Oklahoma Geology Notes

OKLAHOMA GEOLOGICAL SURVEY / VOL. 46, NO. 4 — AUGUST 1986

On the cover—

Flute Casts in the Atoka Formation

Flute casts in the Atoka Formation in the Ouachita Mountains, southeastern Oklahoma, are pictured on the cover of this issue. Flute casts are formed when sand transported and deposited by turbidity currents fills scours eroded by the current in clay that immediately underlies the sand. Flute casts are excellent paleocurrent directional indicators (the deeper and more pointed end points up-current). Most of the flute casts in the Atoka Formation in the Oklahoma Ouachita Mountains indicate an east-to-west current flow direction—down the axis of the Ouachita trough.

Neil Suneson

photo by Neil Suneson

Oklahoma Geology Notes

Editor: Connie Smith
Editorial Assistant: Christie Cooper
Editorial Clerk: Eileen Hasselwander

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

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

Oklahoma Geology Notes

OKLAHOMA GEOLOGICAL SURVEY / VOL. 46, NO. 4 — AUGUST 1986

Contents

126 **Flute Casts in the Atoka Formation**
128 **Physical and Chemical Characteristics of Water in Coal-Mine Ponds of Eastern Oklahoma**
Stephen P. Blumer and Larry J. Slack
135 **Further Notes on Union Valley–Cromwell (Lower Pennsylvanian) Stratigraphic Relationships in Eastern Oklahoma**
Julian M. Busby
140 **Ouachita Guidebooks Indexed**
Neil H. Suneson
146 **OGS Hosts Coal Forum**
LeRoy A. Hemish
150 **99th Annual GSA Meeting Sets Sights on Texas in November**
151 **Christensen New Director of OSMRE**
152 **International Geological Congress Meets in Washington, D.C., in 1989**
153 **British Geology Journal Enters Second Year of Publication**
153 **Tennessee Poster Released**
154 **USGS Consolidates Facilities**
155 **Notes on New Publications**
158 **Oklahoma Abstracts—ACS National Meeting New York City, New York, April 13–18, 1986**
159 **Oklahoma Abstracts—AAPG, Southwest Section, Annual Meeting Ruidoso, New Mexico, April 27–29, 1986**
160 **Oklahoma Abstracts—Geological Society of America**

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, Section 231–238. 1,800 copies have been prepared for distribution at a cost of $1,167 to the taxpayers of the State of Oklahoma. Copies have been deposited with the Publications Clearinghouse of the Oklahoma Department of Libraries.

PHYSICAL AND CHEMICAL CHARACTERISTICS OF WATER IN COAL-MINE PONDS OF EASTERN OKLAHOMA

Stephen P. Blumer[1] and Larry J. Slack[2]

Introduction

Coal-mine ponds in eastern Oklahoma have a total area of about 4,000 acres (Johnson, 1974). The average measured depth of the ponds is about 25 ft; thus, the ponds provide storage for about 100,000 acre-ft of water. These ponds provide habitat for a variety of aquatic and semiaquatic wildlife. Water from some of the ponds is used for stock, irrigation, and municipal supply.

Water from 102 sites in 59 of these ponds was sampled during June to November 1977–81 to determine temperature, specific conductance, dissolved oxygen, pH, and concentrations of dissolved iron, manganese, chloride, and sulfate during a study of the hydrology of the Oklahoma coalfield (Slack and Blumer, 1984). These physical and chemical characteristics were selected as properties and constituents commonly affected by mining. Samples were collected at one or more depths at each site in ponds associated with one unnamed and seven named coal beds in 14 counties (Fig. 1). Variations in degree of mixing of the water in the ponds caused a wide range of measured values for the properties and constituents from site to site within a pond and with depth at a single site. Statistical data and profiles of temperature, specific conductance, dissolved oxygen, and pH for each sampling site and date are included in Slack and Blumer (1984).

Geologic Setting

The mine ponds sampled in the Oklahoma coalfield are located in pits left from mining of bituminous coal beds of Pennsylvanian age. The origin of the coal-mine ponds is described in Johnson (1974). The northeastern part of the Oklahoma coalfield is in the northeast shelf area, which is underlain mostly by interbedded sandstone, shale, and limestone; included are the following coal beds: Dawson (Seminole Formation), Iron Post (Senora Formation), Croweburg (Senora Formation), Weir-Pittsburg (Senora Formation), and Secor (Boggy Formation). Rocks of the shelf area contain more limestone than rocks of the southern part of the coalfield in the Arkoma basin (Friedman, 1978). The Arkoma basin is an eroded structural and

[1]U.S. Geological Survey, Oklahoma City.
[2]U.S. Geological Survey, Tuscaloosa, Alabama.

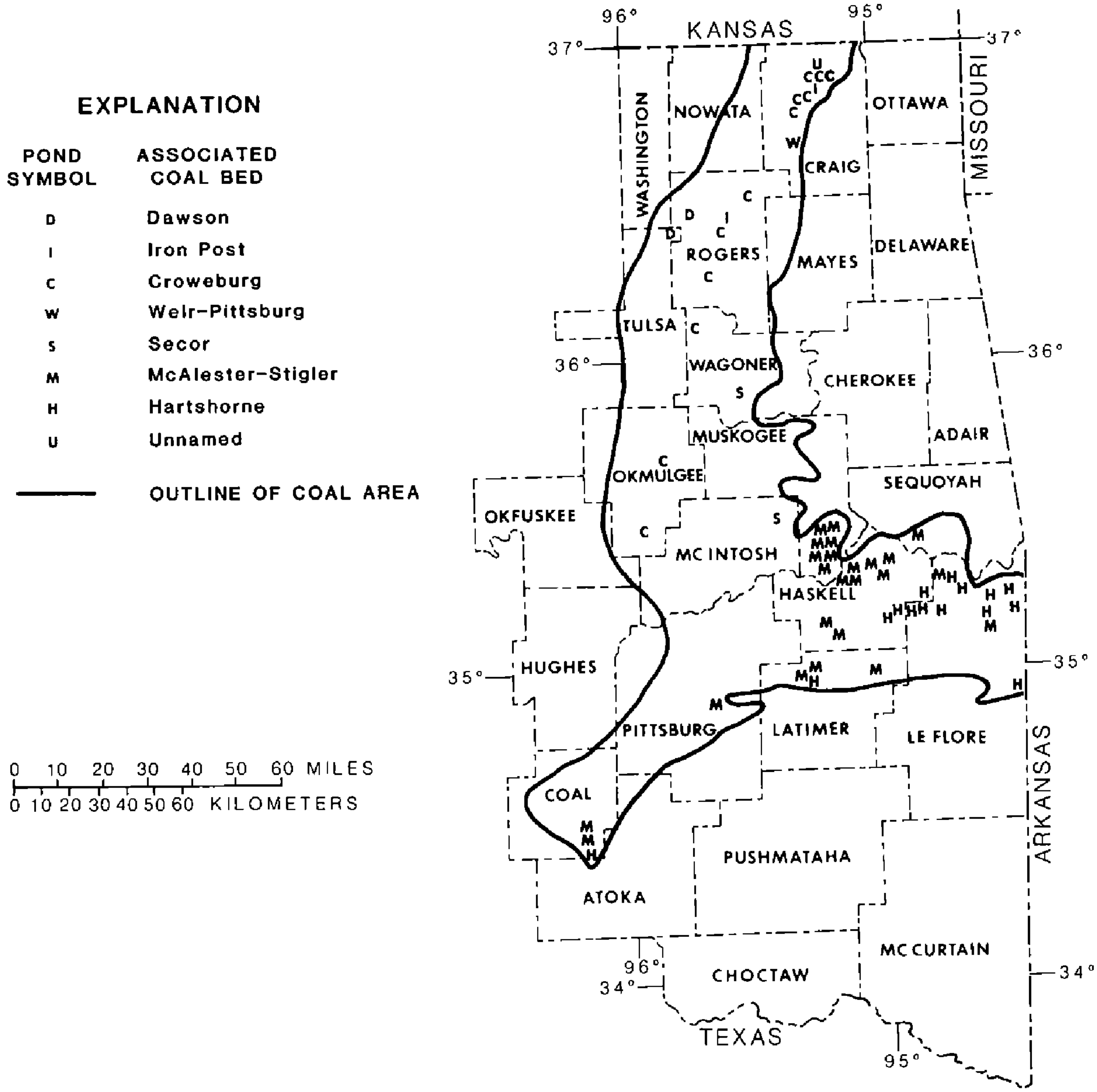


Figure 1. Location of study area and coal-mine ponds.

depositional basin which mostly contains sandstone, siltstone, and shale; included are the following coal beds: Secor (Boggy Formation), McAlester-Stigler (McAlester Formation), and Hartshorne (Hartshorne Sandstone).

Physical Characteristics

Water Temperature

During sampling in the summer months, surface water heated by the sun was less dense and was not mixed well with the underlying colder, denser water. Lack of mixing, especially in the ponds deeper than about 10 ft, resulted in thermal stratification of the water. A trend of lower temperatures with increased depth was determined for most of the ponds. Below a depth of about 30 ft the temperature usually showed no further change with depth.

From June to October, many Oklahoma coal-mine ponds were poorly mixed, and surface temperatures were as much as 23.5°C greater than bottom temperatures. Typical temperatures of a 20-ft-deep pond ranged from about 30°C at the surface to about 15°C at the bottom. Ponds that showed little or no change of temperature with depth generally were shallow or were sampled in early November when surface cooling causes ponds to become well mixed.

Specific Conductance

Specific conductance, a measure of dissolved solids in water, ranged from 93 to 4,800 μmho/cm at 25°C. This variation can be partly attributed to precipitation. Periods of increased precipitation dilute the ponds, resulting in a decrease in specific conductance. Sulfate is the principal ion in mine-pond water, and the specific conductance of mine-pond water varies from pond to pond in direct proportion to sulfate concentration. The specific conductance increased with depth for about 40% of the ponds, regardless of the mined coal bed.

The mean specific conductance was greatest in those ponds resulting from mining of the Dawson, Weir-Pittsburg, and Secor coal beds. The smallest specific-conductance values were for ponds associated with the McAlester-Stigler coal bed. The mean specific conductance of the mine ponds associated with each of the coal beds is shown in Figure 2.

Dissolved Oxygen

The dissolved-oxygen concentration of the coal-mine ponds usually decreased with depth during June to early October. Thermal stratification resulted in warmer, less-dense water at the surface, insulating the colder, denser water below. This prevented the denser water from contacting atmospheric oxygen. During the summer months, differences in dissolved-oxygen concentration of 6–8 mg/L from the surface to the bottom occurred in about 70% of the ponds. By November, usually little or no variation in dissolved-oxygen concentration with depth was detected.

pH

The pH of a solution is the negative base-10 log of the hydrogen-ion activity. The pH of pure water at 25°C is 7.0. In natural waters, pH usually is within the range 6.0–8.5, depending on equilibria reactions of species in the water (Hem, 1970). In coal-mine ponds, pH is governed by oxidation of sulfide minerals and subsequent buffering by carbonate minerals.

If the pH in coal-mine ponds were dependent only on the equilibria reactions of sulfate and ferrous iron, pH could be correlated with the mined coal bed and its associated impurities, especially pyrite. However, in the Oklahoma coal region, the median pH for the ponds associated with the

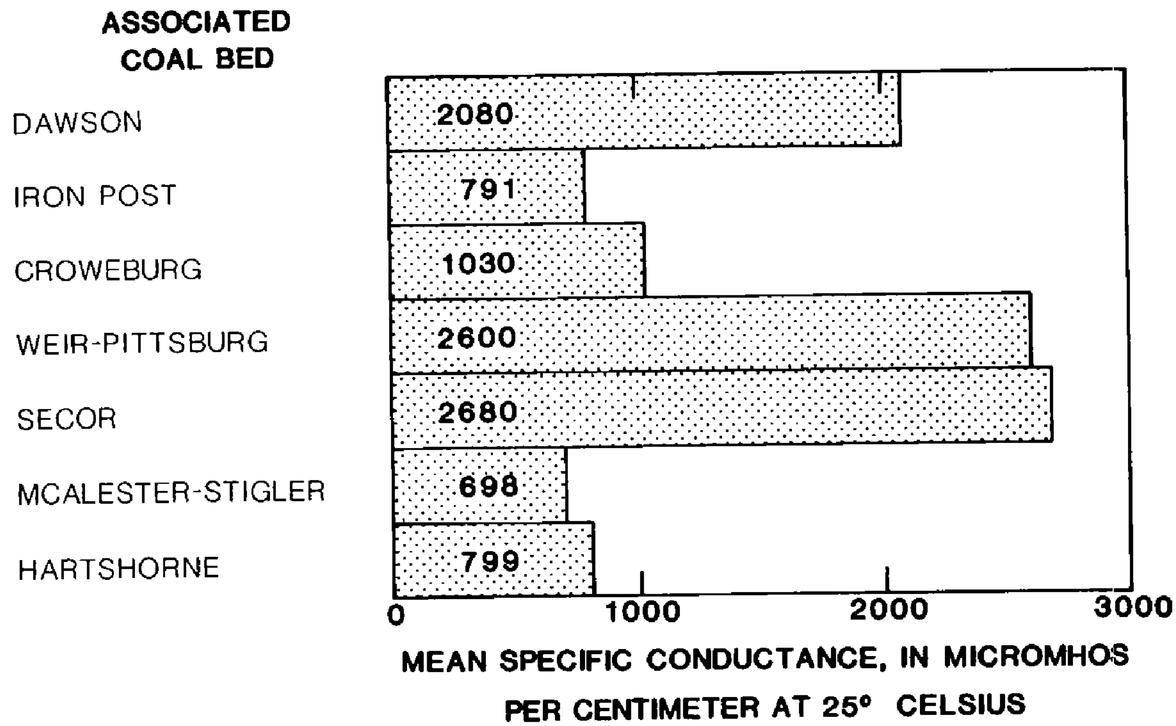


Figure 2. Mean specific conductance in coal-mine pond water associated with each coal bed.

Dawson, Iron Post, Croweburg, Weir-Pittsburg, McAlester-Stigler, and Hartshorne coal beds showed little variation (7.4–7.8). The only significant deviation was for ponds associated with the Secor coal bed (median pH 3.3). Excluding one of the two ponds associated with the Secor coal bed, the median pH for the ponds associated with the Secor coal bed was 7.7, virtually the same as for the ponds associated with all other coal beds. The pH of water in the coal-mine ponds generally decreased with depth.

Chemical Characteristics

Dissolved Iron

Iron is abundant in soils and sedimentary rocks both as ferrous (Fe^{+2}) and ferric (Fe^{+3}) iron. Sources of iron in natural waters generally include soils enriched with organic material, and iron-bearing minerals, chiefly sulfides, carbonates, and silicates.

Pyrite (FeS_2), a mineral common in coal, contains iron in its reduced (ferrous) form. When exposed to aerated water, pyrite is oxidized directly by oxygen or is dissolved and then oxidized. Conversely, ferric iron is dissolved in a reducing environment, which may exist at the bottom of a stratified lake.

The dissolved-iron concentration in the sampled coal-mine ponds usually was small; the median for all samples was 40 $\mu g/L$. In contrast though, the mean concentration of dissolved iron was greatest in those ponds associated with the Secor (3,000 µg/L), Dawson (2,100 µg/L), and Hartshorne (800 µg/L) coal beds (Fig. 3).

Dissolved Manganese

Thermal stratification and the limited mixing common in coal-mine ponds create a reducing environment at the pond bottom. In this environment manganese oxides are dissolved. Therefore, an increase in dissolved manganese with depth would be expected. This increase occurs in many of the eastern Oklahoma coal-mine ponds. For several ponds, the concentration of dissolved manganese varied as much as several thousand micrograms per liter from the surface to the bottom. The mean concentration of dissolved manganese was greatest in those ponds associated with the Secor (35,000 µg/L), Dawson (4,300 µg/L), and Weir-Pittsburg (3,700 µg/L) coal beds (Fig. 4). The mean dissolved-manganese concentrations were least for water associated with the Iron Post (850 µg/L) and McAlester-Stigler (910 µg/L) coal beds.

Dissolved Chloride

The most common source of chloride in natural waters is sedimentary rocks. Fine-grained marine shales and clays commonly contain sodium chloride from sea water. The chloride in most coal-mine ponds probably

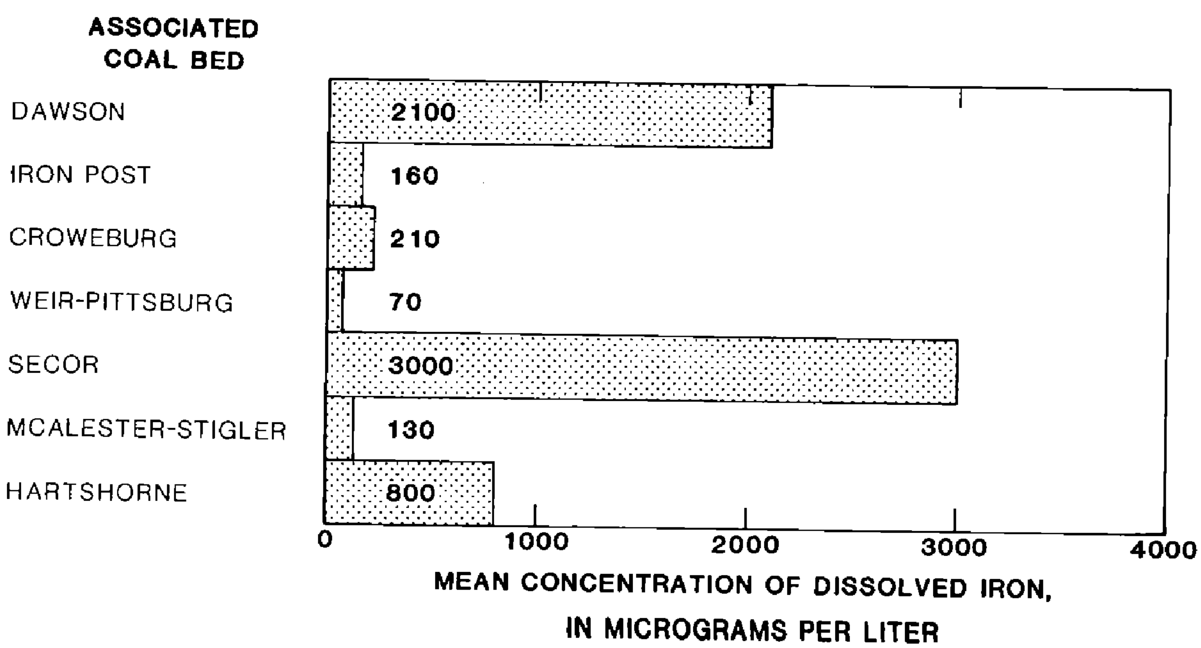


Figure 3. Mean dissolved-iron concentration in coal-mine pond water associated with each coal bed.

originated from leaching of sodium chloride from the surrounding shale, clay, and spoils by ground water and surface runoff.

The mean dissolved-chloride concentration was 140 mg/L for water in mine ponds associated with the Dawson coal bed. For mine-pond water associated with all the other coal beds, the mean concentration of chloride was 11 mg/L or less (Fig. 5).

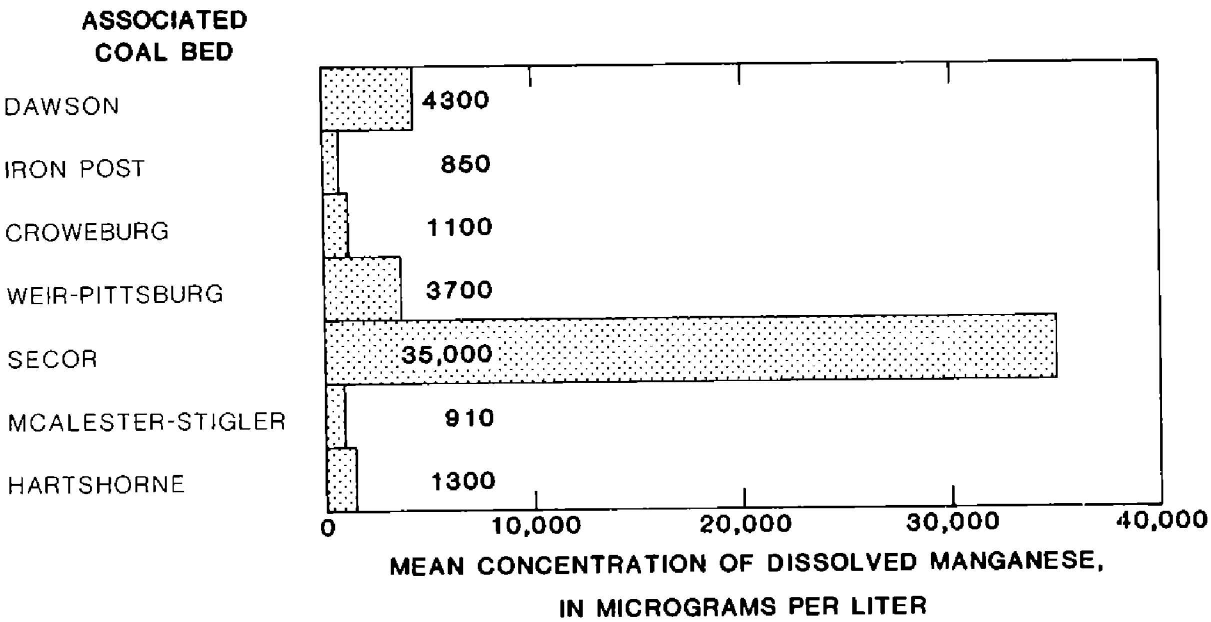


Figure 4. Mean dissolved-manganese concentration in coal-mine pond water associated with each coal bed.

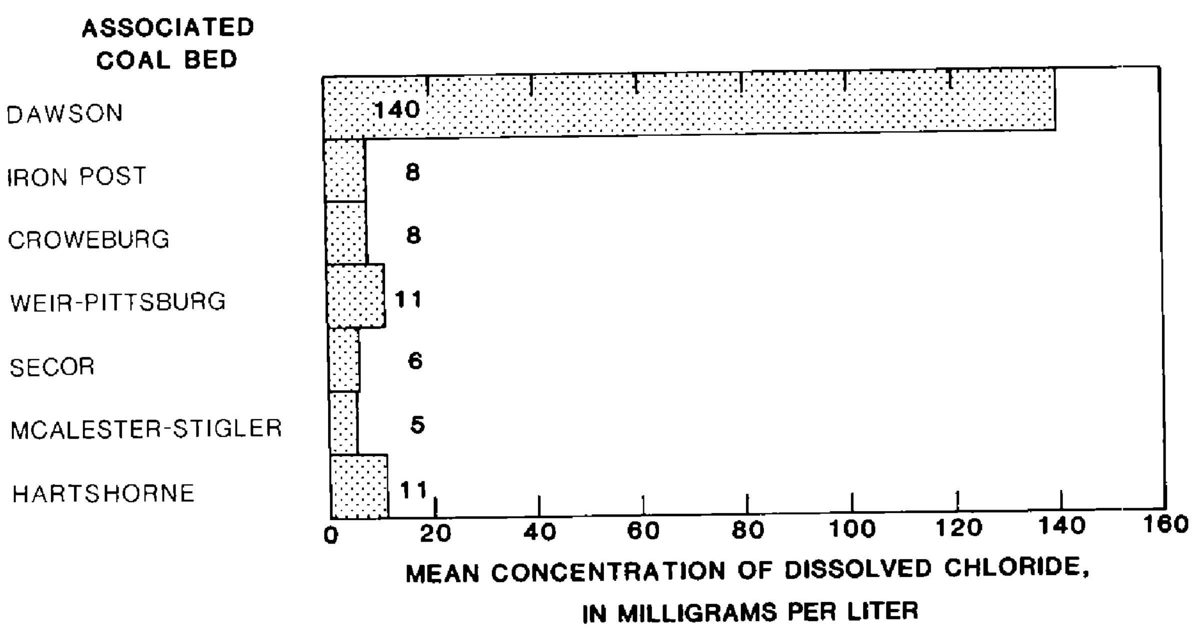


Figure 5. Mean dissolved-chloride concentration in coal-mine pond water associated with each coal bed.

Dissolved Sulfate

Pyrite contains most of the sulfur in Oklahoma coals (Friedman, 1974). The anaerobic conditions under which the coal was deposited was a favorable environment for the formation of pyrite. When the pyrite is later exposed to aerated water it is oxidized, producing sulfate ions in the water. The mean sulfur content (Friedman, 1974) of the seven named coal beds is as follows: Dawson, 4.6%; Iron Post, 4.0%; Croweburg, 1.9%; Weir-Pittsburg, 4.8%; Secor, 4.9%; McAlester-Stigler, 1.8%; and Hartshorne, 1.8%.

Mean dissolved-sulfate concentrations (Fig. 6) were greatest for the water in ponds associated with the Weir-Pittsburg (1,700 mg/L), Secor (1,700 mg/L), and Dawson (900 mg/L) coal beds, which beds have the greatest mean sulfur content. Sulfate concentrations were least for water associated with the Hartshorne (200 mg/L) and McAlester-Stigler (230 mg/L) coal beds.

References Cited

Friedman, S. A., 1974, Investigation of the coal reserves in the Ozarks section of Oklahoma and their potential uses: Oklahoma Geological Survey Special Publication 74-2, 117 p. (Final report to the Ozarks Regional Commission, July 1974.)

——— 1978, Field description and characterization of coal sampled by the Oklahoma Geological Survey, 1971–1976, *in* Dutcher, R. R. (ed.), Field description of coal: American Society for Testing and Materials Special Technical Publication 661, p. 58–63.

Hem, J. D., 1970, Study and interpretation of the chemical characteristics of natural water [2nd ed.]: U.S. Geological Survey Water-Supply Paper 1473, 363 p.

Johnson, K. S., 1974, Maps and description of disturbed and reclaimed surface-mined coal lands in eastern Oklahoma, showing acreage disturbed and reclaimed through June 1973: Oklahoma Geological Survey Map GM-17, scale 1:125,000, 3 sheets, 12-p. text.

Slack, L. J.; and Blumer, S. P., 1984, Physical and chemical characteristics of water in coal-mine ponds, eastern Oklahoma, June to November, 1977–1981: U.S. Geological Survey Open-File Report 84-446, 183 p.

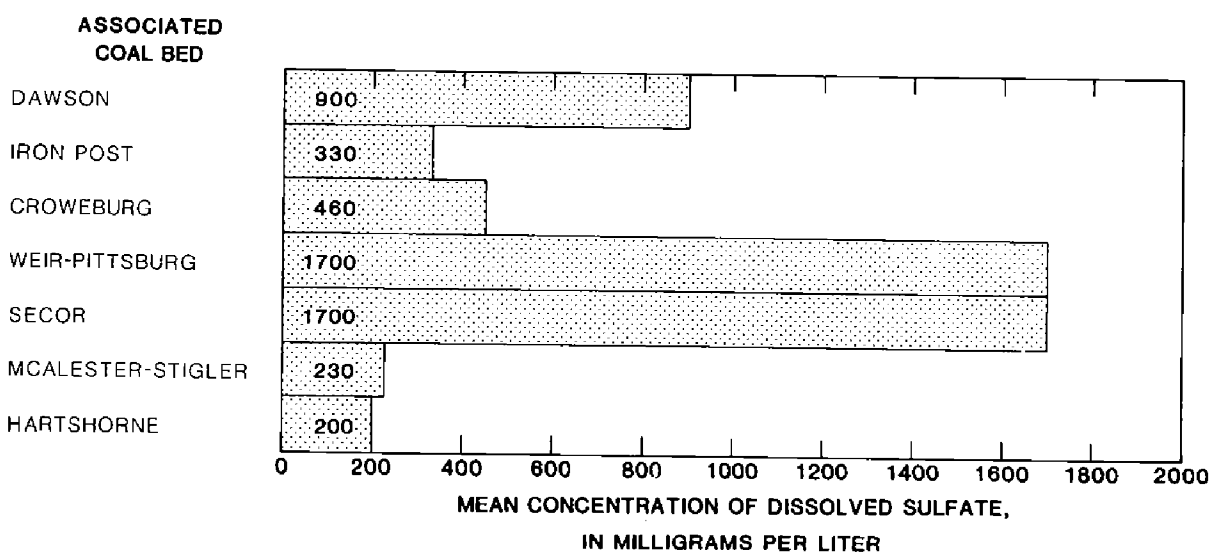


Figure 6. Mean dissolved-sulfate concentration in coal-mine pond water associated with each coal bed.

FURTHER NOTES ON UNION VALLEY–CROMWELL (LOWER PENNSYLVANIAN) STRATIGRAPHIC RELATIONSHIPS IN EASTERN OKLAHOMA

Julian M. Busby[1]

In a previous note (Busby, 1983), the relationships between the Union Valley limestone and Cromwell sandstone sequence were shown schematically. Five cross sections presented here (Fig. 1) better illustrate geographic variations in the stratigraphic relationships and provide a basis for regional studies. These cross sections represent the eastern edge of the platform and extend southeast into the Arkoma basin, from T13N, R8E, southeast to T10N, R11E.

Cross section A–A′ illustrates that the Cromwell interval comprises three sandstones and two intervening shales. Below these sandstones is a third shale, underlain in turn by a Pennsylvanian limestone or calcareous shale. All of these units overlap the Mississippian Chesterian Series toward the northwest. A number of questionable correlations have appeared in the literature. The Cromwell sequence probably is Springeran, and the overlying Union Valley has been definitely established as Morrowan. There is a pronounced unconformity at the base of the Cromwell which truncates the Chesterian rocks, and the Cromwell sequence likewise is truncated by an unconformity. As much as 300 ft of the Cromwell sequence has been removed by erosion.

The depositional sequence in cross section A–A′ is relatively simple and is easily followed in the subsurface, where postdepositional movement has not changed the pattern significantly.

In the area of cross section B–B′, slight downwarping and some faulting have occurred. This movement has preserved small downwarped or downfaulted areas of the Cromwell sequence; such areas are found in T12N, R9E, and T12N, R10E.

Cross section C–C′ shows three pre-Union Valley stream channels cut into Chesterian rocks and filled by redeposited sands eroded from the thick Cromwell sequence to the south and east. These channel sands are 6–12 mi north of the Cromwell subcrop.

The channels trend more or less N–S; they are about 1 mi wide and as much as 50 ft thick. The edges of the channels are rather steep.

As interpreted here, these N–S channels are perpendicular to a broad regional uplift to the south which allowed for formation and filling of the channels as the Cromwell sands were exposed to erosion.

[1]Busby and Associates, Inc., Muskogee, Oklahoma.

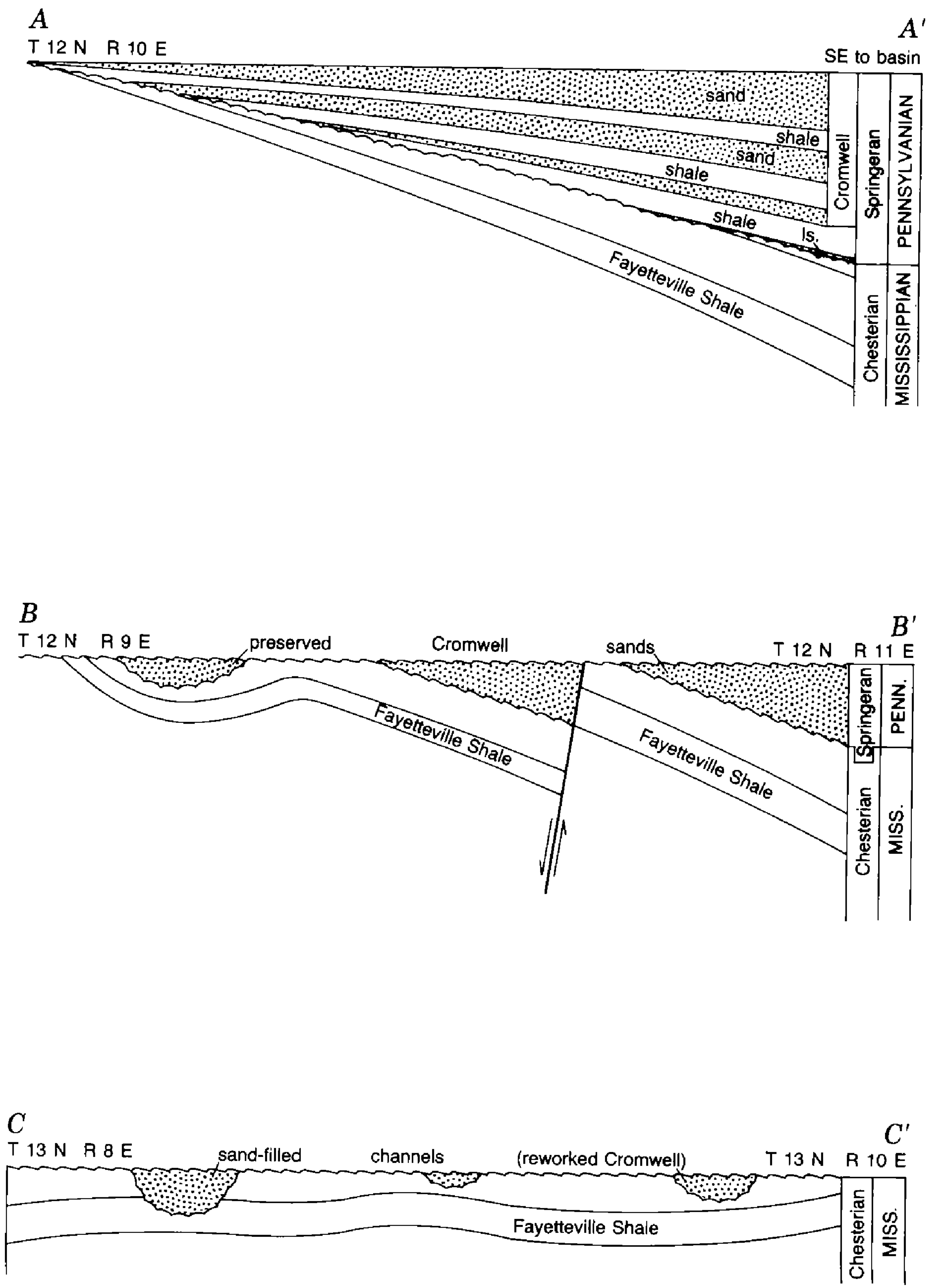
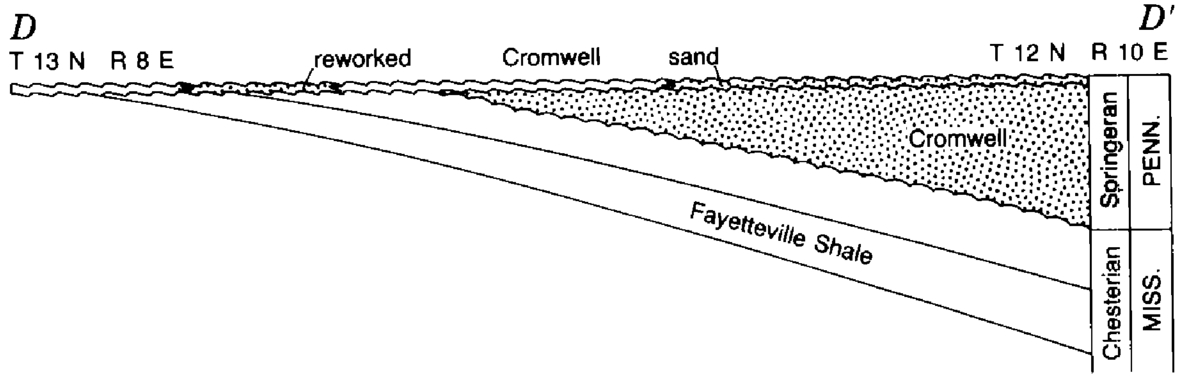
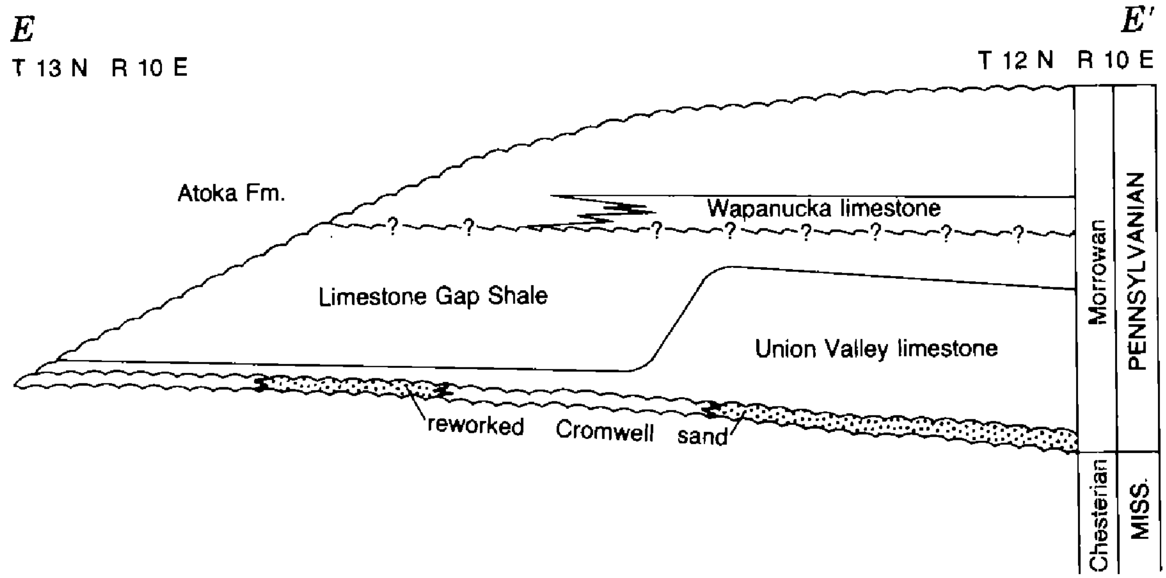


Figure 1. Cross sections (*above* and *opposite, above*) showing stratigraphic relationships of the Cromwell sequence and Union Valley limestone with underlying and overlying rocks in eastern Oklahoma.





The aggregate volume of these sand-filled channels is small, indicating that uplift was slight. Land slope may have been less than 0.25° toward the north. The pre-Morrowan erosion surface between these channels has modest relief, further indicating a slight regional uplift.

Cross section D–D′, which is simplified, shows the results of erosion on the broad area of the Cromwell and Chesterian rocks. Over a wave-cut surface, a thin veneer of sand was reworked and transported at most a few miles. This thin veneer (where present) thickens from a feather edge to 10 ft. This zone contains glauconite.

In oil and gas wells this zone is generally more dense than the underlying Cromwell where it directly overlies the Cromwell subcrop. In drilling through this zone, shows of oil and gas may be found; as the true Cromwell sand is penetrated there is usually a marked increase in oil and gas. The same increase in water occurs in areas lacking petroleum. Where this thin veneer of sand directly overlies Chesterian limestone and shale, it may contain some oil, gas, or water, if it has porosity.

This zone of reworked Cromwell sand sometimes has been misidentified as the Cromwell proper.

Cross section E–E′ is similar to that published previously (Busby, 1983). In the Union Valley, a thin limestone extends at least 20 mi north and west from a 150-ft limestone buildup. The thick limestone buildup extends to the south and east; it contains an abundant microfauna.

Figure 2 shows the abrupt thickening in the Union Valley limestone from west to east in Okfuskee County. During post-Union Valley erosion, streams cut valleys into the steep slope of this limestone buildup. Farther east, the Union Valley is constant in thickness or gradually thickens toward the southeast.

Morrowan shale was deposited on the eroded Union Valley limestone. This shale is in turn overlain by Wapanucka limestone, which thickens to the south and east toward the basin.

Before there was adequate electric-log coverage, cable-tool logs from the area of the abrupt thickness change were termed "boilerhouse logs," because of the seemingly erratic tops. However, electric logs have borne out the high gradients in Union Valley structure contours and isopachs.

The east-west trend of the inferred post-Union Valley streams shown in Figure 2 is almost 90° from the trend of the post-Cromwell, pre-Union Valley streams.

Secondary porosity has developed along these valley walls. As a result, excellent oil production is found parallel to the stream-cut cliff faces. On the interfluves, secondary porosity is negligible, and petroleum production is low or nil.

Outcrops illustrating the subsurface stratigraphic relationships discussed here may be lacking.

Selected References

Busby, J. M., 1983, Cromwell–Union Valley (Lower Pennsylvanian) relations in eastern Oklahoma: Oklahoma Geology Notes, v. 43, p. 4–9.

Ham, W. E., 1969, Regional geology of the Arbuckle Mountains, Oklahoma: Oklahoma Geological Survey Guidebook 17, 52 p.

Jordan, Louise, 1957, Subsurface stratigraphic names of Oklahoma: Oklahoma Geological Survey Guidebook 6, p. 107–108.

Sutherland, P. K.; and Manger, W. L. (eds.), 1977, Upper Chesterian–Morrowan stratigraphy and the Mississippian–Pennsylvanian boundary in northeastern Oklahoma and northwestern Arkansas: Oklahoma Geological Survey Guidebook 18, 185 p.

Sutherland, P. K.; and Manger, W. L. (eds.), 1979, Mississippian–Pennsylvanian shelf-to-basin transition, Ozark and Ouachita regions, Oklahoma and Arkansas: Oklahoma Geological Survey Guidebook 19, 72 p.

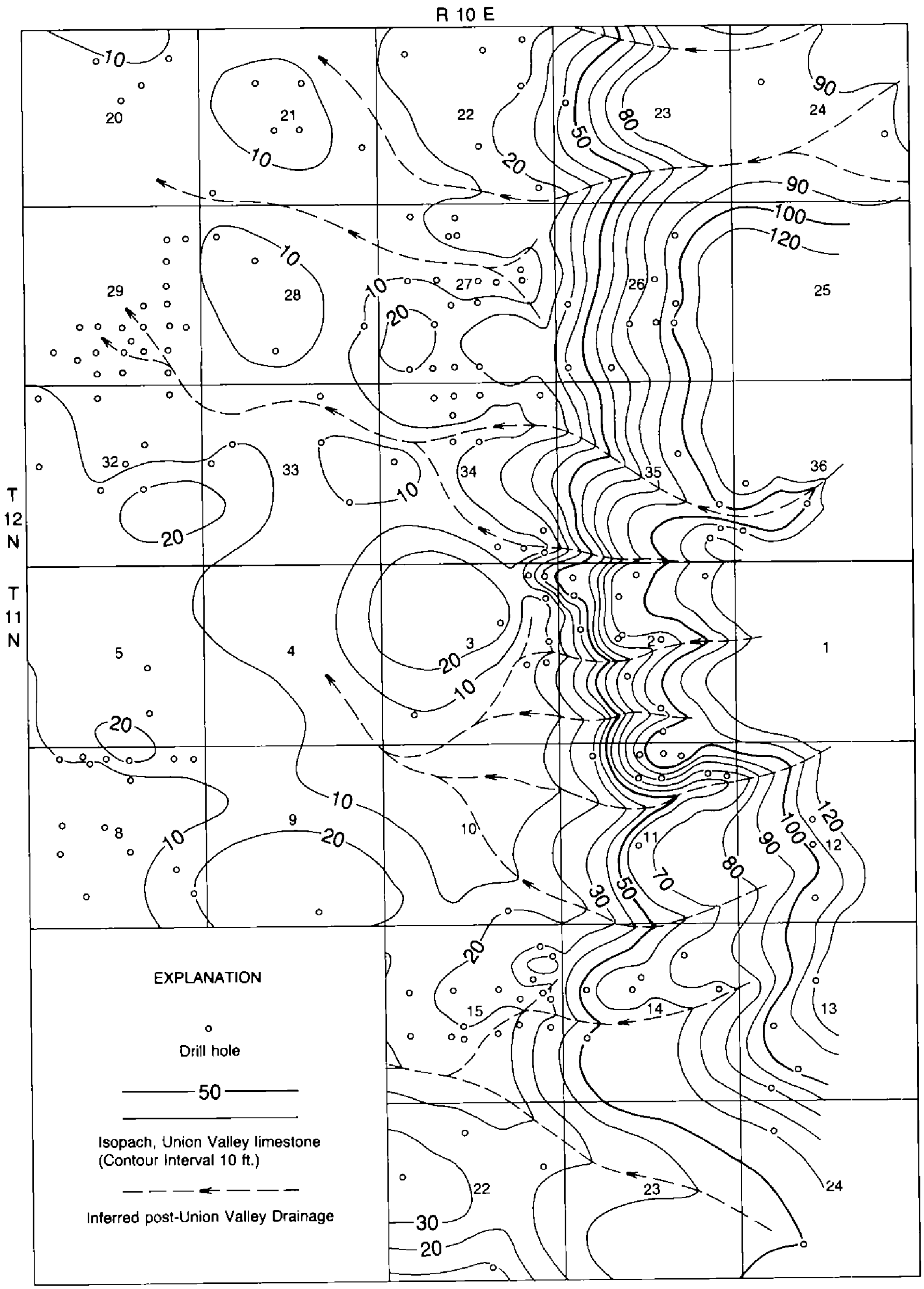


Figure 2. Isopach map of the Union Valley limestone in T11–12N, R10E, Okfuskee County, Oklahoma.

OUAChITA GUIDEBOOKS INDEXED

Neil H. Suneson[1]

Introduction

In 1985, the Oklahoma Geological Survey and the U.S. Geological Survey began a cooperative study of the Ouachita Mountains under the COGEOMAP program. One aspect of this study is an evaluation of existing geologic maps. In the course of reviewing existing maps of the Ouachita Mountains in Oklahoma, the author reviewed many of the field-trip guidebooks published by various geological societies and other organizations. The resulting index to guidebooks of the Ouachita Mountains may be helpful to students of Ouachita geology, to professors planning course-related field trips, and possibly to oil-company geologists interested in visiting a classic deep-water sequence of clastic rocks. In addition, some of the older guidebooks are interesting from a historical perspective, not only because the participants faced logistical obstacles but also because many of the early greats of Ouachita geology led or participated in those field trips.

Discussion

In 1931, the Kansas Geological Society ran the first field trip to the Ouachita Mountains in southeastern Oklahoma. Participants included such notables as Charles N. Gould, director of the Oklahoma Geological Survey; C. W. Honess, geologist with Gypsy Oil Co.; Hugh D. Miser, geologist in charge of the geology-of-fuels section of the U.S. Geological Survey; and C. W. Tomlinson, geologist with Schermerhorn–Ardmore Co. Much of the trip was over dirt roads, and part of the road log (miles 50.9 to 63.1) reads:

> Slow down. Bad hairpin turn. Right turn. Narrow bridge. Hump in road. Sharp right turn. Narrow bridge. Right curve. Winding road. Bump in road. Slow. Rough road. Narrow bridge.

Since 1931, 21 field trips with published or readily accessible guidebooks have been run through parts of the Ouachita Mountains in Oklahoma. Most of the recent trips follow paved roads and examine large road cuts not present 30 years ago. Many of the early field trips presented data and ideas that formed the basis for later studies. This brief note is a summary—by way of map and table—of all the published or readily accessible guidebooks to the geology of parts of the Oklahoma Ouachita Mountains. It updates and attempts to present in a slightly more usable form the information in the "Union List of Geologic Field Trip Guidebooks of North America," published by the American Geological Institute in 1978. It does not claim to be comprehensive. Guidebooks that are privately circulated or compiled by schools, universities, or companies that use the Ouachita

[1]Oklahoma Geological Survey.

Mountains as a training ground for stratigraphic and structural studies are not included. In addition, some published guidebooks may not be included in this list.

Figure 1 shows major roads in the Oklahoma Ouachita Mountains, as well as the towns, post offices, and other landmarks listed in Table 1. Table 1 lists guidebooks to field trips through the Ouachita Mountains and the towns or other places that those trips passed through or went near. Most of the recent trips traveled on the roads shown in Figure 1; in places, of course, the trips traveled on graded gravel or dirt roads that can only be found by using local U.S. Forest Service, county, private company (e.g., Weyerhaeuser), or U.S. Geological Survey topographic maps. Many of the older trips also traveled on paved roads; however, some of the roads referred to in those guidebooks may no longer exist, may have been moved, or may be numbered differently. Another caution in attempting to follow any guidebook, be it old or new, is that mileage between stops and from landmark to landmark can vary.

The reference list explains the abbreviations used in Table 1. Field-trip leaders are those who led the Ouachita Mountains part of the field trip. However, the dates cover the entire field trip.

It is hoped that the information in Table 1 will be useful to any geologist planning a trip through the Ouachita Mountains. Once a route has been chosen and the towns to be passed through noted, the appropriate guidebooks can be borrowed and the localities described in the guidebooks can be plotted on a modern highway map or on topographic maps.

References and Chronology

Kansas Geological Society. Guidebook: Fifth annual field conference. August 30–September 5, 1931. Leaders: C. W. Tomlinson, C. E. Decker, J. Fitts, H. D. Miser, and C. W. Honess.

Ardmore Geological Society. Field trip: Ardmore to the Ouachita Mountains, Oklahoma. June 6, 1936. Leaders: W. L. Russel and B. A. Ray, assisted by J. Fitts.

Tulsa Geological Society. Guidebook: Field conference in western part of the Ouachita Mountains in Oklahoma. May 8–10, 1947. Leaders: T. A. Hendricks, L. E. Fitts, V. W. Russell, and C. T. Jones. Additional discussions: H. C. Rea, R. Engleman, J. V. Howell, and H. D. Miser.

Oklahoma City Geological Society. Guidebook: Field conference in eastern part of the Ouachita Mountains, with special reference to the pre-Pennsylvanian and lower Pennsylvanian rocks. November 4–5, 1950. Leader: H. D. Miser.

Ardmore Geological Society. Field trip: Study of Paleozoic structure and stratigraphy of the Arbuckle and Ouachita Mountains in Johnson and Atoka Counties, Oklahoma. April 25–26, 1952. Leaders: C. W. Tomlinson, T. A. Hendricks, and R. Engleman.

Oklahoma Academy of Science, Sigma Gamma Epsilon. Road log: Geological field trip in eastern part of the Ouachita Mountains, Oklahoma. April 26–27, 1952. Leader: H. D. Miser.

Ardmore Geological Society. Guidebook: Ouachita Mountain field conference, southeastern Oklahoma. May 4–5, 1956. Leaders: W. D. Pitt and L. M. Cline, assisted by D. P. H. William and B. W. Miller.

Dallas Geological Society, Ardmore Geological Society. Guidebook: Ouachita field

TABLE 1.—KEY TO FIELD-TRIP ROUTES IN THE OUACHITA MOUNTAINS OF OKLAHOMA

Town, post office, or other place on field-trip route	KGS '31	AGS '36	TGS '47	OCGS '50	AGS '52	OAS/SGE '52	AGS '56	DGS/AGS '59	TGS/FSGS '61	KGS '66	OCGS '68	SGS '73	GSA '74	DGS '75	TGS '75	GCAGS '76	AAPG '78	SEPM '78	OGS '79	GSA '84	SS '84
Albion	X		X	X		X	X														
Antlers	X						X														
Atoka	X	X	X		X			X				X									
Beavers Bend St. Park				X		X						X					X			X	
Bengal																		X	X		
Bethel				X		X	X	X				X									
Big Cedar							X	X	X	X	X	X		X		X	X	X	X	X	
Broken Bow	X			X		X	X	X				X		X		X	X				
Damon								X			X	X	X	X		X		X			
Fanshawe	X																				
Finley	X						X														
Glover				X		X	X					X				X	X			X	
Hartshorne	X		X					X				X	X			X		X	X		
Heavener									X	X	X			X			X				
Higgins			X																		
Honobia				X		X	X	X													
Kiamichi Mountain							X	X	X	X	X	X		X		X	X	X	X	X	
Kiowa	X		X					X				X							X		

Mount Herman	X			X		X	X	X						X		X	X			X	
Moyers																					X
Nashoba	X						X														
Pittsburg			X					X							X				X		X
Red Oak	X								X									X	X		
Redden			X												X						X
Skyline Drive												X				X			X		
Smithville												X		X		X	X			X	
Stringtown	X	X	X		X			X				X			X						
Talihina	X							X				X		X		X		X	X	X	
Tuskahoma	X		X			X	X														
Whitesboro											X			X				X		X	
Wilburton	X							X	X		X	X	X	X		X		X	X		
Yanush			X			X															

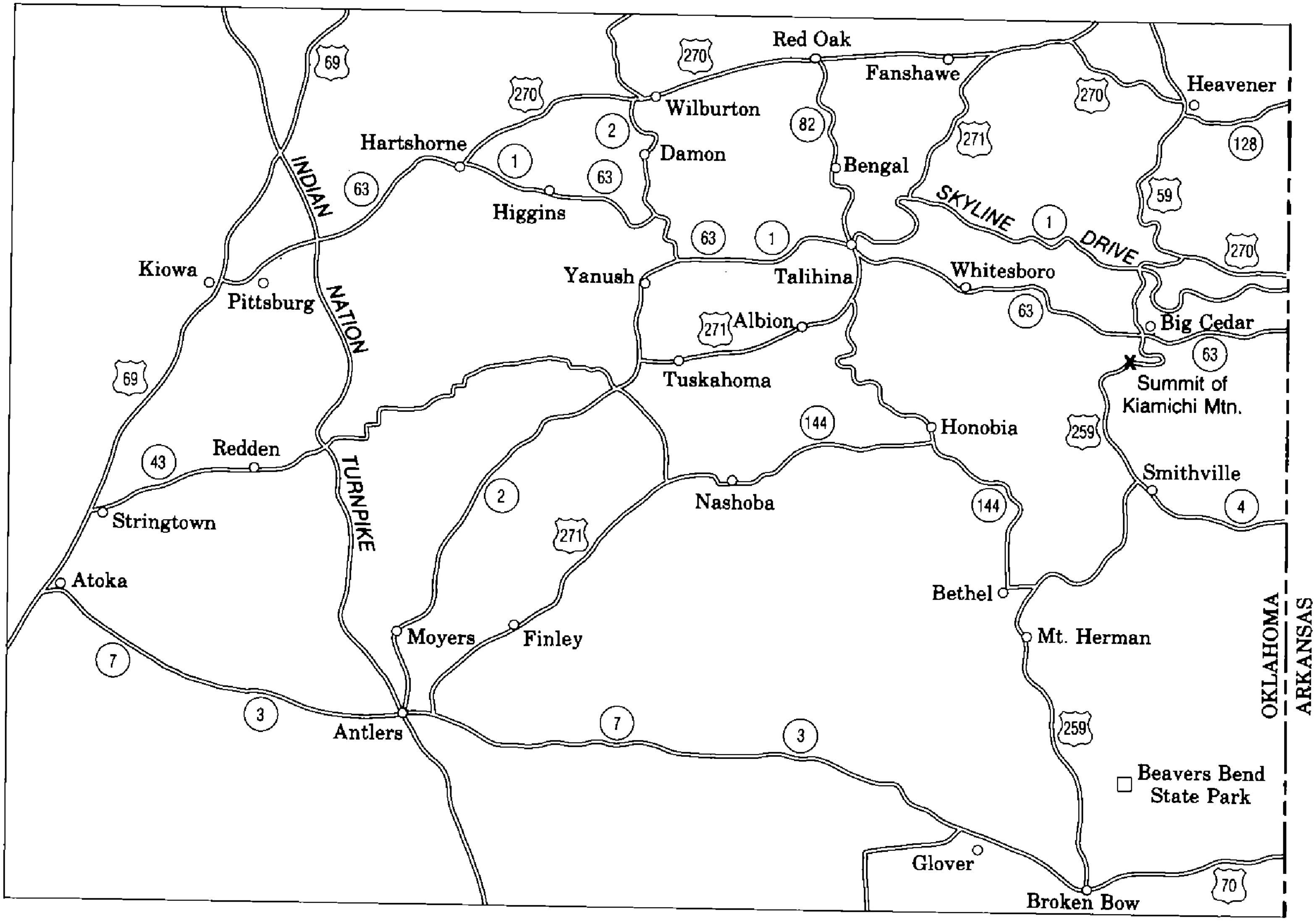


Figure 1. Highway map of the Ouachita Mountains of southeastern Oklahoma, showing places listed in Table 1.

trip. Annual convention of the American Association of Petroleum Geologists and Society of Economic Paleontologists and Mineralogists. March 20–21, 1959. Edited by D. E. Feray and W. J. Hilseweck. Leader: L. M. Cline.

Tulsa Geological Society, Fort Smith Geological Society. Guidebook: Arkoma Basin and north-central Ouachita Mountains, field conference. April 14–15, 1961. Leaders: H. H. Hall, R. B. Laudon, E. Bloesch, R. Planalp, and J. C. Perryman.

Kansas Geological Society. Guidebook: Field conference on flysch facies and structure of the Ouachita Mountains. November 1966. Leader: L. M. Cline, assisted by P. H. Stark.

Oklahoma City Geological Society. Guidebook: Geology of the western Arkoma Basin and Ouachita Mountains, Oklahoma. Annual meeting of the American Association of Petroleum Geologists and Society of Economic Paleontologists and Mineralogists. April 20–21, 1968. Leaders: L. M. Cline, K. Arbenz, R. M. Berry, A. L. Bowsher, and N. L. Johnson.

Shreveport Geological Society. Guidebook: A study of Paleozoic rocks in Arbuckle and western Ouachita Mountains of southern Oklahoma. April 12–14, 1973. Edited by M. G. Hare. Leaders: R. O. Fay, C. G. Stone, and B. R. Haley.

Geological Society of America. Guidebook: Depositional environments of selected Pennsylvanian sandstones and carbonates of Oklahoma. South-Central Section meeting, Geological Society of America. March 1974. By J. W. Shelton and T. L. Rowland.

Dallas Geological Society. Guidebook: Sedimentology of Paleozoic flysch and associated deposits, Ouachita Mountains–Arkoma Basin, Oklahoma. Annual meeting of the American Association of Petroleum Geologists and Society of Economic Paleontologists and Mineralogists. April 1975. Leaders: G. Briggs, E. F. McBride, and R. J. Moiola.

Tulsa Geological Society. Guidebook: A new look at the Ouachita corner—basinward facies changes in the Wapanucka Limestone (Lower Pennsylvanian), Indian Nations Turnpike, Ouachita Mountains, Oklahoma. May 3–4, 1975. Edited by A. Bennison. Leaders: P. K. Sutherland and R. C. Grayson, Jr.

Gulf Coast Association of Geological Societies. Guidebook: A study of Paleozoic rocks in Arbuckle and Ouachita Mountains of southern Oklahoma. Shreveport Geological Society Field Trip. November 15–17, 1976. Edited by R. E. Decker and B. Black. Leaders: R. O. Fay, C. G. Stone, and B. R. Haley.

American Association of Petroleum Geologists. Field Guide: Structure and stratigraphy of the Ouachita Mountains and the Arkoma Basin. Annual meeting of the American Association of Petroleum Geologists. April 13–14, 1978. Leaders: G. Visher, C. Stone, and B. Haley.

Society of Economic Paleontologists and Mineralogists. Guidebook to the trace fossils and paleoecology of the Ouachita Mountains. April 8–9, 1978. Leaders: C. K. Chamberlain and P. B. Bason.

Oklahoma Geological Survey. Guidebook for Field Trip 11: Mississippian–Pennsylvanian shelf-to-basin transition, Ozark and Ouachita regions, Oklahoma and Arkansas. Ninth International Congress of Carboniferous Stratigraphy and Geology. May 27–June 1, 1979. Edited by P. K. Sutherland and W. L. Manger. Leaders: C. G. Stone, R. J. LeBlanc, Sr., B. R. Haley, J. D. McFarland III, P. K. Sutherland, and R. C. Grayson, Jr.

Geological Society of America. Guidebook: Comparative structural evolution of the Arbuckle and Ouachita Mountains. South-Central Section meeting of the Geological Society of America. March 28–29, 1984. Edited by K. C. Nielson and W. G. Brown. Leaders: K. C. Nielson and W. G. Brown.

Oklahoma City Geological Society Discussion Group. Guidebook: Ouachita Mountains field trip. December 1, 1984. Leader: R. O. Fay. Published in Shale Shaker, v. 35, no. 3, p. 64–73.

OGS HOSTS COAL FORUM

LeRoy A. Hemish[1]

The Oklahoma Geological Survey hosted the 10th Annual Forum of Western Interior Coal Basin Geologists at Tulsa, Oklahoma, April 28–29. Participants included one geologist from the U.S. Geological Survey National Center in Reston, Virginia; nine geologists (or other persons associated with coal projects) from the state geological surveys of Iowa, Kansas, and Oklahoma; one geologist from the Arkansas Geological Commission; one geologist from the Arkansas Energy Office; and three geologists from the Missouri Department of Natural Resources, Division of Geology and Land Survey.

Samuel A. Friedman, senior coal geologist from the Oklahoma Geological Survey, coordinated the activities and chaired the sessions. On April 28, the morning session was devoted to reports on the coal industry in the various states, while the afternoon session was devoted to reports on ongoing coal research. The status of the National Coal Resources Data System (NCRDS) cooperative program between the USGS and states in the western interior coal basin was also discussed during the afternoon session.

During the morning session, Lawrence Brady reported that coal production in Kansas in 1985 was down by 24% compared to 1984. Five coal companies produced 989,000 tons from five coal beds in five surface mines. The coal mined in Kansas had a sulfur content of 2.5–5.5% and was used primarily for fuel in cement plants and power plants.

Joy Bostic reported that coal production in Missouri in 1985 was down by 1.3 million tons from the record high of 6.8 million tons set in 1984. Fifteen companies mined coal in Missouri in 1985, nearly half of the state's production coming from two of these, Associated Electric Co-op (1,718,300 tons) and NEMO Coal Co. (892,670 tons). Of interest was the report that the University of Missouri–Columbia is installing on campus fluidized-bed boilers which will generate power from high-sulfur Missouri coal.

William V. Bush reported that Arkansas's coal production was only 50,000 tons for 1985. All of this tonnage was from small surface mines. Most of the production was from the bituminous-rank Lower Hartshorne coal bed. In addition to its bituminous coal, Arkansas also has semianthracite coal and lignite. Although no lignite is now being mined, the state has reserves of 13.5 billion tons in beds 5–10 ft thick.

According to Friedman, 23 companies produced bituminous coal from nine coal beds in 31 mines in Oklahoma during 1985. The total production of 3.4 million tons was down about 21% from 1984. The weighted average sulfur content of all coal produced in Oklahoma in 1985 was 2.1%. The

[1]Oklahoma Geological Survey.

most tonnage was produced in Craig County, where 2 million tons was mined. A minor tonnage of coal was produced from the Lower Hartshorne bed by underground methods, which may indicate the beginning of a return to underground mining of Oklahoma's thicker, higher-quality coal beds.

Mary Howes reported that coal production in Iowa was up during 1985. A total of 585,387 tons was produced from both surface and underground mines, primarily from the Laddsdale coal bed. The coal produced in Iowa was high-volatile C bituminous in rank. Washed coal averaged 4.15% sulfur, 13.9% ash, and 9,293 Btu/lb. All production from Iowa coal mines was used in the state.

During the afternoon session Lawrence Brady, Mike Slaton, and Dave Killen reported on coal research in Kansas. A subsurface study using geophysical logs to correlate coals is being conducted in the Sedgwick basin in southeastern Kansas. A similar study is being made in the Cherokee basin in southeastern Kansas. These studies and others completed previously suggest that Kansas has about 50 billion tons of deep coal resources in the eastern part of the state.

Bush said that no current coal research projects are being conducted in Arkansas. An extensive research project involving coal was done in the late 1970s and early 1980s, when 1,800 holes were drilled by the Arkansas Geological Commission to depths of 150–200 ft to evaluate the state's lignite resources. All the data have been entered in NCRDS.

Bostic reported that entry of Missouri coal data into NCRDS is continuing. Larry Nuelle reported on coal research involving the Riverton Formation in southwestern Missouri. Through a study of spores and depositional environments, previous miscorrelations have been revealed and new cyclothems have been identified. Resolution of the Atokan–Desmoinesian boundary is expected soon in Missouri as a result of this research.

Dave Lumbert of the Arkansas Energy Office reported on his work with statistical data concerning uses of coal. Although 62% of Arkansas's energy for electricity production is from coal, the state's utility companies do not use coal from Arkansas. One of the missions of the Energy Office is to promote use of Arkansas coal.

Howes discussed publication of palynological research on Iowa coals. Further research is being done on the conodont stratigraphy of the Cherokee and Marmaton Groups in Iowa. A project for preservation and restoration of old abandoned-mine maps is under way. Iowa is in the last year of its cooperative agreement with NCRDS.

Tom Kuehn of the USGS reported on the status of NCRDS funding. The outlook for funding is bleak because of federal budget cutbacks. The only states in the western interior coal basin that probably will receive funding for FY 1987 data entry into NCRDS are Texas ($25,000) and Oklahoma ($10,000). Oklahoma's share is down $50,000 from the initial projected agreement for funding from the USGS ($60,000).

Friedman briefly reviewed some of the current research projects in Oklahoma. Brian Cardott presented a report on petrographic and chemical criteria for identifying effects of weathering on coal. Laurie Warren reported on progress in entry of data into NCRDS and presented a poster depicting methods used in computerizing the data. LeRoy Hemish reported on the identification of a minable coal bed in Pontotoc County which expands Oklahoma's coal belt and increases the state's coal resources by almost 9 million tons. To prepare the group for the field trip scheduled for the following day, Hemish also presented a talk and slide show in which he reviewed the stratigraphy and coal geology of the northeastern Oklahoma shelf area.

On April 29, Friedman led the field trip through the shelf area in eastern Tulsa County, western Rogers County, and northwestern Wagoner County. Visited points of interest included the Blue Circle Cement Co. limestone and shale quarry and kiln. About 530 lb of high-sulfur Oklahoma coal is blended with limestone, shale, and gypsum to produce each ton of cement in this plant.

Another stop was at the McNabb Stone Co. quarry and coal mine (Fig. 1). The 18- to 20-in.-thick Croweburg coal is of high quality, averaging 0.5–0.7% sulfur and more than 13,000 Btu/lb. Overburden includes the Lagonda Sandstone, which is quarried and sold, as is some of the underlying shale, and the Verdigris Limestone, which is quarried and crushed to make aggregate (Fig. 2) that is sold in the Tulsa area. Currently, McNabb is experimenting with methods for concentrating the phosphate-bearing nodules in the black shale underlying the Verdigris Limestone. The phosphate could be used in fertilizer.

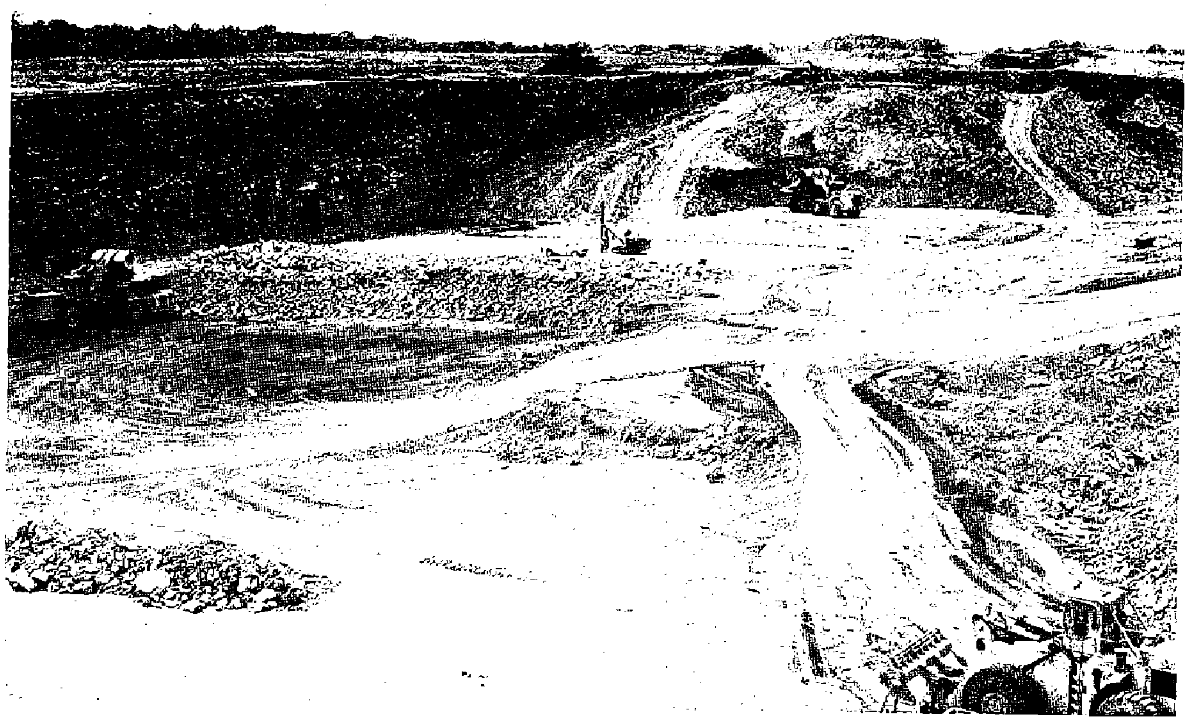


Photo by Michelle Summers.

Figure 1. McNabb Stone Co. quarry and coal mine, sec. 33, T15N, R20E, Rogers County, Oklahoma. The Lagonda Sandstone is at the top of the highwall, and the Verdigris Limestone underlies the bench where the pickup truck is parked.

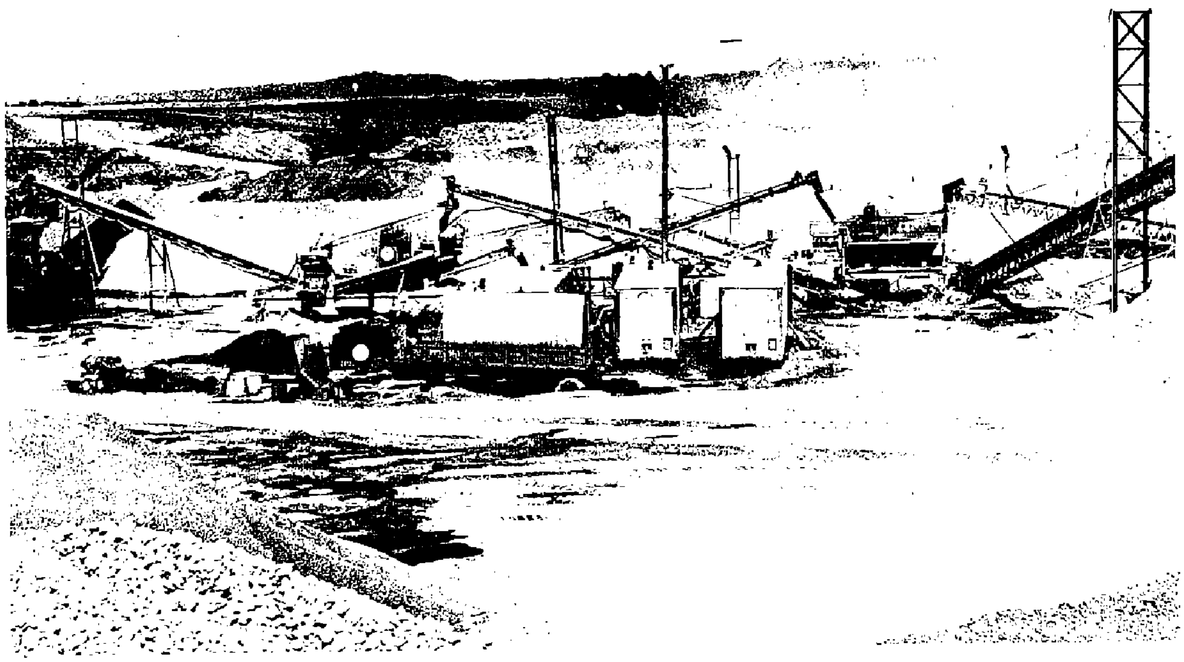


Photo by Michelle Summers.

Figure 2. McNabb Stone Co. limestone-crushing facility, sec. 33, T15N, R20E, Rogers County, Oklahoma. Note stockpiles of aggregate of various sizes.

Other stops on the field trip included Port Verdigris 33 on the McClellan–Kerr Arkansas River Navigation System; Transwestern's mine north of Claremore, where the Iron Post coal is mined; and the BELLCO Materials, Inc. quarry, where the Higginsville Limestone Member of the Fort Scott Formation is quarried.

The Missouri Division of Natural Resources, Division of Geology and Land Survey, will host the 11th Annual Forum of Western Interior Coal Basin Geologists in 1987. Columbia, Missouri, has been tentatively selected as the meeting site.

99th ANNUAL GSA MEETING SETS SIGHTS ON TEXAS IN NOVEMBER

San Antonio, Texas, will be the gathering point for Geological Society of America members this fall as they hold their 99th annual meeting November 10–13 at the San Antonio Convention Center. Preregistration for the meeting is due October 10.

Charles J. Mankin, OGS director, will take part in a panel discussion on "Future Employment Opportunities in the Geological Sciences." Other speakers will be Dick Paull, FORUM chairman, University of Wisconsin; J. D. Edwards, Pecten International Co.; Penny Hanshaw, USGS; J. D. Mancuso, Chevron Resources Co.; Dave Stephenson, Dames & Moore; and Steve Stow, Oak Ridge National Laboratory. The forum will be held Monday, November 10, 1–3 p.m. The presentations of panel members will be summarized and published by the Society in a booklet that will be available in the first quarter of 1987. There is no admission charge to attend the forum.

Among the many titles and scheduled speakers for the invited symposia are: "New Techniques for Coal Characterization," Jesse Yeakel, Exxon Production Research Co.; "Engineering Geology and Public Policy," Christopher Matthewson, Texas A&M, and John S. Scott, Geological Survey of Canada; "Hydrology of Sedimentary Basins," Charles Kreitler, Texas Bureau of Economic Geology; "Paleozoic Southern Margin of the United States," M. Charles Gilbert, Texas A&M; and "Mineralization in Restricted Basins," Gregory E. McKelvey, Cominco American, Inc.

San Antonio offers ready access to a number of interesting geological exposures in Texas and adjoining states, prompting the scheduling of a number of both premeeting and postmeeting field trips. Registration for the trips begins August 1. Premeeting trips include: Quaternary Geology and Geomorphology of the Rolling Plains, Texas Panhandle; Ouachita Mountain Geology—Structure, Stratigraphy, Depositional and Thermal History, Arkansas; Engineering Geology of San Antonio; Petrology of the Cambrian Wichita Mountains Igneous Suite; The Slick Hills of Southwestern Oklahoma—Fragments of an Aulacogen?

Among the field trips to leave after the meeting are: Economic Geology of the Ouachita Mountains and Vicinity, Southwestern Arkansas; and Upper Cretaceous Volcanic Centers of South and Central Texas.

Short courses are also scheduled for the meeting and among the topics will be: "Exploration Geochemistry—Design and Interpretation of Soil Surveys"; "Fossil Land Plants"; "Basic Principles of Rock Mechanics"; and "Computer Graphics for Geologic Applications".

Two GeoRef workshops will be given, along with "The Earth as a Planet" (sponsored by the Lunar and Planetary Institute and the GSA Planetary Geology Division).

Another highlight of the meeting will be the 200-booth Geoscience Exhibit that opens Sunday, November 9, 6–9 p.m. Exhibitors will display and demonstrate computer hardware and software, measurement equipment, maps, X-ray-diffraction and other instruments, cameras, publications, field supplies, and dozens of other items. Participants are invited to see the latest in Oklahoma Geological Survey publications and projects and talk with staff members at the OGS exhibit booth.

Guests traveling with GSA members will also find many activities to participate in while meetings and seminars are in session. Tours of missions, art museums, gardens, and caverns are scheduled, along with style shows and luncheons.

For more information about the meeting, contact: Meetings Department, Geological Society of America, P.O. Box 9140, Boulder, CO 80301; (303) 447-2020.

CHRISTENSEN NEW DIRECTOR OF OSMRE

Jed D. Christensen was sworn in last spring as the third Director of the Office of Surface Mining Reclamation and Enforcement (OSMRE) by Interior Secretary Don Hodel. Christensen, who has been serving as acting director of OSMRE since April 1985, was confirmed on May 20 by unanimous voice vote of the Senate, and sworn in on May 30.

"While Jed has been serving as acting director, he has made substantial progress in improving the management of the agency charged with implementing the Surface Mining Control and Reclamation Act (SMCRA)," Hodel said. "Notably, Jed has set up a regulatory development program, using public involvement, that is designed to complete the body of rulemaking needed to implement the surface mining law as Congress intended.

"Recognizing that state primacy is essential, with the coal states themselves in charge of reclamation and enforcement within their own borders, Jed has moved to strengthen that relationship through increased federal financial support and improved oversight for the approved state programs."

OSMRE also is now on schedule with a computer system to aid in penalty collections and verification of mine-permit information, Hodel added.

Secretary Hodel said that he and Under Secretary Ann McLaughlin continue to have a strong personal interest in improvements and positive action by OSMRE and that both would be available to the director and assistant secretary in providing general policy guidance.

INTERNATIONAL GEOLOGICAL CONGRESS MEETS IN WASHINGTON, D.C., IN 1989

The 28th meeting of the International Geological Congress (IGC) convenes in Washington, D.C., July 9–19, 1989. The meeting, hosted by the National Academy of Sciences and the U.S. Geological Survey, marks the first time the congress has met in the United States since 1933.

The International Geological Congress is a nonprofit scientific and educational organization under the sponsorship of the International Union of Geological Sciences (IUGS) and exists to encourage the advancement of fundamental and applied research in the earth sciences worldwide. To achieve this purpose, an international geological congress is organized approximately every four years by scientists in member countries to provide a forum for the communication of ideas and information, research developments, and other matters related to the earth sciences. The congress brings together a broad representation of the world's earth scientists for an opportunity to exchange scientific information and concepts.

The scientific program of the congress will consist of symposia, regular sessions, and poster presentations covering virtually every aspect of basic and applied earth science. Interdisciplinary symposia will be featured as a reflection of the growing requirement for broad, multidisciplinary approaches to many earth-science problems.

A large area will be provided for exhibition of state-of-the-art technology for the broad range of earth sciences—including laboratory instrumentation, computers, remote-sensing equipment, geophysical exploration instrumentation, and other sophisticated field equipment. Exhibits will be organized to demonstrate the integration of technology with the substance of scientific research.

In addition, approximately 100 pre- and post-congress field trips are being planned throughout the United States, including Alaska and Hawaii. During the congress, local field trips will be offered, including visits to local museums, historical locations, and U.S. federal agencies.

More than 40 short courses and workshops will be offered at the congress. These will cover a spectrum of fields and topics and will provide up-to-date information and training in critical research areas.

The organizers of the 28th IGC are compiling digitized lists of U.S. and international organizations, agencies, and individuals associated with the earth sciences for distribution of the first circular in autumn 1986. Organizations and agencies that have access to useful digitized lists of this kind are requested to contact the Secretary General, 28th International Geological Congress, P.O. Box 1001, Herndon, VA 22070-1001.

BRITISH GEOLOGY JOURNAL ENTERS SECOND YEAR OF PUBLICATION

Geology Today, a bimonthly journal sponsored by the Geological Society of London and the Geologists Association, entered its second year of publication recently. The journal has more than 2,000 subscribers worldwide and aims its articles at both professionals and amateurs. The magazine is published by Blackwell Scientific Publications.

In its first year of publication, the journal articles covered a variety of topics that included marine mineral resources, oil in chalk, the Precambrian boundary, the age of the Earth and the oldest rocks, limestones on shelves and ramps, and geological tours of the southwest U.S. The journal has recently commissioned a number of articles from North Americans and is seeing an increasing number of subscribers from the U.S., Dr. Allen Stevens of the *Geology Today* staff said.

Regular features include news and comment, museum file, fossils and minerals explained, history of geology, tailor-made geology, and book reviews. The cover of each issue carries a color photo of a geological feature, and the text is liberally illustrated.

To subscribe to *Geology Today* or to receive a free sample copy, contact: Blackwell Scientific Publications Ltd., P.O. Box 88, Oxford, England. Subscriptions are $20 per year.

TENNESSEE POSTER RELEASED

The Tennessee Department of Conservation, through its Division of Geology, has released posters for Homecoming '86 displaying a satellite view of the state of Tennessee. This unique geographic composite, a mosaic of images transmitted by LANDSAT, has been made available by the Department of Geography and Geology, Middle Tennessee State University.

The poster, which demonstrates the geologic features of Tennessee, shows a light spot in its lower right corner that differentiates the Copper Hill area. Here the obvious effects of industrial pollution are graphically illustrated by the lack of vegetation.

To the immediate west of this area lies the folded landscape of the Valley and Ridge physiographic province. Farther to the west, the elongated north-south Sequatchie Valley trench is outlined on either side by the dark-green patches of the Cumberland Plateau.

This poster for Homecoming '86, 11½ by 16 in., is on sale for $2.50. Postage and handling are $1 for 1–3 posters, and $1.50 for 4–10 posters. There is an additional charge of 10¢ for each poster above 10. Payment is required in advance. Order from: Tennessee Department of Conservation, Publications Sales Office, 701 Broadway, Nashville, TN 37219-5237; phone (615) 742-6706.

USGS CONSOLIDATES FACILITIES

The U.S. Geological Survey has begun consolidating its facilities for nationwide distribution of maps, scientific books and reports, and general-interest publications into a single building in suburban Denver, in a move expected to save up to $1 million per year in operating costs.

"The move into Building 810 at the Denver Federal Center also should result in improved service to consumers," said Lowell E. Starr, chief of the USGS National Mapping Division at the Survey's National Center in Reston, Virginia.

The consolidation will result in phasing out the USGS Eastern Distribution Branch, which has facilities in Arlington and Alexandria, Virginia. The phaseout began April 21 and is scheduled to be completed by September 30.

The Eastern Distribution Branch will merge with the Western Distribution Branch at the Denver Federal Center in suburban Lakewood, Colorado, to form the consolidated facility, Starr said.

The Eastern Distribution Branch facility at 1200 South Eads St. in Arlington, Virginia, sells maps and distributes map indexes for states east of the Mississippi River, including Minnesota, and for Puerto Rico and the Virgin Islands. Over-the-counter sales were terminated May 1, and mail-order processing was discontinued July 1.

After consolidation, map distribution services for all states will be provided by the U.S. Geological Survey, Map Distribution Section, Federal Center, Box 25286, Denver, CO 80225. Over-the-counter sales will continue at the existing facility in Lakewood pending a final move to a larger building.

The consolidation will not affect customer service at the more than 2,800 non-USGS map dealers (among them the Oklahoma Geological Survey) in the nation who sell USGS topographic maps. They will continue to provide this service in their respective state and regional market areas.

Computerized operations for order processing, customer accounting, and inventory control will make the new facility more efficient and less costly to operate, Starr said.

Although the Eastern Distribution Branch facilities in Alexandria and Arlington are being closed, over-the-counter services for USGS maps and reports will continue at two USGS Public Inquiries Offices in the Washington, D.C., area. The PIO in Room 1028 of the General Services Administration Bldg., 18th and F Sts., N.W., Washington, D.C., and the PIO in Room 1C402 of the USGS National Center, 12201 Sunrise Valley Dr., Reston, VA, will continue selling limited numbers of maps and books. Large orders should be directed to the consolidated facility in Denver.

The USGS also has a PIO in downtown Denver (Room 169, Federal Bldg., 1961 Stout St.); and others in Dallas (Room 1C45, Federal Bldg., 1100 Commerce St.); Salt Lake City (Room 8105, Federal Bldg., 125 South State St.); Los Angeles (Room 7638, Federal Bldg., 300 North Los Angeles St.);

San Francisco (Room 504, Custom House, 555 Battery St.); Menlo Park, California (Room 128, Bldg. 3, 345 Middlefield Road); Spokane, Washington (Room 678, U.S. Courthouse, West 920 Riverside Ave.); and Anchorage, Alaska (Room 101, 4230 University Drive and also in Room E-146, Federal Bldg., 701 C St.).

NOTES ON NEW PUBLICATIONS

Petroleum Geology

F. K. North's recent book on petroleum geology was published in December of 1985 by Allen & Unwin. North is professor emeritus at Carleton University, Ottawa, Canada. The large 607-page book is printed in an 8½- × 11-in. format and has a large number of tables, graphs, and illustrations.

The introduction begins with a look at petroleum geology as a field of study and goes on to examine the basic vocabulary and basic statistics as well as the historical development of petroleum geology. Other chapters discuss a variety of topics, including composition of petroleum and natural gas, origin of petroleum hydrocarbons, source sediments, oil-field waters, porosity and permeability, reservoir rocks, migration, well logs, seismology, and other subjects before ending with case studies of selected fields.

Order from: Allen & Unwin, Inc., 8 Winchester Place, Winchester MA 01890. The price is $60 cloth, $34.95 paperback.

Computer Graphics: Minicomputer Results from a Micro

Order A. F. Theisen's eight-page USGS open-file report OF 85-0675 from: U.S. Geological Survey, Books and Open-File Reports, Federal Center, Bldg. 41, Box 25425, Denver, CO 80225. The price is $4 for microfiche and $1.50 for a paper copy; add 25% to the price for shipment outside the U.S. (except Canada and Mexico).

Acid Mine Drainage from Inactive Eastern Coal Operations

The most widely used technique for abatement of acid drainage from inactive surface mines and refuse disposal areas is revegetation of soil cover applied to the waste material. Nonetheless, acid production often persists and, in some cases, limits establishment of vegetation. This paper reports on several field studies intended to determine the location of pyrite-oxidation zones and migration pathways of oxidation products at inactive spoil and refuse sites.

The paper, written by P. M. Erickson, K. J. Ladwig, and R. L. P. Kleinmann, was published in *Geochemistry and Health*, v. 7, no. 1, March 1985, p. 16–25.

USGS Research on Energy Resources, 1986; Program and Abstracts

The 88 extended abstracts in this volume are summaries of talks and posters presented at the second V. E. McKelvey Forum on Mineral and Energy Resources. Topics represent a broad spectrum of USGS energy research and include: coal-deposition and coal-forming processes and geochemical and microprobe studies of coal; geothermal research and research techniques; uranium and rare-earth exploration and uranium ore-forming processes; alternate or experimental forms of energy; hydrocarbon generation and entrapment related to tectonics, metamorphism, diagenesis, thermal maturity, structure, and stratigraphy; computer applications to energy research; and seismic, borehole geophysical, and sea-floor sidescan sonar studies. Data presented are being used in building models of geothermal energy settings, basin histories, and the occurrence of energy resources. Each USGS Energy Resource Program is also summarized. The 84-page USGS circular is edited by L. M. H. Carter.

Order C 0974 from: U.S. Geological Survey, Books and Open-File Reports, Federal Center, Bldg. 41, Box 25425, Denver, CO 80225. The circular is available free of charge.

Seismograph Station Codes and Coordinates

The 1985 edition of this USGS open-file report was written by B. W. Presgrave, R. E. Needham, and J. H. Minsch. The volume contains 391 pages.

Order OF 85-0714 from: U.S. Geological Survey, Books and Open-File Reports, Federal Center, Bldg. 41, Box 25425, Denver, CO 80225. The price is $4 for microfiche and $59 for a paper copy; add 25% to the price for foreign shipment.

Activities in Geological Remote Sensing: August 1984–Late 1985

C. S. Southworth and R. S. Williams, Jr. are the authors of this eight-page USGS open-file report.

Order OF 85-0743 from: U.S. Geological Survey, Books and Open-File Reports, Federal Center, Bldg. 41, Box 25425, Denver, CO 80225. The price is $4 for microfiche and $1.50 for a paper copy; add 25% to the price for shipment outside North America.

GSDRAW and GSMAP: Prototype Programs for the IBM PC or Compatible Microcomputers to Assist Compilation and Publication of Geologic Maps and Illustrations

This USGS open-file report by G. I. Selner, R. B. Taylor, and B. R. Johnson contains 40 pages.

Order OF 86-0042 from: U.S. Geological Survey, Books and Open-File Reports, Federal Center, Bldg. 41, Box 25425, Denver, CO 80225. The price is $4 for microfiche and $6 for a paper copy; add 25% to the price for foreign shipment.

Guidelines for Petroleum Emergency Field Situations in the State of Oklahoma

This report is recommended to the Oklahoma petroleum industry by the Industry Advisory Committee and the Oklahoma Corporation Commission, Oil and Gas Conservation Division.

The 65-page publication is available for reference at the Oklahoma Corporation Commission, Field Operations Office, Room 225, Jim Thorpe Bldg., 2101 North Lincoln, Oklahoma City, OK 73105.

Symposium Proceedings: A National Agenda for Coal-Quality Research

Edited by Susan Garbini and S. P. Schweinfurth, this 334-page publication presents the proceedings of a symposium on coal quality held at the USGS in Reston, Virginia, April 9–11, 1985. The proceedings include the formal presentations that were made at the meeting and workshop recommendations for a natural research agenda on coal quality. An analysis of the workshop recommendations is also included. A summary of a presentation by OGS coal geologist Samuel A. Friedman, entitled "A Geochemical Study of Bituminous Coal Resources of Middle Pennsylvanian Age in Eastern Oklahoma; Part 1, Maps Showing Distribution of Fixed Carbon and Sulfur, and Lead, Zinc, and Manganese," appears on p. 230–231.

Order C 0979 from: U.S. Geological Survey, Books and Open-File Reports, Federal Center, Bldg. 41, Box 25425, Denver, CO 80225. The circular is available free of charge.

Annual Yield and Selected Hydrologic Data for the Arkansas River Basin Compact, Arkansas–Oklahoma, 1985 Water Year

M. A. Moore and T. E. Lamb are the authors of this 39-page USGS open-file report.

Order OF 86-0066 from: U.S. Geological Survey, Books and Open-File Reports, Federal Center, Bldg. 41, Box 25425, Denver, CO 80225. The price is $4 for microfiche and $6.50 for a paper copy; add 25% to the price for shipment outside North America.

Oil and Gas Production of Oklahoma

A new oil and gas production map of Oklahoma is available, featuring oil fields, gas fields, county lines and names, township-and-range grid and numbers, and basement rock. Also shown are oil and gas pipelines, longitude and latitude lines, section lines, county seats, and major bodies of water. Scale is 1 in. = 21 mi, and the map measures 13 × 24 in. The map is also available at 1:500,000 scale.

Order from: Terra Graphics Maps, 1915 Clarkson St., Denver, CO 80218. The price is $10; Colorado residents add 3.5% and Denver residents add 6.5%.

OKLAHOMA ABSTRACTS

ACS National Meeting
New York City, New York, April 13–18, 1986

The following abstract is reprinted as published by the American Chemical Society, Division of Geochemistry. Permission of the authors and of the ACS to reproduce the abstract is gratefully acknowledged.

The Petroleum Geochemistry of Oils and Source Rocks from the Pauls Valley Area of the Anadarko Basin, Oklahoma

P. J. JONES and R. P. PHILP, School of Geology and Geophysics, University of Oklahoma, Norman, OK 73019

The geology of the Pauls Valley area is extremely complex with producing formations ranging from the Cambro–Ordovician Arbuckle Limestone to the Pennsylvanian (Virgilian) Tonkawa sand. The Basal Pennsylvanian Unconformity, which coincides with the Wichita Orogeny, often controls or greatly affects the production in the area. Hydrocarbon accumulations occur in traps varying from purely structural to purely stratigraphic in nature. Often production is found at the up-dip truncation of a reservoir by the BP unconformity or at the up-dip portion of reservoirs that onlap the unconformity. Oils produced in the area range from distillates to heavy crudes. Biomarkers in oils from reservoirs of ten different ages and whole rock extracts from six potential source rocks were analyzed by GC/MS-SIM. Data from these analyses have been used to classify source rocks into different genetic groups and assign source rocks to the hydrocarbons being produced. The source rock and oil data have subsequently been examined in light of the sub-surface geology in order to find relationships which may explain the areal distribution of oil types in the region.

OKLAHOMA ABSTRACTS is intended to present abstracts of recent 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.

AAPG, Southwest Section, Annual Meeting
Ruidoso, New Mexico, April 27–29, 1986

The following abstract is reprinted as published in the *Bulletin* of the American Association of Petroleum Geologists, v. 70, no. 3, p. 345. Permission of the authors and of the AAPG to reproduce the abstract is gratefully acknowledged.

Basement Structures and Geophysical Anomalies in Eastern New Mexico

G. R. KELLER and A. S. SULEIMAN, University of Texas at El Paso, El Paso, TX

Eastern New Mexico contains many prominent basement features that developed primarily during deformation of the Ancestral Rocky Mountains. The nature and extent of many of these features are poorly known. To understand basement structures in eastern New Mexico better, an integrated analysis of subsurface and geophysical data in the area was undertaken. A data base of 6,600 gravity stations was used to generate complete Bouguer anomaly, polynomial, and residual maps. Aeromagnetic data for the New Mexico area were used to generate total intensity, residual, and low-pass filtered magnetic maps.

The complete Bouguer gravity and total intensity magnetic maps show a large relief, which indicates substantial structures are present. A fifth-order polynomial surface map shows a regional gravity increase from the northwest to the southeast, and the residuals with respect to this surface provide a better definition of upper crustal structures, which are somewhat obscured in the complete Bouguer gravity map. A low-pass filtered magnetic map, which was constructed from the third-order residual magnetic map, enhanced the major structures of interest in this study. These anomaly maps and the drilling results in the area were used to construct new maps of the depth to the Precambrian basement in the area.

We obtained four major results concerning the features in this study area: (1) we believe the Southern Oklahoma aulacogen extends northwest as far as the Cimarron arch; (2) the north–south-trending, negative anomalies located along long. 105°W in southern New Mexico possibly represent an extension of the Tucumcari basin or a new basin; (3) the exposed Precambrian rocks located west of the Raton and Las Vegas basins may be allochthonous, because they overlie the negative anomalies associated with these basins; and (4) the Central Basin platform is underlain by a large mafic mass, which has been recently penetrated by deep drilling in Pecos County, Texas.

Geological Society of America

The following abstracts are reprinted as published in the *Bulletin* of the Geological Society of America. Volume and page numbers are given in brackets below the abstracts. Permission of the authors and of the GSA to reproduce the abstract is gratefully acknowledged.

Foraminiferal Characterization of the Morrowan–Atokan (Lower Middle Pennsylvanian) Boundary

JOHN R. GROVES, School of Geology, Oklahoma State University, Stillwater, OK 74078

Designation of a lower Atokan (lower Middle Pennsylvanian) boundary stratotype is necessary because the traditional type Atokan Series is inadequate as a chronostratigraphic standard of reference. Foraminiferally, the boundary between the Atokan and the underlying Morrowan Series (Lower Pennsylvanian) is best defined by the appearances of the primitive fusulinaceans *Eoschubertella* and *Pseudostaffella*. Recrystallized staffellids (*Staffella* and *Nankinella*) appear at or near this level at some localities. The appearance of the fusiform fusulinid *Profusulinella* is considerably higher, and its range defines an informal middle Atokan interval. Upper Atokan rocks are characterized by the range of *Fusulinella* below the appearance of *Beedeina* and/or *Wedekindellina*.

Foraminiferal successions across the Morrowan–Atokan boundary have been documented at many localities in the south-central and western United States and in the Arctic. The merits of these sites as potential boundary stratotypes are evaluated herein. The Arctic is unsuitable as a reference area for the Atokan Series because taxon ranges there are seemingly atypical of ranges elsewhere in North America. Of the remaining sites where successions have been reported, those in southern New Mexico (type Derryan area), southeastern Arizona (Pedregosa Basin), southern Nevada (Las Vegas area), and east-central Idaho (Lost River and Lemhi Ranges) exhibit the best foraminiferal faunas in apparently continuously deposited strata. [v. 97, p. 346]

Southern Provenance of Upper Jackfork Sandstone, Southern Ouachita Mountains: Cathodoluminescence Petrology

MICHAEL R. OWEN and ALBERT V. CAROZZI, Department of Geology, University of Illinois, Urbana, IL 61801

The source area of the upper Jackfork Sandstone of the southern Ouachita Mountains of Arkansas has been located by means of cathodoluminescence (CL) of quartz in conjunction with standard petrography. Comparison of frequency distributions of quartz CL colors between the Jackfork

and approximately coeval sandstones of the Black Warrior basin detected genetically based affinities which were not apparent by inspection of gross petrology.

The upper Jackfork was derived from the same source area as the Parkwood Formation of the Black Warrior basin of Alabama. The Parkwood is known to have come from the south, and so the Jackfork did also. The Jackfork represents a deep-water lithologic equivalent of the deltaic and nearshore marine Parkwood, deposited as turbidites in the deeper water of the Ouachita trough. [v. 97, p. 110]

Geomorphic Development of the Canadian River Valley, Texas Panhandle: An Example of Regional Salt Dissolution and Subsidence

THOMAS C. GUSTAVSON, Bureau of Economic Geology, University of Texas, Austin, TX 78713

Development of the Canadian River Valley in the Texas Panhandle resulted mostly from regional subsidence following dissolution of Permian bedded salts. Salts of the Clear Fork, Glorieta, San Andres, and Seven Rivers Formations have undergone dissolution along the margins of the Palo Duro, Dalhart, and Anadarko Basins. The Canadian River Valley follows a zone of subsidence for >208 km (130 mi) across the High Plains. High solute loads (3,000 ppm chloride) in the Canadian River and historical development of sinkholes indicate that dissolution and subsidence processes are still active. Evidence that these processes have been active in the region since the middle Tertiary includes Pliocene lake sediments and Quaternary terrace alluvium that have been deformed by dissolution-induced subsidence as well as former sinkholes filled with lacustrine sediments of the lower Ogallala Formation (Miocene). [v. 97, p. 459]

Textures of Paleozoic Chert and Novaculite in the Ouachita Mountains of Arkansas and Oklahoma and Their Geological Significance

WALTER D. KELLER, Department of Geology, University of Missouri, Columbia, MO 65211; CHARLES G. STONE, Arkansas Geological Commission, 3815 W. Roosevelt Road, Little Rock, AR 72204; and ALICE L. HOERSCH, Department of Geology, LaSalle University, Philadelphia, PA 19141

Scanning electron micrographs of cherts and novaculites from the Ouachita Mountain fold belt of Arkansas and Oklahoma show a sequential range in textures from cryptocrystalline, anhedral quartz <1 μm in diameter in the nonmetamorphosed chert and novaculite, to coarse, polygonal triple-point, euhedral quartz 100 μm or more in diameter where the cherts have been thermally metamorphosed, the coarsest being in xenoliths. The textures have been correlated with similar texture and crystal sizes in the chert from a contact metamorphic aureole on the Isle of Skye, Scotland,

where classic metamorphic mineral assemblages from talc through tremolite, diopside, and forsterite grades have been identified. Texture of chert thus can be used as an indicator of elevated temperature.

Mean apparent crystal diameters measured of the quartz in the Arkansas Novaculite and associated cherts were plotted on a map of the Ouachita Mountain fold belt extending from Little Rock, Arkansas, to near Broken Bow, Oklahoma. The regional trend in texture parallels the structural core trend and, in addition, is strongly overprinted by localized areas of coarser crystallinity near Little Rock, Magnet Cove, and Potash Sulphur Springs, Arkansas, where igneous intrusions have occurred, and near Broken Bow, Oklahoma.

Temperature estimates from studies of fluid inclusions, stable isotope ratios, mineral-chemical phase relationships in associated rocks, and novaculite as xenoliths suggest that maximum temperatures as high as 760°C may have been reached by portions of the novaculite.

Other examples of triple-point texture in chert collected from distant localities, which range in age from Precambrian to Tertiary, show that polygonal triple-point texture in chert is world-wide in occurrence. It follows that small samples of chert-novaculite can yield evidence of a history of elevated temperature. Such evidence may be used to estimate maturation or degradation of hydrocarbons in the rocks and to furnish clues during exploration for thermally related metallic and nonmetallic minerals.

[v. 96, p. 1353]

Geological Society of America

The following abstracts are reprinted as published in *Geology*, a monthly publication of the GSA. Volume and page numbers are given in brackets below the abstracts. Permission of the authors and of the GSA to reproduce the abstracts is gratefully acknowledged.

Sea-Level Curve for Pennsylvanian Eustatic Marine Transgressive-Regressive Depositional Cycles Along Midcontinent Outcrop Belt, North America

PHILIP H. HECKEL, Department of Geology, University of Iowa, Iowa City, IA 52242

At least 55 cycles of marine inundation and withdrawal are recognized in the mid-Desmoinesian to mid-Virgilian Midcontinent outcrop sequence in North America. They range from widespread major cycles (classic cyclothems) with deep-water facies extending across the northern shelf, through intermediate cycles persisting as marine horizons across the shelf, to minor cycles developed on the lower shelf or as parts of major cycles. Biostratigraphic differentiation of the cycles should establish interbasinal

correlation on a scale fine enough to allow evaluation of differential tectonics and sedimentation. Sequential groupings of cycles are more irregular than proposed megacyclothems or mesothems, but they may be obscured by the distinctness of the major cyclothems. Estimates of cycle periods range from about 40 to 120 $\times$ 10^3 yr for the minor cycles up to about 235 to 400 $\times$ 10^3 yr for the major cyclothems. The range for all cycles corresponds well to the range of periods of Earth's orbital parameters that constitute the Milankovitch insolation theory for the Pleistocene ice ages, and it further supports Gondwanan glacial control for the Pennsylvanian cycles. Even though the dominant period of the major Pennsylvanian cyclothems is up to four times longer than the dominant 100,000-yr period in the Pleistocene, the shapes of both curves display rapid marine transgression (rapid melting of ice caps) and slow interrupted regression (slow buildup of ice caps), which suggest similar linkages between the climatic effects of the orbital parameters and ice-cap formation and melting, at the two different scales, widely separated in time. [v. 14, p. 330]

Fluids Expelled Tectonically from Orogenic Belts: Their Role in Hydrocarbon Migration and Other Geologic Phenomena

JACK OLIVER, Department of Geological Sciences, Cornell University, Ithaca, NY 14853

This paper presents and supports a speculative hypothesis, the essence of which follows. When continental margins in zones of convergence are buried beneath thrust sheets, fluids expelled from the margin sediments travel into the foreland basin and the continental interior. These tectonic fluids have key roles in phenomena such as faulting, magma generation, migration of hydrocarbons, transport of minerals, metamorphism, and paleomagnetism. The thrust sheet, crudely speaking, acts like a great squeegee, driving fluids ahead of it and producing widespread geologic consequences. [v. 14, p. 99]