of The American Association of Petroleum Geologists and the U.S. Geological Survey have teamed with The University of Kansas in planning a research conference on remote sensing, which will be held February 18-20 at the university's Space Technology Center in Lawrence.

The stated objective of the conference is dissemination of specific applications of remote-sensing technology, with stress on exploration for and exploitation of natural resources. The conference speakers, drawn from industry, government, and academic institutions, will present case histories that have utilized ERTS, side-look-airborne-radar (SLAR), thermal-infrared, conventional, low-altitude, snow-enhanced, low-sun-angle, multi-spectral, and sonar imagery.

For information on registration and other details, contact Dr. Louis Dellwig, Remote Sensing Laboratory, The University of Kansas, 2291 Irving Hill Drive, Lawrence, Kansas 66044.

OKLAHOMA ABSTRACTS

GSA ANNUAL MEETINGS, MIAMI BEACH, FLORIDA NOVEMBER 18-20, 1974

The following abstracts are reprinted from the *Abstracts with Programs* of The Geological Society of America, v. 6, no. 7. Page numbers are given in brackets below each abstract. Permission of the authors and of Mrs. Jo Fogelberg, managing editor of GSA, to reproduce these abstracts is gratefully acknowledged.

Gravity Tectonic Model for Development of Junction between Appalachian and Ouachita Orogenic Systems

JOHN M. DENNISON, Department of Geology, University of North Carolina, Chapel Hill, North Carolina

Gravity tectonics have been recently advocated for the Ouachitas (Viele, 1973) and the Appalachians (Dennison, 1974). Their junction in central Alabama probably formed by this succession of events:

1. The region was Middle Ordovician-Middle Mississippian craton margin, accumulating limestone, chert, and dolomite, some sandstone from an eastern source (Ordovician and Silurian) and the craton (Devonian), and shale. Four regional unconformities occur in this time span.
2. Late Mississippian eastern and southwestern source areas rapidly rose, with the tilting developing a trough between the uplifted areas and the craton margin. Pennington Formation red shale and sandstone came from the east, and from the southwest came Floyd Shale, Hartselle-type sandstone, and Parkwood Formation.
3. Pottsville clastics indicate both sources, with over 9,000 feet accumulation in a broad basin near the juncture of the two downward-tilted blocks, with syndepositional structures that influenced later tectonic fragmentation patterns of the broad basin.
4. More rapid uplift of the southern block resulted in unstable slopes displaced northward by Ouachita gravity tectonics. Folds and faults trend east in the Alabama subsurface and crop out in Chilton County.
5. Northwestward tilting of the eastern block resulted in Alleghany orogeny gravity tectonics, with northeast-trending folds and faults overprinting the Ouachita trend in Chilton County. The broad depositional basin was fragmented by the Alleghany orogeny, producing the separate Warrior, Cahaba, and Coosa basins.

The Ouachita-Appalachian junction is angular because the two orogenic belts formed at different times, probably mid-Pennsylvanian and Permian. [708]

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.

U-Pb Ages of the Spavinaw and Tishomingo Granites, Oklahoma

R. D. LEWIS and M. E. BICKFORD, Department of Geology, University of Kansas, Lawrence, Kansas

Exposures of Precambrian basement rocks in Oklahoma include the Spavinaw Granite in the northeastern part of the state and the Tishomingo Granite in the Arbuckle Mountains region. U-Pb ages of suites of cogenetic zircons from both rocks are about 1400 m.y. Previously reported mineral ages from these granite bodies are about 1350 m.y. and a Rb-Sr isochron derived from whole-rock samples from the northeastern Oklahoma basement has yielded an age of about 1320 m.y.

The zircon ages reported here suggest that the rock bodies studied are somewhat older than previous measurements indicated, but they are significantly younger than the 1500 m.y. zircon ages of rocks from the St. Francois Mountains of Missouri, which are petrographically similar to the Spavinaw Granite and many other rocks in the Oklahoma basement. Although basement rocks of major segments of the midcontinent region are petrographically similar, they are apparently not coeval and may record a complex history of crustal evolution. [844-845]

U.S. Department of the Interior Energy Data Files

RICHARD F. MEYER, Office of Energy Resources, Geologic Division, U.S. Geological Survey, Reston, Virginia

Interior Department energy-related data files are maintained in the Bureau of Mines and Bureau of Land Management and in the Geological Survey. Most such files were operational or in process of construction before the recent oil embargo accented their need. The files cover leasing, production, reserves, and geological occurrence of petroleum liquids, natural gas, oil shale, nuclear fuels, coal, and geothermal resources. Most of the files are built and maintained in-house, such as the Geological Survey's CRIB system but others are operated through contract. An example of the latter is the Survey's Petroleum Data System. The CRIB file is comprised of 25,000 records of 150 entries each and utilizes IBM 360/370 hardware with GIPSY software. This file is in the process of being made publicly available. The Petroleum Data System was built under contract to the University of Oklahoma, uses hardware and software compatible with CRIB, is open to the public, and consists of 65,000 oil and gas pool records as well as a separate file of well records. The oil and gas pool records are derived from published documents and are continually up-dated. The other energy-related files are similarly prepared, with major efforts now being made to make them compatible in both hard- and software. Significant steps are being taken within Government to identify existing and proposed data systems and coordinate their inputs as well as outputs. [868]

Correlation of Tremadocian Conodont and Trilobite Faunas, Europe and North America

JAMES F. MILLER, Earth and Planetary Sciences, University of Pittsburg at Johnstown, Pennsylvania, RICHARD A. ROBISON, Department of Geology, University of Kansas, Lawrence, Kansas, and DAVID L. CLARK, Department of Geology and Geophysics, University of Wisconsin, Madison, Wisconsin

Further study of faunas from the Tiñu Formation of Oaxaca, Mexico, provides new evidence for correlation of Tremadocian faunas. Trilobites from the lower calcareous member of the formation show strong similarity to Lower Tremadocian faunas in Europe, but little similarity to North American faunas. However, the presence of *Pseudagnostus, Richardsonella* and *Saukia* was used to correlate with the Upper Cambrian *Saukia* Zone elsewhere in North America (Robison & Pantoja-Alor, 1968). Restudy of conodonts from the Tiñu Formation now allows more precise comparison with conodont faunas from Texas, Oklahoma, Utah, and Alberta, and in combination with trilobites, improves the correlation between North America and Europe. The lower part of the lower member of the Tiñu Formation contains *Proconodontus notchpeakensis, Cordylodus proavus,* and *C. oklahomensis,* a conodont assemblage known elsewhere from the Cambrian *Corbinia apopsis* and Ordovician *Missisquoia* and *Symphysurina* trilobite zones. The upper part of the lower member contains *Cordylodus lindstromi, C. prion,* and *C. intermedius.* Elsewhere these species first occur somewhat above the base of the *Symphysurina* Zone. The upper shaly member of the Tiñu has an Upper Tremadocian trilobite fauna but no conodonts.

These data indicate: 1) at least part of the Lower Tremadocian of Europe correlates with the Lower Ordovician of North America; 2) the Lower-Upper Tremadocian boundary falls within the *Symphysurina* Zone; 3) the base of the Tremadocian probably is closer in age to the base of the North American Ordovician than has usually been suggested; and 4) the *Saukia* from Oaxaca, which has an Asiatic aspect, is probably Early Ordovician by North American standards. [1048-1049]

The Louisiana State University

Tephrochronology, Petrology, and Stratigraphy of Some Pleistocene Deposits in the Central Plains, U.S.A.

JOHN DAVID BOELLSTORFF, The Louisiana State University, PhD. dissertation, 1973

A simplified method of fission-track dating rhyolitic volcanic glasses has been developed. Eleven deposits of volcanic ash of Pleistocene age from the Central Plains have been dated by means of this technique. The Pearlette Ash (previously assigned late Kansan in age) consists of four significantly different ages of ash—about 0.61 m.y., 0.74 m.y., 1.21 m.y., and 1.97 m.y. The diverse ages of these ash deposits demonstrate some regional correlations are in error.

A new terminology for Pleistocene volcanic ashes in Central Plains is presented. This terminology requires knowledge of the age and the iron, manganese, and samarium content of the ash. This terminology includes both the Pearlette and non-Pearlette ashes.

ASH NAME	AGE CRITERION	CHEMICAL CRITERIA
Pearlette (restricted)	≃0.61 m.y.	≃1.1% Fe, 280 ppm Mn, 12 ppm Sm
Hartford	≃0.74 m.y.	≃1.1% Fe, 280 ppm Mn, 13 ppm Sm
Bishop	≃0.82 m.y.	≃0.6% Fe, 200 ppm Mn, 5 ppm Sm
Coleridge	≃1.21 m.y.	≃1.0% Fe, 240 ppm Mn, 11 ppm Sm
Borchers	≃1.97 m.y.	≃1.2% Fe, 280 ppm Mn, 14 ppm Sm

Heavy minerals and pebble types are useful for correlating tills over a large area. New correlations made with the aid of these types of data show several generally accepted till correlations may be in error. The new correlations indicate the Nebraskan Till of Shimek (1909) correlates with the upper till (Kansan of Bain, 1896 and Chamberlin, 1896) near Afton, Iowa, rather than the lower till (pre-Kansan). In addition, these correlations indicate Reed and Dreeszen's (1965) Nebraskan sequence in eastern Nebraska is older than the lower till (pre-Kansan or Nebraskan) near Afton, Iowa, and several formally designated till names with separate age-assignments have been applied to a single till sheet in Nebraska.

A chronology of early and middle Pleistocene deposits in the Central Plains, U.S.A., has been inferred from the till correlations and volcanic ash dates. This chronology indicates that the Nebraskan of eastern Nebraska is older than about 1.2 m.y. and is older than Shimek's (1909) Nebraskan Till and the pre-Kansan or Nebraskan till of the Afton, Iowa, area. The base of the Pleistocene in the Central Plains is at least about 2.0 m.y. old.

A comparison of the inferred chronology for the Central Plains with that of the Gulf of Mexico (Beard, 1969) suggests sediments termed Nebraskan in the Gulf of Mexico are older than those termed Nebraskan in the Central Plains.

As they stand, the new correlations and dates on volcanic ashes indicate much of the current terminology used to communicate information about early and medial Pleistocene events in Nebraska and adjoining areas may not be useful. In addition, the stage names Nebraskan, Aftonian and Kansan need reevaluation and possibly redefinition.

(Reprinted from *Dissertation Abstracts International*, Pt. B, v. 35, p. 891-B)

The University of Oklahoma

Algae and Paleoecology of Algal and Related Facies, Morrow Formation, Northeastern Oklahoma

DAVID ARTHUR KOTILA, The University of Oklahoma, Ph.D. dissertation, 1973

The Morrow Formation (Lower Pennsylvanian) in the Tenkiller-Ferry and Greenleaf Lake area of northeastern Oklahoma includes those strata unconformably overlying the Pitkin Formation and unconformably underlying the Atoka Formation. These two unconformities define the boundaries of the Morrow.

In the studied area the Morrow Formation is informally divided into four members which are, in ascending order: (1) Sandy Member, (2) Mixed Carbonate and Shale Member, (3) Algal Limestone and Shale Member, and (4) Black Shale and Carbonate Member.

Nine species of calcareous algae from six genera are described including one proposed new species and one proposed new genus.

The abundance and distribution of certain calcareous algae, corals, carbonate lithologies, and the stratigraphic framework of these within the Algal Limestone and Shale Member are interpreted as representing an algal bank environment in the south, southwest, and western parts of the studied area. Similarly the abundance of carbonate muds, intraclastic carbonates, burrows, and desiccation features within the same member are interpreted as representing a tidal-flat environment for the north-central part of the studied area.

Cessation of prolific carbonate deposition was caused by influx of large amounts of terrigenous clay, silt, and sand.

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