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Cover Picture
MEDICINE BLUFFS, WICHITA MOUNTAINS

The cover picture is a view of Medicine Bluffs, at the east end of the Wichita Mountains, about 3 miles north of Lawton on the Fort Sill Military Reservation. Outcrops of the Carlton Rhyolite form a shear drop of about 200 feet for a distance of 1 mile along Medicine Creek (lower right).

The carlton Rhyolite is one of the major rock units making up the basement complex of southern Oklahoma. It is overlain disconformably by Upper Cambrian sedimentary rocks in both the Wichita and Arbuckle Mountains, and its isotopic age of 525 ± 25 million years indicates that it is probably of Middle Cambrian age. The rocks at Medicine Bluffs formed as part of an enormous volcanic field made up mainly of rhyolite flows, water-laid and welded tuffs, and agglomerates that are at least 4,500 feet thick in parts of the mountains.

Derivation of the name *Medicine Bluffs* was explained by Buford Morgan in an article on "Treasures of the Wichitas" (seventh of a series), published in 1960 in *The Chronicles of Comanche County* (v. 6, p. 30-36):

"Ranking with Mt. Scott in popular appeal, Medicine Bluffs were long revered by Indians because of their peculiar appearance. Medicine Men journeyed to the top of the bluffs for night-long vigils to summon the spirits of their animal counterparts, to conjure visions, or for other forms of 'making medicine.' Young braves visited the bluff tops for long periods of fasting and meditation before [taking] part in war parties or other dangerous expeditions. Hallucinations or 'visions' caused by this fasting were interpreted by medicine men, and set the pattern for the braves' behavior during the following escapade. Sick or ailing Indians were sometimes carried to the top of the bluffs, placed on low rock altars or inside circles of stones, and left to the care of the Great Spirit. If the Indian recovered it was great medicine; if he succumbed it was because the Great Spirit so decreed. It was from these practices that the bluffs received their name."

—*Kenneth S. Johnson*

(Cover photograph by William E. Ham, 1960)

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

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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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NANNOFOSSILS OF THE OZAN FORMATION (UPPER CRETACEOUS) OF SOUTHEASTERN OKLAHOMA

ANTHONY E. KRANCER[1]

Abstract—A preliminary investigation of the Ozan Formation (Upper Cretaceous) of McCurtain County, Oklahoma, using the scanning electron microscope (SEM), is reported. Apparent from this study, the Ozan Formation is a shallow, transgressional marine sequence of early Campanian age. The Ozan sediments contain a diverse assemblage of *Inoceramus*, oyster, and cephalopod fragments, and a microfossil assemblage of foraminifers, ostracodes, dinoflagellates, acritarchs, spores, and pollen. The most abundant microfossils are the nannoplankton forms. Twenty-three nannofossil species are reported, and they are accompanied by 27 scanning-electron photomicrographs.

INTRODUCTION

The nannofossil flora reported here is from the Oklahoma portion of the Ozan Formation (Upper Cretaceous) and was studied with the aid of the scanning electron microscope (SEM). Table 1 shows the known range of nannofossil species in the formation.

The Ozan Formation was initially described by C. H. Dane (1929) from a lithic unit cropping out near Ozan, Hempstead County, Arkansas. In Oklahoma, this unit is exposed in a 3-square-mile area in the extreme southeastern part of McCurtain County. The Ozan section described herein is exposed by a road cut of Oklahoma Highway 21, near the village of Tom, in sec. 29, Tps. 9-10 S., R. 27 E. Cushman (1946) placed the Ozan Formation in the Late Cretaceous, of Tayloran age, based on a study of the foraminifers. Oklahoma studies of the formation include one by Davis (1960), which focuses on water resources, and a palynological examination by Morgan (1967, M.S. thesis), which reports and illustrates several nannofossil types.

Dane (1929) originally described the Ozan Formation as sandy, micaceous marl in the upper part and glauconitic marl and sand in the lower part. The sediments are mainly unconsolidated, and fossils are easily extracted by agitating samples in water.

The upper part of the marl contains *Inoceramus*, oyster, and cephalopod fragments. The microbiota consists of foraminifers, both megalospheric and microspheric generations, ostracodes, dinoflagellates, acritarchs, spores, and pollen. The most abundant fossils are coccoliths and their associated nannofossils. Paleontologic evidence indicates that the Ozan Formation was a shallow-water, transgressional deposit during the early Campanian.

Preparation of the Ozan samples followed the standard technique for nannofossil study. Samples were crushed to a coarse powder, and a 20-gram portion was placed in a jar of distilled water and agitated mechanically for several hours. Clay-size particles were removed from the specimens with the

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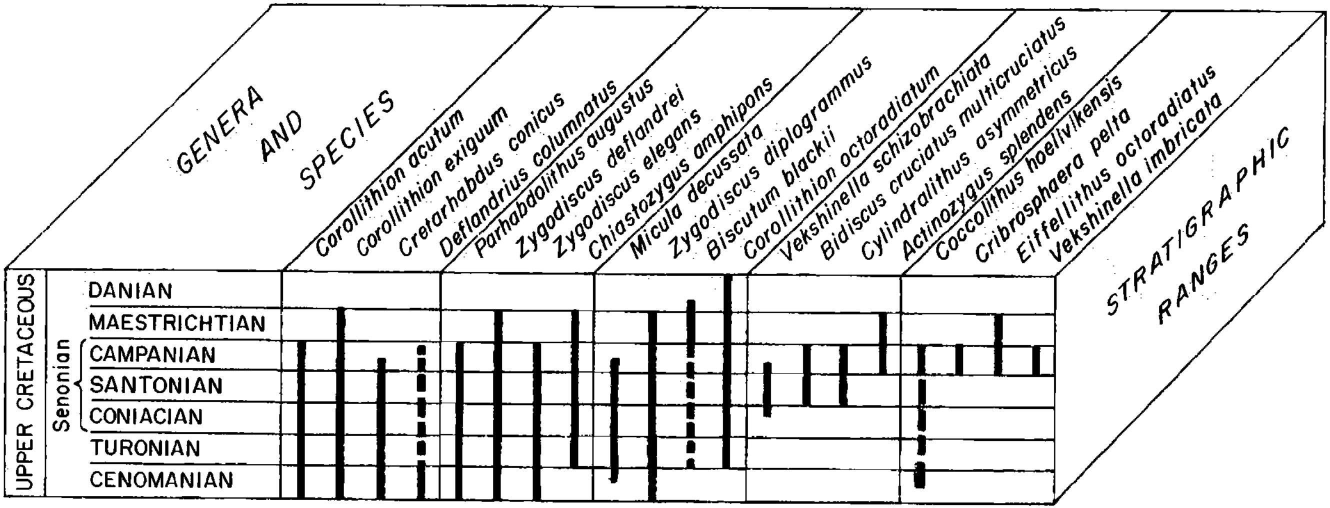
TABLE 1.—KNOWN RANGE OF NANNOFOSSIL SPECIES IN THE OZAN FORMATION (UPPER CRETACEOUS) OF SOUTHEASTERN OKLAHOMA



use of the ultrasonic generator. By allowing the sample to settle for 30 seconds and then decanting the liquid, virtually all of the larger particles were removed. A subsequent settling period of 15 minutes allowed removal of most of the coccoliths, leaving only clay-sized particles in suspension. This last solution was discarded. For the SEM examination, a small number of coccoliths in distilled water were placed on a standard SEM cover glass and dried. These mounts were then prepared and studied by standard SEM technique.

ACKNOWLEDGMENTS

I would like to thank Mobil Oil Corporation, whose grant to Dr. L. R. Wilson supported the field work for this project. For use of the scanning electron microscope that made this study possible, appreciation is expressed to Cities Service Oil Company and to Dr. Charles J. Mankin, director of the Oklahoma Geological Survey. My special thanks go to Dr. L. R. Wilson, whose patience and guidance have assisted me throughout this endeavor.

SYSTEMATIC PALEONTOLOGY

Family ARKHANGELSKIELLACAE Gartner, 1968

Genus **Gartnerago** Bukry, 1969

Type Species: **Gartnerago concavum** (Gartner), Bukry, 1969

Gartnerago costatum cf. **costatum** (Gartner), Bukry, 1969

Arkhangelskiella costata GARTNER, 1968, p. 37, pl. 8, figs. 1-3; pl. 11, figs. 1a-c; pl. 28, fig. 2.

Gartnerago costatum costatum (Gartner), BUKRY, 1969, p. 24, pl. 4, figs. 7-9.

Remarks.—This subspecies consists of at least four closely appressed shields, the smallest being the proximal shield. The rim of the proximal shield consists of 2 series of elements: the inner series, 60-75 dextrally imbricate elements, and the outer series, an equivalent number of elements sloping in a clockwise direction and encompassing approximately one-third of the proximal shield. This subspecies differs from *Gartnerago costatum costatum* (Gartner), Bukry, 1969, in the relative sizes of the rims and the design of the central area. The central area is deeply recessed and is located on the distal shield, having the other tiers stacked upon it when viewed proximally. The central area is divided into quadrants by two axial bars in the form of a cross, which is clearly visible with transmitted-light microscopy. Paralleling the longitudinal bar on both sides is a series of rectangular spacings that are transected by a series of 3 or 4 calcite rods oriented parallel to the axial bar. Another set of rectangular pores along the outer rim of the central area is also divided by rods, which are oriented parallel to the shorter axial bar.

Size.—Maximum diameter: 10.5 microns.

Range.—Campanian. Occurrence in Ozan Formation common.

Illustrations.—Pl. 1, fig. 1, proximal view, SEM photomicrograph, ×10,000.

Family Coccolithaceae Kamptner, 1928

Genus **Biscutum** Black, 1959

Type species: **Biscutum testudinarium** Black, 1959

Biscutum blackii Gartner, 1968

Biscutum blackii Gartner, 1968, p. 18, pl. 1, fig. 7; pl. 6, figs. 2a-c.

Remarks.—Circular shield consists of 16-22 elements on smaller proximal shield. Center appears disaggregate, suggesting an opening that has been filled.

Size.—Diameter: 4.5-6.8 microns.

Range.—Campanian-Maestrichtian. Occurrence in Ozan Formation common.

Illustrations.—Pl. 1, fig. 2, proximal view, SEM photomicrograph, ×20,000.

Genus **Bidiscus** Bukry, 1969

Type species: **Bidiscus cruciatus cruciatus** Bukry, 1969

Bidiscus cruciatus multicruciatus Bukry, 1969

Bidiscus cruciatus multicruciatus Bukry, 1969, p. 27, pl. 6, fig. 12; pl. 7, figs. 1, 2.

Remarks.—Proximal shield is smaller than distal shield and is composed of 12-15 radially arranged elements. Central area contains a series of crosses consisting of two or more crosses surrounding a central pore. The largest cross has four imbricate elements sloping clockwise. This subspecies differs from *Bidiscus cruciatus cruciatus* Bukry, 1969, by having more than one central cross.

Size.—Maximum diameter: 3-4.8 microns.

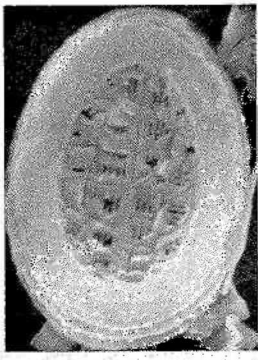
Range.—Santonian-Campanian. Occurrence in Ozan Formation rare.

Illustrations.—Pl. 1, fig. 3, proximal view, SEM photomicrograph, ×26,000.

Plate 1

Figure

1. *Gartnerago costatum* cf. *costatum* (Gartner), Bukry, 1969, OPC 1163-1-CM, proximal view, 10.5 microns, ×10,000.
2. *Biscutum blackii* Gartner, 1968, OPC 1163-1-EM, proximal view, 4.55 microns, ×20,000.
3. *Bidiscus cruciatus multicruciatus* Bukry, 1969, OPC 1163-2-EM, proximal view, 3 microns, ×26,000.
4. *Coccolithus hoellvikensis* Forchheimer, 1968, OPC 1163-1-BM, proximal view, 8.2 microns, ×11,000.
5. *Deflandrius columnatus* Stover, 1966, OPC 1163-3-EM, complete side view; base, 6 microns; height, 9 microns, ×8,000.
6. *Deflandrius columnatus* Stover, 1966, OPC 1163-2-CM, side view—tip partially destroyed; base, 5.8 microns; height, 8.9 microns, ×14,000.
7. *Actinozygus splendens* (Deflandre), Gartner, 1968, OPC 1163-4-EM, distal view, 3.5 microns, ×18,000.
8. *Actinozygus splendens* (Deflandre), Gartner, 1968, OPC 1163-3-CM, side view, height 5 microns, ×10,000.
9. *Chiastozygus amphipons* (Bramlette and Martini), Gartner, 1968, OPC 1163-5-EM, distal view, 3.4 microns, ×20,000.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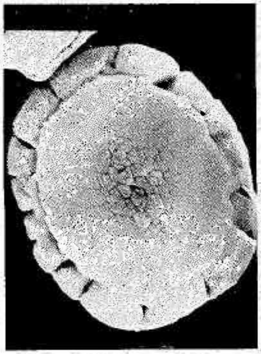
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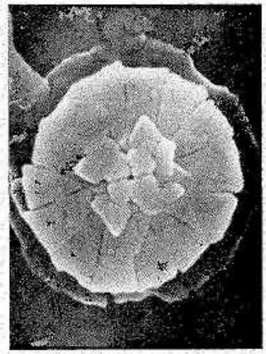
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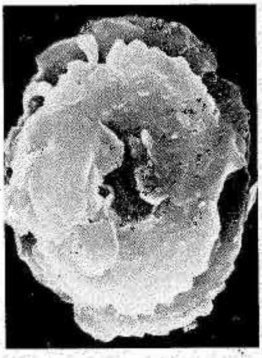
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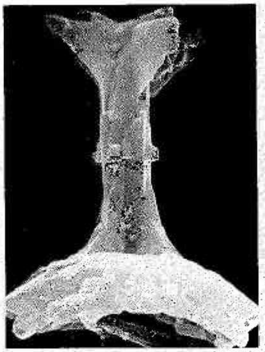
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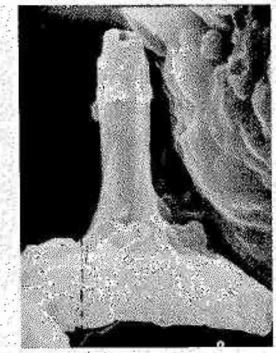
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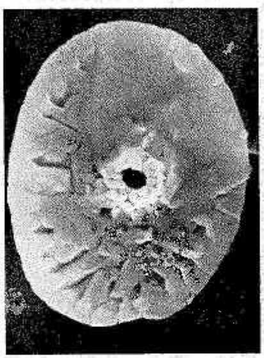
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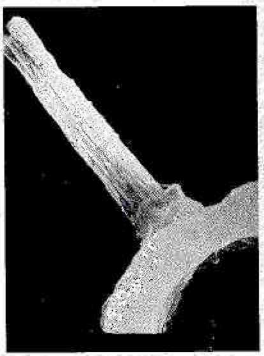
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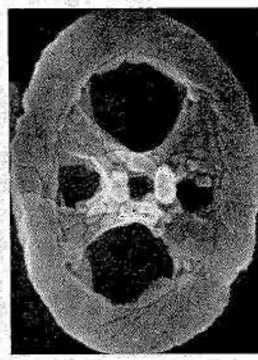
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Genus **Coccolithus** Schwarz, 1894

Type species: **Coccolithus oceanicus** Schwarz, 1894

(=**Coccosphaera pelagica** Wallich 1877; see Braarud and others, 1964)

Coccolithus hoellvikensis Forchheimer, 1968

Coccolithus hoellvikensis FORCHHEIMER, 1968, p. 28, pl. 1, figs. 2a-b, 5a-6b; text-figs. 2 (2, 6, 23), 6-9.

Remarks.—Specimens viewed with the SEM showed excessive calcification; therefore, no accurate element counts could be made.

Size.—Diameter: 8.2 microns.

Range.—Cenomanian. Occurrence in Ozan Formation common.

Illustrations.—Pl. 1, fig. 4, proximal view, SEM photomicrograph, ×11,000.

Genus **Deflandrius** Bramlette and Martini, 1964

Type species: **Rhabdolithus intercisus** Deflandre, 1954

Deflandrius columnatus Stover, 1966

Deflandrius columnatus STOVER, 1966, p. 141, pl. 6, figs. 6-10; pl. 9, fig. 16.

Remarks.—This rhabdolith has a circular base and flaring stem. In side view, the distal and proximal sides appear to be fused. The shields consist of dextrally imbricate elements. The distal side supports a large stem, with the aid of four supports that flare out at the stem's base. Many of the specimens viewed have four rectangular elements half way up the stem, near the top of the basal supports. These protrusions become diagnostic, since many specimens have lost their distinctive flaring tips. The systematics of this species have undergone much change, and several synonyms exist, but Loeblich and Tappan (1971) accept *D. columnatus* as the senior synonym. They recognize *Prediscosphaera columnatus* (Stover), Bukry and Bramlette, 1969, as the junior synonym.

Size.—Basal diameter: 6 microns. Height: 9 microns.

Range.—Albian-Campanian. Occurrence in Ozan Formation common.

Illustrations.—Pl. 1, figs. 5, 6: fig. 5, complete side view; fig. 6, side view with upper flaring elements missing. SEM photomicrographs, fig. 5, ×8,000; fig. 6, ×14,000.

Family RHABDOSPHAERACEAE Lemmermann, 1903

Genus **Actinozygus** Gartner, 1968

Type species: **Actinozygus regularis** (Gorka), Gartner, 1968

Actinozygus splendens (Deflandre), Gartner, 1968

Rhadolithus splendens DEFLANDRE, 1953, p. 1786, figs. 4-6; Deflandre and Fert, 1954, p. 158, figs. 88-89; pl. 13, figs. 1-3.

Actinozygus splendens (Deflandre), GARTNER, 1968, p. 25, pl. 5, figs. 1-2; pl. 10, fig. 1; pl. 11, fig. 15.

Remarks.—Specimens viewed distally show that the base has a centrally located stem, apparently open at the base. In the specimen illustrated, excessive calcification is apparent. The rim consists of 33-40 clockwise, radially imbricate elements. Stem appears to be of interwoven calcite threads held together by a calcite bond.

Loeblich and Tappan, 1966, listed this species under the genera *Rhabdolithus, Ahmuellerella,* and *Cretarhabdus*. In 1971 they listed it as *Parhabdolithus* and *Rhabdolithus*, with *Actinozygus splendens* (Deflandre), Gartner, 1968, as a junior synonym of *Rhabdolithus splendens*.

Size.—Maximum diameter: 7.5-8.8 microns.

Range.—Campanian-Maestrichtian. Occurrence in Ozan Formation rare.

Illustrations.—Pl. 1, figs. 7-8; fig. 7, distal view; fig. 8, side view. SEM photomicrographs, fig. 7, ×18,000; fig. 8, ×10,000.

Genus **Chiastozygus** Gartner, 1968

Type Species: **Zygodiscus? amphipons** Bramlette and Martini, 1964

Chiastozygus amphipons (Bramlette and Martini), Gartner, 1968

Zygodiscus? amphipons BRAMLETTE and MARTINI, 1964, p. 302, pl. 4, fig. 9-10.

Chiastozygus amphipons (Bramlette and Martini), GARTNER, 1968, p. 26, pl. 8, figs. 11-14; pl. 22, figs. 10-11.

Remarks.—Specimens viewed distally show crossbars that flare in a deltaic pattern at the junction with the rim. Rim consists of 31-35 dextrally imbricate elements. Stem is hollow with an angular opening.

Chiastozygus amphipons (Bramlette and Martini), Gartner, 1968, shows great similarity with *C. garrisonii* Bukry, 1969. They possess similar plate elements and sculpture; both have large and small pores and flaring crossbars, and they differ only in the stem opening and the size and thickness of the rim.

Size.—Maximum diameter: 3.4-5.8 microns.

Range.—Turonian-Maestrichtian. Occurrence in Ozan Formation common.

Illustrations.—Pl. 1, fig. 9, distal view, SEM photomicrograph, ×20,000.

Genus **Cretarhabdus** Bramlette and Martini, 1964

Type species: **Cretarhabdus conicus** Bramlette and Martini, 1964

Cretarhabdus conicus Bramlette and Martini, 1964

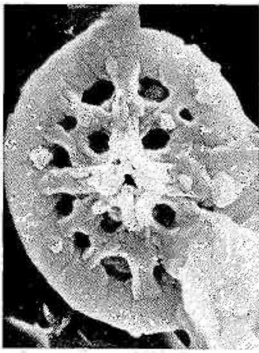
Cretarhabdus conicus BRAMLETTE and MARTINI, 1964, p. 299, pl. 3, figs. 5-8.

Remarks.—Viewed distally, the tip of the stem has extending elements that form a cross paralleling the supporting crossbars at the stem base. The stem opening, where present, is rectangular to square in the specimens viewed.

Size.—Maximum diameter: 4-9.2 microns.

Range.—Albian-lower Campanian. Occurrence in Ozan Formation common.

Illustrations.—Pl. 2, figs. 1, 2, distal views, SEM photomicrographs, ×15,000.



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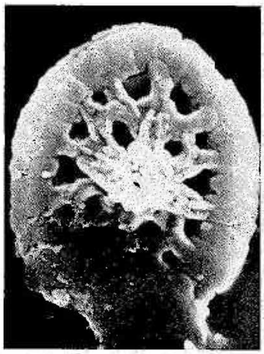

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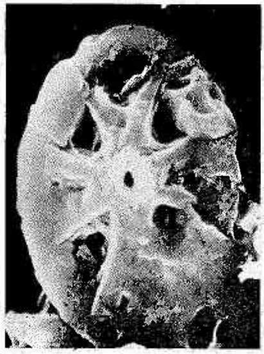

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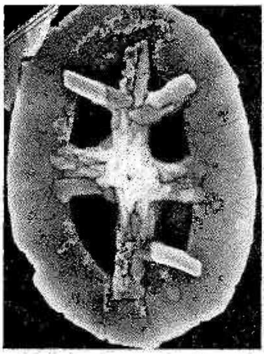

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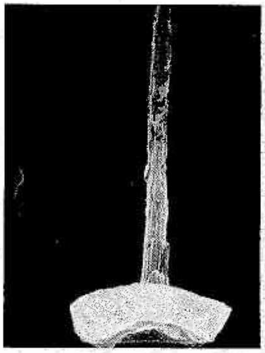

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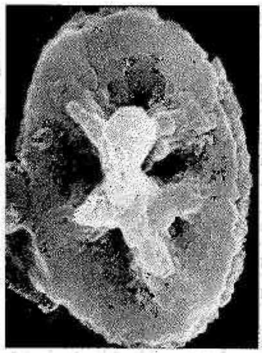

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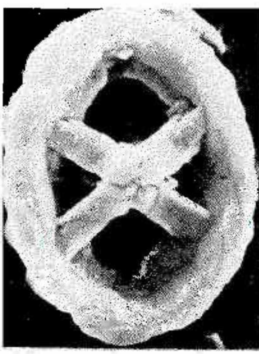

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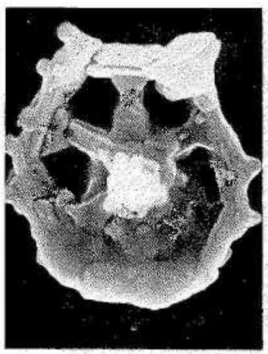

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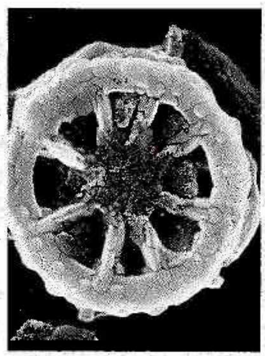

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Genus **Eiffellithus** Reinhardt, 1965

Type species: **Zygolithus turriseiffeli** Deflandre, 1954

Eiffellithus octoradiatus (Gorka), Gartner, 1968

Discolithus octoradiatus GORKA, 1957, p. 259, pl. 4, fig. 10.

Zygolithus octoradiatus (Gorka), STRADNER, 1963, p. 14, pl. 5, figs. 2-2a.

Zygolithus? octoradiatus (Gorka), BRAMLETTE and MARTINI, 1964, p. 304, pl. 4, figs. 15-16.

Eiffellithus octoradiatus (Gorka), GARTNER, 1968, p. 25, pl. 2, figs. 17-21; pl. 13, fig. 11; pl. 15, fig. 20; pl. 12, fig. 10.

Remarks.—Many specimens of this species exhibit a corrosion of the crossmembers.

Size.—Maximum diameter: 5.5-7.7 microns.

Range.—Campanian-Maestrichtian. Occurrence in Ozan Formation common.

Illustrations.—Pl. 2, fig. 3, distal view, SEM photomicrograph, ×16,000.

Genus **Vekshinella** Loeblich and Tappan, 1963

Type species: **Vekshinella acutifera** (Vekshina), Loeblich and Tappan, 1963

Vekshinella imbricata Gartner, 1968

Vekshinella imbricata GARTNER, 1968, p. 30, pl. 9, figs. 16-17; pl. 13, figs. 8-9.

Remarks.—The elliptical base is constructed of 40-50 large, sinistrally imbricate elements that possess numerous crossbars made up of parallel calcite rods. Gartner (1968) notes that "At their intersection the crossbars are surmounted by a spine or stem, constructed of radially arranged calcite rhombs." In the specimens viewed, the rods constituting the stem appear to have no preferred orientation. The stem is twice as long as the base.

Plate 2

Figure

1. *Cretarhabdus conicus* Bramlette and Martini, 1964, OPC 1163-6-EM, distal view, 4 microns, ×15,000.
2. *Cretarhabdus conicus* Bramlette and Martini, 1964, OPC 1163-7-EM, distal view, 4.1 microns, ×15,000.
3. *Eiffellithus octoradiatus* (Gorka) Gartner, 1968, OPC 1163-4-CM, distal view, 5.5 microns, ×16,000.
4. *Vekshinella* sp. Loeblich and Tappan, 1963, OPC 1163-8-EM, distal view, 4 microns, ×22,000.
5. *Vekshinella imbricata* Gartner, 1968, OPC 1163-9-EM, side view; height, 7 microns; base, 3.65 microns, ×10,000.
6. *Vekshinella schizobrachiata* Gartner, 1968, OPC 1163-10-EM, distal view, 4.75 microns, ×15,000.
7. *Corollithion acutum* Thierstein, 1972, OPC 1163-2-CF, distal view, 3.3 microns, ×22,000.
8. *Corollithion exiguum,* Stradner, 1961, OPC 1163-11-EM, distal view, 3.5 microns, ×20,000.
9. *Corollithion octoradiatum* Gartner, 1968, OPC 1163-12-EM, proximal view, 3.75 microns, ×25,000.

Size.—Basal diameter: 3.65 microns. Height: 7 microns.

Range.—Lower to middle Campanian. Occurrence in Ozan Formation common.

Illustrations.—Pl. 2, fig. 5, side view, SEM photomicrograph, ×10,000.

Vekshinella schizobrachiata Gartner, 1968

Vekshinella schizobrachiata GARTNER, 1968, p. 31, pl. 13, figs. 10-11; pl. 20, fig. 5.

Remarks.—The base is elliptical and is constructed of 40-50 dextrally imbricate elements. Specimens viewed exhibit excessive calcification of the distal shields and crossbars. Crossbars consist of 2 major axes. The longer axis is aligned with the long axis of the ellipse, and it bifurcates at one end only; the short crossbar crosses the long crossbar off-center.

Size.—Maximum diameter: 5-9 microns.

Range.—Santonian-lower Campanian. Occurrence in Ozan Formation rare.

Illustrations.—Pl. 2, fig. 6, distal view, SEM photomicrograph, ×15,000.

Vekshinella sp.

Remarks.—The elliptical distal shield is constructed of 21-23 dextrally imbricate elements. Proximal side was not viewed. The central area is occupied by two thick crossbars that are aligned with the major and minor axes of the elliptical ring. The longitudinal crossbar is divided at each end. At one end, the crossbar is trident shaped, and at the opposite end the crossbar bifurcates in a Y pattern. Stem appears to be hollow, although it is not clear that it is open at the proximal side. The stem lies directly in the center of the ellipse. The crossbars appear to lie directly on the distal ring, but they are not incorporated into it. This *Vekshinella* species differs from *Vekshinella schizobrachiata* Gartner, 1968, in having fewer rim elements—21-23, as compared to 40-50 in *V. schizobrachiata.*

Size.—Maximum diameter: 4 microns (in photographed specimen).

Range.—Lower Campanian, photographed from level E, OPC-1163. Occurrence in Ozan Formation rare.

Illustrations.—Pl. 2, fig. 4, distal view, SEM photomicrograph, ×22,000.

Family STEPHANOLITHIACEAE Bukry, 1969

Genus **Corollithion** Stradner, 1961

Type species: **Corollithion exiguum** Stradner, 1961

Corollithion cf. **acutum** Thierstein, 1972

Corollithion acutum THIERSTEIN, 1972, p. 438, pl. 2, figs. 1-9.

Remarks.—This elliptical-shaped species has 40-50 nonimbricate elements, according to the specimens viewed. The elements proceed outward from the center to the rim. The central area is spanned by compressed, X-shaped crossbars forming 2 acute angles with the short axis. A calcite accumulation at the junction of the crossbars indicates that a short knob or stem may be present.

Size.—Maximum diameter: 3.3-7 microns.

Range.—Aptian-Campanian. Occurrence in Ozan Formation common.

Illustrations.—Pl. 2, fig. 7, distal view, SEM photomicrograph, ×22,000.

Corollithion exiguum Stradner, 1961

Corollithion exiguum Stradner, 1961, p. 83, figs. 58-61.

Remarks.—In distal view, the ring exhibits radially imbricate crystals that radiate to form a subhexangular shape. A stem is generally present. The specimens observed show evidence of excessive calcification at the crystal tips and protuberances. The six radial spokes are joined at the rim by trapezoidal crystals.

Size.—Maximum diameter: 3.5-5.5 microns.

Range.—Senonian-Maestrichtian. Occurrence in Ozan Formation common.

Illustrations.—Pl. 2, fig. 8, distal view, SEM photomicrograph, ×20,000.

Corollithion octoradiatum Gartner, 1968

Corollithion octoradiatum Gartner, 1968, p. 35, pl. 6, fig. 5; pl. 10, figs. 14-15; pl. 11, fig. 7; pl. 22, fig. 19.

Remarks.—Ring consists of eight spokes radiating from a large central area. The spokes are joined to the rim by two interlocking keystone elements; the central area consists of interlocking angular crystals.

Size.—Maximum diameter: 3.75-5.5 microns.

Range.—Common throughout the Senonian. Occurrence in Ozan Formation common.

Illustrations.—Pl. 2, fig. 9, distal view(?), SEM photomicrograph, ×25,000.

Genus **Cylindralithus** Bramlette and Martini, 1964

Type species: **Cylindralithus serratus**

Bramlette and Martini, 1964

Cylindralithus asymmetricus Bukry, 1969

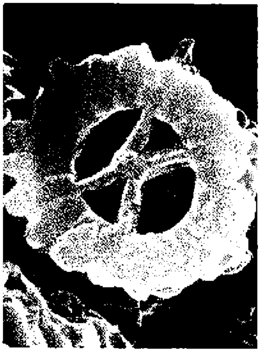
Cylindralithus asymmetricus Bukry, 1969, p. 42, pl. 19, figs. 9-12.

Remarks.—This is a double-flaring cylindrical form having a dentate margin. Crossbars are slender and have a secondary row of smaller, rhomb-shaped elements lying directly on the major structure.

Size.—4.56-5.9 microns.

Range.—Santonian-Campanian. Occurrence in Ozan Formation common.

Illustrations.—Pl. 3, fig. 1, distal view, SEM photomicrograph, ×16,000.



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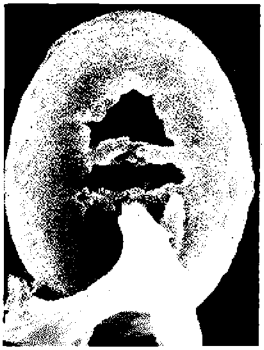

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Family SYRACOSPHAERACEAE Lemmermann, 1908

Genus **Cribrosphaera** Arkhangelsky, 1912

Type species: **Cribrosphaera ehrenbergi** Arkhangelsky, 1912

Cribrosphaera pelta Gartner, 1968

Cribrosphaera pelta GARTNER, 1968, p. 41, pl. 10, figs. 24-25.

Remarks.—Examination shows an elliptical disc consisting of three progressively larger tiers (viewed proximally), the proximal disc being smallest. Specimens are highly concave, and the central area contains 10-14 pores, centered at the junction of 4 regularly shaped interlocking elements.

Size.—Maximum diameter: 4.4-5.7 microns.

Range.—Campanian. Occurrence in Ozan Formation common.

Illustrations.—Pl. 3, fig. 2, proximal view, SEM photomicrograph, ×16,000.

Genus **Parhabdolithus** Deflandre, 1952

Type species: **Parhabdolithus liasicus** Deflandre, 1952

Parhabdolithus augustus (Stradner), Bukry, 1969

Rhabdolithus augustus STRADNER, 1963, p. 178, pl. 5, figs. 6-6a.

Parhabdolithus elongatus STOVER, 1966, p. 144, pl. 6, figs. 16-19; pl. 9, fig. 18.

Parhabdolithus augustus (Stradner), BUKRY, 1969, p. 53, pl. 29, figs. 8-11.

Remarks.—The central area has no apparent pattern, except for the prominent hollow spine in the center. The wall is made up of approximately 50 imbricate calcite rhombs that are raised or upwardly tilted to form a wall or raised rim.

Size.—7-9 microns.

Range.—Neocomian-Campanian. Occurrence in Ozan Formation rare.

Illustrations.—Pl. 3, fig. 3, distal view, SEM photomicrograph, ×18,000.

Plate 3

Figure

1. *Cylindralithus asymmetricus* Bukry, 1969, OPC 1163-13-EM, distal view, 4.56 microns, ×16,000.
2. *Cribrosphaera petta* Gartner, 1968, OPC 1163-14-EM, proximal view, 4.4 microns, ×16,000.
3. *Parhabdolithus augustus* (Stradner), Bukry, 1969, OPC 1163-3-CF, distal view, 5.3 microns, ×18,000.
4. *Zygodiscus deflandrei* Bukry, 1969, OPC 1163-1-FM, distal view, 4.8 microns, ×25,000.
5. *Zygodiscus diplogrammus* (Deflandre), Gartner, 1968, OPC 1163-2-BM, proximal view, 5.2 microns, ×15,500.
6. *Zygodiscus diplogrammus* (Deflandre), Gartner, 1968, OPC 1163-2-FM, distal view, 5.25 microns, ×15,500.
7. *Zygodiscus elegans* Gartner, emend. Bukry, 1969, OPC 1163-15-EM, distal view, 5.8 microns, ×12,000.
8. *Micula decussata* Vekshina, 1959, OPC 1163-1-PM, plan view, 5 microns, ×12,000.
9. *Staurolithites* sp. Caratini, 1963, OPC 1163-16-EM, proximal view, 5.5 microns, ×1,000.

Genus **Zygodiscus** Bramlette and Sullivan, 1961

Type species: **Zygodiscus adamas** Bramlette and Sullivan, 1961

Zygodiscus deflandrei Bukry, 1969

Zygodiscus deflandrei BUKRY, 1969, p. 59, pl. 34, figs. 3-5.

Remarks.—In distal view, the species has 2 large openings in the central area and a small pore near the junction of the 2 parallel crossbars on the short axis at either side of the ellipse. A distinct stem is present, and it is supported by two wide crossbars that are separated by a suture in the central area but diverge at the edges to form keystone elements in the rim.

Size.—Maximum diameter: 4.8-6.7 microns.

Range.—Albian-Maestrichtian. Occurrence in Ozan Formation abundant.

Illustrations.—Pl. 3, fig. 4, distal view, SEM photomicrograph, ×25,000.

Zygodiscus diplogrammus (Deflandre), Gartner, 1968

Zygolithus diplogrammus DEFLANDRE, 1954, p. 148, pl. 10, fig. 7.

Zygodiscus diplogrammus (Deflandre), GARTNER, 1968, p. 32, pl. 14, fig. 18; pl. 17, fig. 4; pl. 19, fig. 3; pl. 21, fig. 2; pl. 22, fig. 7; pl. 23, figs. 12-14; pl. 24, fig. 6

Remarks.—In distal view, specimens exhibit much imbrication, but the crossbars are not as distinct as in *Zygodiscus deflandrei* Bukry, 1969, and they lack the keystone elements at their junction with the rim. Viewed proximally, the shield is made up of a second cycle of nonimbricate elements (slightly dentate at their ends). Proximal side has the same number of elements as the distal side. In light microscopy the proximal elements are not apparent. Proximal shield is smaller than distal. Although some specimens have a stem, most lacked a stem and displayed only two thin parallel crossbars.

Size.—Maximum diameter: 4.3-5.2 microns.

Range.—Cenomanian-Maestrichtian. Occurrence in Ozan Formation abundant.

Illustrations.—Pl. 3, figs. 5, 6, proximal view, SEM photomicrographs, ×15,500.

Zygodiscus elegans Gartner, emend. Bukry, 1969

Zygodiscus elegans GARTNER, 1968, p. 32, pl. 10, figs. 3-6; pl. 12, figs. 3a-c, 4a-c; pl. 34, figs. 6-8.

Zygodiscus elegans Gartner, emend. BUKRY, 1969, pl. 34, figs. 6-8.

Remarks.—Specimen is disc shaped, constructed of approximately 40 dextrally imbricate elements that incline counterclockwise when viewed distally. Thick crossbars are surmounted by a stem constructed of large calcite crystals.

Size.—Maximum diameter: 5.8-11 microns.

Range.—Albian-Campanian. Occurrence in Ozan Formation rare.

Illustrations.—Pl. 3, fig. 7, distal view, SEM photomicrograph, ×12,000.

Genera Incertae Sedis

Genus **Micula** Vekshina, 1959

Type species: **Micula decussata** Vekshina, 1959

Micula decussata Vekshina, 1959

Micula decussata VEKSHINA, 1959, p. 71, pl. 1, fig. 6; pl. 2, fig. 11.

Remarks.—Specimens viewed with the SEM are concave, which may explain the cross-shaped appearance under light microscopy.

Size.—4.5-9 microns.

Range.—Upper Cenomanian-lower Campanian. Occurrence in Ozan Formation common.

Illustrations.—Pl. 3, fig. 8, plan view, SEM photomicrograph, ×12,000.

Genus **Staurolithites** Caratini, 1963

Type species: **Staurolithites laffittei** Caratini, 1963

Staurolithites sp. Caratini, 1963

Remarks.—Specimen closely resembles the illustration and description of *S. laffittei* Caratini, 1963. The elliptical ring is made up of 50-65 dextrally imbricate elements that flare distally from the smaller, almost-smooth proximal side. Crossbars parallel the axes of the ring and are made up of two series of rhomb-shaped elements meeting at a median suture line that crosses in the center of the specimens. Viewed proximally, the four large openings are irregularly shaped.

This genus, although it belongs to the family Syracosphaeraceae Lemmermann, 1908, is in a state of confusion (as explained by Thierstein, 1973, p. 37). Further SEM study of the holotype and specimens is needed.

Size.—Maximum diameter: 5-7 microns.

Range.—Cenomanian-Campanian. Occurrence in Ozan Formation rare.

Illustrations.—Pl. 3, fig. 9, proximal view, ×1,000.

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GSA South-Central Section Selects Austin

The Thompson Conference Center in Austin, Texas, will be the site, March 12-15, for technical sessions of The Geological Society of America's South-Central Section annual meeting. A short course on carbonates will be offered in Austin March 9-12, just prior to the general meeting. The course will cover depositional environments, petrography, facies, and diagenesis of carbonates and evaporites, and will include field studies.

Four faculty members of the OU School of Geology and Geophysics will present papers at the technical sessions. Howard W. Day will discuss "The Stability of Gibbsite, Boehmite, and Diaspore"; Robert L. Dubois, "Secular Variation from Archeomagnetic Data"; Edward C. Stoever, Jr., "Earth's Crustal Evolution: A Vehicle for Interdisciplinary Curriculum Development"; and Jiri Zidek will give a paper on the Pennsylvanian Acanthodii of Kansas.

Students who plan to offer papers include Rena Mae Bonem, "Morrowan Paleoecology—A Comparison with Modern Environments"; David Bradshaw, "An Introduction to the Magnetotelluric Method"; Robert C. Grayson, Jr., "Lithostratigraphy and Conodont Biostratigraphy of the Hindsville Limestone (Mississippian), Northwestern Arkansas"; Sheng-Shyong Lee, "A Comparison of the Thelliers' Double-Heating Method and Alternating Field Demagnetization Method in Archeomagnetic Field Intensity Study"; Charles D. Lewis, Jr., "A Paleomagnetic Investigation of Three Selected Intrusives from Big Bend National Park, Brewster County, Texas"; and Ronald F. Nichols, "Archeomagnetic Investigation of Anasazi Related Sediments of Chaco Canyon, New Mexico."

Patrick K. Sutherland, OU professor of geology, is a member of the

Management Board of the South-Central Section and will attend a preconvention meeting of that body.

Four post-convention field trips are offered to examine the Precambrian of the area, the use of land resources in and around Austin, the Paleozoic of the Llano region, and the stratigraphy of the Austin Chalk in the vicinity of Pilot Knob, a volcanic structure near Austin.

Information concerning the meeting is available from Robert E. Boyer, Chairman, Department of Geological Sciences, Box 7909, Austin, Texas 78712 (phone 512-471-5172).

THE MINERAL INDUSTRY OF OKLAHOMA IN 1974[1] (Preliminary)

L. G. SOUTHARD[2]

The value of minerals produced in Oklahoma in 1974 was $2,153 million. This was a net gain of 62.6 percent over 1973. Fossil fuels remained the State's dominant minerals and accounted for 95.0 percent of the total mineral value. Nonmetallic mineral value increased 9.1 percent and accounted for 4.8 percent of the State's gross mineral value. The value of metals increased slightly and was less than 0.2 percent of the total value of minerals produced in Oklahoma during 1974.

MINERAL FUELS

The value of mineral fuels rose to $2,039 million, 67.3 percent above the value of 1973. The value of all fossil fuels increased in 1974. Production of helium increased above that in 1973 by 1.4 percent, whereas value decreased 2.7 percent.

NONMETALS

Nonmetallic mineral production value amounted to $103 million compared with $94 million in 1973, with the largest gains in value coming from stone and cement.

METALS

Copper and silver, the only metals produced in Oklahoma in 1974, increased 37.7 percent in value compared with that of the previous year.

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[1]Prepared December 18, 1974, in Division of Fossil Fuels, U.S. Bureau of Mines, through a cooperative agreement between the USBM and the Oklahoma Geological Survey that calls for collecting information on all minerals except fuels.

[2]Minerals specialist, U.S. Bureau of Mines, Washington, D.C.

TABLE 1.—MINERAL PRODUCTION IN OKLAHOMA[1]

MINERAL	1973 QUANTITY	1973 VALUE (THOUSANDS)	1974 (PRELIMINARY) QUANTITY	1974 (PRELIMINARY) VALUE (THOUSANDS)
Clays[2] (thousand short tons)	1,298	$ 1,871	1,300	$ 2,017
Coal (bituminous) (thousand short tons)	2,183	16,779	1,927	16,860
Gypsum (thousand short tons)	1,429	5,796	1,359	5,502
Helium				
High-purity (million cubic feet)	181	6,335	170	5,950
Crude (million cubic feet)	115	1,380	130	1,560
Natural gas (million cubic feet)	1,770,980	334,110	1,785,682	426,778
Natural-gas liquids:				
LP gases (thousand 42-gallon barrels)	29,044	95,264	30,985	203,262
Natural gasoline and cycle products (thousand 42-gallon barrels)	14,674	49,070	13,804	91,935
Petroleum (thousand 42-gallon barrels)	191,204	723,273	179,580	1,300,159
Pumice (thousand short tons)	1	W	1	W
Salt (thousand short tons)	5	36	W	W
Sand and gravel (thousand short tons)	12,154	14,941	10,331	15,186
Stone (thousand short tons)	22,316	34,999	23,474	39,589
Value of items that cannot be disclosed[3]: cement, clay (bentonite), copper, lime, silver, tripoli, and values indicated by symbol W	XX	40,415	XX	44,292
Total	XX	$1,324,269	XX	$2,153,090
Total 1967 constant dollars	XX	1,007,205		

W Withheld to avoid disclosing individual company confidential data; included with "Value of items that cannot be disclosed." XX Not applicable.
[1]Production as measured by mine shipments, sales, or marketable production (including consumption by producers).
[2]Excludes bentonite.
[3]Revised figures.

Pack Your Bag for Big D

Dallas, Texas, is the site of The American Association of Petroleum Geologists-Society of Economic Paleontologists and Mineralogists 1975 annual convention April 7-9. Technical sessions and other convention activities will be held in the Dallas Convention Center, and the Statler Hilton will serve as the headquarters hotel.

The theme of this year's meeting is "Frontiers of Exploration," and various symposia will be offered on phases of this subject. Other AAPG sessions will provide a forum for papers on geochemistry, sedimentology, fossil-fuel resources, the status of energy minerals, regional geology, the applications of computer systems to geology, and land use with reference to environmental geology. Kenneth S. Johnson, geologist with the Oklahoma Geological Survey, will present a paper, "Stratigraphy of the Permian Blaine Formation and Associated Strata in North-Central Texas," which he coauthored with Wayne D. Wolfe and Melvin V. Smith of the U.S. Army Corps of Engineers, Tulsa District.

The SEPM program includes symposia and general sessions focused on beach processes, deep-sea carbonates and other sedimentology of modern and ancient deposits, stratigraphy, mineralogy, petrography, and paleontology. Patrick K. Sutherland, professor of geology in the School of Geology and Geophysics at OU, will present a paper on "Age and Correlation of the Wapanucka Formation (Pennsylvanian) in the Ouachita Mountains."

Altogether, over 200 papers will be presented at the meetings.

In addition, three short courses and 9 research colloquia will be offered April 5 and 6 before the meeting; these will involve study of paleoenvironments, ancient deltas, seismic stratigraphy, environmental geology, computer technology, and various aspects of sedimentation.

Four preconvention field trips will be offered: to study the Delaware Basin—deep-water carbonates exposed in the Sacramento and Guadalupe Mountains; the Ouachita Mountains—sedimentology and structures; North Central Texas—Late Pennsylvanian shelf sediments; and the Arbuckle Mountains—regional geology. A 1-day, post-convention trip (April 10) will provide an opportunity to study the Central Texas-Edwards (Lower Cretaceous) reef complex and associated sedimentation. Among the leaders of the Arbuckle field trip are Thomas W. Amsden and Robert O. Fay, geologists with the Oklahoma Geological Survey.

The Survey will also be well-represented in preconvention committee meetings. Charles J. Mankin, OGS director, is a member of the Continuing Education Committee and the Academic Advisory Committee of the AAPG and is acting chairman of the AAPG's Visiting Petroleum Geologists Program. S. A. Friedman, coal geologist, is a member of the Committee on Energy Minerals. William D. Rose, geologist-editor, is a member of the Public Information Committee and is an alternate for the AAPG House of Delegates.

John F. Roberts, petroleum geologist with the Survey, will have charge of a booth displaying the activities of the Survey and of the OU School of

Geology and Geophysics, and Betty Bellis of the OGS staff will "man" a Sigma Gamma Epsilon booth at the meeting. OU alumni functions, including a cocktail party and a luncheon, will be hosted by Dr. Mankin.

Dallas is widely known for its cultural and epicurean offerings, for its blending of heritages, and for its hospitality, and the ladies of Dallas have outdone themselves in providing varied entertainment opportunities for the women attending the convention. Highlights include a gourmet festival, a ranch barbecue party, and a seminar at the DeGolyer hacienda, complete with the Ballet Folklorico and Mexican food.

Information concerning this convention and hotel forms can be obtained from AAPG Headquarters, Box 979, Tulsa, Oklahoma 74101.

A Rare Inadunate Crinoid from the Barnsdall Formation (Upper Pennsylvanian) of Oklahoma

Harrell L. Strimple[1]

Crinoids of the genus *Exoriocrinus* Strimple and Moore, 1971a, have very thin ossicles, and therefore they are seldom preserved as articulated specimens. *Exoriocrinus* crowns are exceedingly rare; in fact, complete specimens have heretofore been reported only from the LaSalle Limestone Member of the Bond Formation (Missourian) of Livingston County, Illinois. Several years ago, however, A. Allen Graffham recovered an excellent specimen, although it had been laterally compressed, from shale approximately 20 feet below the Wildhorse Dolomite, Barnsdall Formation (Upper Pennsylvanian), in Osage County, Oklahoma (from a deep draw north of Oklahoma Highway 20 in the NW¼ sec. 21, T. 22 N., R. 10 E.). A molluscan fauna predominates in shales of the area, but disarticulated crinoids and bryozoans are the most common elements in the shale closest to limestone layers. Oakes (1952) considers the entire Barnsdall Formation to be of Missourian age, but he correlates all of the formation above the Birch Creek Limestone, the basal member, with the lower part of the Weston Formation of Kansas. Zeller (1968) believes that the Weston Formation is basal Virgilian, which is accepted by this author but not by the Oklahoma Geological Survey.

Graffham's specimen (fig. 1) was obtained by the Oklahoma Geological Survey and is part of The University of Oklahoma's Museum of Invertebrate Paleontology collection (OU 7147). Carl C. Branson, then director of the Survey, sent the specimen to this writer for examination and preparation of a report. The crinoid is identified as *Exoriocrinus ramonaensis* (Strimple). The length of the crown is 61.0 mm, the cup width is 23.0 mm, and the height is 11.5 mm. The cup appears to be almost ovoid, as preserved, but it has upflared

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infrabasals. The posterior interradius is very broad and has three large anal plates in normal (primitive) arrangement. There are 20 arms—uniserial, keeled, and composed of cuneate brachials, each of which bears a stout pinnule on alternate sides. Branching takes place on primibrach *1* and on secundibrach *8* or *9*.

E. ramonaensis had hitherto been known only from a monotypic cup with the first few brachials attached. Fortunately, identification of isolated cup plates has been possible because of several distinctive denominators, particularly the wide, low ridges that pass from plate to plate and that may strengthen the cup structure.

Figure 1. *Exoriocrinus ramonaensis* (Strimple), ×1.6, from the Barnsdall Formation, Osage County, Oklahoma. Hypotype crown (OU 7147) viewed from *a*, anterior and *b*, posterior.

The following species of *Exoriocrinus* are now known.

E. lasallensis (Worthen, 1875)	LaSalle Limestone Member, Bond Formation (type species), Missourian	LaSalle and Livingston Counties, Illinois
E. ramonaensis (Strimple, 1939)	Avant Formation and Barnsdall Formation (reported in this paper), Missourian	Washington and Osage Counties, Oklahoma
E. rugosus Strimple and Moore, 1971b	Francis Shale, Missourian	Pontotoc County, Oklahoma
E. pentacolumnus (Strimple, 1940)	Wewoka Formation, Desmoinesian	Hughes County, Oklahoma
Exoriocrinus sp.	Wewoka Formation, Desmoinesian	Hughes County, Oklahoma

Most species of *Exoriocrinus* were originally assigned to *Poteriocrinites* Miller, 1821 (*=Poteriocrinus),* based primarily on similarities in cup shape, i.e., more or less cone shaped, with infrabasals visible in side view and radial articular facets that do not fill the distal faces of the radials. The radial articular facets of *Exoriocrinus,* however, are more advanced than those of *Poteriocrinites;* they have a well-defined transverse ridge, distinct inner and outer ligament areas, and prominent muscular fossae. *Poteriocrinites* specimens have a narrow, horseshoe-shaped articular facet with a weak transverse ridge.

The only inadunate crinoid genus of Pennsylvanian age that has plates as thin as those of *Exoriocrinus* is *Elibatocrinus* Moore, 1940. Articulated *Elibatocrinus* specimens are also rare, and their cups are strengthened by the development of inwardly projected ridges. In the description of the type species *E. leptocalyx* Moore (p. 37), it is noted that "The distal edges of the *IBB* plates are thin, delicately marked by ligament grooves, and show a buttress-like thickening at five points." The internal "buttress-like thickening" is evident in Moore's illustrations (figs. 2b, 3, 4c).

Elibatocrinus is more advanced than *Exoriocrinus* in having 3 rather than 5 infrabasals (apparently the number was reduced by fusion) and a round rather than pentagonal stem. *Exoriocrinus* is more advanced in having a broader cup, whereas *Elibatocrinus* retains a tall, cone-shaped cup; a single primibrach in all rays, whereas *Elibatocrinus* has 2 in some (or all) rays of some (but not all) species; and arms that branch more than once, whereas *Elibatocrinus* has only 10 arms. The similarities between *Elibatocrinus* and *Exoriocrinus,* however, indicate that they probably share a common progenitor.

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A Different Kind of Space Symposium Is Announced

Underground space—it has long been used to accommodate transportation facilities, to provide shelter from climatic and martial violence, to house Alice's white rabbit, to harbor hospitals (as in Stockholm), and to provide waste-disposal sites. With the shrinking of available space in overcrowded urban areas, however, there is a growing interest in the possibilities of expanding usage of natural and man-made excavations.

In line with such interest is the announcement of a symposium, "Development and Utilization of Underground Space," to be held in Kansas City March 5-7, 1975, under the sponsorship of the Department of Geosciences of the University of Missouri at Kansas City. The symposium will include open discussions and formal delivery of papers of local, nationwide, and worldwide significance, as well as several field trips in the Kansas City area.

Support for the meeting has been provided by local underground industry in Kansas City and by the National Science Foundation. Registration is limited to 150 persons and the sponsors will be selective to include a wide spectrum of academic and industrial participants. For information, contact Dr. Eldon J. Parizek, Chairman, Department of Geosciences, University of Missouri-Kansas City, 5100 Rockhill Road, Kansas City, Missouri 64110.

The Enid Flood Report: An Appraisal

The heavy rainfall and devastating floods in parts of north-central Oklahoma in the fall of 1973 are the subject of a recent report by the U.S. Geological Survey. The report, released as Water-Rescurces Investigations 27-74, is entitled *Flood of October 1973 in Enid and Vicinity, North-Central Oklahoma,* by R. H. Bingham, D. L. Bergman, and W. O. Thomas, Jr. A summary of it was published in the December 1974 issue of *Oklahoma Geology Notes* (p. 209-212).

The report consists of 2 large sheets, each containing 1 large map along with supporting text, charts, graphs, and photographs. The maps are done in two colors, and the essential technical information, such as rainfall data, flood-frequency curves, and profiles of flooding streams, has all been clearly presented and should further our understanding of the hazards that are involved in the unwise use of urban or rural lands that are prone to flooding.

Single copies of Water-Resources Investigations 27-74 are available free from District Chief, U.S. Geological Survey, Water Resources Division, 201 NW 3d Street, Oklahoma City, Oklahoma 73102.

—*Kenneth S. Johnson*

OKLAHOMA ABSTRACTS

Oklahoma State University

Geology for Land-Use Planning of Western Rogers County and Southern Washington County, Oklahoma

JARRETTE LYNN IRELAND, Oklahoma State University, B.S. thesis, 1973

The purpose of this study is to contribute to efficient land-use by translation of geologic information into forms that would be directly usable by laymen. Five maps show the physical conditions that should have the greatest effect upon the development of the region: (1) an environmental geology map, (2) a land-resource capabilities map, (3) a current land-use map, (4) a relief map, and (5) a hydrology and mineral resources map.

OKLAHOMA ABSTRACTS is intended to present abstracts of recent unpublished papers relating to the geology of Oklahoma and adjacent areas of interest. The editors are therefore interested in obtaining abstracts of formally presented or approved documents, such as dissertations, theses, and papers presented at professional meetings, that have not yet been published.

The study area, located in western Rogers and southern Washington Counties, Oklahoma, includes about 450 square miles. Parts of the region undoubtedly will become part of metropolitan Tulsa. All parts of the study area are within 50 mi of the relatively new Port of Catoosa on the Verdigris River. Thus urbanization and industrialization within the study area are to be expected.

The bedrock that crops out in the study area includes the Desmoinesian and Missourian Series of the Pennsylvanian System. The strata are chiefly shale, siltstone, sandstone, and limestone. Stream terrace deposits and floodplain alluvium of the Quaternary System cover much of the bedrock. Formal stratigraphic units were not mapped. The environmental geology map shows the areas in which the above-mentioned rock types crop out. This method of mapping was chosen on the basis of the assumption that the environmental geology map would be more useful to the laymen.

Bedrock units, soil units, and man-made units are shown on the land-resource capabilities map. These units are classified according to type of bedrock, its engineering and chemical characteristics, and the thickness and physical properties of the soil. The legend of the map shows the suitabilities of the units for specified uses of land.

The current land-use map and the relief map show the various uses of the land and the major aspects of the topography of the study area. The combined hydrology and mineral-resources map shows location and general quality of surface water, availability and quality of ground water, and location of known resources, including petroleum and natural gas, coal, limestone, sand, and gravel.

The five maps are designed to be useful in regional planning. The maps do not show the detailed information that is necessary to determine the final commitment of a specific tract of land.

Environmental Geology of the Mannford Area, Oklahoma

PHILLIP RANDALL KEMMERLY, Oklahoma State University, Ed.D. dissertation, 1973.

SCOPE AND METHOD OF STUDY: This study is an assessment of physical environment of the 12 sq/mi. Mannford area in Creek County, Oklahoma. Data were compiled from the U.S. Army Corps of Engineers, the Oklahoma Highway Department, the City of Mannford, the Soil Conservation Service, and the Oklahoma Geological Survey. These data were supplemented by field mapping of the bedrock and surficial geology and by a seismic refraction survey of the depth to bedrock. The following 12 factor maps at a scale of 1:12,000 have been produced: (1) topography; (2) slope; (3) drainage; (4) bedrock geology; (5) surficial geology; (6) soils; (7) depth to bedrock; (8) erosion susceptibility; (9) corrosivity potential for uncoated steel pipe; (10) recreational suitability; (11) plasticity of solum and of subsoil; and (12) geologic constraint for general land use.

FINDINGS AND CONCLUSIONS: The 12 factor maps, 11 figures, and 15 tables present a three-dimensional picture of most aspects of the physical environment in the Mannford area. These can be used by laymen, politicians, geologists, engineers, and planners in developing recreational areas, housing developments, routes for subsurface pipe, storm drainage and other engineering and planning purposes.

Potential environmental geologic problems in the Mannford area include waste disposal and Keystone Reservoir pollution. Soil erosion also is a problem in terms of silting of the water supply reservoir of Mannford. Slope stability and excavation problems occur locally where seeps, springs, and plastic soils occur. The Mannford area also is in an area where the possibility of earthquakes does exist. The probability of earthquakes that would be dangerous to life and property, however, is low.

(Reprinted from *Dissertation Abstracts International,* Pt. B., v. 35, p. 2265-B)

Geology for Land-Use Planning of Southeastern Osage, Eastern Pawnee, Northern Creek, and Western Tulsa Counties, Oklahoma

MICHAEL J. MCGUIRE, Oklahoma State University, M.S. thesis, 1974

Mapping of geology for land-use planning of approximately 680 sq mi in southeastern Osage, eastern Pawnee, northern Creek, and western Tulsa Counties, Oklahoma was accomplished by interpreting published and unpublished geologic and soil data, and a variety of other information. Four maps show the physical conditions that should have the greatest effect upon the development of the region described above: (1) an environmental geology map, (2) a current land-use map, (3) a combined mineral-energy and water-resources map, and (4) a land-resource capability map. With today's rapid urbanization and emphasis on energy, it is essential for man to understand and to learn to manage the environment in which he lives. These maps and the accompanying text will assist in the making of important decisions about the long-term management of the environment in the study area.

The bedrock of the study area includes most of the Missourian Series and part of the Virgilian Series, both of the Pennsylvanian System. The Quaternary System includes stream-terrace deposits of the Pleistocene Series and alluvium of the Holocene Series. The Environmental Geology Map shows lithologic types of bedrock. Traditional stratigraphic boundaries are not shown. This map is considered to be less confusing and therefore more useful to the layman than traditional geologic maps.

The Land-Resource Capability Map is designed for use in evaluating land for urban, industrial, and agricultural development. Basic mapping units have been delineated by integrating geologic information with information about various properties of soil and about known hazards. Using this approach, the type of bedrock, its engineering and chemical characteristics, and the thickness and physical properties of the soil are all considered.

The Current Land-use and Vegetation Map provides an inventory of land-use patterns in the study area. The combined Mineral-energy and

Water-resources Map shows known locations and the distribution of deposits of some resources, such as petroleum and natural gas, limestone, sandstone, clay, coal, sand and gravel, and surface water and ground water.

The key to proper management of land resources is the evaluation of the impact of man's activities on tracts of land well in advance of development. The proper use of studies such as this one can aid in land-use planning. When properly informed, men will be able to make intelligent decisions in planning for community growth.

University of Missouri at Columbia

A Study of the Barite-Lead-Zinc Deposits of Central Missouri and Related Mineral Deposits in the Ozark Region

DAVID LAMAR LEACH, JR., University of Missouri at Columbia, Ph.D. dissertation, 1973

The more than 250 small, high grade deposits of galena, sphalerite, and barite that occur in the central Missouri barite district are believed to be part of the general Mississippi Valley-type mineralization found throughout the Ozark region, covering more than 125,000 square kilometers.

Homogenization temperatures for sphalerite from rock quarries, drill cuttings, and lead-zinc, barite, and coal mines in central Missouri are in the range 80°C to 110°C. Freezing point depression determinations show that the fluids that deposited the sphalerite had salinities generally greater than 22 NaCl equivalent weight per cent salts. At some time after cessation of the lead-zinc mineralization in central Missouri, barite was deposited at temperatures less than approximately 40°C by solutions containing 4 to 10 weight per cent salts. The lack of any mineral deposition in central Missouri in the temperature range 80°C to 40°C and salinity range 21 to 10 weight per cent salts, suggests the possibility of two distinct (and perhaps completely unrelated) episodes of mineralization.

Homogenization temperatures for sphalerite from the northern Arkansas zinc district are in the range 83°C to 132°C. Freezing point depression determinations for sphalerite from northern Arkansas are nearly identical to those for sphalerite from central Missouri, being generally greater than 22 weight per cent salts. A limited number of homogenization and freezing point temperature determinations were made on sphalerite from the Tri-State district and are in agreement with the available data in the literature. The data show that sphalerite from the Tri-State district was deposited by fluids having salinities greater than 22 weight per cent salts, in the temperature range, 83°C to 120°C.

It is believed that the lead-zinc deposits in northern Arkansas, Tri-State, and central Missouri are the results of one episode of widespread mineralization in the Ozark region rather than multiple and unrelated episodes. A possible source for the lead-zinc ore-solution may have been the predominately shaley sediments in the Ouachita geosyncline, expelled during diagenesis and low-grade metamorphism in Late Pennsylvanian-Permian time.

Fluid inclusion studies on barite from the Southeast Missouri barite district show that the barite mineralizing fluids were nearly identical to those for central Missouri. The similar mineralogy, fluid inclusion data, and geographic proximity of the two barite districts suggest they may be genetically related.

The complete absence of barite in the Southeast Missouri lead district suggests that it may be genetically distinct from the adjacent Southeast Missouri barite district.

Electron microprobe analysis of barite from central Missouri shows that small scale, repetitive, strontium-rich bands are common in many clear barite cyrstals. These bands are believed to be annual growth bands, similar to the varvelike bands reported in celestite from Clay Center, Ohio. Estimated growth rates for some barite crystals from central Missouri are in the range 1 cm/500 years to 1 cm/10,000 years.

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The University of Nebraska

Comparison of Two Late Paleozoic Red Shales of the Midcontinent Region

JOHN LYSLE RUSSELL, The University of Nebraska, Ph.D. dissertation, 1974

During more than 135 years of continuing interest in red beds, their common color has been assumed to result from special conditions of deposition (van Houten, 1961). Environments of deposition postulated for thin, nonfossiliferous, red mudstone layers interbedded with marine beds of the Late Paleozoic in the Midcontinent have played an important role in the construction of cyclothemic interpretations. However, detailed studies of the nature of these red layers and their stratigraphic relationships to the enclosing rocks have not been published.

This investigation of the Rock Lake Shale Menber of the Stanton Limestone Formation (Pennsylvanian System) and the Eskridge Shale Formation (Permian System) exposed in the Midcontinent suggests that red mudrocks within these units can best be attributed to deposition as primary oxidized sediments on high intertidal mud flats marginal to the late Paleozoic sea. Red and brown, fine-grained sediments presently being deposited on high intertidal mud flats of estuaries and lagoons near Guaymas, Sonora, Mexico provide a modern analogue of the ancient examples. It is not proposed that all red shales originated in this manner.

The Rock Lake Shale contains portions of a regressive-transgressive sequence. The regressive sequence begins in the Stoner Limestone and ends at a diastem within the Rock Lake Shale. Deposition of nonfossiliferous reddish brown mud of the Rock Lake, in the area of western Cass and Sarpy Counties, Nebraska, occurred on a high intertidal mud flat during regression. The regressive phase of the Rock Lake in Missouri and Kansas consists of green or gray mudrocks deposited in a marine environment where submergence exceeded subaerial exposure. Fine-grained marine mudstone in Nebraska containing the brachiopod *Crurthyris*, and siltstone and sandstone of littoral origin in Kansas and Nebraska compose transgressive rocks of the Rock Lake Shale above the diastem.

The Eskridge Shale consists primarily of greenish gray mudstone with lesser amounts of red or brown mudrock interbedded with limestone, dolostone, rock gypsum, and coal. These lithologies were deposited in intertidal and shallow neritic environments that fluctuated spatially and temporally creating rapid facies changes. Greenish gray mud was deposited in the shallow neritic environment contemporaneously with the deposition of red or brown mud on high intertidal mud flats.

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THE UNIVERSITY OF OKLAHOMA

Mineralogic Dispersal Patterns in the Vanoss Formation, South-Central Oklahoma

JOHN BYRON THOMAS, The University of Oklahoma, Ph.D. dissertation, 1973

One hundred forty-seven samples of the Permo-Pennsylvanian Vanoss Formation of south-central Oklahoma were collected for purposes of determining mineralogic dispersal patterns from the Arbuckle Mountains. Light mineral, heavy mineral and clay mineral fractions were examined to evaluate their value in indicating such dispersal patterns as well as the effect of diagenesis on the Vanoss mineralogy.

There appear to be two principal source areas, based primarily on the light mineral evaluations. An igneous source apparently located near T. 3-4 N., R. 5-6 E. is best shown by distribution maps or trend maps of granitic detritus; specifically granite rock fragments, microcline-perthite, total feldspar and polycrystalline quartz. The source rocks were presumably Precambrian granites which presently are exposed 28 miles south of the indicated source area. This source, however, appears to be structurally unlikely based on present tectonic information.

A second source area is predominantly carbonate and friable sandstone located along the southern boundary of the Vanoss outcrop belt on the north side of the Arbuckles. The greatest floods of clastics seem to have come from the highland region located in T. 2-3 S., R. 1 W., as evidenced by the distribution of limestone and chert rock fragments and also overgrown quartz grains.

Without knowledge of the mineralogy of the igneous source rocks for comparison, interpretation of the petrology of the Vanoss Formation would lead to misconceptions about the geologic history of the unit. The non-opaque heavy mineral suite composed of predominantly ultra-stable zircon, tourmaline, rutile and garnet strongly indicates sedimentary or metamorphic sources for the Vanoss. Heavy minerals present in the Precambrian granite source rocks are not unique to granites and are common in metamorphic rocks. A metamorphic source is further indicated by the high concentrations of albite-twinned plagioclase (Slemmons, 1962) but this is due to disintegration of the coarser, simple Carlsbad twins during transport.

The original clay mineralogy of the Vanoss Formation has been largely obliterated by the diagenetic reconstruction to kaolinite with vestiges of the original suite present only in more argillaceous portions of the formation.

In future studies of clastic rocks where source areas are not exposed for comparison, recognition of the mineralogic limitations pointed out by this study should lead to fewer misconceptions concerning the accuracy of provenance determinations of sandstone units.

The University of Tulsa

A Comparison of the Chemical Composition of Interstitial Waters of Shales and Associated Brines

ABDOLHOSSEIN BAHARLOUI, The University of Tulsa, Ph.D. dissertation, 1973

Interstitial water from Paleozoic shales and sandstones of Oklahoma shows a marked contrast in composition and concentration. The total dissolved solids in the interstitial water of shales is about 50,000 milligrams per liter, which is about one-third that of the brines contained in the associated sandstones. Pore water of the shales contains abundant sulfate, but usually no measurable calcium or magnesium. In striking contrast, sandstone water contains almost no sulfate, but abundant calcium and magnesium.

These data have profound implications and require the revision of ideas which are widely held concerning origin, concentration and composition of brines.

The abundant amount of sulfate in shale water may also alter the idea that the lack of sulfate in deep subsurface waters in the sands is a result of sulfate-reducing bacteria.

The results of this study also suggest that the conventional explanation of the self-potential log is only partly correct; potential differences between sand and shale exist even when there is no mud in the borehole.

A "sulfate-sodium" class is proposed to characterize pore water in shale.

Three parameters are presented to explain the concentration and composition of interstitial water within a particular formation.

Stratigraphic Analysis of the Interval from the Hogshooter Limestone to the Checkerboard Limestone, a Subsurface Study in North-Central Oklahoma

SAMSON BANDELE EKEBAFE, The University of Tulsa, M.S. thesis, 1973

The Coffeyville interval was studied to determine its stratigraphic behavior and its depositional environment. The Coffeyville is an isochronous unit that is defined by the Hogshooter and the Checkerboard stratigraphic time markers. The stratigraphic characteristics of the interval were defined by cross sections, isopach, sand/shale ratio and isolith maps coupled with core and Coffeyville outcrop studies. The Coffeyville interval is divisible into an upper sandstone zone and a lower shale zone. The sandstone (Layton) represents delta distributary channel deposits pushing southwestward and northwestward from the southeast. The shale zone is mostly marine shales.

Eight facies of the Layton sandstone are recognized in the study area and each facies is related to an environment of deposition characteristic of a delta. These facies are: (1) delta distributary channel deposit; (2) delta distributary system deposit; (3) crevasse deposit; (4) bay deposit; (5) delta fringe deposit; (6) offshore bar deposits; (7) prodelta deposits; and (8) carbonate shelf deposits.

Semiquantitative Analysis of Crude Oil in Lacustrine Sediments

LLOYD DAVID GOSSETT, The University of Tulsa, M.S. thesis, 1973

A technique for determining the relative contributions of crude oil and recent biologic matter in lake sediments by infrared spectrometry was investigated. The procedure consisted of extracting the organic matter by solvent reflux and measuring the magnitude of 2925 cm^{-1} (-CH_2- stretching band) absorbance of crude oil and the 2925cm^{-1} and 1710 cm^{-1} (presumably C=O stretching) bands of biologic matter.

The bottom sediments accumulating in six lakes were sampled (five were considered as uncontaminated organic background), extracted in a Soxhlet apparatus, and tested by infrared spectrometry. Evidence of contamination by crude oil was found in the Lake Keystone sediments near an unplugged oil well. Crude oil was estimated to compose from 50% to 73% of the total extractable organic matter in one Keystone sediment sample.

Some Physical Properties of Coal: Porosity and Pore Size Distribution

JOSEPH ROBERT KOLMER, The University of Tulsa, M.S. thesis, 1972

The increasing concern for safety and pollution controls has generated research in these areas. For this reason research on the pore structure of the coal system was undertaken. These studies were conducted both visually and analytically.

It was found that helium gas should be used in conjunction with the Boyle's law porosimeter when coal porosities are being determined. The porosity of the coal examined by these methods was between 2.36 and 4.86%. The majority of this porosity was in the fracture system of the coal. These fractures were found to be interconnected and therefore the coal was permeable. Also, it was found that as the distance from the mined face increased, the frequency and width of the fractures decreased. The method of mercury injection also was used to determine porosity and pore size distributions.

The results of this test are not conclusive, since the possibility of interference from system errors exists. These results, however, are presented and discussed. This study is the first known study done on lump coal.

Patterns of Pressure in the Morrow Sands of Central Oklahoma

LUIS FELIPE MASROUA, The University of Tulsa, M.S. thesis, 1973

The Morrow Formation is the basal transgressive unit of the Pennsylvanian System unconformably overlying the Mississippian. In Blaine County, Oklahoma, the formation includes numerous lenticular reservoir sandstones. The erratic and discontinuous nature of these sands is the reflection of the irregularities of the pre-Pennsylvanian unconformity, which was characterized by topographic lows oriented in a northeast-southwest direction. The best sand development is within the limits of these erosional troughs.

For the purpose of correlating the Morrow sands, electric logs and pressure data were used. Each gas reservoir has its own initial pressure and pressure decline history, which is quite different from that of adjacent sand lenses; consequently, problematical correlations can be solved by comparing the corresponding pressure decline curves.

In Blaine County, the Morrow sands have abnormal pressure; whereas, in Woodward County, the pressures are normal, and in the Panhandle, they are subnormal. However, all these areas exhibit certain lithologic characteristics of overpressured zones, which suggests that several factors are responsible for the pressure distribution. The suggestion is made that all those areas once had abnormal pressure, and that the Panhandle area has been uplifted and eroded. The removal of part of the overburden may have caused a decrease in temperature and the expansion of the reservoir pore volume, both of which would cause a decrease in pressure, possibly even to subnormal values.

Environmental Significance of Shale Properties

RANDY V. MILLER, The University of Tulsa, M.S. thesis, 1973

Physical and chemical properties of Pennsylvanian shales were measured for a group of 41 core samples selected from known or inferred depositional environments. They represented four generalized environmental groups; prodelta, marine, nearshore marine, and crevasse splay.

Classification of samples into two depositional environmental groups was possible by discriminant function analysis. Two highly significant groupings were crevasse-nearshore, and prodelta-marine. The variables correlated differently in each of these groupings. For the prodelta-marine group, illite/chlorite+kaolinite, organic carbon, and sulphur formed a net of significant correlations, with subsidiary correlations with porosity, percent chlorite, illite, kaolinite, and percentages of clay, sand and silt. The nearshore-crevasse splay group showed strong correlation nets between relative disaggregation, percent clay, and kaolinite; percent illite, chlorite, pH and carbonate carbon; and between sulphur, organic carbon and calcium phosphate. Variables with the most significance in separating the two environmental groupings are porosity, aluminum and iron phosphate, calcium phosphate fraction, grain density, illite/chlorite+kaolinite, and percent kaolinite. Only two of the 41 samples were not properly classified by this analysis.

Analysis of the combined data from linear regression, discriminant function and physical properties of the environments of deposition provided insights into the origin of specific correlations. Scanning electron microscope examination showed open conical patterns for marine shales, probably deposited as floccules, and sheaf-like arrays for those deposited in fresh to brackish water. This fabric difference suggests explanations for variations in porosity, disaggregation potential and density. Also the sulphur, organic carbon, and calcium phosphate net was related to deposition of detrital organic materials in nearshore environments.

Zinc, Lead and Cadmium Distribution and Mode of Occurrence in Oklahoma Reservoir Sediments

FRANK WILLIAM PITA, The University of Tulsa, M.S. thesis, 1972

The bottom sediments accumulating in five Oklahoma reservoirs were sampled. Zinc, lead, and cadmium occur in relatively high concentrations in the bottom sediments of Oklahoma reservoirs, as compared to uncontaminated soils. The reservoirs located in the drainage basin of the lead-zinc mining district have a higher concentration of metals than the other reservoirs. Zinc and lead content strongly correlate with percent organic carbon and percent clay-size material in the sediments and water depth in the reservoirs.

The samples were separated into three components (organic material, clay-organic complexes, and sulfides) based on specific gravities. It was found that the free organic material (density < 2.0) contains a small quantity of zinc, lead, and cadmium; the clay-organic complexes (density between 2.0 and 2.87) contain the bulk of these metals; and the sulfides (density > 2.87) are low in these metals. The movement of the sulfides into reservoirs is suggested to be by airborne dust and is relatively small. The major occurrence of zinc and lead in reservoir sediments is either on the organic material adhering to clay minerals and/or on the clay minerals. Comparison of zinc/lead ratios in ore minerals, soils, and reservoir sediments suggests zinc is significantly more mobile and/or more readily extracted from water than lead.

Chemical Composition of Deep Subsurface Waters of the Anadarko Basin

CARLOS SOTO RUIZ, The University of Tulsa, M.S. thesis, 1974

Waters in the Permian gas-producing formations are concentrated brines, resembling the typical connate waters of the chloride-calcium class, except that they contain unusually large amounts of sulfate. The sulfate probably was derived from anhydrite common in Permian strata.

The Morrow waters of Cimarron County, Oklahoma, are chloride-calcium brines but less concentrated and with somewhat less sulfate. There may be a connection to the overlying Permian sands through the granite wash facies to the west. The Morrow sands of Texas County, Oklahoma, contain a typical chloride-calcium brine. The same water is found in post-Morrow (Pennsylvanian) formations including the Lansing, Tonkawa, and Toronto formations. The Oswego Formation is a chloride-calcium brine but is less concentrated. Eastward in Oklahoma and south into the Texas Panhandle, the Morrow waters are dilute and belong to the bicarbonate-sodium class. This composition may have resulted from hydrodynamic circulation along the pre-Morrow unconformity shortly after Morrow deposition.

The Skinner Sandstone Zone in Central Oklahoma

RAFAEL VALDERRAMA, The University of Tulsa, M.S. thesis, 1974

The interval between the Verdigris and the Pink limestones corresponds to regressive phases of deltaic type. A change of regional dip is detected after deposition of the Henryetta coal zone. This tilting made it possible to divide the Skinner Zone into two generations of sand bodies: a lower unit with distributary patterns trending southwestward and an upper unit with a regional dip trending northwestward.

This movement that occurred during Middle Pennsylvanian time is evidenced by petrographic analysis of source of sediment, distributary patterns of sedimentation, paleocurrent indicators, and textural analysis of lithologic units and SP log shapes.

Stratigraphic cross sections, and isopach, isolith, and environmental maps illustrate the sedimentary facies that occurred at the time of Skinner deposition.

The integration of surface and subsurface data determines four environmental facies: (1) upper deltaic plain; (2) lower deltaic plain; (3) marginal marine; and (4) pro-delta deposition.

USGS Initiates Land-Use-Map Series

Nine counties of the San Francisco Bay region are covered in the prototype of an experimental series of U.S. Geological Survey maps showing various categories of land use and their changing patterns. The 44 maps included in the set cover 7,000 square miles and provide information on 14 major categories of land use, from unimproved open space to multi-family residence. James R. Wray, geographer-cartographer at the USGS National Center at Reston, Virginia, anticipates that the series will be "of particular use to urban and regional planners, administrators, environmentalists, and others concerned with monitoring and planning urban growth and changing land use."

Mapping for the series is done at a scale of 1:62,500 (approximately 1 inch to the mile) and utilizes a technique of combining remote-sensing data with information from ground-level surveys. It represents one segment of USGS research in the use of satellite and aircraft imagery to provide current information on land-use changes such as increased conversion to shopping and office centers. Such recent information has already proved valuable.

Future maps in the series are being prepared for seven other metropolitan areas of the United States: Boston, Massachusetts; Cedar Rapids, Iowa; New Haven, Connecticut; Phoenix, Arizona; Pontiac, Michigan; Tucson, Arizona; and Washington, D.C.

Arrangements for reproducing the San Francisco maps can be made through the USGS Public Inquiries Office, 504 Custom House, 555 Battery Street, San Francisco, California 94111. Copies of the maps are available for inspection only at the USGS libraries at Menlo Park, California, and Washington, D.C. For further information, contact Chief Geographer, Mail Stop 115, USGS National Center, Reston, Virginia 22092.

SEG Midwest Section to Meet in Tulsa

"Search for Fuel Independence" is the timely theme selected by the Society of Exploration Geophysicists for their 28th annual Midwestern Exploration meeting, scheduled for Tulsa, March 19-21. Technical sessions will be held in the Tulsa Assembly Center, and convention headquarters will be at the Mayo Hotel. A varied program of social events and excursions in downtown Tulsa will be offered "for the ladies" under the direction of Mrs. William B. Brinnon.

The Geophysical Society of Tulsa will host the meeting. M. E. Arnold, Amoco Production Company, is the general chairman; Eugene L. Current of Cities Service Oil Company is the chairman responsible for technical programs; and Ray Sanders of Amoco is the registration chairman.

Questions concerning the meeting should be addressed to Mr. Arnold, P.O. Box 591, Tulsa, Oklahoma 74102 (phone 918-627-3400).

OGS Geologists Turn to Teaching

Two geologists for the Oklahoma Geological Survey are sharing their expertise with The University of Oklahoma's School of Geology and Geophysics by teaching new geology courses this semester.

S. A. Friedman is presenting a graduate seminar in coal geology. He will cover some of the same material that he recently outlined in a short course at the Oklahoma Center for Continuing Education (see *Oklahoma Geology Notes*, v. 34, p. 158-159, August 1974). The origin, occurrence, and geographic distribution of coal will be examined, and types of coal mining and trends in coal production will be spotlighted.

Kenneth S. Johnson is teaching a course on the economic geology of nonmetallic minerals. The origin, distribution, and geologic features of principal nonmetallic resources will be examined, and special emphasis will be placed on deposits in the United States. Several 1- and 2-day field trips are planned, and methods of evaluating mineral properties will be demonstrated through these trips and through preparation of reports on selected deposits in Oklahoma and neighboring states.

Both courses are part of the School's effort to offer information especially relevant to current problems facing business, industry, and government.

U.S. Board On Geographic Names Decisions

The following Oklahoma place names were approved by the U.S. Board on Geographic Names in recent issues of *Decisions on Geographic Names in the United States*.

Jackfork Mountain (variants: Jack Fork Mountain, Jacques Fork Mountain, Middle Mountain) has been adopted by the U.S. Board on Geographic Names to identify a 19-mile-long (30 km) mountain 13 miles (21 km) south of Hartshorne, Oklahoma, in Atoka, Pittsburg, and Pushmataha Counties (34° 40′ 30″ N., 95° 28′ 10″ W., NE end; 34° 32′ 00″ N., 95° 46′ 00″ W., SW end). The decision was published in *Decisions on Geographic Names in the United States* (Decision List 7403, July through September 1974, p. 22).

Mission Mountain: hill, elevation 1,455 feet (440 m), 6 miles (9.5 km) south of Watts; named for the Mission Church established by Rev. Jesse Bushyhead in 1939 at the base of the hill; Adair County, Oklahoma; secs. 13 and 24, T. 18 N., R. 25 E., Indian Meridian; 36° 01′ 55″ N., 94° 35′ 15″ W. Variant: Bushyhead Mountain. (Decision List 7303, July through September 1973, p. 7).

AAPG News-Release Handbook Now Available

The American Association of Petroleum Geologists has announced the availability of a handbook to guide geologists in preparing news copy for the print and broadcast media. *News-Release Handbook for Local Public Information Chairmen* was prepared by the association's Public Information Committee, under the chairmanship of Gary A. McDaniel. Compiled by committee member William D. Rose, editor for the Oklahoma Geological Survey, the loose-leaf publication was designed primarily for use by public-information representatives of the AAPG's affiliated societies. Limited copies of the 24-page handbook can be obtained for $3.00 apiece, prepaid, from AAPG headquarters.

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