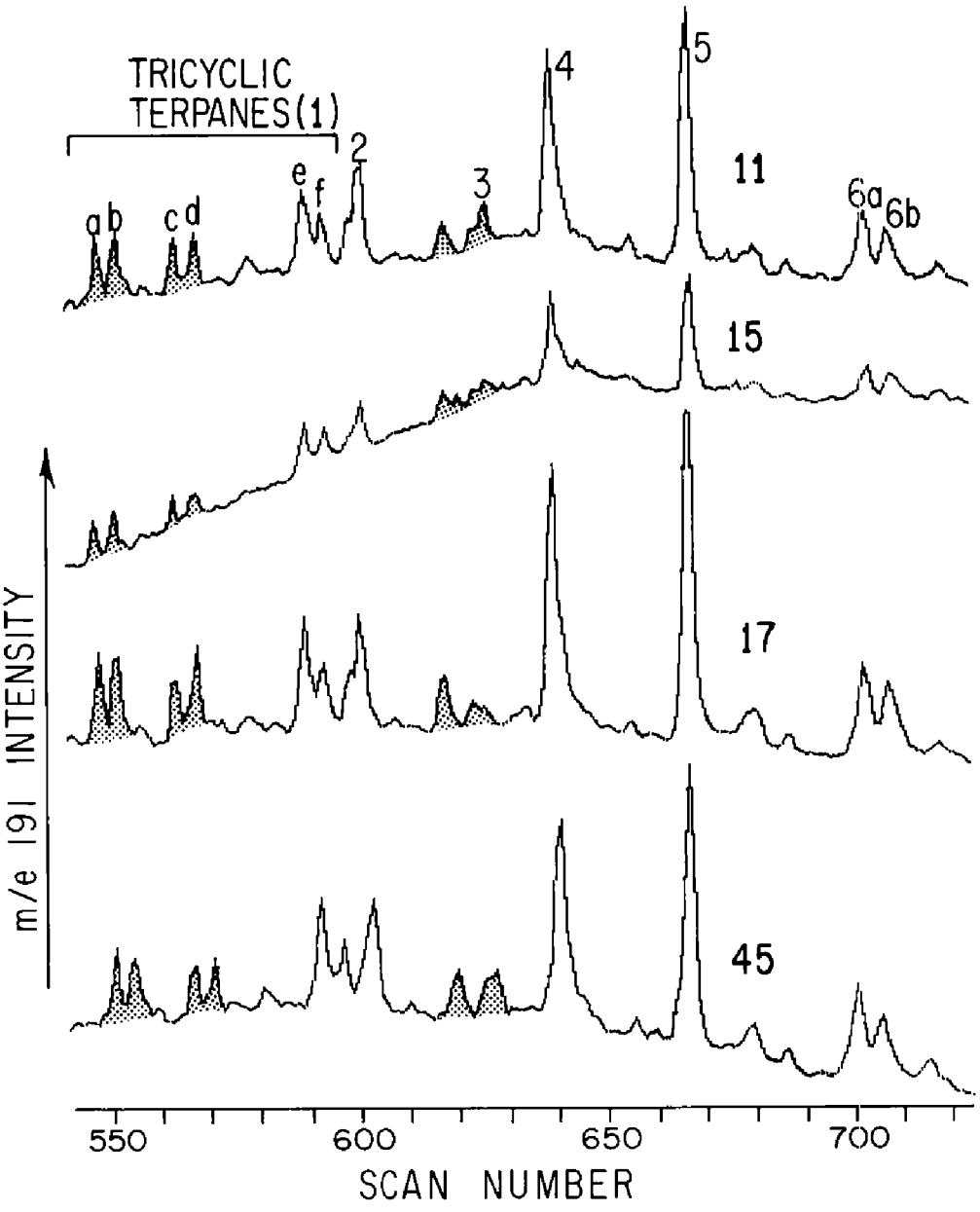
Oklahoma Geology Notes

OKLAHOMA GEOLOGICAL SURVEY / VOL. 43, NO. 4 - AUGUST 1983



On the cover—

Mass Chromatograms Correlate Ouachita Oils

The cover diagram is taken from figure 12 of a forthcoming bulletin (no. 135) that will be published by the Oklahoma Geological Survey late this fall. The bulletin, authored by Joseph A. Curiale, a geochemist with Union Oil Co. of California, and a former graduate research assistant with the Survey, is entitled *Petroleum Occurrences and Source-Rock Potential of the Ouachita Mountains, Southeastern Oklahoma.* It is a condensed version of his doctoral dissertation and presents the results of his research on the crude oils, solid bitumen, and potential oil-source rocks of the frontal and central Ouachita Mountains of Oklahoma. The 65-page bulletin contains 55 figures and 15 tables. It will sell for $12 clothbound and $8 paperbound.

Chemical analyses suggest a marine source for the organic matter that formed the crude oils depicted by the chromatograms in the picture (samples 11, 15, 17, and 45). These oils are produced from South Bald, Bald, Redden, and North Daisy Fields, respectively. The fields are in northern Atoka and southern Pittsburg Counties, in the complexly folded and faulted Ouachita Mountain province. The Jackfork and Stanley Groups of Early Pennsylvanian and Late Mississippian age are the productive units.

When compounds are bombarded with electrons, a characteristic pattern of fragments of different masses serves to identify that specific compound. Each of the major peaks in the chromatograms corresponds to a specific biomarker compound, and the height of the peak is a measure of concentration.

This illustration shows the relative concentrations of terpanes (as indicated by a mass/charge ratio of 191) in the four samples of Ouachita oils. In addition, peak 2 indicates trisnorhopane, peak 3 bisnorhopane, peak 4 norhopane, peak 5 hopane, and peaks 6a and 6b homohopane.

Such diagnostic patterns are useful for oil-oil correlation work as well as for paleothermometry investigations, which can determine maturity levels of oils.

Oklahoma Geology Notes

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

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Contents

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COSMETOCRINUS EVENTUS (STRIMPLE) A UNIQUE CRINOID FROM THE PITKIN LIMESTONE (MISSISSIPPIAN), EASTERN OKLAHOMA

D. W. Burdick[1] and H. L. Strimple[2]

Introduction

Cosmetocrinus eventus (Strimple, 1953) is a rather distinctive inadunate crinoid that is known only from the Pitkin Limestone of Mississippian (Chesterian) age in northeastern Oklahoma. Although the crown is rather large, durable, and easy to identify, few representatives of the species are known. The original description of the species was based on a holotype and two paratype specimens. Subsequent to that description, two additional crowns have been collected from the type locality. These additional specimens exhibit some characters not described on the original type material; these characters provide the basis for the present paper.

Cosmetocrinus eventus was originally assigned to the genus *Carcinocrinus* Laudon, 1941. Subsequently, based on an examination of a well-preserved specimen collected by Allen Graffham, of Ardmore, Oklahoma, Strimple (1967, p. 81–82) referred the species to *Cosmetocrinus* Kirk, 1941. *C. eventus* somewhat resembles the type species of both *Carcinocrinus* and *Cosmetocrinus* in that all have cone-shaped cups with three anal plates in the *CD* interray, long, slender crowns, and multiple branching rays composed of cuneate brachials.

The original assignment of *Cosmetocrinus eventus* to *Carcinocrinus* was based on the similar characters listed above, and on the prominent elongate anal sac displayed by *Carcinocrinus stevensi* Laudon, 1941, type species of its taxon. *C. eventus* was subsequently removed from *Carcinocrinus* because the latter genus typically has several primibrachs in each ray and has articular facets which are widely separated.

The holotype of *C. eventus* (as discerned from a text-figure by Strimple, 1953, p. 202, fig. 1) has radials that appear to flare outward more than the inclination of the cone-shaped cup. This factor is specifically deceiving and is apparently due to the state of preservation of the specimen, which Strimple

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(1953, p. 202) listed in a footnote as "mildly distorted by compression." The distortion apparently occurred when the enclosing sediment was compacted, resulting in the flattening out of the cup. The hypotypes examined for the present study are not as compacted as the holotype. The outward slopes of the radials in the holotype specimens are more in line with the outward inclination of the cone-shaped cups.

In the original description of *Cosmetocrinus eventus* the proximal portions of the primibrach series is described as not filling the distal face of the radials (Strimple, 1953, p. 201). In those specimens the cups are somewhat compacted, and the primibrach appears slightly separated. The cups of the present materials are more wholly preserved, and the proximal portion of the primibrachials in the present material appears to extend through the full distal width in *A*, *B*, and *E* radials. The left side of radial *D* and possibly the right side of radial *C* on the larger hypotype (SUI 49585) extend slightly above the adjacent radials, and the facet ends about 1 mm short of the outer distal width.

The primibrach series of ray *A* were not preserved in the original type material, but the other rays were known to be axillary on primibrach *1*.

In the secundibrach series the types are reported to branch on secundibrach *8* to *9* (Strimple, 1953, p. 201) in rays *B*, *C*, and *E*. The present material exhibits similar branching on secundibrach *9* and *12*. These are not axillary. The longer brachial series and more distal branching in ray *A* are common in many inadunate crinoids (Strimple, 1975, p. 2) and should be considered separately in any statistical comparison. A third branching takes place in tertibrachs *6* to *17* in the type material and in the specimens presently being described.

Another important difference between *C. eventus* and *C. stevensi* is found in the composite structure of the anal sac. The anal sac of *C. eventus* is composed of six longitudinal columns of plates, while that of *C. stevensi* is composed of more than six columns of plates. There is also a difference in the pore structures that penetrate the sutured areas of the anal sacs. *C. eventus* has major pores at the suture intersections, while *C. stevensi,* as discerned from Laudon's illustration (1952, pl. 57, fig. 5), has a series of pores or slits along all common sutures in the anal sac. Additionally, the anal sac of *C. eventus* is proportionally shorter.

To the present writers, the characters discussed above are too dissimilar to allow *C. eventus* and *C. stevensi* to be placed in the same genus. The complete primibrach structure was not known to Strimple when he described *C. eventus.* This structure is now known from the two hypotypes discussed in this paper. The present authors agree with remarks published by Strimple (1967, p. 82) and believe that *C. eventus* appears more closely related to *Cosmetocrinus gracilis* Kirk, 1941, type species of that taxon. Besides the similarities discussed earlier in this paper, both species have brachials that are axillary on primibrach *1* in all rays.

Proximal portions of the primibrachs in *Cosmetocrinus gracilis* Kirk, 1941, appear to be in contact, or nearly in contact, with one another. This

character also appears in *Cosmetocrinus eventus* but not in *Carcinocrinus stevensi,* where the brachial series are widely separated by interradial gaps.

The anal tube of hypotype OU 4315 appears to be bilaterally symmetrical in that the longitudinal row of pits at the suture intersections above the *CD* interray and above ray *A* are similar. Longitudinal rows of pits on either side of the above-mentioned rows are larger, and most exhibit a series of pore slits deep within themselves. The significance of these variations in pore structure is not known. It seems significant that the two columns of anal plates in the *CD* interray terminate at the same height, and the distalmost plate of each flexes inward sharply. These factors indicate some change in structure above this point. The holotype (Strimple, 1953, p. 201–202) is described as having six columns of plates in the proximal portion of the anal sac and with "numerous smaller interposed" plates in the distal portion. Judging from the illustration of the holotype, the exact nature of the distal structure cannot be determined because of its compacted nature and because of obscuring matrix. However, it appears the tube has looped, causing an expansion. The anal opening is probably on the anterior side somewhat below the summit of the sac.

Systematic Description

Cosmetocrinus Kirk, 1941

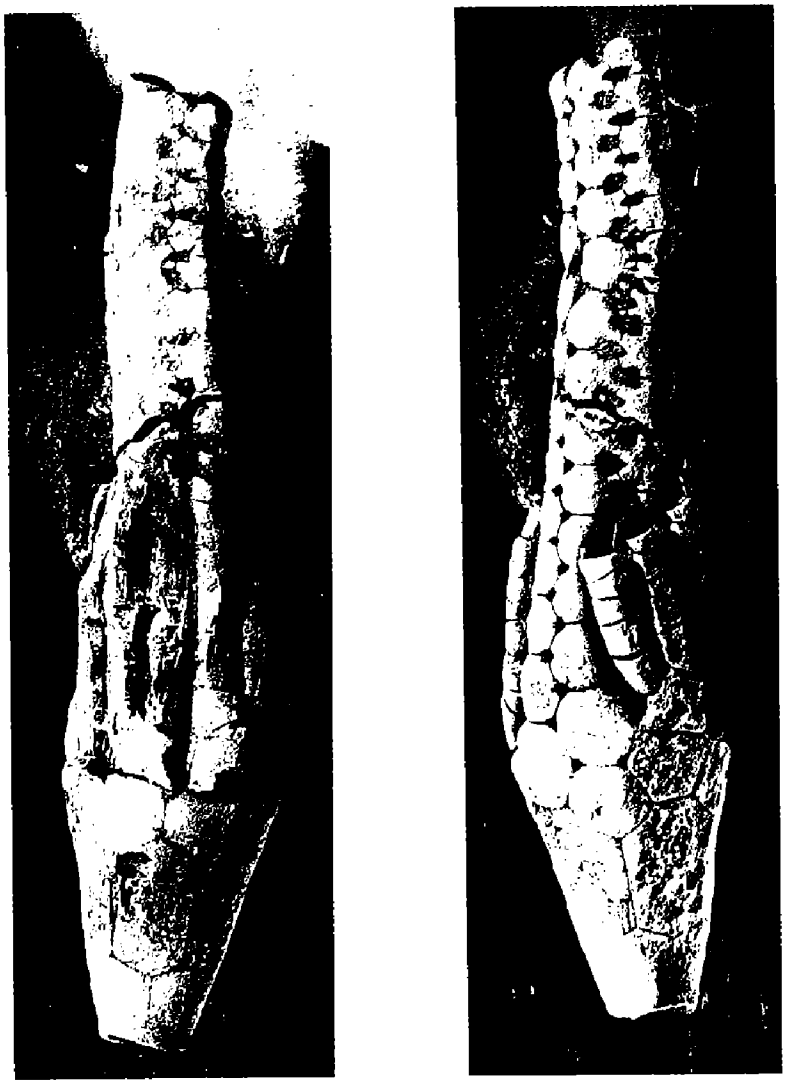
Cosmetocrinus eventus (Strimple, 1953)

Text-figures 1, 2

Diagnosis.—Cup slightly higher than wide. Infrabasals and basals longer than wide; radials wider than long. Primibrachs wider than long. Anal tube strong; proximal portion composed of six longitudinal rows of plates.

Hypotype OU 3915.—Specimen consists of well-preserved cup, proximal portion of anal sac, and proximal portions of all rays. Extreme proximal portion of infrabasals that attach to the column is broken off and missing.

Description.—Cup cone-shaped, about one and three-tenths as high as wide, sides flaring upward and outward from basal plane at 75°. Proximal portion of cup at point of column attachment unevenly fractured; but apparently little has been lost, remaining proximal diameter being about four-tenths that of maximum cup diameter; sutures in cup very slightly impressed; cup plates large and inornate. Infrabasals are upflared, one and three-tenths as long as wide; appear pentagonal in side view, and extend to about one-third height of cup; greatest width across distal portions of inter-infrabasal sutures. Basals, largest elements of the cup, hexagonal (except in *CD* interray where anal plates are inserted), about one and one-half times as long as wide, widest across distal portions of interbasal sutures, extend distally to about



A B

Figure 1. *Cosmetocrinus eventus* (Strimple), hypotype OU 3915. *A*, anterior view; *B*, posterior view; x 1.5.

eight-tenths of the height of the cup. Radials pentagonal about one and three-tenths as wide as long, widest across distal ends of interradial sutures. Articular facet on outer edge of radial covering nearly entire distal width: deep ligament furrow pit under full width of primibrach, ligament pit slightly over one-fourth of length, pronounced outer ligament ridge, very narrow outer ligament furrow full length of ligament pit furrow, thin but obvious outer marginal ridge.

Three plates of the anal series are within the distal limits of the cup. All are prominent, and in typical primitive position anal *X* and the right tube plate

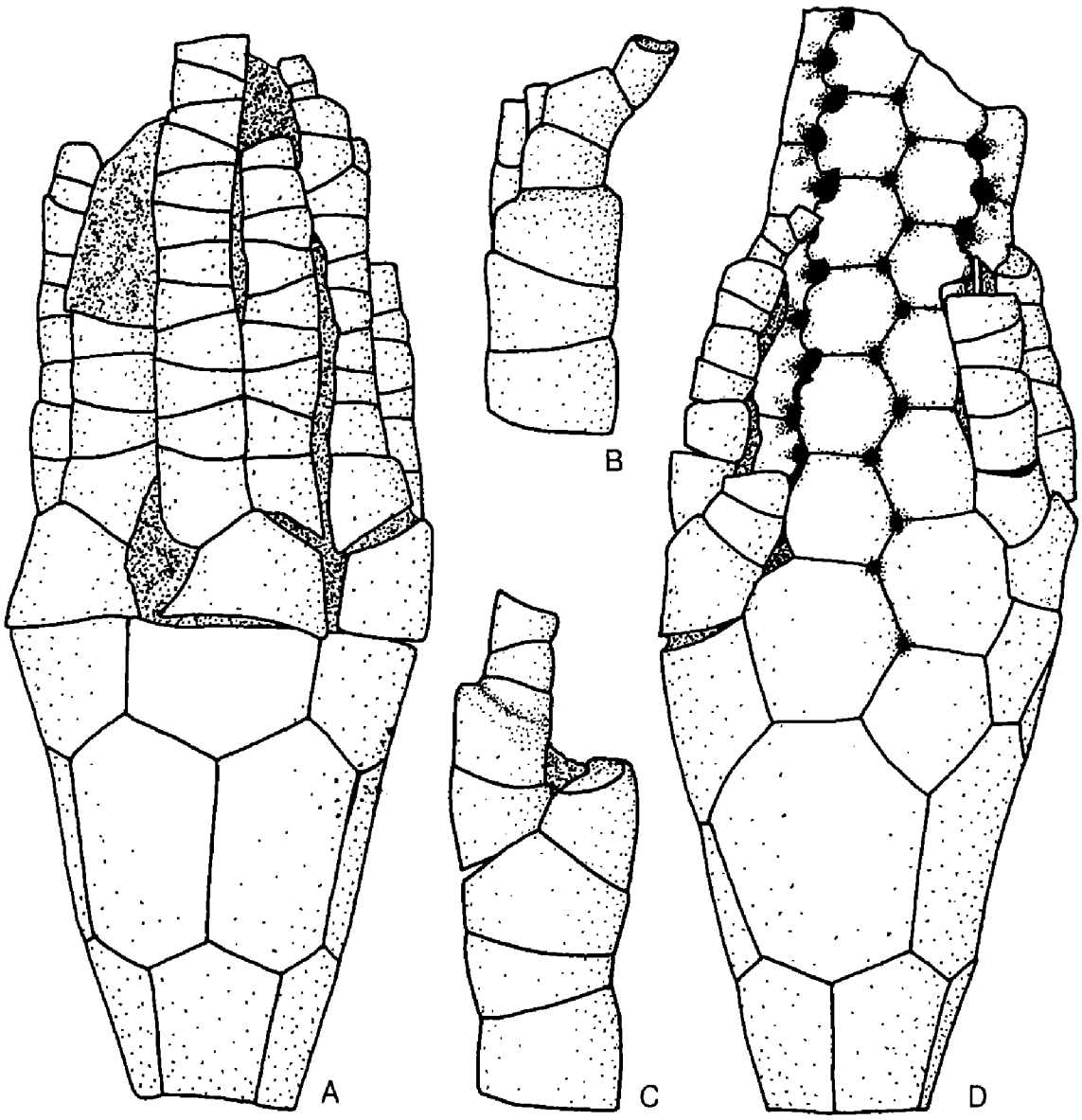


Figure 2. Drawing of *Cosmetocrinus eventus* (Strimple) exclusive of distal portion of anal sac, camera lucida, hypotype OU 3915. *A*, anterior view; *B*, posterior view; *C*, further enlargement of distal portion of left half ray of *D* ray arm to illustrate regeneration; *D*, further enlargement of distal portion of left ray of *E* ray arm to illustrate regeneration of distal portion.

are slightly larger than the radianal. The anal tube is prominent, elongate, and composed of six longitudinal rows of plates. All plates are fairly large, thick, and tumid. Distal portion of the tube is not preserved. Intact portion extends distally about 44 mm above the cup, being about two and one-half times as long as the cup. Suture intersections between the columns of plates above anal *X* and the right tube plate are marked by small pits. A similar series of pits extends distally between the columns of tube plates in the position of ray *A*. Other suture intersections are marked by larger pits and (or) pore

slits. As preserved, there is a column of 12 plates above anal *X*, and above the right tube plate. These two columns terminate distally at about the same height. The distal portion of the last distal plate flexes sharply inward. The distal portion of other plates at this point are broken or have a flat suture. The six-column structure of the anal sac is interrupted by a couple of small intercalated plates inserted in positions between rays *A* and *B*. These plates do not appear to alter the overall shape or structure of the anal sac.

Only the proximal portions of the rays are preserved. Except for the *CD* interray, lateral portions of the arms form a tight enclosure around the anal sac. The brachials are cuneate, have well-rounded backs, and are generally shorter than wide, with the proximal brachials commonly being longer than the distal ones. Primibrach *1* is axillary in all rays. The rays are wider than long, the proximal portion being the widest, and they are slightly constricted medially. A second branching occurs on secundibrach *7* on the left side of ray *B*, and secundibrach *8*, on the left side of rays *D* and *E*. Other secundibrach series do not have axillaries preserved. Incomplete secundibrach series are composed of six or fewer brachials. Only a few plates of tertibrach series are preserved and none are axillary.

The left side of ray *D* is regenerated above secundibrach *6*. As preserved, the regenerated ray segment is composed of two secundibrachs, the second being axillary, and one tertibrach, on the right side of the axillary. The left side of ray *E* is regenerated above tertibrach *2* and consists of two small tertibrachs. The regenerated rays are positioned on the inside near the ambulacral groove. Each is situated on a pad or platform that appears secreted or fused to the original brachial series (see figs. 1, 2).

Hypotype SUI 49585.—Specimen consists of a partial, slightly compacted crown. Sides of cup extend upward and outward from basal plane at about 75°. Infrabasals and proximal portions of most basals are missing. Basal *BC* is the only complete basal. That plate is one and one-half times as long as it is wide. Basal *CD* is missing. Basals and radials are very slightly convex laterally. Medial portions of basals are slightly thicker than edges. All radials are preserved. They are wider than long. Right side of radial *C* and left side of radial *D* extend slightly above distal limit of adjacent radials.

Sutures on adjacent plates indicate there were three plates of the anal series within the cup in normal primitive arrangement. The radianal is missing; anal *X* and the right tube plate are preserved and are fairly long. Anal tube is slightly disarticulated and mostly covered by matrix. Preserved portion extends about 6 cm above the cup, and distal portion is composed of six longitudinal rows of plates. An estimated 11 plates are preserved in a column above anal *X*, and a similar number above the right tube plate. The distal portion beyond that limit is broken and missing. Preserved distal portions of the rays form a tight enclosure around the anal sac except in the *CD* interray. Backs and sides of the arms are well rounded. Primibrachs are wider than long and axillary in all rays. Proximal portions of primibrachs as wide as, or nearly as wide as, the distal portion of a radial. There are six to 10 secundibrachs, and six to 17 tertibrachs known in exposed portions of the rays. Except for the ax-

illary primibrach, ray *A* is completely covered with matrix. Nonaxillary brachials are cuneate, and each bears a pinnule on the long side.

Comments.—The above specimen is smaller than the holotype but larger than the other hypotype described in this paper. The incomplete nature of the specimen impedes the comparison of individual plate-size ratios with other known specimens. Known structure of the anal tube agrees with that of the other described specimens ascribed to *Cosmetocrinus eventus.*

Types and Locality

This study is based on two hypotype specimens collected from the type locality. References to other type materials are based on published descriptions and illustrations. All materials were collected from an exposure of the Pitkin Limestone (Chesterian, Upper Mississippian) in bluffs overlooking the Arkansas River about 4 mi southeast of Greenleaf Lake, in the Cookson Hills, Muskogee County, Oklahoma (SE¼, sec. 27, T13N, R20E).

The two hypotype specimens described in this study are reposited at The

TABLE 1.—MEASUREMENTS OF *COSMETOCRINUS EVENTUS* (STRIMPLE) IN MILLIMETERS

	Paratype OU 3915	Paratype SUI 49585	Holotype USNM S-4843
Cup			
height	19.0	---	37.0
width (*BC-DE*)	14.4	24.0	32.2
width (*A-CD*)	14.0	18.8	*
Infrabasals			
length of *A*	5.7	---	*
distal width of *A*	4.5	---	*
length of *D*	6.0	---	*
distal width of *D*	4.5	---	*
Basals			
length of *BC*	9.5	15.0	*
greatest width of *BC*	7.2	10.5	*
length of *DE*	9.5	---	21.2
greatest width of *DE*	6.2	8.8	10.3
Radials			
length of *D*	5.2	7.8	8.8
distal width of *D*	6.3	9.2	12.6
length of *A*	5.2	6.7	*
distal width of *A*	7.2	9.9	*

*Not reported. Measurements of holotype are from Strimple (1953, p. 202).

University of Oklahoma, Norman, Oklahoma (specimen OU 3915), and the University of Iowa, Iowa City, Iowa (specimen SUI 49585).

The holotype and the two reported paratypes (Strimple, 1953, p. 203) are reposited in the National Museum of Natural History, Washington, D.C. The specimens are part of the Springer Collection. The holotype is USNM S-4843, and one paratype is USNM S-4796. The whereabouts of another paratype is not known.

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Laudon, L. R., 1941, New crinoid fauna from the Pitkin limestone of northeastern Oklahoma: Journal of Paleontology, v. 15, p. 384–391, pls. 56, 57.

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GEOLOGIC AND LAND-USE EFFECTS ON GROUND-WATER QUALITY IN SHALLOW WELLS OF THE ANADARKO BASIN

James W. Naney and S. J. Smith[1]

Abstract—Local geologic environment and land use have been related to the concentrations of nutrients and selected chemical constituents in waters sampled at depths of less than 75 ft. Changes over a four-year period (1979–82) of levels of nitrate-N (NO_3–N), ammonium-N (NH_3–N), total water-soluble phosphate (TWS-P), chloride (CL^{-1}), and sulfate (SO_4^{-2}), have been monitored in order to relate ground-water quality to causative factors such as agricultural practices, oil-field activities, or the predominance of the local geology. The wells sampled are part of a water-quality- monitoring system used to evaluate the Model Implementation Plan (MIP) on the Little Washita River watershed in Oklahoma (U.S. Soil Conservation Service, 1978, p. 1–17). Harlin (1982, p. 170–171) described the watershed as nearly perpendicular to the axis of the Anadarko Basin. Chemical analysis of samples from 32 wells in the 246 mi^2 (637 km^2) watershed indicate, to date, that local geology and climate have caused increased concentrations of as many as 350 mg/L SO_4^{-2}. Some increase in NO_3–N has occurred; however, levels of N are less than 5.0 mg/L and remain acceptable for domestic use. Increases in ammonium-N to 100 mg/L have occurred at improperly cased well sites that are in or nearby cattle feedlots or pastures. In general, however, the concentrations of NH_3–N have remained less than 0.5 mg/L in 27 of the 32 monitored wells.

Introduction

The Little Washita River watershed, a tributary of the Washita River in southwestern Oklahoma, was selected by the U.S. Environmental Protection Agency (EPA) to be monitored to assess the water-quality impact of a Model Implementation Plan. This watershed was selected for the monitoring program because it is representative of watersheds in the Cross Timbered and Reddish Prairie land resource areas of the southern plains of the United States. Its size of 246 mi^2 (637 km^2) also conforms to EPA's plans for using watersheds comparable in size to projects anticipated in the Rural Clean Wa-

[1]Geologist and soil scientist, respectively, U.S. Department of Agriculture, Agriculture Research Service, Water Quality and Watershed Research Laboratory, Durant, OK.

ter Program. The monitoring plan is designed to measure the effects of some of the Best Management Practices (BMP) to be implemented under the plan in the control of nonpoint-source pollution. The plan includes the measurement of hydrologic variables, such as precipitation, runoff, erosion, and ground-water levels, as well as the monitoring of various surface- and ground-water-quality parameters. Information reported herein was collected to determine, to the extent possible, the cause-effect relationships between such factors as agricultural practices, oil-field activities, or the influence of local geology and the quality of ground water in the watershed.

Background

Native vegetation of the area is predominantly prairie and blackjack oak. Improper management of both croplands and rangelands has resulted in some severe gullying, especially on the more erosive soils and steeper slopes. Information about the hydrology of the area is presented in table 1. For 18 years of record (1964 through 1981), precipitation ranged from 20 to 45 in. (50.8 to 114.3 cm), averaging 32.1 in. (81.6 cm). Runoff ranged from 0.66 to 4.5 in. (1.68 to 11.43 cm), averaging 1.9 in. (4.83 cm). Sediment production ranged from 158 to 2,500 tn/mi^2 (55,343 to 875,676 kg/km^2), averaging 1,096 tn/mi^2 (383,896 kg/km^2). In each case the low value occurred in 1966 and the high value, in 1973. From the western edge of the watershed, the geologic outcrops (fig. 1) and their percentages of watershed area are: the Cloud Chief Formation (18.4 percent), Rush Springs Sandstone (49.8 percent), and Marlow Formation (12.9 percent), which make up the Whitehorse Group (see Harlin, 1982, p. 170). The undifferentiated Dog Creek Shale and Blaine Formation (7.8 percent), and the Chickasha formation (2.7 percent), were classified by Davis (1955, p. 62) as part of the El Reno Group, which is in the middle of the Permian System. Quaternary alluvium covers 8.4 percent of the watershed area. Well-water quality for domestic and agricultural purposes is generally good in the Rush Springs Sandstone but poor in the other units. Along the stream courses, alluvial deposits of unconsolidated sand, silt, and clay are widely distributed but contain water of poor quality owing to evaporites (gypsum, halite, and epsomite) in the adjacent bedrock. Tanaka and Davis, (1963, p. 47) reported similar water-quality conditions within these deposits. Depth to ground water in the alluvium varies from 6 to 17 ft (1.83 to 5.19 m), and water quality is generally poor. Depth to water in the upland wells is 50 to 75 ft (15.2 to 22.8 m).

Results and Discussion

The locations of the ground-water wells monitored for this study are shown in figure 2. They were selected to provide good geographic coverage of

TABLE 1.—PRECIPITATION, RUNOFF, AND SEDIMENT TRANSPORT[1]

Date	Precipitation		Runoff	Sediment	Tn/ac[5]
	Inches[2]	Departure* from Normal (Inches)	(Inches)	Tn/sq mi[3,4]	
1962	30.45	- 1.48			
1963	17.72	- 14.21			
1964	30.84	- 1.09	1.169	1,920	3.0
1965	25.70	- 6.23	1.247	828	1.3
1966	19.60	- 12.33	0.659	158	0.2
1967	26.33	- 5.60	0.685	334	0.5
1968	34.02	+ 2.09	1.386	760	1.2
1969	28.03	- 3.40	1.844	1,486	2.3
1970	21.14	- 10.79	0.696	188	0.3
1971	31.30	- 0.63	1.164	679	1.1
1972	26.06	- 5.87	1.102	573	0.9
1973	45.03	+ 13.10	4.506	2,561	4.0
1974	31.69	- 0.24	2.537	1,006	1.6
1975	36.74	+ 4.81	4.443	2,239	3.5
1976	24.24	- 7.69	1.763	349	0.5
1977	29.70	- 2.23	2.020	1,067	1.7
1978	27.67	- 4.26	1.944	1,221	1.9
1979	32.36	+ 0.43	2.550	2,057	3.2
1980	22.84	- 9.09	2.013	1,526	2.3
1981	37.02	+ 5.09	1.771	776	1.2
1982	35.11	+ 3.18	2.842	1,514	2.3
AVG. (1964 through 1981)	29.22	- 2.69	1.891	1,096	1.7
High	45.03		4.506	2.561	4.0
year	1973		1973	1973	1973
Low	19.60		0.659	158	0.2
year	1966		1966	1966	1966

*Based on normal of 30.52 at Anadarko, 31.60 at Chickasha, 33.41 at Marlow, and 32.30 at Apache for an average normal of 31.93 in. Thiessen weighted normal rainfall, U.S. Weather Bureau (1931–1960).

These runoff data are available as maximum discharge (in./hr) and maximum volumes of runoff (in.) for selected time intervals, i.e., 1-hour, 2-hour, 6-hour, 12-hour, 1-day, 2-day, and 8-day daily, monthly, and yearly discharges.

[1]Expanded from Naney and others (1979, p. 395).

[2]To convert to cm, multiply by 2.54.

[3]To convert to kg/km^2, multiply by 350.27.

[4]Area above gage is 207.8 mi^2.

[5]To convert to kg/m^2, multiply by 0.2242.

the watershed and to monitor a variety of land uses. Results of chemical analyses of waters sampled before the BMP were implemented for the watershed are reported earlier (Naney and others, 1979, p. 398–399).

In 1979 a network of 32 monitoring wells was completed on the watershed (fig. 2). During the period 1979–82, ground-water quality was sampled on the

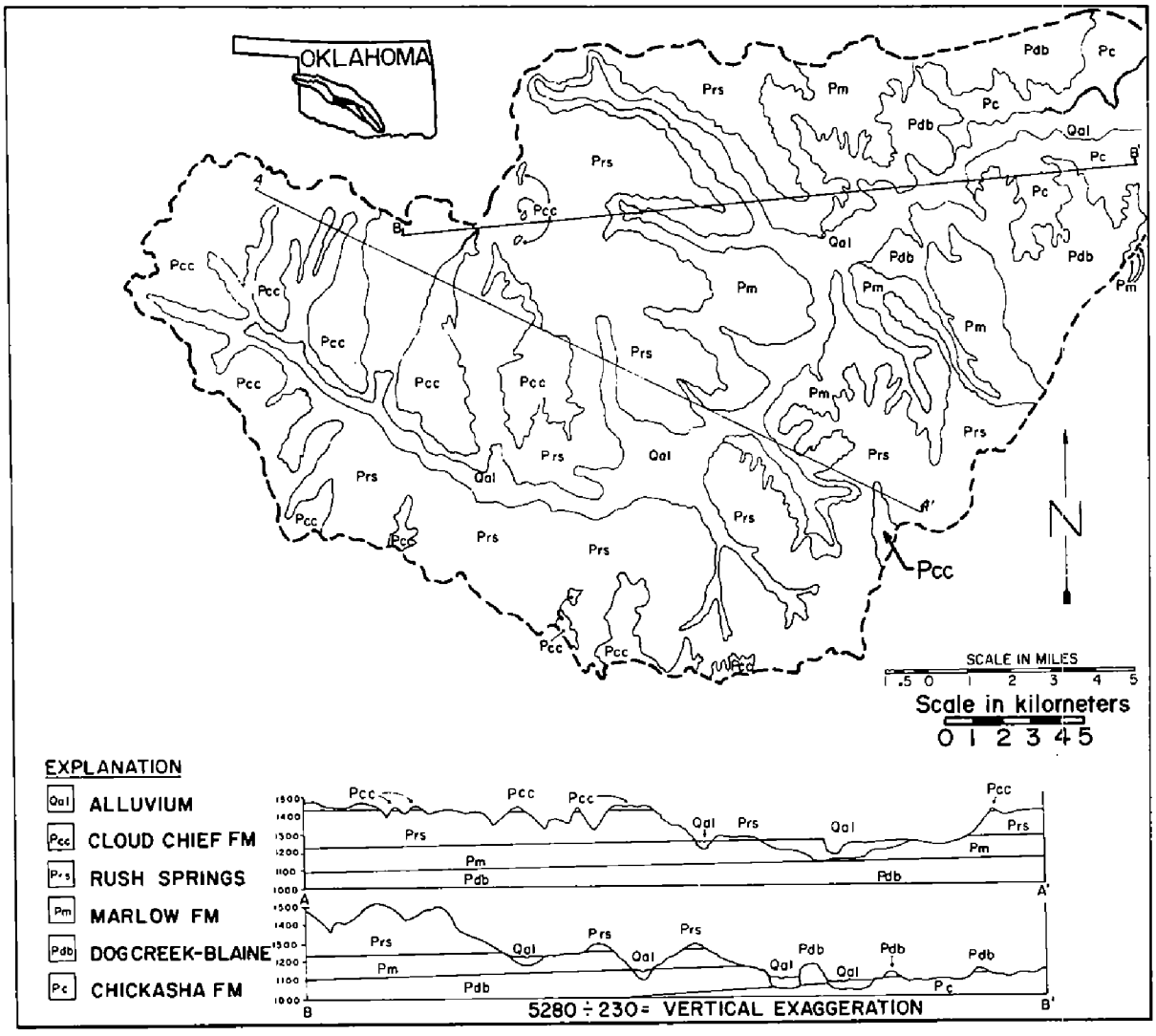

Figure 1. Geologic map showing Little Washita River watershed. After Naney and others, 1979.

basis of land use, such as wheat, grassed pasture, domestic well location, oil-field activity, and geologic environment. Several wells were identified as having a mixed environment of grass and wheat pasture. The geologic setting of the well was described as either alluvium or upland for those completed in the Permian red beds. The watershed was reported by the U.S. Soil Conservation Service in 1978 to have 76 percent area in pasture or range, 21 percent in cropland, and 3 percent in roads and other uses. Petroleum activity increased in Grady County, Oklahoma, from 91 wells drilled in 1978 to 170 wells in 1982 (Petroleum Information Corp., 1982, p. 1). Several of these wells were drilled in the Little Washita River basin during the study period. A chemical constituent, which changed significantly over the study period, was the sulfate (SO_4^{-2}) associated with the gypsum ($CaSO_4 \cdot 2H_2O$) and epsomite ($MgSO_4 \cdot 7H_2O$) common to the Permian red beds and their weathered products in the alluvium. Until the spring of 1981, SO_4^{-2} content for the various land uses,

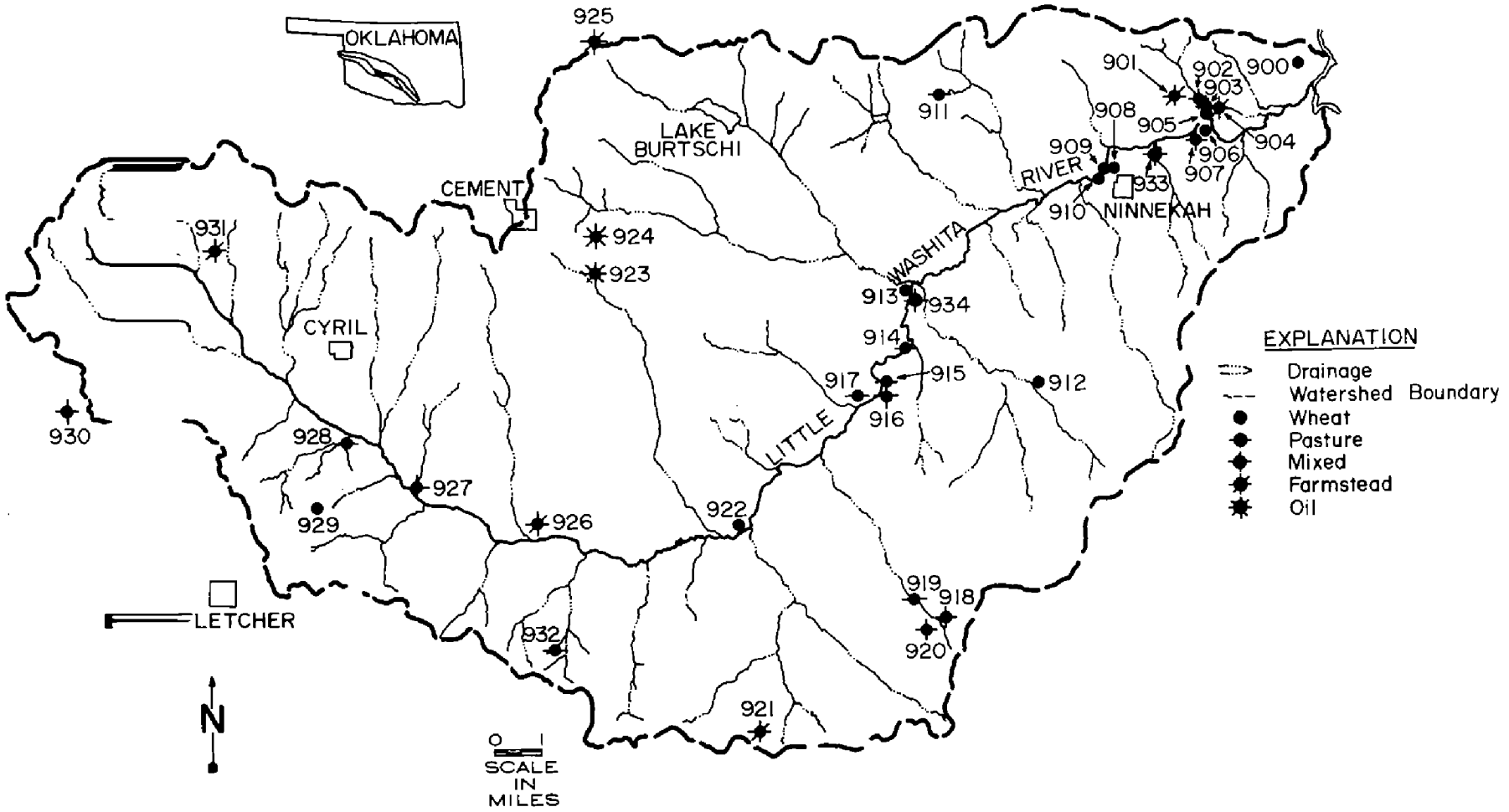

Figure 2. Map showing location of water-quality and water-level monitoring sites.

based on 11 selected wells, increased as shown in the data presented in table 2. The increase in SO_4^{-2} is associated with lower than normal rainfall and a decline in well-water levels until June 1981.

The period of declining water levels, shown in figure 3, increased the sulfate-water ratio until above average rainfall in 1981 resulted in increased ground-water-storage, which reduced the sulfate–water ratio. This pattern of

TABLE 2.—SULFATE CONCENTRATIONS (mg/L) IN WELLS IN SELECTED LAND USES ON THE LITTLE WASHITA WATERSHED

	Well no.	11/20 1979	2/19 1980	6/25 1980	8/12 1980	12/11 1980	4/21 1981	6/24 1981	1/18 1982	9/7 1982
						SO_4^{-2} mg/L				
Wheat	900	34.8	133	29.1	——	16.9	12.2	14.8	——	33.6
	906	145	166	275	336	336	596	548	——	239
	908	84.1	109	119	165	161	192	187	——	197
	913	——	——	——	1196	1454	1708	136	——	420
	929	802	322	912	1396	——	1640	1490	——	211
Pasture	915	134	125	145	184	202.5	207	——	——	175
	932	131	1212	163	230	218	233	213	——	165
Mixed	907	11.2	10	12	17.3	14.8	17.6	16.0	——	16.3
Farmstead	921	112	120	128	138	339	169	160	——	170
	924	114	114	99.8	135	317	141	150	——	143
	925	10.1	14	20.5	17.8	19.5	13.3	17.5	——	15.9
	Geo $\bar{x}$	78.2	70.7	63.2	51.5	133.6	153.14	115.97	——	108.9

TABLE 3.—SULFATE CONCENTRATIONS (mg/L) IN UPLAND AND ALLUVIUM WELLS ON THE LITTLE WASHITA WATERSHED

	Well no.	11/20 1979	2/19 1980	6/25 1980	8/12 1980	12/11 1980	4/21 1981	6/24 1981	1/18 1982	9/7 1982
						SO_4^{-2} mg/L				
Alluvium < 20 ft	900	34	133	29	——	16	12	14	——	33
	906	145	166	275	336	336	596	548	——	239
	908	84	109	119	165	161	192	187	——	197
	913	——	——	——	1196	1454	1708	136	——	420
	915	134	125	145	184	203	207	——	——	175
	907	11	10	12	17	15	17	16	——	16
Upland > 50 ft Red Beds	921	112	120	128	138	339	169	160	——	170
	924	114	111	100	135	317	141	150	——	143
	925	10	14	21	18	20	13	18	——	16
	929	802	322	912	1396	——	1640	1490	——	211
	932	131	1212	163	230	218	233	213	——	165

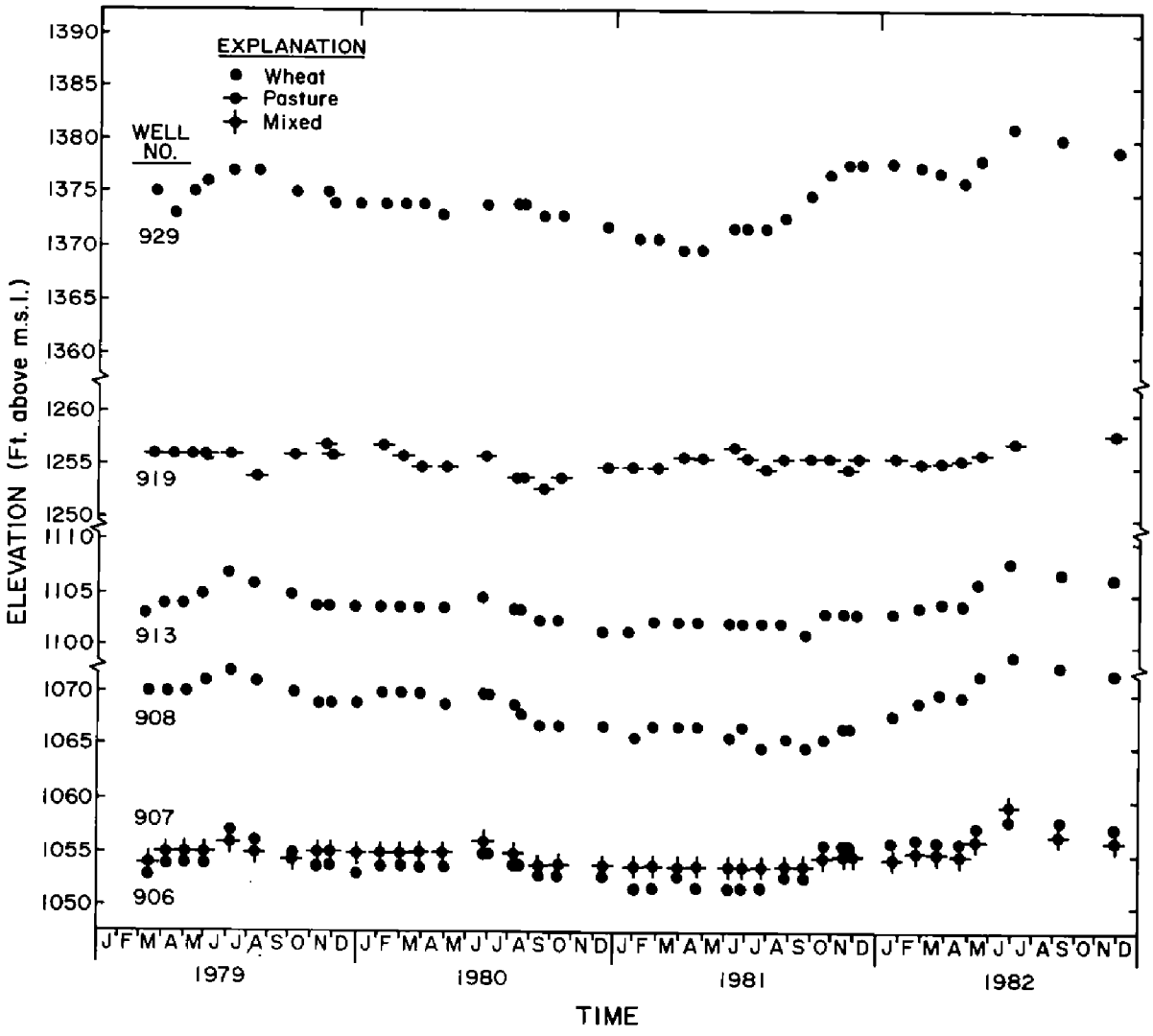

Figure 3. Ground-water levels for 1979-82 in the Little Washita River basin.

concentration and dilution of SO_4^{-2} was seen in both red bed and alluvium wells, as shown by data presented in table 3. An annual summary of nutrient and chemical data for all wells monitored during the study is presented in table 4. These data show that whereas SO_4^{-2} and NO_3–N concentrations increased during the period, P concentration generally decreased to less than 20 µg/L from 1979 values of less than 200 µg/L. The SO_4^{-2} increase was due in part to the availability of highly soluble gypsum locally, which provided additional SO_4^{-2} to the sulfate-water mixture, which subsequently caused higher concentrations in the wells during a period of declining water levels. While some locally high Cl^{-1} concentrations have been observed in streams of the area (Naney and others, 1979, p. 393–400), Cl^{-1} concentrations in the wells

TABLE 4.—LITTLE WASHITA RIVER BASIN GROUND-WATER QUALITY SUMMARY (GEOMETRIC AVERAGES)

Land use	No. of wells	1979	1980	1981	1982
			SO_4^{-2} mg/L		
Wheat	8	117	128	140	170
Pasture	7	237	682	468	——
Mixed	9	51	52	160	——
Farmstead	6	87	148	105	16
Oil	2	114	317	150	143
			Cl^{-1}mg/L		
Wheat	8	23	21	34	——
Pasture	7	28	21	35	——
Mixed	9	20	19	40	——
Farmstead	6	2	8	2	——
Oil	2	20	16	30	——
			NO_3-N mg/L		
Wheat	8	0.32	0.82	1.13	1.51
Pasture	7	0.46	0.36	0.28	0.73
Mixed	9	0.57	0.69	0.85	——
Farmstead	6	2.20	2.80	2.98	4.13
Oil	2	0.36	0.17	Nil	0.17
			NH_3-N mg/L		
Wheat	8	2.15	0.96	0.45	0.21
Pasture	7	0.80	0.49	0.15	0.21
Mixed	9	2.33	0.18	0.18	0.14
Farmstead	6	1.76	3.27	0.18	0.13
Oil	2	Nil	0.05	0.21	0.14
			TWS-P μg/L		
Wheat	8	294	258	69	19
Pasture	7	239	54	15	7
Mixed	9	261	29	33	14
Farmstead	6	53	13	26	——
Oil	2	16	14	9	——
			EC μmhos/cm @25°C		
Wheat	8	579	1,021	1,470	827
Pasture	7	734	1,635	1,439	848
Mixed	9	682	645	680	——
Farmstead	6	727	892	910	656
Oil	2	630	726	788	807

were uniformly low. The electrical conductivity (EC μmhos/cm @ 25°C) displayed a pattern of increase similar to that of SO_4^{-2}, which is expected, as EC has been shown to be a reliable indicator of the dissolved solids (Reeves and Miller, 1978, p. 169).

The NO_3-N content of ground water in wheat and domestic wells increased during the study period but remained well within the acceptable range for domestic use. Inorganic N contents (NO_3^{-1} and NH_4^{-1}) were within acceptable

levels, and higher concentrations of ammonium-N were found to be related to runoff and percolation associated with isolated barnyard activities.

Summary and Conclusions

Water-level and water-quality data for the years 1979–82 were analyzed to determine how and to what extent ground-water quality of the Little Washita River basin has changed during that time. A Model Implementation Plan was initiated for the watershed using a series of Best Management Practices to reduce nonpoint-source pollution for the watershed.

Data gathered to date indicate that the major source of pollution in the Little Washita River watershed, as in most watersheds in southwestern Oklahoma, is the sediment in the streams. Chemical analyses of ground water and base-flow water indicated acceptable levels of nitrogen and phosphorus in these waters.

Locally high concentrations of SO_4^{-2} and Cl^{-1} are present and may be associated with the solution activity within the local geologic formations. In order to separate this possible source of ground water pollutants from those affected by the selected management practices, the data-collection network was augmented and the number of samplings increased as part of the monitoring program used to evaluate the Model Implementation Plan.

Land use did not appear to have a significant impact on the nutrient, P, or chemical constituents, SO_4^{-2} or Cl^{-1}. There were, however, some effects of -geology and climate on SO_4^{-2} concentrations in the ground waters of the watershed.

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STATE'S GEOTHERMAL RESOURCES INVESTIGATED IN NEW STUDY

Results of a study undertaken in 1980 to evaluate the geothermal potential of Oklahoma have been published by the Oklahoma Geological Survey. The report, issued as Special Publication 83-1, was prepared by William E. Harrison, OGS petroleum geologist and geochemist; Kenneth V. Luza, OGS engineering geologist; M. Lynn Prater, formerly with the Survey, now with E-Systems, Greenville, Texas; and Paul K. Cheung, of Tangram Resources, Ltd., Calgary, Alberta, Canada. Work was done in cooperation with the U.S. Department of Energy (DOE).

The project of assessing geothermal resources in the State has involved preparation of a geothermal-gradient map of Oklahoma and site-specific investigations of areas that appear to have geothermal potential. The areas chosen for specific investigation are in eastern Oklahoma in Pittsburg and Haskell Counties, where mapping indicated high geothermal-gradient anomalies of 2.1°F per 100 ft. The authors of the report hope to expand their investigations into other areas that have high gradients.

This Oklahoma study is part of a DOE national study initiated to investigate the possibility of using the natural heat stored in hot waters deep under the surface of the Earth as an auxiliary source of energy. Many boreholes that have been plugged and abandoned contain formation water that is very warm. This type of heat has been used in some areas as an energy source to heat buildings.

Three Pennsylvanian-age sandstones—the Spiro, Cromwell, and Hartshorne—have been selected as potential sources of hot water for low-temperature geothermal applications. The report contains data on the temperatures, resistivity, salinity, etc., of water in wells that penetrated these sandstones and describes methods of securing and correcting these data. Included with the report are three maps at a scale of 1:84,480 that delineate the Hartshorne, Spiro, and Cromwell sandstones in Pittsburg, Haskell, and Le Flore Counties and give related temperature measurements for each.

OGS Special Publication 83-1, *Geothermal Resource Assessment in Oklahoma*, can be obtained from the Survey office at the address given inside the front cover. The price is $8.

OGS ISSUES GROUND-WATER REPORT ON WICHITA MOUNTAINS AREA

A need for more water for Lawton, in southwestern Oklahoma, has resulted in a reconnaissance investigation to evaluate subsurface water resources in the area of the Wichita Mountains. Results of this study have been published by the Oklahoma Geological Survey (OGS) in newly released Circular 85, *Reconnaissance of Ground Water in Vicinity of Wichita Mountains, Southwestern Oklahoma.* The publication was prepared by John S. Havens of the Oklahoma City district office of the Water Resources Division of the U.S. Geological Survey (USGS).

Although towns, communities, and rural water districts surrounding Lawton obtain subsurface water from alluvial deposits along streams as well as from older rock units such as the Rush Springs Formation (Permian) and the Arbuckle Group, the city itself relies on surface water from Lake Lawtonka and Lake Ellsworth. With urban and industrial growth, supplies from these lakes have been inadequate to meet the demand during periods of drought, and the city of Lawton put in a request to the OGS for assistance in evaluating ground-water potential.

Since 1937 the Oklahoma Geological Survey has had a cooperative agreement with the USGS for water investigations, and the problem was relayed to the federal agency for study. The investigation focused on the Arbuckle Group of early Paleozoic age, although information on other potential aquifers was collected also.

Results show that alluvial aquifers yield from 5 to 500 gallons of water per minute, with recharge limited to precipitation on the flood plains; Permian aquifers yield 10 to 300 gallons per minute of very hard water, with a limited recharge area; and the Arbuckle yields as much as 600 gallons per minute of soft water in the southern part of the area and 100 gallons per minute of very hard water in the Limestone Hills to the north. High concentrations of dissolved solids make the water suitable only for industrial or recreational use.

Results of chemical analyses of water from 91 wells, including two test holes drilled for the investigation into the Arbuckle Group, are presented on a large table. A large color map shows both geology and ground-water data for the area. One illustration shows water-level and precipitation data for a three-year period in an Arbuckle well; another reproduces lithologic and geophysical logs of two wells.

Circular 85 can be obtained from the Oklahoma Geological Survey at the address given inside the front cover. The price is $10 for a clothbound copy,

$6 for paperbound.

WATT DESIGNATES OKLAHOMA SITE AS NATIONAL NATURAL LANDMARK

Salt Plains National Wildlife Refuge, Oklahoma, is one of the sites designated recently as National Natural Landmarks by Secretary of the Interior James Watt. The other sites named are Salyer's Ridge Natural Area in North Carolina, Catfish Creek in Texas, Eureka Dunes in California, and the Hudson Palisades in New York. The Oklahoma site is used by 75 percent of the nation's rare whooping cranes.

"These designations give national recognition to five significant natural areas without affecting ownership," Watt said. "I am pleased to add these areas to the National Registry of Natural Landmarks which now recognizes 548 carefully evaluated sites."

To be named to the Registry, a site must meet scientific criteria qualifying it as a nationally significant example of ecological or geological features representing America's natural heritage. The sites are identified through studies conducted by Interior's National Park Service (NPS). Further evaluations are made by scientific specialists.

Geologists for the NPS say the Palisades are known worldwide as an example of an intrusive body of igneous (molten, now solidified) rock known as diabase. They rate the landmark as "the best example of a thick diabase sill in the United States." The Palisades Interstate Park Commission, owner of the Palisades landmark, said it is pleased at the designation of this part of its park. The States of New York and New Jersey also endorsed the designation.

Natural landmark owners, whether private citizens or local, State, or Federal governments, are encouraged to protect their properties. Each owner is invited by NPS to enter into a voluntary agreement to protect the area.

Salt Plains National Wildlife Refuge in Alfalfa County provides a stopping place in its 31,996 acres for three out of four migrating whooping cranes. It is also a wintering area for bald eagles and golden eagles and a nesting site for the Mississippi kite. Fall populations of 90,000 ducks and 30,000 geese are not uncommon with some 3 million Franklin's gulls stopping during the season. White pelicans also use this site, the largest inland saline basin in the Central Lowlands and one of the Lowlands' few remaining habitats for the inland least tern, snowy plover, avocet, and Canada goose.

Among the 30 mammal residents are the badger, coyote, blacktailed jackrabbit, Eastern cottontail, and Ord's kangaroo rat. The site is a center for research on the uniquely hourglass-shaped selenite crystals formed just below the salt plains surface.

DOE REPORTS LATEST ESTIMATES OF U.S. URANIUM RESERVES

The January 1, 1983, U.S. uranium reserves estimated by the Grand Junction, Colorado, Area Office, U.S. Department of Energy (DOE), are lower than the 1982 estimates. Reserves producible at $30 per pound, or less, are 180,000 tons U_3O_8 (see table), as of January 1, 1983, compared with 205,000 tons in 1982. Reserves in other cost categories were also reduced. DOE reserves are estimates of resources that are well defined by drill-hole or other sample data. U_3O_8 (uranium oxide) is the standard measure of uranium in concentrates and ores.

Estimated operating and capital costs which have not yet been incurred, but which would be required to develop and produce the uranium, are used in estimating uranium reserves in each of the forward-cost categories of $30, $50, and $100 per pound U_3O_8. Costs for property acquisition, exploration, and mine development that already have been incurred are excluded in determining the appropriate cost categories for reserves. Income taxes, cost of money, and profit are also excluded. Thus, the $30, $50, and $100 per pound U_3O_8 cost categories are not representative of actual selling prices, which normally would be higher.

Reserves estimates include only U_3O_8 considered recoverable in the mining process. In traditional resource estimation practice, no adjustments have been made in these DOE estimates for milling losses that will occur when these reserves are converted to concentrates.

The following table presents the current estimates of uranium reserves in the United States as compared with the estimates of 1 year ago. The estimates include uranium recoverable by solution mining, but they do not include U_3O_8 by-product recovered from phosphate and copper production.

Estimates of reserves as of January 1, 1983, are lower than the January 1, 1982, estimates in all cost categories because of increases in operating costs, as well as a low rate of exploration and development drilling to delineate new reserves to replace those mined. The decreases range from 0.6 percent in the $100 per pound U_3O_8 category to 12 percent in the $30 category.

TABLE 1.—CURRENT ESTIMATES OF URANIUM RESERVES IN THE U.S. COMPARED TO ESTIMATES OF 1 YEAR AGO

Cost Category ($/lb, U_3O_8)	Reserves January 1, 1983 (tons U_3O_8)	Reserves January 1, 1982 (tons U_3O_8)
$30	180,000	205,000
$30-$50 Increment	396,000	389,000
$50	576,000	594,000
$50-$100 Increment	313,000	300,000
$100	889,000	894,000

STATE GYPSUM PRODUCTION RANKS SECOND IN 1982

The output of Oklahoma's gypsum industry in 1982 was ranked second among the states producing in the U.S. Seven firms were active in Oklahoma in 1982.

Output of the Southard mine (Blaine County) of U.S. Gypsum Co. led the Oklahoma producers and ranked sixth in output among individual gypsum mines in the U.S.

The source for this information is the U.S. Bureau of Mines, Mineral Industry Surveys, Gypsum Annual Advance Summary Supplement, Washington, D.C., July 25, 1983.

NOTES ON NEW PUBLICATIONS

Federal Coal Resource Occurrence and Federal Coal Development Potential Maps of the Stigler East 7.5-Minute Quadrangle, Muskogee and Haskell Counties, Oklahoma

Open-File Report OF 79-0307, by Geologic Services of Tulsa, Inc., and B. T. Brady, USGS, consists of 39 pages, 11 over-sized sheets, and is at a scale of 1:24,000.

Order from: Western Distribution Branch, U.S. Geological Survey, Box 25425, Federal Center, Denver, CO 80225. The price is $9 for microfiche, $25 for paper copy.

Preliminary Appraisal of the Hydrology of the Blocker Area, Pittsburg County, Oklahoma

This U.S. Geological Survey publication is the first in a series of similar reports that will describe the hydrology of the Stigler, Rock Island, Red Oak, and Panama areas. The report was prepared in cooperation with the U.S. Bureau of Land Management under the Energy Minerals Rehabilitation Inventory and Analysis Program.

The purpose of this report, Open-File Report 81-1187, is to describe the hydrology of the Blocker area in eastern Oklahoma and to identify some of the

potential hydrologic changes that may occur as the result of strip mining.

The report is available free on request from the USGS office in Oklahoma City, while the limited supply lasts. After that, it can be obtained from the Distribution Branch in Denver. For further information, contact the Oklahoma City USGS office at 215 Dean A. McGee St., Oklahoma City, OK 73102. The telephone number is 405-231-4259.

Saturated Thickness of the High Plains Regional Aquifer in 1980, Northwestern Oklahoma

Consisting of two sheets, this 1:250,000-scale map by John S. Havens, is part of a five-year study of the High Plains regional aquifer system to provide hydrologic information for evaluation of the effects of long-term development of the aquifer and to build computer models for prediction of aquifer response to alternative changes in ground-water management.

Single copies may be obtained free of charge from the Oklahoma City USGS office at 215 Dean A. McGee St., Oklahoma City, OK 73102. The telephone number is 405-231-4259. A limited supply is available.

Volume II: Area Reports: Domestic. Centennial Edition, 1981

Prepared by the staff of the U.S. Bureau of Mines in 1983, this 561-page minerals yearbook marks the centennial of the first annual publication of comprehensive minerals-industry statistics by the federal government.

The publication, GPO stock number 024-004-02114-4, may be ordered from: Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. The price is $17.

Coal Resource Classification System of the U.S. Geological Survey

H. G. Wood and others describe the coal classification used by the U.S. Geological Survey and include an explanation of the problems, procedures, and philosophy of estimating resources. The definitions, terminology, criteria, and guidelines for delineating and quantifying the coal resources, the reserve base, and reserves of areas ranging in size from a mine to the nation are outlined in detail. A chapter on the use of geophysical logs as related to coal is included.

Order circular C 0891 from: Eastern Distribution Branch, Text Products Section, U.S. Geological Survey, 604 South Pickett St., Alexandria, VA 22304.

GeoRef Serials List and KWOC Index

Orders for the 1984 edition of the list of serials covered in the GeoRef database and the companion Key Words Out of Context Index, entitled *GeoRef Serials List and KWOC Index,* are now being accepted.

The new edition of the Serials List is an alphabetical listing of all journals and serially-numbered reports monitored from 1967 through June 1983 by the American Geological Institute to produce the *Bibliography and Index of Geology* and its online counterpart, GeoRef. More than 8,600 serial publications are cited in the list, including nearly 1,500 titles added since the last edition. More explanatory notes giving information about current journal titles and the history of title changes have also been added. Regular online searchers use the Serials List to identify the CODEN or ISSN of specific journals to be searched.

The KWOC Index allows a user to identify a serial by any significant word in the title or publisher's name. Titles can be found by searching for a subject or an organization. For a subject such as water, the Index lists more than 500 serials that contain a word in the title beginning with "hydro-," "water," or "wasser-." Or, one can look under the term "Survey," for example, and find publications of the geological surveys of many countries.

The *GeoRef Serials List and KWOC Index* is available in paper or microfiche from the AGI Customer Service Department. Paper copy ($95) consists of 1,622 unbound, prepunched pages (pages are 8½ x 11 inches and are printed on both sides). Microfiche ($20) consists of a set of 34 fiche.

GeoRef provides global coverage of the earth-science literature in 1984, indexing some 60,000 individual research articles and extending the database's coverage back to 1933. GeoRef is available for online searching, worldwide, through DIALOG, ORBIT, and CAN/OLE.

Carbonate Depositional Environments

AAPG Memoir 33 has been specifically designed to help the explorationist to recognize the ancient environments in which carbonates were deposited. The 700-page book focuses on visual examination of rocks and touches on log, geophysical, and thin-section interpretation. The volume is aimed at geologists in academic fields as well as petroleum exploration and development. The volume includes 1,300 color pictures, most enhanced by laser and computer technology.

Order from: AAPG, P.O. Box 979, Tulsa, OK 74101. Price: $48, AAPG-SEPM members; $58, nonmembers. Catalog no. 656.

Products Pipeline Map of the United States

This newly-revised map is printed in eight colors and has been converted to the standard USGS map base. Features include: large inset of the Houston-

Gulf Coast Area; pump stations, terminals, interconnections and refinery locations listing owner and refining capacity; spotted and named towns at the hub of petroleum activity; county seats and capitols; and locations for petrochemical and natural gas liquids plants.

Order this 40" x 57" map, scale 1:3,600,000, from: PennWell Books, P.O. Box 21288, Tulsa, OK 74121.

A Data Management System for Areal Interpretive Data for the High Plains in Parts of Colorado, Kansas, Nebraska, New Mexico, Oklahoma, South Dakota, Texas, and Wyoming

This 118-page water resources investigation report by R. R. Luckey and C. F. Ferrigno, can be ordered from: Open-File Services Section, Western Distribution Branch, U.S. Geological Survey, Box 25425, Federal Center, Denver, CO 80225. The price for WRI 82-4072 is $15.25 for a paper copy, and $3.50 for microfiche.

Urban Flood Analysis in Oklahoma City, Oklahoma

R. L. Tortorelli, T. L. Hutzinger, D. L. Bergman, and A. L. Patneaude, of the U.S. Geological Survey have produced this 98-page report dealing with the Oklahoma City area.

Order from: National Technical Information Service, U.S. Department of Commerce, Springfield, VA 22161. Order number OF 83-0026. Price: $12.50 for a paper copy, $3.50 for microfiche.

Report of the Annual Yield of the Arkansas River Basin for the Arkansas River Basin Compact, Arkansas-Oklahoma, 1982 Water Year

Open-file report OF 83-0046, by T. E. Lamb and M. A. Moore, is 28 pages long.

Order from: Open-File Services Section, Western Distribution Branch, U.S. Geological Survey, Box 25425, Federal Center, Denver, CO 80225. The price is $3.50 microfiche or paper copy.

Ground-Water Records for the Area Surrounding the Chickasaw National Recreational Area, Murray County, Oklahoma

Prepared by R. L. Goemaat and C. C. Willard, of the U.S. Geological Survey, this 16-page open-file report is no. OF 83-0027.

Order from: National Technical Information Service, U.S. Department of Commerce, Springfield, VA 22161. The cost is $2 for a paper copy, and $3.50 for microfiche.

Minerals Data Source Directory, January 1983 (An Update of IC 8881)

Compiled by the federal Minerals Data Working Group, Interagency Minerals Information Coordinating Committee, the directory is a compilation of descriptive information on the availability, content, and location of minerals data in the federal government. It is intended to assist government personnel and the general public in locating and acquiring minerals information. Included in the directory are descriptions of data bases, publications, information systems, and information offices containing data pertaining to all aspects of mineral production, consumption, trade, and related information.

Order GPO stock no. 024-004-02116-1 from: Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. The price is $9.50.

Volume III: Area Reports: International. Centennial Edition, 1981

Also prepared by the staff of the Bureau of Mines, this 1,413-page edition of the *Minerals Yearbook* contains mineral data on more than 130 foreign countries and discusses the importance of minerals in the economies of those nations. A separate chapter reviews the international minerals industry in general and its relationship to the world economy.

Order GPO stock no. 024-004-021110-0 from: Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. The price is $22.

Remote Sensing

Editors Ken Watson and Robert D. Regan bring together a collection of key papers representing scientific activity and progress in the field of remote sensing. The papers were selected by soliciting the recommendations of a wide range of scientists and using a cutoff date prior to 1978. The editors then chose those articles which they felt were significant in their own right or representative of the field at that particular time. The collection consists of 39 papers from 21 journals and conferences, plus 56 color illustrations.

Order from: SEG, Book Orders, P.O. Box 3098, Tulsa, OK 74101. The price is $40 to SEG members in the United States; $42 to SEG members outside the United States; $50 to nonmembers in the United States; $52 to nonmembers outside the United States.

Regional Tectonics of the Cordilleran Fold and Thrust Belt (1983)

In this lecture, David R. Lageson discusses regional structural geology and tectonic evolution of the Cordillera of the western United States. Particular emphasis is on new concepts relating to transverse and longitudinal variations in tectonic study. Lageson presented this 2-hour-and-55-minute talk as

part of the 1982 AAPG Fall Education Conference in Denver.

Order from: AAPG, P.O. Box 979, Tulsa, OK 74101. Catalog no. 916 consists of 213 slides and 6 tapes and requires the use of 1 projector. The price is $295 in the U.S., and $420 outside the U.S.

Gravity Anomaly Map of the United States

Sponsored by the Society of Exploration Geophysicists (SEG), this map was developed primarily from the digital files of the U.S. Defense Mapping Agency. Solicitation of data for this map resulted in the release of about 1-million land and 0.8-million marine gravity values previously contributed to DMA and members of the committee that compiled the map. Onshore data consist of Bouguer density of 2.67 g/cm^3. Offshore, where data are less adequately corrected for topography, free air gravity anomaly values are incorporated. Datum control for the gravity computations is based on the International Gravity Standardization Net of 1971 and the 1967 Geodetic Reference System formula for theoretical gravity (International Association of Geodesy, 1971). The scale for the two sheets is 1:2,500,000.

Order from: SEG, Map Orders, P.O. Box 3098, Tulsa, OK 74101. The price for members is $22 folded and $28 rolled. For nonmembers, the price is $28 folded, and $33 rolled.

Study of Stability Problems and Hazard Evaluation in the Missouri Portion of the Tri-State Mining Area

A 2-year investigation has disclosed 469 hazardous sites resulting from past zinc-lead mining in the vicinity of Joplin, Missouri. Open shafts, subsidence pits, and other mine-related dangers exist in areas easily accessible to the public, relate authors Michael C. McFarland and James C. Brown, Jr. Accidents involving humans and livestock have been reported. Some recent damage to buildings and livestock can be attributed to the collapse of underground mine workings.

Other than backfilling shafts, nothing has been done to stabilize undermined areas. A continuing problem is indicated. Under present laws, most government reclamation funds are designated for coal-mined lands. The report says a comprehensive program of hazard control and monitoring for the entire study area is warranted. Research for this project was done under contract by the Missouri Department of Natural Resources, Division of Geology and Land Survey. This 141-page report, containing 39 figures, is available for reference at the Bureau of Mines facilities in Denver, CO, Rolla, MO, and Pittsburgh, PA. Copies of the report will not be available for purchase.

A related report that covers mining in Oklahoma, by Oklahoma Geological Survey engineering geologist Kenneth V. Luza, is on file at the Oklahoma Geological Survey office at the address given inside the front cover. For additional information about this report, see the April 1983 issue of *Oklahoma Geology Notes* (v. 43, no. 2, p. 36).

Technical Program Abstracts and Biographies

Available for the first time, these expanded 1,000- to 2,000-word abstracts with up to six figures or illustrations are from the 52nd annual meeting of the Society of Exploration Geophysicists. The meeting was held October 17-21, 1982, in Dallas, Texas.

Order from: SEG, P.O. Box 3098, Tulsa, OK 74101. The price has been reduced to $20.

Map Available

The following map with text is available from the Geological Society of America: MC-24R, *Geological Cross-section from the Arbuckle Mountains to the Muenster Arch, Southern Oklahoma and Texas*, by Roger E. Denison, 1982. The map is in color, 31 x 16 in., at a scale of 1:125,000. The price is $9.50 folded, and $11.50 rolled.

Order from: Marketing Manager, Geological Society of America, P.O. Box 9140, Boulder, CO 80301.

Aquifer at Great Salt Plains

Report PB-83 151 431, *Preliminary Projections of the Effects of Chlorine-Control Structures on the Quaternary Aquifer at Great Salt Plains, Oklahoma*, by J. E. Reed, has 50 pages and is available from National Technical Information Service, U.S. Dept. of Commerce, Springfield, VA 22161. The price is $10.

Sandstone Uranium Deposits in the United States: A Review of the History, Distribution, Genesis, Mining Areas, and Outlooks

Written by Richard A. Crawley of the U.S. Department of Energy, this report reviews the uranium industry in the United States and includes a brief history.

Order Report GJBX-15(83) from: Bendix Field Engineering Corp., P.O. Box 1569, Grand Junction, CO 81502. Price: microfiche, $4; printed $9.