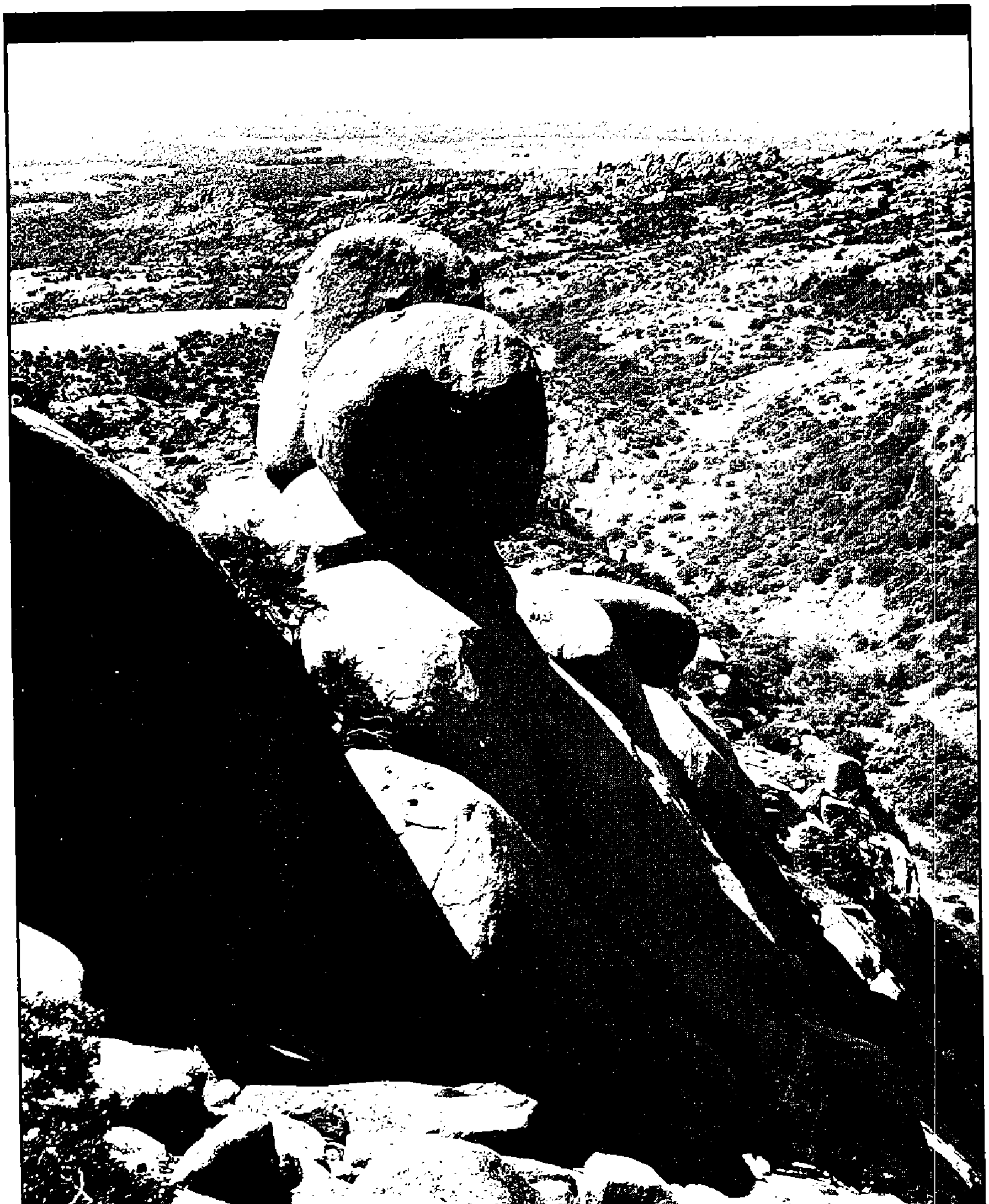
Oklahoma GEOLOGY Notes



OKLAHOMA GEOLOGICAL SURVEY VOL. 47, NO. 5 OCTOBER 1987

On the cover—

Tors on the Southwestern Side of Elk Mountain

Elk Mountain is in the north-central part of sec. 24, T. 3 N., R. 15 W., in the Wichita Mountains of southwestern Oklahoma. The area is in Comanche County, within the Wichita Mountains Wildlife Refuge, and in what the Refuge designates as the Charons Garden Wilderness Area. The view is toward the south-southwest from the high west end of Elk Mountain. The mountain, as well as all the rugged terrain in view, is composed of the Quanah Granite, one of the youngest and coarsest-grained (up to 1 cm) members of the Cambrian Wichita Granite Group. In the distance, the flat plains are made up of the Permian Post Oak Conglomerate (conglomeratic sandstones) interfingering with the Hennessey Shale. The contact between these two terrains is an unconformity representing a time gap in the stratigraphic record of 300 m.y. The present surface of the mountains extends below the level of the plains. One can visualize the plains as the sea partially burying the older mountain range. The mountain shapes, now being exhumed represent an ancient land surface of Permian age. Such features are relatively rare in the geologic record, as most landscapes are young, being continually rejuvenated.

The topographic forms on Elk Mountain are typical of fractured granitic rocks which have been buried. Spheroidal weathering has caused the rounded surfaces, which on being exhumed, the more-weathered rock being eroded away, can stand up in dramatic fashion, making monuments and pedestals called *tors*. These tors can be seen from U.S. Highway 62 looking north, about 20 mi west of Lawton. The view closest to these tors by car is from the Treasure Lake–Post Oak Lake parking area off the Indiahoma Road within the Refuge. They are accessible by hiking from Sunset Camp on the north side of Elk Mountain. For more information on the Wichita Mountains granitic rocks and landscape, see OGS Guidebook 21.

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OKLAHOMA GEOLOGICAL SURVEY
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Oklahoma Geology Notes, ISSN 0030-1736, is published bimonthly by the Oklahoma Geological Survey. It contains short technical articles, mineral-industry and petroleum news and statistics, abstracts, notices of new publications, and announcements of general pertinence to Oklahoma geology. Single copies, $1.50; yearly subscription, $6. Send subscription orders to the Survey at 830 Van Vleet Oval, Room 163, Norman, Oklahoma 73019. Short articles on aspects of Oklahoma geology are welcome from contributors; general guidelines will be sent on request.

This publication, printed by the Transcript Press, Norman, Oklahoma, is issued by the Oklahoma Geological Survey as authorized by Title 70, Oklahoma Statutes 1981, Section 3310, and Title 74, Oklahoma Statutes 1981, Sections 231–238. 1,800 copies have been prepared for distribution at a cost of $1,058.40 to the taxpayers of the State of Oklahoma. Copies have been deposited with the Publications Clearinghouse of the Oklahoma Department of Libraries.

Oklahoma GEOLOGY Notes

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OKLAHOMA GEOLOGICAL SURVEY VOL. 47, NO. 5 OCTOBER 1987

LYNN MOUNTAIN OR ATOKA FORMATION? A SUMMARY

Neil H. Suneson[1]

Introduction

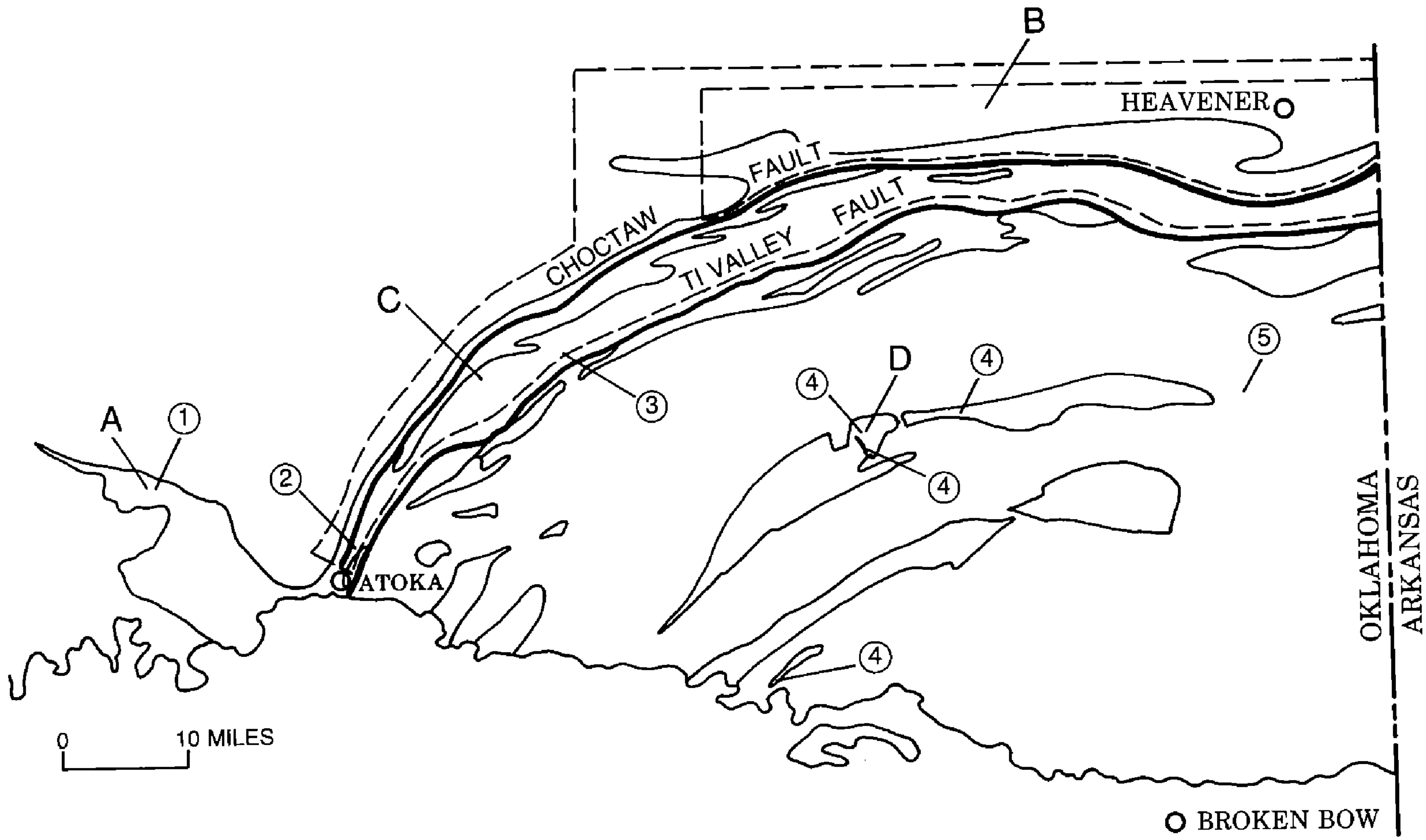
Several type sections, type localities, and type areas have been proposed in the literature for the Atoka Formation (Fig. 1). This confusion—coupled with disagreements over the definition of the Atokan Series, the problems of working with sparsely fossiliferous or unfossiliferous rocks, and lateral and basinward facies changes—is the basis for some Pennsylvanian stratigraphic problems in the Ouachita Mountains of southeastern Oklahoma. Historical precedence suggests that the term "Atoka Formation" be retained until detailed mapping and micropaleontological studies discover a complete, representative, and well-exposed section.

Atoka Formation

The Atoka Formation was named by Taff and Adams (1900) for exposures in the Choctaw coalfield (Arkoma basin) immediately north of the Choctaw fault in southeastern Oklahoma. They showed that the Atoka overlies the Hartshorne Sandstone, one of the principal coal-bearing formations in the area. Taff (1902) mapped Atoka Formation overlying the Wapanucka Limestone around the southeast, south, and southwest flanks of the Lehigh syncline west of the Ouachita Mountains. Collier (1907) first applied the name Atoka Formation to strata within the Ouachita Mountains frontal belt in western Arkansas. Taff (1909) mapped Atoka Formation south of the Choctaw fault in the Windingstair Mountains in Oklahoma. All subsequent studies considered rocks of the Atoka Formation to be above the Wapanucka or equivalents and below the Hartshorne or equivalents. The name "Atoka" continued to become more firmly established in the literature and was shown on Miser's (1926, 1954) geologic maps of Oklahoma in the frontal and central Ouachita Mountains and southern part of the Arkoma basin.

Despite the widespread use of the term "Atoka" throughout the first half of the 20th century, no type area was designated until 1962 (Branson, 1962), and this type area is not universally accepted. As discussed by Sutherland and Manger (1984), it seems that Branson's type area was selected more for its proximity to the town of Atoka, Oklahoma, than for the quality of exposures, diversity or richness of fauna, or similarity of rocks exposed there to Atoka mapped elsewhere. Strimple and Watkins (1969) proposed, and Sutherland and Manger (1983) endorsed, a type area for the Atoka northwest of Clarita, in Coal County, Oklahoma. The Atoka Formation

[1]Oklahoma Geological Survey.



A. ATOKA TYPE AREA OF STRIMPLE AND WATKINS (1969) AND SUTHERLAND AND MANGER (1983)
B. ATOKA TYPE AREA OF LANE AND WEST (1984)
C. ATOKA TYPE AREA OF SHAVER (1984)
D. LYNN MOUNTAIN TYPE SECTION OF PITT (1982)

1. MIDDLE ATOKAN CONODONTS IN BASAL ATOKA
2. DESMOINESIAN (UNRES.) PALYNOMORPHS IN ATOKA
3. MORROWAN (UNRES.) PALYNOMORPHS IN BASAL ATOKA
4. MORROWAN (UNRES.) PALYNOMORPHS IN LYNN MOUNTAIN
5. MORROWAN FORAMINIFERA IN BASAL ATOKA OR UPPER JACKFORK

Figure 1. Outcrop areas of Atoka Formation north of the Choctow Fault and type areas and microfossil localities of Atoka and Lynn Mountain Formations.

in this area is mostly shale and mudstone, with rare, thin, moderately fossiliferous micritic limestone (Archinal, 1977). An alternative "type area" for the Atoka Formation is the southern edge of the Arkoma basin in Latimer and Le Flore Counties, Oklahoma (Lane and West, 1984, p. 92–93). Shaver's (1984) "type area" appears to include this area, as well as the southern edge of the Arkoma basin in Pittsburg and Atoka Counties and the northern part of the frontal Ouachita Mountains in all four counties.

Atokan Series

The difficulty in locating a type section, a type locality, or a type area for the Atoka Formation is compounded by problems concerning the age of the Atoka Formation and the precise definition of the Atokan Series. Spivey and Roberts (1946) recommended that the term "Atokan Series" replace the older terms "Bendian," "Derryan," and "Lampasan," and "be defined to include all the beds from the top of the Wapanucka limestone, Morrow series, to the base of the Hartshorne sandstone, Des Moines series" (p. 185). However, the base of the Atoka in its Coal County type area is an unconformity, and detailed studies of conodonts (Grayson, 1984, p. 44) indicate that the basal part of the Atoka Formation there is middle Atokan in age. Morrowan–Atokan deposition apparently was continuous in the frontal belt of the Ouachita Mountains (Lumsden and others, 1971); however, lateral facies changes make the exact location of the boundary difficult to recognize. For example, the top of the Wapanucka in the frontal belt has been placed at the top of two different lithostratigraphic units; one is a lower (main) limestone (Morrowan), and the other is a sandstone–limestone (mostly Atokan). The Morrowan–Atokan boundary probably is within an unfossiliferous shale that separates these two units (Sutherland and Manger, 1984, p. 6). Definition of the top of the Atokan Series is slightly less confusing. The Atoka Formation yields fusulinids that are present in the base of the Desmoinesian Series at its type locality (Shaver, 1984, p. 108). A locality better than southeastern Oklahoma for the Atokan Series stratotype may be present elsewhere in North America (Groves, 1986).

Not all workers in the Ouachita Mountains area have accepted the term "Atokan Series." Pitt (1982, fig. 1b) omitted it from his stratigraphic column of Pushmataha County, Oklahoma, but did not explain why he did so. It is possible that the considerable confusion over the boundaries of the series suggested to him that he not use "Atokan." Wilson's several reports on the Atoka Formation (cited in Wilson, 1976) also fail to mention the Atokan Series, despite numerous references to the Morrowan and Desmoinesian. His Morrowan and Desmoinesian may therefore be considered in an unrestricted sense, and parts of either may be correlative with the Atokan of conodont and foraminifera workers.

Lynn Mountain Formation

The Lynn Mountain Formation was named by Pitt (1982) for exposures along the axis of the Lynn Mountain syncline south of Clayton, Oklahoma, and was subsequently used by Marcher and Bergman (1983) and Fay (1984). Cline (1960) mapped these strata as Atoka. Similarly, strata mapped as Lynn Mountain in Latimer County by Pitt (1982) were mapped as Atoka by Hendricks and others (1947). The type section overlies the Morrowan Johns Valley Formation (approximate Wapanucka equivalent). Pitt (1982, pl. 1) and Marcher and Bergman (1983) showed the "Lynn Mountain" to be Morrowan. Fay (1984) and Pitt (1982, p. 3 and 35) show it to be Morrowan–Desmoinesian. Pitt (1982) may have used "Lynn Mountain" to distinguish it from Atoka strata which are mostly "Atokan," which he did not recognize as a valid chronostratigraphic unit. The controversy over the validity of using "Lynn Mountain" is based partly on whether strata overlying the Morrowan Johns Valley Formation south of the Ti Valley fault and Morrowan Wapanucka Limestone, Chickachoc Chert, and "Springer" formation (terminology of Hendricks and others, 1947) between the Choctaw and Ti Valley faults are Morrowan or younger (Atokan or Desmoinesian), and partly on whether Atokan is a valid series term.

Discussion

As stated previously, the base of the Atoka Formation in its southwestern Coal County type area is middle Atokan based on conodonts (Grayson, 1984) (Fig. 1). Based on palynomorphs, the age of the Atoka near the town of Atoka is Desmoinesian (unrestricted) [present author's parentheses] according to Wilson (1976, p. 88). Wilson (1976) stated that his collection was from the Atoka in its type area, but it is clear that the palynomorphs were extracted from shales that are part of the frontal-belt flysch-facies Atoka Formation between the Choctaw and Ti Valley faults. The lower Atoka (as mapped by Hendricks and others, 1947) is Morrowan (unrestricted) in the area of the Pine Mountain sheet just north of the Ti Valley fault, based on palynomorphs (Wilson, 1965, p. 18). South of the Ti Valley fault in the central Ouachita Mountains, the base of the Atoka(?) is Morrowan based on foraminifera (Stark, 1963, p. 29). ["Atoka" is queried here because other workers (Briggs, 1973; Marcher and Bergman, 1983) have mapped Stark's (1963, Section 103K, p. 19–22) dated rocks as upper Jackfork.] Most of the Lynn Mountain (Atoka of Cline, 1960) "contains Atoka palynomorphs of Desmoinesian (unrestricted) age" (Pitt, 1982, p. 35). It appears (1) that some Desmoinesian and Morrowan palynomorph ages overlap Atokan conodont and foraminifera ages, and (2) that the base of the Atoka Formation (or Lynn Mountain Formation) south of the Ti Valley fault may be Morrowan (restricted). A Morrowan age of the base of the Atoka Formation in the frontal zone of the Ouachita Mountains agrees with the observation of Grayson (1979) that the Chickachoc Chert, which conformably underlies (Hendricks and others, 1947) the Atoka between the Katy Club and Pine Mountain faults, is equivalent to the lower part of the Morrowan Wapanucka Limestone.

It is possible that the base of the lithostratigraphically defined Atoka Formation is time-transgressive. In its Coal County type area, the base of the Atoka appears to be middle Atokan in age. Immediately south of the Choctaw fault—and possibly in the subsurface in the southern part of the Arkoma basin—the base of the Atoka may be earliest Atokan, if the top of the Wapanucka Limestone is considered to be the top of the lower main limestone. South of the Ti Valley fault, and possibly south of the Katy Club fault, the base of the Atoka Formation may be Morrowan.

This is precisely the relation (minus the queries) shown for the central Ouachita Mountains by Fay and others (1979, p. R10) and Sutherland and Manger (1979, p. 2).

In summary, there is little evidence that the bulk of the "Lynn Mountain Formation" is Morrowan. The Atoka Formation is widely used and recognized, despite the fact that it has not been formally defined and fails to meet all the requirements set forth in the North American Stratigraphic Code (North American Commission on Stratigraphic Nomenclature, 1983). One goal of future work in the frontal Ouachita Mountains and/or southern Arkoma basin should be establishing a type locality and type section of the Atoka Formation. This type section may have to be composite and consist of shallow-water, largely deltaic sediments north of the Choctaw fault and deep-water turbidites south of the fault, because both have historically been mapped as Atoka Formation. The term "Lynn Mountain" should be abandoned until it meets the criteria for recognition as described in the Code. Problems bracketing the age of the "Atokan Series" should not influence use of Atoka Formation. The series may not be the same age as the formation, because, in places, the base of the Atoka Formation may be Morrowan and the top Desmoinesian.

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AN UNUSUALLY WELL-PRESERVED PENNSYLVANIAN AMMONOID FROM COLLINSVILLE, OKLAHOMA

Royal H. Mapes and Thomas A. Bergstein[1]

Introduction

In 1937, Miller and Owen described a well-preserved Pennsylvanian cephalopod fauna from Collinsville, Oklahoma. Intensive recollecting efforts during the past 15 years have only slightly expanded the known ammonoid fauna that occurs there (Table 1); however, the ammonoid-bearing units in the area are now considered to be uppermost Desmoinesian—Lost Branch Formation, Nuyaka Creek Shale Member (Wilson, 1976,1979; Bennison, 1985)—rather than lower Missourian (Seminole Formation) in age as originally reported by Miller and Owen. The ammonoid cephalopods occur in carbonate concretions in a black, platy shale which overlies the Dawson coal. The most productive collecting location is ~1.2 km (0.75 mi) south of Collinsville, Tulsa County, Oklahoma. From this site, an exceptionally well-preserved specimen of *Glaphyrites warei* (Fig. 1) has been recovered and is reposited at the University of Oklahoma.

TABLE 1.—AMMONOID OCCURRENCES AND MAXIMUM DIAMETERS KNOWN FROM THE LOST BRANCH FORMATION, NUYAKA CREEK SHALE MEMBER (PENNSYLVANIAN, UPPER DESMOINESIAN) AT COLLINSVILLE, OKLAHOMA (MODIFIED FROM MAPES, 1976)

Designation by Miller and Owen (1937)	Current taxonomic designation	Maximum known diameter (mm)
Bisatoceras primum	*Bisatoceras primum*	34
Eudissoceras collinsvillense	*Gonioglyphioceras gracile*	14
Gastrioceras clinei warei	*Glaphyrites warei*	60
Gastrioceras clinei clinei	*Glaphyrites clinei*	75
Gastrioceras jonesi	*Glaphyrites excelsus*	290
Gastrioceras prone	*Trochilioceras prone*	12
Gastrioceras retiferum	*Owenoceras retiferum*	23
Prothalassoceras inexpectans	*Eothalassoceras inexpectans*	42
Schistoceras unicum	*Eoschistoceras unicum*	56
	Maximites cherokeensis	9

[1] Professor and undergraduate student, respectively, Dept. of Geological Sciences, Ohio University, Athens.

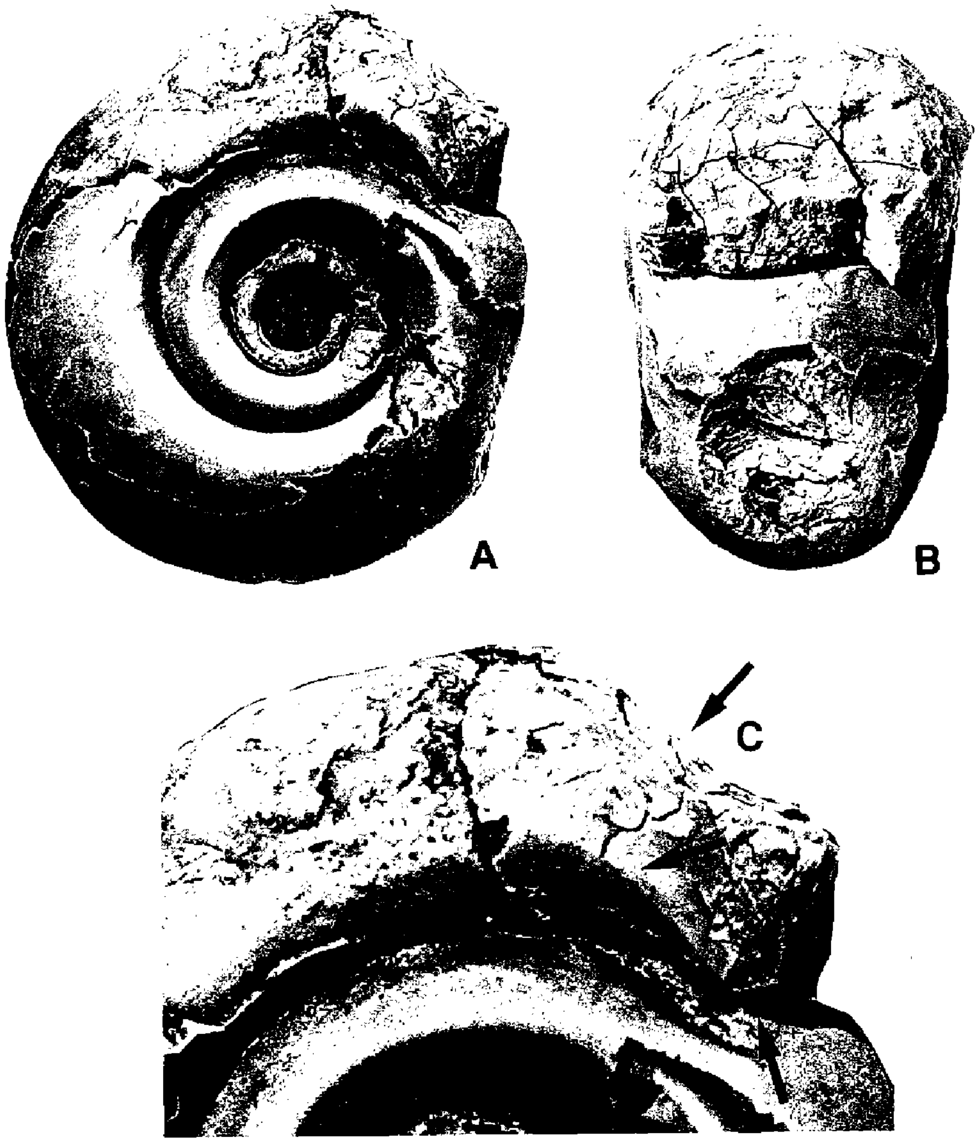

Figure 1. *A,B*. **Lateral and ventral views of *Glaphyrites warei* (OU 9652) from the Lost Branch Formation (upper Desmoinesian) from Collinsville, Oklahoma, at ×1. C. Enlarged view (×2) of the mature modification, showing the apertural constriction and change in coiling (see arrows).**

Description

The newly recovered specimen of *Glaphyrites warei* (OU 9652) from Collinsville has low, broad whorls on a moderately evolute conch; conch measurements and ratios are as follows: maximum diameter = 60.0 mm, width = 33.9 mm, height = 15.6 mm, U-maximum = 36.9 mm, U-minimum = 29.4 mm. The ratios H/D, W/D, and Umin/D are 0.26, 0.57, and 0.49, respectively. The specimen is a calcitic internal mold which retains portions of essentially smooth shell. Shell thickness varies from 2.0 mm at the umbilical shoulder to 0.4 mm near the venter.

The suture pattern on this specimen has been essentially destroyed by calcite recrystallization. Furthermore, this specimen shows a well-preserved mature modification in the form of an apertural constriction which extends about 11 mm past the maximum diameter of the conch.

Discussion

Mature modifications are best understood in cephalopods by comparison to Recent *Nautilus*. When mature modifications are attained in *Nautilus*, the growth of the animal ceases. By direct analogy the same termination of growth can be applied to the extinct ammonoids. Thus, when mature modifications are preserved on ammonoids, conclusions can be drawn about maximum size ranges, sexual dimorphism, and speciation.

According to Davis (1972), mature modifications are typically expressed in one or more of the following ways: changes in ornament, generation of an ultimate peristome, changes in shell deposition and approximation of ultimate septa, increasingly simple ultimate sutures, thickening of the last septum, development of muscle scars, apertural shell thickening, changes in coiling, and development of an apertural constriction. The specimen from Collinsville shows pronounced changes in coiling and a relatively well-preserved apertural constriction. Such modifications are rarely encountered, since all too often the apertural region is damaged or broken off by predators prior to deposition of the conch (Boston and others, 1987; Mapes and others, 1987; Sims and others, 1987), obscured or destroyed by diagenesis, or damaged by the collecting process. Of more than 30,000 Middle and Upper Pennsylvanian ammonoids collected (R.H.M.) in the past 15 years, fewer than 50 have any trace of a mature modification.

The specimen of *Glaphyrites warei* recently collected from Collinsville is essentially identical in conch form with the largest (diameter = 44.0 mm) specimen of *G. welleri* reported by Miller and Owen (1939, pl. 51, figs. 8–9). However, *G. welleri* has prominent longitudinal lirae located on the umbilical shoulders, whereas no such lirae were present on the mature conch of *G. warei*. This feature could be a product of the mature modification, since juvenile specimens of *G. warei* do exhibit longitudinal lirae on the umbilical shoulder. Finally, *G. warei* has an apertural constriction which is more compressed and elongated than *G. welleri* (see Miller and Owen, 1939, pl. 18, figs. 12,13). In their 1939 paper Miller and Owen concluded that *Glaphyrites warei* is "almost identical" with *Glaphyrites welleri*. Based on the Collinsville specimen described herein, it appears that *Glaphyrites warei* and *Glaphyrites welleri* are, in fact, distinct species.

Acknowledgments

We extend our gratitude to David M. Work, who provided an excellent critique of the literature and constructive suggestions. Our thanks are also extended to Tina P. Parsons for photographic work. Also, the specimen was collected with an Ohio University Research Committee grant.

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TANKS AFLOAT: JUST ONE DETRIMENTAL SIDE EFFECT OF A NEAR-SURFACE WATER TABLE

***Deborah A. Ragland*[1] *and Tommy V. Ragland*[2]**

Three empty gasoline-storage tanks at an abandoned service station responded to the effects of higher-than-normal rainfall in Oklahoma by breaking through the overlying concrete pad. They remained floating at surface level for two months, creating an impressive illustration of nature's power.

Archimedes' principle was alive and well in northern Oklahoma during the winter of 1987. Unusually high rainfall over the preceding year saturated the ground, raising water tables near the surface and causing three gasoline-storage tanks to break through the overlying concrete pad at an abandoned gas station in Ponca City, Oklahoma (Fig. 1).

Figure 1. Emerged gasoline-storage tanks in northeast Ponca City, Oklahoma, March 1987.

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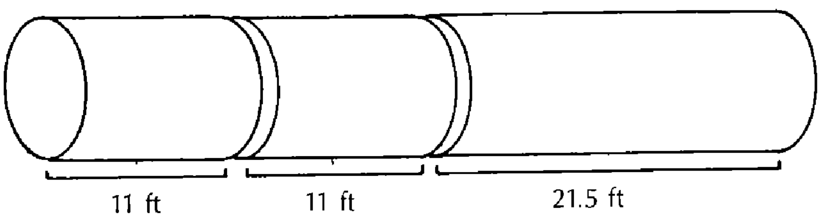
[2]Conoco, Inc., Ponca City, Oklahoma.

The tanks, two measuring 11 ft in length by 8 ft in diameter and one measuring 21.5 ft in length by 8 ft in diameter (combined capacity ~18,000 gal), were emptied of their gasoline with the demise of the convenience gas station at the corner of 14th Street and Prospect Road. The tanks first emerged during the second week of February, the buoyant force of the water acting on the tanks being great enough to push the tanks through the overlying reinforced concrete slab (Fig. 2). (Many parameters, such as the amount of sand in the water and the structural strength of the concrete pad, were not measurable.) Additional rain and snow raised the tanks to their final position by late March. This last stage of movement comprised both a translational component and a rotational component.

This textbook example of the interaction of physics, hydrogeology, and nature ended during the first week of April 1987. The tanks were removed from their water-logged site and the remaining hole was filled in.

The authors would like to thank Glen Nickles of Evans and Associates for taking the time to discuss the event and helping to acquire tank dimensions, and Paul A. Long and Sons Petroleum Co. for allowing the authors to peruse their catalogs for additional statistics.



combined tank length (L) = 43.5 ft
tank diameter = 8.0 ft
surface area = $6(\pi r^2) + 2\pi r(L) = 1394.9\ ft^2$
weight for 0.25-in.-gauge steel = 10.2 lb/ft^2
weight of tanks = 14,227.6 lb

Dimensions for overlying concrete slab:
volume = $8\ ft \times 43.5\ ft \times .4167\ ft = 145.0\ ft^3$
weight = $2.69 \times 62.45\ lb/ft^3 \times 145.0\ ft^3 = 24{,}358.6\ lb$

combined weight of tanks and slab: 38,586.2 lb

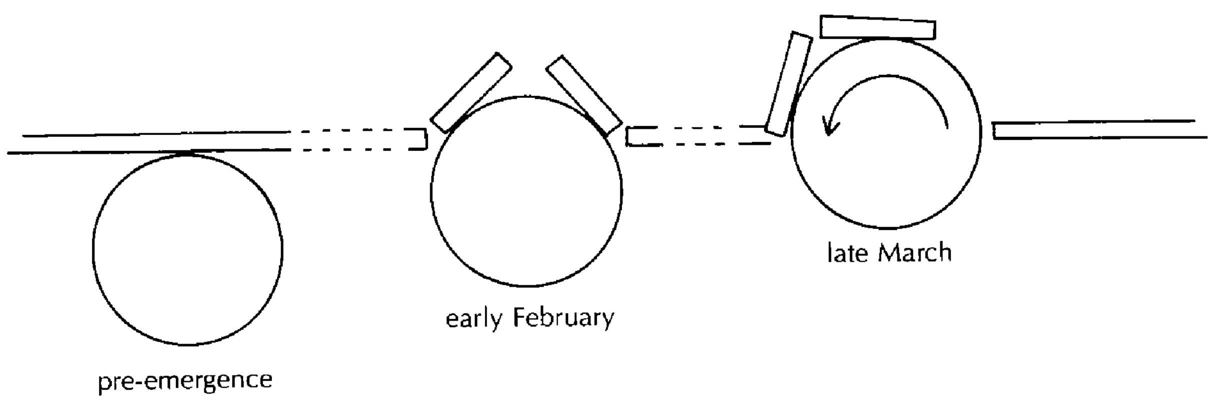


Figure 2. Diagrammatic representation of the buoyant force of water on the gasoline-storage tanks.

OGS CORE AND SAMPLE LIBRARY POLICIES EXAMINED

The Oklahoma Geological Survey hosted a one-day meeting July 28 in Norman to discuss the policies of the OGS Core and Sample Library and to receive suggestions to improve its operation. Petroleum-industry personnel were well represented among the 47 people who attended the meeting.

The Core and Sample Library was established in 1937 to store cores and samples from drilling in Oklahoma, donated by companies and government agencies. The Library, managed by Eldon R. Cox, has become the most extensive repository in the State for rock materials valuable for research purposes. Currently, the Library contains more than 55,000 boxes of cores from about 2,500 wells, and samples from approximately 35,000 wells, and new donations arrive steadily. However, the budget may at some point require that only cores be maintained, because samples are being offered for examination by the private sector.

The collections of the Core and Sample Library are organized into groups, of which the petroleum material is the largest and most used. Other groups include coal cores, mineral cores, and special-studies cores. A fifth group comprises report materials—scout tickets, electric logs, and Oklahoma Corporation Commission logs. Report materials may be examined free of charge at the Library, but they cannot be loaned.

Cores are identified by location (section, township, and range), county, operator and well name, depth, core diameter, and formation. Because of limited space, no out-of-state material is stored in the Library.

The cost for on-site observation of cores and samples is $5 per box, for an indefinite period of observation. It was suggested at the meeting that charging for use of the facility on a per-day basis might be better than charging for use of individual cores. Materials may also be borrowed from the Library for $10 per box for 30 days, the borrower paying shipping charges. Students, faculty, and staff members affiliated with academic institutions, and scientists working for the State or federal government may use core and sample material free of charge, provided they furnish the OGS copies of the results of their work to be placed on open file. These charges help pay for operation of the Core and Sample Library; this income covers about 10–15% of the total operating costs of the facility.

The borrower has permission to slab the core, cut plugs, or make thin sections, at his own expense, although one vertical half of the core must remain in its original condition for future examination by others.

Plans are to eventually bring the facilities of the Core and Sample Library together under one roof with the related files of the OGS Log Library, now housed in Gould Hall under the supervision of Joy Hampton. To provide adequate storage for the Library's collection, plans have been developed for a new building. However, current funding projections indicate that it may be several years before these plans are realized.

At present, a catalog listing only the petroleum cores is available, because this group draws the most use. An updated catalog is due to be released, incorporating detail about the size and physical condition of the materials stored in each box.

Some cores have been tested repeatedly, both before and after donation to the Library—to the point that there is little material left. For this reason, many who attended the meeting thought it would be helpful to require that a copy of past analyses on a specific core be provided when cores and samples are donated, to save the time of re-examinion, thus preserving the specimens longer. At this time, however, the Library staff is too small to maintain files of such analyses.

Although not listed in the catalog of petroleum cores, other core and sample collections are listed in a card file at the Library and are readily accessible to borrowers. If sufficient interest were indicated to warrant a catalog for the other core and sample collections, eventually one could be made available. It was suggested at the meeting that, since the other non-petroleum core categories may have a bearing on petroleum analysis, it would be helpful if they were also included in the catalog.

The point was made that there is an ultimate need for a national system with standard procedures to be followed by all regional repositories. The Survey welcomes suggestions on how to implement such a system (or suggestions for good interim procedures). It was suggested that an advisory committee be established, consisting of a cross section of all users, to make recommendations on how best to catalog collections and operate the facility.

It was generally agreed that there is an ongoing need for the State to maintain a core and sample library containing this invaluable research information. This need for information derived from cores will continue to increase as more of the State's crude-oil production is obtained from the recovery of additional oil from existing fields through targeting unswept mobile oil and enhanced oil recovery.

Christie Cooper

COAL-MINE POND WATERS SUBJECT OF NEW OGS SPECIAL PUBLICATION

Physical and Chemical Characteristics of Water in Coal-Mine Ponds, Eastern Oklahoma, June to November 1977–81 is the title of Special Publication 87-2, recently released by the Oklahoma Geological Survey. The report was written by Larry J. Slack and Stephen P. Blumer of the USGS Water Resources Division in cooperation with the OGS, and is part of a larger program to gather and interpret limnological information on the water resources created by strip mining. The considerable analytical data in this report are presented in six tables, and profiles representing variations in certain parameters with water depth are shown in more than 100 figures; site locations are shown on topographic maps.

Authors' abstract:

> Water at 102 sites in 59 coal-mine ponds in eastern Oklahoma was sampled at least twice during June to November 1977–81 to determine temperature, specific

conductance, dissolved oxygen, pH, and dissolved sulfate, chloride, iron, and manganese—as part of a study of the hydrology of the Oklahoma coalfield. These determinations show that during June to October water in ponds deeper than ~10 ft was stratified; ponds which had little or no change of temperature with depth generally were shallow or were sampled in early November. Temperature, dissolved oxygen, and pH usually decreased with depth, whereas specific conductance usually increased with depth. Concentrations of dissolved sulfate, chloride, iron, and manganese varied from site to site. Specific conductance, which is a measure of dissolved solids in the water, ranged from 93 to 4,800 µmho/cm at 25°C. Some physical and chemical characteristics of the mine-pond water are related to the coal bed adjacent to the pond. Mean specific-conductance values and dissolved-sulfate concentrations were greatest in ponds associated with mining of the Dawson, Weir-Pittsburg, and Secor coals. Mean dissolved-iron concentrations were greatest in ponds associated with mining of the Dawson, Secor, and Hartshorne coals. Mean dissolved-manganese concentrations were greatest in ponds associated with mining of the Dawson, Weir-Pittsburg, and Secor coals, but greatly exceeded secondary drinking-water limits regardless of coal bed mined.

SP 87-2 is available over the counter or postpaid from the Oklahoma Geological Survey at the address given inside the front cover of this issue. The price is $4.

REVIEW:
CONODONT FAUNAS OF THE LLANO UPLIFT

Early and Late Paleozoic Conodont Faunas of the Llano Uplift Region, Central Texas—Biostratigraphy, Systemic Boundary Relationships, and Stratigraphic Importance, by R. C. Grayson, Jr., Glen K. Merrill, James F. Miller, and others, 1987. Guidebook for Field Trip 1, March 28–29, 1987, preceding Annual Meeting of the South-Central Section, Geological Society of America, Baylor University, Waco, Texas. 153 pages.

James R. Chaplin[1]

The major emphasis of this guidebook to the Llano uplift region in central Texas is given to (1) the conodont zonal succession across the Cambrian–Ordovician boundary, (2) conodont evidence for conformity at the Mississippian–Pennsylvanian systemic boundary and the diachronous nature of lithostratigraphic units spanning that boundary, and (3) application of conodont lineages and biofacies to resolution of Carboniferous stratigraphic problems.

A revised conodont zonation for some Upper Cambrian and basal Ordovician strata in the Llano uplift is presented. The relationships of those conodont zonal

[1]Oklahoma Geological Survey.

units to trilobite biostratigraphic units used for chronostratigraphic classification in other parts of North America, including Oklahoma—as well as in other parts of the world—are demonstrated.

The similarity of shifts of Cambrian–Ordovician depositional environments and conodont geochemistry is noted for equivalent strata in the Arbuckle Mountains of Oklahoma.

The authors report that the conodont-defined Mississippian–Pennsylvanian systemic boundary correlates with a geochemical anomaly—enrichment of certain elements—at the J. R. Walker Ranch locality, Lampasas County, Texas (comparable to that observed in Oklahoma). However, the anomaly is significantly greater in magnitude and it persists through a substantially thicker stratigraphic interval than that found in Oklahoma. Mississippian–Pennsylvanian conodont successions demonstrate diachroneity of lithostratigraphic units spanning that boundary, as well as their regional lateral equivalence to rocks in Oklahoma and elsewhere.

In addition, short discussions—including topotypic material of *Gnathodus bilineatus* (Roundy) from Roundy's original locality, and restudy of the localities and Pennsylvanian conodont faunas from Texas published by Stauffer and Plummer (1932)—are significant contributions.

The guidebook includes 10 plates of conodont faunas recovered from rocks collected at classic localities in central Texas, which should be of interest to Carboniferous conodont workers.

Overall, the guidebook represents an excellent compilation of significant biostratigraphic data for lower and upper Paleozoic rocks of the southern Midcontinent and demonstrates well their relationships to equivalent rocks elsewhere in North America.

The guidebook may be purchased from the Department of Geology, Baylor University, Waco, Texas 76703, at a price of $12 per copy.

NOTES ON NEW PUBLICATIONS

GeoRef Serials List and KWOC Index

The new edition of the *GeoRef Serials List and KWOC Index* includes more than 10,000 earth-science serials that have been cited in the GeoRef data base since 1967. The Serials List is arranged alphabetically by title and provides the complete title, abbreviated title, CODEN or ISSN (or both), and country of publication for each entry. The KWOC (key words out of context) Index enables a user to identify a serial quickly by any significant word in the title.

Order from: American Geological Institute, Customer Service Dept., 4220 King St., Alexandria, VA 22302. The price for a 2,089-page paper copy is $95; a set of microfiche is $35.

Digital Simulation of Ground-Water Flow in the High Plains Aquifer in Parts of Colorado, Kansas, Nebraska, New Mexico, Oklahoma, South Dakota, Texas, and Wyoming

R. R. Luckey, E. D. Gutentag, F. J. Heimes, and J. B. Weeks are the authors of this 57-page USGS professional paper. The flow system in the 174,000-mi^2 High Plains Aquifer was modeled in three parts using a two-dimensional digital model that was calibrated for both predevelopment and development periods. The predevelopment-period models were used to estimate natural recharge and refine estimates of hydraulic conductivity. The development-period models were used to estimate return flow from irrigation and additional recharge as a result of human activities. The calibration of the models increased the understanding of the hydrologic system; the calibrated models provide the initial conditions for projecting future water levels in the High Plains.

Order P 1400-D from: U.S. Geological Survey, Books and Open-File Reports, Federal Center, Bldg. 41, Box 25425, Denver, CO 80225. The price is $3.50; add 25% to the price for shipment outside North America.

Determination of Organic Content from Formation-Density Logs, Devonian–Mississippian Woodford Shale, Anadarko Basin, Oklahoma

Authors T. C. Hester and J. W. Schmoker state that a method of determining organic content from formation-density logs offers a practical alternative to laboratory analyses of core or cuttings. In this 11-page USGS open-file report, the density-log method is shown to be applicable to the Woodford Shale in the Anadarko basin. The report reviews the assumptions and methodology of the approach and establishes the validity and limitations of the method for the Woodford Shale by comparing log-derived data to laboratory analyses.

Order OF 87-0020 from: U.S. Geological Survey, Books and Open-File Reports, Federal Center, Bldg. 41, Box 25425, Denver, CO 80225. The price is $2 for a paper copy and $4 for microfiche; add 25% to the price for shipment outside North America.

Flow Characteristics for Selected Springs and Streams in the Ozark Subregion, Arkansas, Kansas, Missouri, and Oklahoma

This USGS hydrologic investigations atlas by E. R. Hedman, John Skelton, and D. A. Freiwald includes four sheets at a scale of 1:750,000. The report provides flow-duration and low-flow frequency data for continuous-record spring- and streamflow-gaging stations. Values of mean annual precipitation (1951–80) and values of mean annual runoff are also presented. The difference between precipitation and runoff (mean annual water loss) has a relatively uniform average value of 29 in. across the subregion, except for areas of known recharge and discharge. The annual precipitation ranges from 34 to 56 in.

Order HA 0688 from: U.S. Geological Survey, Map Distribution, Federal Center, Box 25286, Denver, CO 80225. The price is $10.80; add 25% for mailing to countries outside the U.S. and its possessions.

Isopach and Lithofacies Map of the Sauk Sequence (Excluding Basal Clastics) in the Northern Midcontinent, U.S.A.

Walden P. Pratt compiled this USGS miscellaneous-field-studies map, printed at a scale of 1:1,000,000, which includes a folio of the northern Midcontinent area.

Order MF 1835-D from: U.S. Geological Survey, Map Distribution, Federal Center, Box 25286, Denver, CO 80225. The price is $1.50; add 25% to the price for foreign shipment.

Lithofacies Description and Interpretation of Selected Intervals in the Upper Part of the Ordovician Simpson Group in a Core from the Mazur Well, Southeast Anadarko Basin, Oklahoma

Extensive drilling in the Anadarko basin has yielded a large collection of cores of Paleozoic rocks. The core described in this 39-page USGS open-file report is from the Sunray Parker DX No. 1 Mazur well, and consists of rocks from the middle part of the Early Ordovician Arbuckle Group and the upper part of the Middle Ordovician Simpson Group. Authors R. M. Flores and C. W. Keighlin describe the lithofacies observed in some core from the upper part of the Simpson Group in the Mazur well and interpret the environments of deposition.

Order OF 86-0564 from: U.S. Geological Survey, Books and Open-File Reports, Federal Center, Bldg. 41, Box 25425, Denver, CO 80225. The price is $6.25 for a paper copy and $4.75 for microfiche; add 25% to the price for foreign shipment.

UPCOMING MEETINGS

Society of Mining Engineers, Annual Meeting and Exhibit/AIME, 117th Annual Meeting, January 25–28, 1988, Phoenix, Arizona. Information: Society of Mining Engineers, Meetings Dept., P.O. Box 625002, Littleton, CO 80162-5002; (303) 973-9550.

American Association of Petroleum Geologists, Southwest Section, Annual Meeting, February 21–23, 1988, El Paso, Texas. Information: Robin Hoffer, Dept. of Geology, University of Texas, El Paso, TX 79968; (915) 747-5501.

Geological Society of America, South-Central Section, Annual Meeting, March 14–15, 1988, Lawrence, Kansas. Abstracts due October 30, 1987. Information: Anthony W. Walton, Dept. of Geology, University of Kansas, Lawrence, KS 66045; (913) 864-4974.

American Association of Petroleum Geologists, Annual Meeting, March 20–23, 1988, Houston, Texas. Information: AAPG, Convention Dept., P.O. Box 979, Tulsa, OK 74101; (918) 584-2555.

FOCUS Conference on Southwestern Ground Water Issues, March 23–25, 1988, Albuquerque, New Mexico. Information: National Water Well Association, 6375 Riverside Dr., Dublin, OH 43017; (614) 761-1711.

OKLAHOMA ABSTRACTS

The Oklahoma Geological Survey thanks the Geological Society of America and the authors for permission to reprint the following abstracts of interest to Oklahoma geologists.

The Pre-Cretaceous Surface in Central, North, and West Texas: The Study of an Unconformity

S. C. ATCHLEY, Exxon Co., U.S.A. (Southwestern Division), 25 Desta Dr., Bldg. C, Midland, TX 79705

The Wichita Paleoplain of Texas is a classic example of fluvial denudation. Initial Cretaceous deposits upon the pre-Cretaceous surface were of fluvial origin and unconformably overlie rocks of Mesozoic and Paleozoic age. Modern erosional processes have stripped Cretaceous rocks within this region, thus initially exposing the preserved pre-Cretaceous landscape. Since altered by more recent erosion, at least four physiographic provinces can be recognized on the Wichita Paleoplain. From east to west these are the Eastern Limestone Belt, Western Limestone Belt, Abilene Haskel Plains, and Gypsum Plains.

Analysis of the character and regional geologic features of the Wichita Paleoplain allows for interpretation of the geologic events which formed the Wichita Paleoplain. Subsidence of the Midland basin and formation of the Wichita, Arbuckle, and Ouachita Mountains caused westward and southwestward drainage and initial planation during Middle Pennsylvanian to Late Triassic time. Late Triassic subsidence of the Gulf Coast and East Texas basins caused reversal of the Pennsylvanian/Triassic stream drainage from west to east, thus forming the valley and ridge landscape characteristic of the Wichita Paleoplain. Cretaceous marine inundation over the region of eastward drainage deposited marine sediments over the paleoplain, thus preserving the earlier valley and ridge topography. Since Cretaceous time and continuing to the present, the Cretaceous cover within the study area has been eroded away exposing a preserved Mesozoic landscape at the retreating Cretaceous margin, and a modified landscape west of this retreating margin.

Reprinted as published in the Geological Society of America South-Central Section *Abstracts with Programs, 1987,* v. 19, no. 3, p. 145.

Cyclic Sedimentation in the Strawn and Canyon Groups of the Eastern Shelf, North-Central Texas

A. W. CLEAVES, Department of Geology, Oklahoma State University, Stillwater, OK 74078

The Strawn and Canyon Groups of north-central Texas contain 15 transgressive-regressive format units that were deposited on the Eastern Shelf and in adjacent basins. These units record episodes of deltaic progradation and marine transgression and subdivide the section between the top of the Caddo

Limestone and the top of the Home Creek Limestone into regionally mappable genetic units. Variations in the rate and exact timing of subsidence within the Fort Worth Basin, Midland Basin, Knox–Baylor and Montague–Clay troughs, and on the Eastern Shelf itself, exerted dominant control on the cyclicity and lithofacies geometry of the constituent depositional systems. Uplift in the Ouachita Fold Belt served as the principal source of terrigenous clastic sediment, although at specific times and locations the Wichita and Arbuckle–Criner Hills Uplifts acted as point sources of arkosic sediment to the northern margin of the Shelf.

Although regional tectonism is the preferred explanation for describing Middle and Late Pennsylvanian cyclicity in north-central Texas, four lines of evidence for invoking glacially induced eustatic sea level changes as the master mechanism for generating the format units have been proposed. First, comparison of outcrop Virgilian cycles in Texas and Kansas seems to indicate the same number of cycles for both areas. Second, the development of parallel inner and outer carbonate banks with two of the Canyon cycles is cited as an example of reciprocal sedimentation. Third, several Late Pennsylvanian Shelf black shales comprise radiolarian-bearing, possibly deeper water, units that represent a maximum stage of marine transgression in a eustatic cycle. Fourth, oxygen isotope data from the outcrop Winchell Limestone suggest that the bank was exposed during a drop in sea level and subjected to fresh-water diagenesis. Unfortunately, the eustatic hypothesis fails to explain the response of the deltaic systems to major sea level changes or give a coherent history for sedimentation in the region.

Reprinted as published in the Geological Society of America South-Central Section *Abstracts with Programs, 1987*, v. 19, no. 3, p. 147–148.

Development of Thick Regressive Carbonates on a Basin Hingeline (Middle Pennsylvanian) in Oklahoma and Kansas

KIMBELL L. KNIGHT, Department of Geology, Radford University, Radford, VA 24142

Pronounced thickenings, both in deep-water shales and in shallowing-upward sequences of overlying carbonates within three successive transgressive-regressive Desmoinesian cyclothems (Breezy Hill and Fort Scott Limestone) reflect interaction of eustatic sea-level fluctuations and differential subsidence across an active hingeline between the Arkoma Basin in Oklahoma and the Cherokee Platform in Kansas. During widespread transgressions, an oxygen-minimum zone below a thermocline rose from the basin well up on the platform, depositing phosphatic black shale in deepest water below the zone and gray shale in more shallow water above the zone. Black shales are thickest across the basin and basin-platform hingeline, which spent more time within dysaerobic water during sea-level fluctuations, and thin markedly, or grade into an equal thickness of gray shale within a short distance on the platform. Restriction of meteoric diagenesis, coals, and calcretes to the top of thin regressive carbonates on the platform indicates that during regressions the sea's retreat halted in the vicinity of the platform-edge. Eventually on the basinward, more rapidly subsiding hingeline, carbonate production outstripped subsidence, and resulted in thick deposits of shallowing-upward phylloid algal and associated carbonates that thinned basinward and onto the platform. Significantly, northward imbrication of successive carbonate mounds suggests a northward migration of the hingeline.

This model for vertical accretion on a differentially subsiding hingeline does not require platform-edge topographic highs as the cause for thick carbonate sequences, including phylloid algal-mounds.

Reprinted as published in the Geological Society of America South-Central Section *Abstracts with Programs, 1987*, v. 19, no. 3, p. 172.

Sixth-Order Transgressive-Regressive Units in the Fort Scott Cyclothem of Southeast Kansas

DANIEL R. SUCHY, Department of Geology, Kansas State University, Manhattan, KS 66506

A regional study of stratigraphic units of the lower Marmaton Group (Middle Pennsylvanian Series, Desmoinesian Stage) in SE Kansas, NE Oklahoma, and W-central Missouri was undertaken to examine evidence for small-scale sea level changes. Units examined, previously considered members of the Fort Scott Formation, have recently been reassigned by Knight (1985). Eight outcrop exposures were measured and described and at least six stratigraphic sections were taken from the literature.

These units have traditionally been interpreted in terms of cyclic or rhythmic alternations of specific lithofacies based on models of cyclothems (after Wanless and Weller, 1932) or of Kansas cyclothems (Heckel, 1977). In a very broad sense these interpretations have been useful, but when the rocks are examined in detail, a much more complex sea level history emerges. By carefully noting changes in lithology and changes in fossil types and diversity we have identified four, and part of two other, sixth-order transgressive-regressive units (after Busch and Rollins, 1984), which include 5 transgressive surfaces, in an interval previously interpreted to represent one cyclothem (Knight, 1985). One Kansas cyclothem is equivalent to a fifth-order transgressive-regressive unit in the hierarchy of Busch and Rollins (1984). Interpreting stratigraphic units at a sixth-order scale by tracing genetic surfaces allows a more refined and accurate paleoceanographic and paleogeographic reconstruction of the area and permits a distinction between allocyclic and autocyclic units.

Reprinted as published in the Geological Society of America South-Central Section *Abstracts with Programs, 1987*, v. 19, no. 3, p. 178.

Chert in the Lower Permian of the Northern Midcontinent

R. R. WEST, T. R. BARRETT, and P. C. TWISS, Department of Geology, Kansas State University, Manhattan, KS 66506

Lower Permian limestones of the northern midcontinent (Flint Hills) are known for their chert content. In particular, three limestone members of the Chase Grp., Threemile, Schroyer, and Florence, are characterized by irregular, wavy beds of chert and chert nodules of different sizes. Chert in the Threemile is the topic of this paper.

The chert is secondary; it partially replaces skeletal grains in the carbonate and in the chert beds and nodules, but the original mineralogy of the rock, origin of the silica, and timing of the replacement are unknown. Folk and Pittman (1971) showed that the occurrence of length-slow chalcedony indicates association with evaporites. Recently we have collected specimens of carbonate and chert from the Threemile that contain rosettes that duplicate the crystal habit of gypsum. Some rosettes are spherical vugs composed of radiating voids containing some length-slow chalcedony. Other rosettes are more completely filled with length-slow chalcedony and still other rosettes are only faintly visible within the chert nodules and beds. Thus, the chert seems to have replaced gypsum. Thus, some of the cherty limestones of the Lower Permian in the northern midcontinent represent an ancient evaporitic environment like a sabkha.

The source of the silica and the timing of the replacement are more difficult to determine, however both might be rather recent. In 1975 Amoco drilled the #1 Hargrave well SW of Randolph, KS and cored the Permian section including the Threemile. Chert was absent, but beds and nodules of gypsum were found. Chert is conspicuous in all exposures of the Threemile, including an outcrop six miles SE of the Hargrave well, but seemingly absent a few tens of feet below the surface. Is the chert replacement of the gypsum a recent phenomenon? Could the silica have come from the numerous opal phytoliths produced by the native grasses which have dominated the High Plains since the Early Tertiary? Obviously, more work is needed, including studies of oxygen isotopes.

Reprinted as published in the Geological Society of America South-Central Section *Abstracts with Programs, 1987*, v. 19, no. 3, p. 180.

Paleobathymetry of Fusiform Fusulinids: Two Complementary Schools of Thought

W. MARC CONNOLLY, Department of Geology, Texas A&M University, College Station, TX 77843

The preferred depth of Late Paleozoic fusulinids has received considerable attention in the literature and two schools of thought have emerged. The traditional school proposed depths ranging from 65–260 feet. Their reasoning involved "analogy" with the Recent foraminifer *Alveolinella*, i.e., similarity of form implied similarity of function in response to time-independent environmental forces. *Alveolinella* is distantly related but isomorphic with fusiform fusulinids. This approach involved the direct transfer of ecologic data from the Recent to the Paleozoic and was criticized by a subsequent school that argued for depths on the order of 5–50 feet. These estimates were based upon stratigraphic and petrographic analysis of the sediments in which fusulinids occur, and the paleoecology of the associated fauna.

The disparities between both schools of thought remain unresolved although the former has fallen into disfavor. However, the ecologic data utilized by ear-

lier workers was derived from dead assemblages dredged at depth. Only recently with the advent of Walton's staining technique in 1952, have ecologic data on living assemblages become available. This led to the recognition of numerous discrepancies between living and dead assemblages which are attributed to Pleistocene fluctuations of sea level. Comparisons of relict assemblages with present environmental conditions are meaningless. Live *Alveolinella* inhabit sandy carbonate substrates at depths of less than 100 feet in tropical inner shelf, reefal, back-reef, and lagoonal settings. The revision of alveolinellid ecology brings both schools of thought into agreement. Both independent avenues of reasoning appear to be valid and yield comparable results. Depth preference certainly varied at the species and generic level but, as a generalization, Late Paleozoic fusulinids favored shallow depths and estimates less than 100 feet seem reasonable.

Reprinted as published in the Geological Society of America South-Central Section *Abstracts with Programs, 1987*, v. 19, no. 3, p. 149.

The following are abstracts from University of Oklahoma M.S. theses. Permission of the authors to reproduce the abstracts is gratefully acknowledged.

Depositional History of the Upper Morrowan (Pennsylvanian) Strata of the Ardmore Basin, Oklahoma

MICHAEL PAUL MALEY, School of Geology and Geosciences, University of Oklahoma, Norman, OK

The Ardmore Basin is located in south-central Oklahoma and is part of the Southern Oklahoma aulacogen. During Morrowan time, the Criner Hills to the south of the Ardmore Basin were actively uplifting. This event is termed the Wichita Orogeny.

This study concentrates on the Early Pennsylvanian Golf Course Formation. The members discussed in detail include the Jolliff, unnamed unit I, Gene Autry, Otterville, and unnamed unit II. Ten facies were defined for this interval. They include (1) gray shale (with two subfacies), (2) calcareous shale, (3) conglomerate, (4) pebbly limestone, (5) bioclastic grainstone/packstone, (6) sublitharenite, (7) fine quartz arenite, (8) fine calcarenite, (9) oolitic grainstone (with two subfacies), (10) dark skeletal packstone/wackestone.

Biostratigraphic information is based primarily upon conodonts, goniatites, and foraminifers. Conodont data shows the Jolliff Member to be time equivalent to the Primrose Member. Previously, the Jolliff was thought to overlie the Primrose. The *Declinognathodus* aff. *noduliferous*, *Neognathodus symmetricus*, *Neognathodus bassleri*, and *Idiognathodus sinuosis* conodont zones are recognized in both the Jolliff and Primrose. Unnamed unit I, Gene Autry, Otterville, and unnamed unit II are included in the *Idiognathoides convexus* zone. The only identifiable goniatites recovered were from the Gene Autry Member. An unusual occurrence is seen here as the uppermost Morrowan zonal name-bearer,

Axinolobus, overlaps the lowermost Atokan zonal name-bearer, *Diaboloceras neumeieri*. This overlap persists for at least the upper 800 feet of the Gene Autry (MS 365). Outside the Ardmore Basin, such a co-occurrence has not been observed, however, in these areas, these two zones are separated by a regional unconformity. The overlap may represent deposition within the Ardmore Basin during the period represented by an unconformity seen elsewhere in Arkansas, Oklahoma, and Texas. Only one foraminifer zone is recognized for the entire Morrowan.

The Jolliff Member, found only along the southern part of the basin, consists of conglomerates, limestones, and shales showing considerable lateral variation. Deposition was by sediment gravity flows, primarily debris flows, from the Criner Hills. The Primrose, found only in the northern Ardmore Basin, contains sands and shales from a northern source.

The thick shale interval overlying the Jolliff and Primrose (unnamed unit I–Gene Autry) reflects rapid shale deposition filling the basin. The overlying Otterville Member locally forms marine sand bars, reflecting shallow water conditions after the basin was filled. These bars formed on topographic highs found along the basin margin and anticlines in the interior of the basin. Unnamed unit II represents slightly deeper-water conditions than the Otterville. Biostratigraphic evidence indicates that much of the strata above the Jolliff–Primrose was deposited during the period of the Morrowan–Atokan unconformity. Exposure of adjacent shelf areas during a period of lower sea level would cause increased fine grained clastic deposition in the basin areas.

The Petroleum Geochemistry of the Pauls Valley Area, Anadarko Basin, Oklahoma

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The Pauls Valley area, located near the southeast corner of the Anadarko Basin, is an extremely complex geological region. Producing formations range in age from the Ordovician Chazy Stage to the Pennsylvanian Missourian Series. Trapping mechanisms responsible for the accumulation of hydrocarbons vary from purely structural traps, to fractured reservoirs, to up-dip truncations of a reservoir and up-dip pinchouts of sandstones. Thirty oils from the Pauls Valley area have been analyzed for *n*-alkane distribution, terpane distribution and sterane distribution in an effort to group oils of common genetic origin. Ten rock extracts from the area were also analyzed in an effort to relate hydrocarbons being produced to their probable source rocks.

Results show that 85% of oils in the area have a probable common source. The Woodford Shale is proposed as a source for the large group of oils in this study. A group of oils reservoired in the Viola Limestone exhibit distinct geochemical characteristics and thus are thought to have a different source rock than the majority of the oils in the area. The differences include: an enhanced C_{24} tetracyclic terpane relative to C_{26} tricyclic terpanes; diminished C_{28-30} trycyclic terpanes relative to Ts and Tm; diminished C_{30}-steranes relative to their C_{29} counterparts; predominance of C_{35} over C_{34} extended hopanes and an even/odd predominance of the normal alkane distribution. The Viola rock extract generally exhibits the same qualities as these anomalous Viola oils and thus is proposed as the probable source rock.

Dominance of the C_{29}-steranes for oil samples which appear to have a marine source by their normal alkane distribution, the presence of C_{30}-steranes and high levels of tricyclic terpanes, suggest that caution be used in the interpretation of terrigenous sources based on the high abundance of C_{29}-steranes. The results thus agree with those of previous workers who have warned of this problem.

The Deese Group, the Springer Formation, the Sylvan Shale and the Arbuckle Group are not likely sources for the oils analyzed from the Pauls Valley area. Differences in gross physical parameters of the oils (i.e., API gravity) are not source related and are due rather to maturation and migration related effects.

The Depositional Environment and Diagenetic History of the Chester "J" Limestone in Portions of Dewey and Major Counties, Oklahoma

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Integration of information from 58 petrophysical logs and 20 associated well cores reveals that the Late Mississippian Chester "J" limestone in the Southwest Trivoli Field of Dewey and Major Counties, Oklahoma is an open marine shelf carbonate buildup. The overall regressive vertical sequence indicates deposition in progressively shallower water. The major vertical sequence of lithofacies is a basal brachiopod wackestone, an argillaceous brachiopod mudstone, a mixed skeletal wackestone, an uncoated-coated skeletal bryozoan, crinoidal packstone, an uncoated-coated skeletal bryozoan, crinoidal grainstone, and an oolite skeletal grainstone. All facies are slightly dolomitic. Toward the top of the Chester "J", an overall change in lithology from quartz-free carbonate rock to quartz sandstone, silty sandstone, or dark shale marks the Mississippian–Pennsylvanian unconformity. Petrophysical logs show the unconformity as a change in gamma ray response from very low or low to moderate or to high.

Interparticle and secondary vuggy porosity are the dominant porosity types. Porosity was initially controlled by lithofacies. Overall, high permeability correlates with high porosity in the grainstones. Diagenetic modifications exert the dominant influence on pore system evolution. Suggested diagenetic controls on porosity are the presence of lime mud and the amount of bryozoan versus crinoidal fragments. The former prevents the complete cementing up by sparry calcite; the latter controls the amount of early syntaxial rim cement. Rim cemented barriers and impermeable bedding planes may have controlled the formation of localized porosity and permeability zones; thus adding a diagenetic hydrocarbon trapping mechanism.

The five major diagenetic regimes of deposition are (1) a marine phreatic, (2) a mixing zone, (3) a meteoric phreatic, (4) a meteoric vadose, and (5) an early and late subsurface burial. Diagenetic overprinting by near surface and burial events dominate the diagenetic history.

Changes in Southwest Trivoli Field acoustic impedance as a function of porosity are forward seismic modeled using the AIMS-Geoquest program; however, lithologic changes are not significant. The porosity distribution is corroborated by existent geophysical lines.

The Chester "J" pre-Pennsylvanian land surface was of low relief with a local dendritic paleodrainage pattern to the west–southwest. Truncation and overlying marine shales form a stratigraphic hydrocarbon trapping mechanism. Lateral seals formed in shale filled stream valleys may have caused local reservoirs.

Suggested strategies for regional Chesterian porosity delineation and further diagenetic work are mapping of porosity trends, paleogeographic facies, and paleogeomorphic drainage systems; and searching for acoustic anomalies on seismic lines.

The Lithostratigraphy, Biostratigraphy and Depositional History of the Atokan Series (Middle Pennsylvanian) in the Ardmore Basin, Oklahoma

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The Atokan Series in the Ardmore Basin consists of a complex sequence of shales, limestones, sandstones, and conglomerates that are included in the middle Dornick Hills Group. The biostratigraphic as well as lithostratigraphic investigation of these units has made possible more accurate correlations and interpretations than were previously available.

Most terrigenous sediment in the study interval was derived from the Criner Hills Uplift to the southwest. The Bostwick Member is the most prominant Atokan lithologic unit reaching a thickness of 400 feet in the southern Ardmore Basin adjacent to the Criner Hills Uplift. It consists of conglomerates, shales, limestones, and sandstones that apparently rest unconformably on the uppermost Morrowan marine shales and thin limestones of Unnamed Unit A, as indicated by the absence of lower and middle Atokan biostratigraphic indicators. Conodont and chonetid brachiopod occurrences show that strata correlative with the Bostwick Member do not occur in the northern Ardmore Basin. A second regional unconformity, much better documented than the first, truncates the Bostwick Member and part or all of Unnamed Unit A in the northern Ardmore Basin.

Course terrigenous clastic deposition in the study interval ended at the close of the Wichita orogeny in early Late Atokan time, with the deposition of the highest Bostwick Member conglomerates. Post-Bostwick deposits of mostly marine, Late Atokan, Unnamed Unit B shales, limestones, and sandstones are correlated across the Ardmore Basin without significant interruptions. No depositional break is observed between highest Atokan and lowest Desmoinesian strata.

Fossil occurrences are sporadic due to highly varied facies but conodonts, fusulinids, brachiopods and ostracods are found in the study interval. Microfossils occur with the most regularity and are the most important biostratigraphic indicators but common chonetid brachiopods showing significant evolutionary changes from the Bostwick Member through Unnamed Unit B are also useful for biostratigraphic correlation. The occurrrence of the chonetid brachiopod genus *Mesolobus* in the Upper Atokan, as indicated by conodont and fusulinids correlations, is a significant extension of the lower range of this genera.

Subsurface Geology of the Frederick Area, Tillman County, Oklahoma

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The Frederick area of Tillman County, located in southwestern Oklahoma, is a structurally complex area dominated by four major structural elements that have a west–northwestward trend. The investigated area is situated in the eastern part of the Hollis–Hardeman basin and is bounded by the Wichita–Amarillo uplift to the north, the Waurika–Muenster arch to the east, and the Red River arch to the south.

Three orogenic movements influenced the structure in the investigated area. The effect of the Acadian epeirogeny was a gentle tilting of the strata northward whereas the Wichita orogeny produced the majority of the folding and faulting in the area. The effect of the Arbuckle orogeny was rejuvenation along structural trends previously established during the Wichita orogeny. Fluvial-deltaic sequences and carbonate platform-reef-like environments dominated during Pennsylvanian time. Most of the petroleum fields are combination structural and stratigraphic traps.

Investigation of Paleotemperatures in the Vicinity of the Washita Valley Fault, Southern Oklahoma

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Vitrinite reflectance was measured on 40 samples collected near the Washita Valley Fault in southern Oklahoma for the purpose of determining the paleotemperature field in the vicinity of the fault plane.

Vitrinite reflectance samples were prepared two ways: (1) by concentrating them and (2) by using the whole-rock fraction. There is significant difference in reflectance values between the two methods. Concentrate values have consistently higher reflectances than whole-rock samples. The presence of bitumen in whole-rock samples appears to be the most plausible explanation for reflectance depression. Concentrate samples have higher-reflectances because bitumen has been removed by the concentration process. In this study concentrate values are used rather than whole-rock values because concentrate values are thought to give a more accurate indication of thermal maturity.

Concentrate reflectance values range from 0.35% to 0.77% with a mean reflectance of 0.55%. A reflectance of 0.55% corresponds to a temperature of 107°C (Price, 1983).

Reflectance measurements from the 40 concentrated Woodford Shale samples collected near the Washita Valley Fault do not indicate the presence of a temperature anomaly due to frictional heating. Since the amount of frictional heating depends on the state of stress on the fault and the fault-slip velocity, the lack of a temperature anomaly near the fault suggests that either fault-slip velocity was low and/or stress transmitted across the fault plane was low.

A model for frictional heat generation on a strike-slip fault indicates that the heat production factor (the product of coefficient of friction and fault-slip velocity) could have ranged between 0.0 and about 3.8 cm/yr given the scatter in the data.

A heat production factor of 0.0 cm/yr requires a geothermal gradient of 76°C/km. This rather high geothermal gradient might be explained by intense geologic deformation in the area. A heat production factor of 3.8 cm/yr requires a geothermal gradient of 23°C/km. Assuming the coefficient of friction was 0.85, maximum fault-slip velocity could have been 4.5 cm/yr.

A Sedimentological and Geochemical Study of the Bigfork Chert in the Ouachita Mountains and the Viola Limestone in the Arbuckle Mountains

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The Bigfork Chert (Middle–Upper Ordovician) in the Ouachita Continental Margin (Oklahoma and Arkansas), is composed of partially silicified carbonate sediments such as grainstones, wackestones, and mudstones, interbedded with fissile shale and bedded chert. The formation (about 215 m thick) contains an allochthonous assemblage of shallow-water fossils such as pelmatazoans, brachiopods, ostracods, and trilobites. In addition to the occurrence of stratified resedimented conglomerates, the formation is characterized by the presence of sedimentary structures typical of turbidite sequences, such as graded beds, soft-sediment deformation structures, and erosional features. In the Southern Oklahoma Aulacogen to the west of the Ouachita Continental Margin the stratigraphically equivalent Viola Limestone is composed of carbonate sediments and nodular chert which were deposited in anaerobic and dysaerobic settings near the central segment of the aulacogen. In the northeastern flank of the aulacogen the Viola Limestone was deposited in aerobic and dysaerobic conditions.

Sedimentary structures in conjunction with the presence of resedimented stratified conglomerates, suggest that the silicified and nonsilicified carbonates of the Bigfork Chert are allochthonous, transported from the surrounding shelf and the aulacogen by turbidity currents into the deep marine environment bordering the Ouachita Continental Margin. The silica accumulated biogenically as remains of radiolaria and siliceous sponges. During diagenesis, silica released by the dissolution of siliceous organisms replaced much of the carbonate mud and grains. The abundance of lamination, organic matter and the virtual absence of trace fossils in the Bigfork Chert suggest that the depositional environments were dominated by anaerobic conditions.

Chemical analyses of limestone and replacement chert for major, minor, and trace elements indicate fractionation of Ca, Mg, Sr, and Mn during the silicification of the host limestone.

The presence of felsic volcanogenic matter in the cherts from Arkansas indicates the existence of a volcanic source to the south of the Broken Bow–Benton Uplift during Viola–Bigfork time. The occurrence of extraclasts of an oolitic limestone in the stratified resedimented conglomerates suggests that the carbonate rocks of the shelf edge which is now buried beneath the Ordovician through Mississippian allochthonous thrust sheets of the Ouachita facies, were deposited in shallow water with high-energy environments. The presence of granitic rock fragments in the conglomerates indicates exposure of the crystalline basement on the craton during Bigfork time.

Lithostratigraphy and Depositional History of the Upper Dornick Hills Group (Early Desmoinesian, Pennsylvanian) of the Ardmore Basin, Oklahoma

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The early Desmoinesian portion of the Upper Dornick Hills Group in the Ardmore Basin consists of three named dominantly limestone members, the Lester, Frensley and Pumpkin Creek, with intervening shale intervals which have been informally named Unnamed Units III and IV by Tennant (1981). This study is concerned with the lithostratigraphy and depositional history of the lower Desmoinesian strata in the Ardmore Basin. The study of this sequence primarily consisted of determining facies relationships and sequences through description of rock slabs and thin sections taken from measured sections in the Ardmore Basin.

Thirteen lithofacies were defined in this study. They are as follows: (A) Crossbedded Sandstone Facies, (B) Massive Sandstone Facies, (C) Silty Shale Facies, (D) Calcareous Shale Facies, (E) Limestone Pebble Conglomerate Facies, (F) Chert Pebble Conglomerate Facies, (G) Crinoidal Facies, (H) Mixed Skeletal Facies, (I) Skeletal Wackestone Facies, (J) Phylloid Algal Facies, (K) Mudstone Facies, and (L) Oolitic Facies. Parameters for facies definition included composition, texture, fauna, sedimentary structures and facies associations.

Lithofacies trends indicate unique and consistent patterns for each member or unit. The Lester Member consists of the mature oolitic subfacies near the center of the Ardmore Basin which grades laterally to the coated grain subfacies. The mixed skeletal facies dominates the Lester Member in the northeastern portion of the basin. The Frensley Member is a highly variable interval containing several radically different carbonate and terrigenous facies closely associated with each other. Along the center of the western and northern margins of the Ardmore Basin, the limestone facies of the Frensley Member disappear and are replaced with a thick mostly silty shale interval. The Pumpkin Creek Member is the least variable of the three named members. In the northeast, the Pumpkin Creek Member consists of one or two limestone beds of the phylloid algal facies. In the northwestern and southern portion of the basin chert pebbly-quartz sandy packstones and grainstones of the crinoidal facies dominate the Pumpkin Creek Member. The mixed skeletal facies dominates the western portion of the basin.

Throughout the early Desmoinesian, higher energy environments existed in the western portion of the Ardmore Basin and lower energy environments existed in the eastern portion of the basin. This difference of depositional energy is reflected in the facies trends of the members and units.

The lower Desmoinesian strata in the Ardmore Basin was deposited in an unstable terrigenous-carbonate marine environment with a dominantly south–southwestern source of terrigenous material in the form of prodeltaic muds. A south–southwestern source is indicated by a dominance of north–northeasterly current directions. The source of a majority of the terrigenous material was probably springer sands exposed southwest of the Criner Hills. A minor northern source for terrigenous material is indicated by the occurrence of limestone pebble and chert pebble conglomerates and relatively thick sand bodies in the northeastern portion of the Ardmore Basin. Chert pebbles in the Pumpkin Creek Member in the southern portion of the Ardmore Basin may indicate early deformation of the Ouachita trend.

The Lester Member indicates development of ooid shoals during a time of transgression, near the center of the basin on the actively forming Caddo Anticline with less mature ooids forming on the flanks of the ooid shoals. Unnamed Unit III represents a time of regression when prodeltaic and terrigenous shelf deposition dominated the basin. The Frensley Member represents a minor transgression resulting in limited carbonate deposition between prodeltaic sites. Unnamed Unit IV represents a regression with the return of dominantly terrigenous deposition. The phylloid algal marker bed of Tennant (1931) and the Pumpkin Creek Member indicate renewed transgression forming phylloid algal flats in the eastern half of the basin and crinoid shoals in the southern and northwestern portion of the Ardmore Basin.

Lithofacies Sequence Analysis resulting in a Facies Relationship Diagram indicates that no dominant sequences or cycles of lithofacies exists, and that the dominant transition occurs from any lithofacies to the silty shale facies.

Quartz and Feldspar Types: Key Indicators of Provenance and Diagenesis in the Hennessey Shale, Southwestern Oklahoma

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Forty-four samples of the Permian (Upper Leonardian), marine Hennessey Shale were disaggregated into their Q and F fractions using the sodium bisulfate fusion technique. The Q and F were sieved to determine their size distributions and statistical parameters. Four sieve intervals were chosen to be petrographically analyzed because there were enough of these sizes in most of the samples. The Q and F were stained to aid in the identification of feldspars and then mounted on slides with Petropoxy, a thin section glue that has an index of refraction of 1.540.

Using the Becke line test and other optical properties of the Q and F, they were classified into six catergories: (1) polycrystalline quartz/chert-metaquartz, (2) monocrystalline quartz, (3) microcline, (4) orthoclase, (5) albite, and (6) plagioclase. A total of 300 grains were counted in each thin section.

The statistical parameters were contoured on a base map with the locations of the sample sites. Sediment dispersal trends were delineated based on mean size, mode, and standard deviation maps. In addition, contours of the percentage of Q and F were drawn to delineate trends associated with mineralogic changes within the four size intervals studied.

From this analysis it was determined that with a decrease of the mean grain size of the samples there is a decrease in the amount of quartz and feldspar grains.

Also, with an increase in distance from the source of the Hennessey: (1) mean and modal size decrease, (2) sorting may increase, and (3) the percentage of Q and F decreases.

The amount of feldspar found in the smaller size intervals decreases while the amount of quartz increases. This is probably a result of dilution of the sediment by fine grained quartz. None of the Q and F were altered indicating that these grains underwent little Permian weathering or subsequent diagenesis.

Tide and Storm Dominated Bars on a Distal Muddy Shelf: The Pennsylvanian Cottage Grove Sandstone, Northwestern Oklahoma

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Approximately 20 discrete sand ridges of the Cottage Grove Sandstone can be identified from subsurface control within an 860 km study area in Dewey and Major Counties, Oklahoma. The sand ridges are encased in marine shales of the Skiatook Group (below) and the Ochelata Group. Sand ridge size ranges in width from 1–4 km and in length from 4–30+ km. Maximum sand thickness is about 30 m. The sand ridges are subparallel and trend generally NE–SW, oblique to present structural strike.

The sands show an overall fining upward trend unlike many reported shelf deposits. A generalized vertical facies sequence from an axial core on a sand ridge consists of (1) massive shale (basal), (2) wavy bedded sandstone/shale, (3) alternating massive sandstone containing symmetrical oscillation ripples and flaser bedded sandstone containing herringbone cross stratification, and (4) wavy bedded sandstone/shale which grades into the massive shale facies above.

The Cottage Grove sand ridges were deposited in a distal shelf environment. Depositional processes inferred to be important in the formation of the Cottage Grove sand ridges includes episodic delivery of sediment to the shelf by upper flow regime storm induced currents, subsequent reworking by tidal surge and ebb, and winnowing of ridge crests by wave action during storms.

A Geophysical Investigation of a Possibly Recent Fault in Southwestern Oklahoma

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The Meers Fault of southwestern Oklahoma is part of the frontal fault zone that separates the Wichita Mountains on the south from the Anadarko Basin to the north. In the northwestern corner of Comanche County, the trace of the fault is thought to be a rectilinear, 26 km near-vertical scarp. Recently, it has been suggested by Gilbert and Donovan (1982) that the Meers Fault/Scarp is a very young feature. Field evidence supporting this proposal is found by noting that the uplifted block to the south of the fault is topographically down instead of up. This suggests later, more recent isostatic readjustment has occurred along this plane.

This investigation has two aspects: First, to determine the relationship between the subsurface Meers Fault and the Meers Scarp, a gravity survey of the region was conducted in 1984. A profile of Bouguer gravity versus distance from the fault was created. From this, a subsurface density model was constructed that employed densities from wells and outcrop in the Oklahoma aulacogen area. A polygonal modeling program was employed in the formation of the subsurface model. It is believed that the structure of the ancient subsurface Meers Fault may be better constrained by this particular model. The best density model exhibits a 72 degree fault dip to the southwest, instead of a 40 degree dip as previously proposed.

Second, shallow seismic refraction profiles parallel and perpendicular to the scarp were carried out in 1984 and 1986. Located at sites with extensive fault scarp exposure, these seismic lines supplement information from two trenches excavated across the fault scarp in 1985. Combined with the stratigraphy and radiocarbon dates from the trenching, the seismic refraction survey contributes to understanding the nature, and perhaps timing of the breakage and offset. The results of the investigation indicate this feature is a fault scarp and not a fault-line scarp. This has important implications in the later history of movement along the Meers Fault.

Characteristics of Polycrystalline Quartz/Chert in the Stanley Shale (Mississippian) During Diagenesis/Low-Grade Metamorphism, Ouachita Mountains, Arkansas

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This study attempts to trace the mineralogical and textural changes observed in a pelitic unit comprised of shale, slate and phyllite with respect to diagenesis/ low-grade metamorphism, and to determine if there is any correlation between the field terms shale, slate and phyllite and their thermal maturity determined by illite crystallinity and vitrinite reflectance. The unit of study is the Stanley Shale Formation (Mississippian), which crops out in the Ouachita Mountains of west–central Arkansas. Surface grab-bag samples were analysed using thin-sections, sodium bisulfate fusion, and petrographic grain-mount analysis to determine mineralogic and textural patterns; X-ray diffraction of ethylene-glycolated oriented clay-mounts of less than two micron fraction to determine the degree of illitization (Weaver's sharpness ratio and Kubler's peak-width index) and monochromatic reflected white light on kerogen concentrates to evaluate thermal maturation.

Results of the study indicate that with increasing diagenesis/low-grade metamorphism (based upon rock type) the percent and grain size of chert increases, the percent of monocrystalline quartz and feldspar decreases and their respective grain sizes increase. Differences between the shale/slate and slate/phyllite groups are subtle and reflect gradational change between "diagenesis" and "low-grade metamorphism." The increase in percent and grain size of chert is most significant between the shale and phyllite groups. Illite crystallinity and vitrinite reflectance data were inconclusive. The Stanley contains too little organic material (especially

the slate and phyllite samples) to make reflectance measurements meaningful. Illite crystallinity data, when compared to standard Weaver and Kubler maturation scales, were found to be ambiguous, but when analyzed internally showed the expected general increase in maturation from shale to slate to phyllite. Weaver's sharpness ratios did not always correlate with Kubler's peak-width index values and no definite correlation was found between illite crystallinity, thermal maturation data and rock field terms.