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Cover Picture

Using Sandstone Peels for Better Understanding of Sedimentary Structures

Students in beginning geology courses are often shown photographs and samples of sedimentary structures such as cross-laminations or crossbedding, but they often cannot visualize the actual process by which the structures form. The sandstone peel shown in the cover picture was taken from an unconsolidated sand in the wide channel of the Canadian River at SW¼ SE¼ sec. 2, T. 8 N., R. 3 W., Cleveland County, Oklahoma. It was made by students in an attempt at improving their understanding of a Holocene point-bar deposit and the modifications of sand deposition by changing water currents and wind.

The method closely follows that of Moiola, Clarke, and Phillips (Moiola, R. J., Clarke, R. T., and Phillips, B. J., 1969, A rapid field method for making peels of unconsolidated sands: Geol. Soc. America Bull., v. 80, p. 1385-1386). A surface was prepared (approximately 3 x 4 feet) by digging a trench in the recently deposited point bar down to the top of the water table. After carefully smoothing the surface, a double layer of cheesecloth was fastened to the prepared face by thin wires pushed through the cloth. Students then dissolved Dupont Elvacite 2044 resin in acetone (in a ratio of 1 pound resin to enough acetone to make 1 gallon of solution). The cloth was then liberally painted with the solution several times, allowing about 15 minutes between applications. Total drying time was about 4 hours.

The hardened peel was mounted on a piece of plywood by placing the board in contact with the hardened face and gently pulling the peel from the face. Later, linoleum paste cemented the peel to the backing. A soft brush or air jet was used to remove loose sand, and the surface of the peel was coated with a spray plastic or lacquer.

—*J. B. Thomas*

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Prepared by William D. Rose

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USGS Bibliography of Energy Resources Updated

A new annotated bibliography of nearly 200 selected reports covering the United States and world resources of asphalt, coal, petroleum and natural gas, water power, and atomic, geothermal, tidal, and solar energy has been published by the U.S. Geological Survey.

The bibliography updates a similar guide to energy-resource information prepared 10 years ago and includes selected summary reports applicable primarily to the United States and, secondarily, to the world. The selected reports include data on resources of conventional and unconventional energy, the availability and future prospects of developing each source, overall studies of certain geographic areas, production and use statistics, and the probable future course of energy development. Most of these reports are in English.

The 21-page bibliography, *Selected Sources of Information on United States and World Energy Resources—August 1, 1970: An Annotated Bibliography*, by Paul Averitt and M. Devereux Carter, has been published as U.S. Geological Survey Circular 641. Copies may be obtained free on request from the U.S. Geological Survey, Washington, D.C. 20242.

Oklahoma City Geological Society Celebrates Golden Anniversary

This month the Oklahoma City Geological Society celebrates its 50th birthday. The society is the 7th largest of the geological societies affiliated with the 17,000-member American Association of Petroleum Geologists, with a total membership of 814. Although the society is composed primarily of geologists in the Oklahoma City area, its membership embraces 18 states and 2 foreign countries. Also, the membership rolls refute a general misconception that Oklahoma's petroleum activities are dominated by a few major oil companies. Actually, the membership represents 272 companies, and 233 members are independent geologists.

Activities of the Oklahoma City Geological Society include bimonthly technical meetings, several annual social events, publication of the *Shale Shaker* (monthly except for July and August), and periodic publication of technical books and manuals mainly on Oklahoma geology. The society also provides speakers for civic groups and organizations on request. During the past year the society collaborated with the Oklahoma section of the American Institute of Professional Geologists in establishing an introductory geology course for secondary-school teachers in the Oklahoma City area. The two organizations were also instrumental in bringing the geological sign project on the Oklahoma City oil field to successful completion (*see* cover of February 1971 *Oklahoma Geology Notes*).

The 1970-71 executive board of the Oklahoma City Geological Society is pictured, left to right: Norton R. Perry, past-president; Charles E. Branham, library director; Richard D. Darnell, social chairman; Gary A. McDaniel, second vice-president; Herbert G. Davis, president; Tom G. Robinson, secretary; W. J. Witt, public relations chairman; Janis Calmes, editor; John W. Erickson, first vice-president. Not pictured is Louis M. Ford, treasurer.

Directory of Mineral Producers Available

The Oklahoma Geological Survey has recently issued its annual listing of mineral producers in Oklahoma. This compilation was made possible through the cooperation of the Chief Mine Inspector's office and chambers of commerce, county assessors, and producing companies throughout the State.

The list is divided into two parts: producers by mineral products and producers by counties. The first section is broken into 18 categories of products: bentonite, cement, chat, clay, coal, copper, dimension stone, dolomite, glass sand, granite, gypsum, lead and zinc, lime, limestone, salt, sand and gravel, tripoli, and volcanic ash.

Copies of the 50-page *Directory of Mineral Producers in Oklahoma, 1970,* which have been reproduced by multilith, can be obtained on request from the Oklahoma Geological Survey, 830 Van Vleet Oval, Room 163, Norman, Oklahoma 73069.

—*John F. Roberts*

OKLAHOMA ABSTRACTS

AAPG-SEPM Annual Meetings, Houston, Texas March 29-31, 1971

The following abstracts are reprinted from the February 1971 issue, v. 55, of the *Bulletin* of the American Association of Petroleum Geologists. Page numbers appear in brackets below each abstract. Permission of the authors and of A. A. Meyerhoff, managing editor of AAPG, is gratefully acknowledged.

Geologic Factors Which May Affect Gas Occurrence in Anadarko Basin, Oklahoma

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The Anadarko basin in Oklahoma, the Texas Panhandle, and in southwestern Kansas contains many reservoirs which produce com-

OKLAHOMA ABSTRACTS is intended to present abstracts of recent unpublished papers on Oklahoma geology. 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.

mercial quantities of gas with subordinate quantities of oil. The producing formations are Permian; Upper, Middle, and Lower Pennsylvanian; Upper and middle Mississippian; Hunton; and Ordovician. Each of these groupings can be considered a genetic stratigraphic unit in which the depositional and structural history is closely related.

Gas analysis is a powerful tool in the exploitation of a given reservoir. Some reservoirs in the Anadarko basin are blanket-type sandstones in which the analyses will be uniform over a broad area. Gas analyses showing abnormally high BTU values, subnormal formation pressures, or exceptionally high nitrogen content can be producing from a sandstone lens (either channel or offshore bars) or a limited carbonate porosity zone in which there has been no communication of fluids.

Hunton gas analyses show a higher percentage of CO_2 at depth, whereas the BTU values decrease because of the decreasing percentage of gas liquids below 14,000 ft. Pressures in the Hunton, although a little below the so-called normal bottomhole pressures, increase in a fairly uniform manner. The Morrow sandstones are productive over most of the Anadarko basin. Variations in the analyses from these sandstones appear to depend on the depth of production and on the chemical content of the gases. It is evident that many of the anomalous values of the analyses depend on the extent of the local reservoir and its geometry.

Gas analyses are a major factor in the economics of gas production. The Hunton gases along the northern shelf of the Anadarko basin yield high percentages of valuable gas liquids. Other zones yield variable amounts of gas liquids. Nitrogen values are small in all reservoirs except in the Permian where several "noninflammable" gases are reported. In contrast with the Oklahoma and Texas panhandle gas production, helium does not appear to be a factor—only traces to less than 1.0% helium are reported.

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Origin of Tuffs in Stanley Group, Ouachita Mountains, Arkansas and Oklahoma

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Five major tuff sequences (8-120 ft thick) are interbedded with marine graywacke and shale in the 11,000 ft-thick Mississippian Stanley Group. They are present in the basal 1,500 ft and upper 350 ft of the highly folded flysch group. These widespread sequences are thickest and best exposed in the southern Ouachitas, but are traceable to the central Ouachitas.

Three tuff sequences are composed of massive and bedded crystal tuff; 2 are composed of massive and bedded pumiceous vitric-crystal tuff. All five sequences have massive and sometimes laminated fine-grained vitric upper portions. Crystal-rich and pumiceous tuff sequences probably reflect different settling and/or eruptive histories.

Crystal tuff sequences originated from crystal-rich magmas or from crystal enrichment by gravity sorting of pyroclastic debris settling through long water columns, possibly as a result of vulcanian-type submarine eruptions. Bedded crystal tuff was deposited from a series of ash falls and tuffaceous turbidites. Widespread slumping of bedded crystal tuff produced massive crystal tuff.

Pumiceous tuff sequences probably formed from Katmai-like eruptions. Thick, nonwelded pumiceous vitric-crystal tuffs commonly overlain by thin-bedded pumiceous tuffs were produced from submarine pyroclastic flows covered by contemporaneous ash falls.

Fine-grained vitric tuff formed from slow settling of very fine ash. The ash was possibly the finest size remnants suspended in settling columns after major eruptions and/or was produced by weaker ash falls. Rare cross bedding is evidence for some current reworking. Tuff thickness, grain-size trends, paleocurrent indicators, and paleogeography suggest a southern volcanic source, possibly the buried Luling overthrust front in Texas.

[355-356]

Algal Mudstone Mounds in Morrowan Stage (Lower Pennsylvanian) in Northeastern Oklahoma

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The middle of the Morrowan Stage is marked by the development of an algal carbonate mudstone. The area of exposure covers 700 sq mi in northeastern Oklahoma with a maximum development of 60 ft in the southwestern 30 sq mi of the outcrop. A broad algal bank and smaller algal mounds developed within the area of maximum thickness, on the southwestern margin of the Ozark uplift. This area has high faunal diversity and the bank is cut irregularly by channels of skeletal sandstone. Northeastward, the faunal diversity of the unit is low, and the mudstone thins owing to replacement by skeletal grainstones and shale.

The algal mounds are up to 6 ft high and 10 ft across. The core material consists of *Archaeolithophyllum* and *Cuneiphycus* mudstone and boundstone, whereas the flank and intermound material consists of coarse skeletal packstone and wackestone. Influx of fine terrigenous clastics occurred during formation of this unit, as shale is present in small thin streaks and pockets. Locally, oolitic packstones and beds of algal oncoliths are found in the top. The mudstone is encompassed between skeletal grainstone throughout the areas of exposure.

The overall dearth of skeletal debris, abundance of algae, occurrence of stromatolite-type boundstone, burrowing, and occurrence of dolomite indicate that the mudstone was formed in a shallow subtidal or tidal-flat environment. Abundant recrystallization of matrix mud to microspar and pseudospar has taken place, and dolomite, ferroan dolomite, and siderite are present locally as replacement of skeletal debris and mud matrix.

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AAPG Meeting, Southwest Section
Abilene, Texas, February 7-9, 1971

The following abstracts are reprinted from the January 1971 issue, v. 55, of the *Bulletin* of the American Association of Petroleum Geologists. Page numbers appear in brackets below each abstract. Permission of the authors and of A. A. Meyerhoff, managing editor of AAPG, is gratefully acknowledged.

Alluvial Fans and Fan Deltas: Depositional Models for Some Terrigenous Clastic Wedges

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Alluvial fans and fan deltas are constructed by similar processes; both require a highland and adjacent lowland for development. Alluvial fans are associated with interior basins, whereas fan deltas develop along coastlines. A fan delta is an alluvial fan which progrades into a marine body of water.

Modern alluvial fans are present in both arid and humid regions throughout the world, ranging from Arctic to lower latitudes. Geometry and facies are controlled by rate of basin subsidence, source material, and frequency and magnitude of floods. In arid regions, where fans are most common, principal processes include debris-flows, sieve deposition, and fluvial deposition. Processes are intermittent and commonly one is dominant. Debris-flows and sieve deposits are major contributors to the upper ⅓ to ½ of a fan. Sieve deposits are generally confined to the fan apex. Debris-flows, characterized by a heterogeneous mixture of clay- to boulder-size material, extend for considerable distances downfan where they grade to mudflows containing few large clasts. Debris-flows reflect a fine-grained source area. Fluvial processes are dominant on the distal fan.

Humid-region fans, *e.g.*, Kosi River fan of India, are constructed entirely by fluvial processes during large annual floods. Compared to arid-region fans, humid-region fans have a low slope from apex to toe, are large in areal extent, and thin in cross section. Humid-region fans also contain smaller clasts, less fine material in the upper fan, and sediment is better sorted. Source-area vegetation aids in breakdown of rock material into smaller particles than under arid conditions. Erosion is great in humid areas because of intense flooding.

Alluvial fans in closed drainage basins commonly are associated with lakes. Where alluvial fans build into basins with through-flowing streams, braided-stream deposits of the distal fan are interbedded with floodplain deposits.

Fan deltas may be distinguished from alluvial fans only by the nature of related facies. Modern fan deltas develop in areas of high or low rainfall, from deserts to tropical rain forests, and are associated with a wide range of marine depositional environments, *e.g.*, reef-lagoonal to submarine fan association. Types of depositional environments associated with fan deltas are determined by such factors as tidal range, shelf width, and climate.

Fan deltas differ considerably from modern oceanic (high-constructive) deltas which are constructed by continuously flowing, large rivers characterized by a large suspension-load/bed-load ratio. Deltaic plains of oceanic deltas generally are covered by dense vegetation, whereas subaerial parts of fan deltas are virtually barren. Oceanic deltas have ragged lobate or digitate margins indented by interdistributary bays; fan deltas commonly have a smoothly arcuate distal end with no interdistributary bays. Prodelta deposits associated with oceanic deltas are commonly the thickest delta facies; equivalent facies of fan deltas are comparatively thin.

Fan-delta deposits are continually reworked by marine processes. Deposition is sporadic, therefore marine processes are effective in redistributing prodelta sediment. Marine currents redeposit sediment along the distal fan as beaches and associated berms, and within adjacent shallow marine areas as thin sand sheets and local fan-margin islands or spits.

Many ancient clastic-wedge deposits from Precambrian to Pleistocene ages are alluvial-fan systems. Deposits composing these systems become finer in the direction of transport. Lacustrine or fluvial deposits commonly are associated with the finer grained alluvial-fan deposits. Ancient alluvial fans are known from the (1) Precambrian of Texas, (2) Devonian of Norway, (3) Carboniferous of Canada, (4) Permian-Triassic of England, (5) Triassic of the Connecticut Valley, and (6) Pleistocene of California.

Ancient fan deltas have been described as fanglomerates, continental deposits, and tectonic deltas. Subaerial facies have the same character as ancient alluvial fans but are associated with marine facies ranging from turbidites to tidal-flat deposits. Ancient fan deltas occur in the (1) Devonian of New York and Northwest Territories, (2) Pennsylvanian-Permian terrigenous clastics shed off the Ancestral Rockies, Amarillo Mountains, Wichita Mountains, and Arbuckle Mountains, (3) Miocene of Texas and California, and (4) the Pleistocene of Baja California.

Fan deltas and possibly high-destructive deltas prograded shorelines and filled basins during early geologic periods, prior to evolution of terrestrial vegetation. High-destructive deltas are produced by marine reworking of river-borne sediment. Streams associated with high-destructive deltas are characterized by short duration peak discharge which allows sediment deposited at the mouths to be immediately reworked into spits and beach ridges. Lag time between precipitation and runoff was short and the fluvial systems which developed these 2 delta types were either braided streams or coarse-grained meander belts.

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History and Anatomy of Arkansas River Sand Bar Near Tulsa, Oklahoma

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Several authors have demonstrated the dipmeter's ability to resolve internal crossbed dips. Analyses of the dip patterns, which result from paleocurrent flow directions, are interpreted to determine different sand body types.

This paper shows the relation between crossbed variation in a fluvial sand bar and known channel patterns which existed during deposition. The sand bar studied is in the Arkansas River valley approximately 10 mi upstream from Tulsa. From aerial photo sequences plus discharge and river stage records, it can be shown that the entire sand bar (600,000 cu yd) was deposited during two floods—May 19-22, 1957 (60 hours), and October 3-6, 1959 (96 hours).

The sand bar was studied in detail along a 500-ft natural cutbank parallel with the valley and in a 700-ft trench dug at right angles to the valley. Crossbed types were studied and 210 crossbed measurements (true dip direction and true dip angle) were recorded at 12 vertical sections.

Results show that the highly variable patterns of crossbed dips match the erratic and changing flow directions prevalent during flood stages. In some vertical sections crossbed dip directions are at many angles to the overall east-west orientation of the Arkansas River valley. These results verify the expected crossbed variability in fluvial sands and suggest that dipmeter patterns from wells in channel sandstone bodies should be interpreted and projected with caution.

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GSA Meeting, South-Central Section
Lubbock, Texas, March 25-27, 1971

The following abstracts are reprinted from the South-Central Section Program of the Geological Society of America and Associated Societies, v. 3, no. 3. Page numbers are given in brackets below each abstract. Permission of the authors and of Mrs. Jo Fogelberg, managing editor of GSA, to reproduce these abstracts is gratefully acknowledged.

Palynological Evidence for Assignment of the Gearyan Stage of Kansas to the Pennsylvanian

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Palynology offers no support for placement of a System boundary at the base of the Gearyan Stage in Kansas. The Virgilian and Gearyan (Wolfcampian) Stages of Kansas are, palynologically, so closely related that they must be considered together as a part of a fundamental chronologic unit (a System). Gearyan age spores and pollen demonstrate no profound floral change from the underlying Virgilian. The occurrences of *Lycospora*, the culmination of monolete spore genera, the limited occurrence of bisaccate, striate forms and the continuance

of numerous Pennsylvanian trilete spores are together taken as positive evidence of the Pennsylvanian age of the Virgilian and Gearyan collectively. The plant fossil *Callipteris conferta* is rejected as an infallible indicator of Permian time because it has been demonstrated that *Callipteris* bearing beds and associated strata of Kansas contain palynomorphs intimately related to Virgilian assemblages. There is, relative to the assemblages of the underlying strata, a pronounced numerical increase in bisaccate pollen at the Wymore shale, Chase Group. This situation continues into the lowermost beds of the Cimarronian (Leonardian) Stage. The numerical increase in pollen preserved in the sediments during this segment of earth history (Wymore shale to basal Wellington shale) is interpreted as representing floral response to environmental changes. The abundant pollen are considered to be harbingers of the explosive evolutionary outburst of the bisaccate, striate pollen types reported from younger strata and recognized as "typically" Permian. The "typically" Permian pollen genera are but feebly represented in the strata under discussion here.

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Studies on Foraminifera from the Comanchean Series (Cretaceous) of Texas

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This investigation represents the first attempt to make a detailed analysis of the planktonic Foraminiferal assemblage of the Comanchean Series (Aptian—early Cenomanian) of Texas. Studies of numerous samples collected from the Comanchean Series indicate that it is now possible to divide the Washita Group into at least three zonal units. The investigator feels that the *Hedbergella washitensis* lineage is particularly important in developing this system of planktonic Foraminiferal zonation. Members of the *H. washitensis* lineage are distinctive and show rapid morphological change in the section. To date, five species have been recognized and interrelated in the *H. washitensis* lineage.

In the North-Central Texas area an inner neritic environment is postulated for the Washita Group, while a more near-shore (shallow neritic to littoral) environment is indicated for both the Fredericksburg and Trinity Groups.

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Early Cretaceous Benthic Communities in Washita Rocks, Northeastern Texas

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Several types of benthic community structures are represented in the abundant and diverse faunal assemblages of the Washita Group. Species-dominant communities were characterized by the abundance of one or two species, and at least one community was characterized by species diversity.

Suspension-feeding epifaunal communities consisted of one or two very abundant taxa such as *Gryphaea, Exogyra, Lopha,* or *Kingena.* In addition, detritus-feeding echinoids either dominated discrete colonies or were intermixed with the epifaunal suspension feeders. Locally, adjacent species-dominant communities converged to form more diverse assemblages. Each of these communities occupied carbonate substrates, and the *Lopha* and *Gryphaea* communities also inhabited terrigenous substrates.

Species diversity characterized infaunal communities of suspension feeders and detritus feeders. These groups inhabited terrigenous mud and sand substrates.

The relation of ammonoids and nautiloids to these communities is not clear. Some species may have been nektonic bottom feeders and others probably occupied positions higher in the water column.

These communities replaced each other spatially and temporally as environmental conditions fluctuated. Salinity, temperature, food, and oxygen content probably were relatively uniform in this area. Likely limiting factors were substrate, turbidity, and the gregarious tendency of some species. The oysters and echinoids formed large colonies placed randomly on the substrate partly in response to the tendency of their spat to set among adults. *Kingena* prospered in low turbidity waters.

[244-245]

Depositional Patterns of the Morrow Series (Lower Pennsylvanian) in Northeastern Oklahoma and Northwestern Arkansas

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The type region of the Lower Pennsylvanian Morrow Series in northeastern Oklahoma and northwestern Arkansas is characterized by rapid lateral facies changes. Sediments were deposited on a broad, shallow marine shelf, developed on the southwestern margin of the Ozark uplift. Directly to the south in the subsurface at the margin of the Ouachita geosyncline, the series increases in thickness.

Limestone is the dominant rock type on the outcrop in Oklahoma, whereas eastward into Arkansas, there is a significant increase in thickness and percentage of sandstones and shales, indicating a terrigenous source to the east. The southwesternmost exposure in northeastern Oklahoma includes spiculiferous and siliceous carbonate mudstone resulting from deeper water deposition. All other exposed carbonate rocks represent deposition on a shallow shelf. During early Morrow time, the irregular nature of the underlying eroded Mississippian surface controlled the distribution of tidal channels that cut the shelf, and in which erratically distributed oolitic and quartz sands were deposited, encompassed within a skeletal sand framework.

The middle of the series is marked, near the southwestern shelf margin, by the development of a broad *Archaeolithophyllum* and *Cunei-*

phycus carbonate bank that has high faunal diversity and is cut irregularly by channels of skeletal sands. Northeastward, the faunal diversity of this unit is low, but scattered patch reefs of the coral *Lithostrotionella* occur. The influx of fine terrigenous clastics at times interrupted carbonate deposition, resulting in the accumulation of muds and some silts, especially in the upper portion of the series.

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Depositional Environments in a Pennsylvanian Clastic Sequence

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The Wewoka Fm. (Desmoinesian) in Hughes County, Oklahoma, is composed of alternating shale, claystone and sandstone units. Detailed analysis of fossil assemblages in one shale and claystone interval and study of the overlying sandstone unit indicates five depositional environments that represent a transgressive-regressive sequence.

Large fragments of plant fossils (*Stigmaria, Lepidodendron* and *Calamites*), crossbedding and conglomeratic layers within the sandstone units support a deltaic origin for these units as proposed by Weaver (1954). A tidal flat to marshy area (intertidal to shallow subtidal) along the margin of a shallow epicontinental sea is represented by black pyritic, fossiliferous shale overlying the sandstone. Subtle lithologic changes and marked differences in the fossil assemblages suggest three separate environments within the claystone. In ascending order these are: (1) shallow subtidal, possibly analogous to the enclosed bay area of Parker (1960) or a delta front area (Parker, 1956), represented by a molluscan claystone, (2) subtidal (farthest from shore), possibly analogous to a prodelta region or the central portion of an open bay, represented by a brachiopodal claystone and (3) return of nearshore subtidal conditions represented by a silty, foraminiferal claystone (underlying the next higher sandstone).

Examination of shale and claystone sequences above and below the one studied in detail suggest that there is a cyclicity of these environments within the Wewoka Formation. Fluctuations in the amount and type of terrigenous clastics carried into the area by streams may be the primary key to this cyclicity.

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Palynological Evidence for a Pennsylvanian Age Assignment of the Gearyan Series in Kansas and Oklahoma

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The systemic assignment of the Gearyan Series in Kansas and Oklahoma has been a matter of discussion for many years. Placement of the series has varied from Upper Pennsylvanian to Lower Permian, based upon evidence derived from vertebrate and invertebrate faunas. Plant evidence for age determination was not fully explored until palynological studies were begun 17 years ago on Pennsylvanian strata in Oklahoma and Kansas. Subsequently these studies were extended to the Permian rocks; then the age of the Gearyan Series became a crucial question. For the investigation reported here, palynological collections were made at 88 locations in all lithologies and parts of the Gearyan Series in Oklahoma and Kansas. Samples from 34 localities contained palynomorphs. These fossils have been described and compared with palynomorphs occurring in Pennsylvanian strata below and Permian strata above. Although a small number of genera and species of palynomorphs in the Gearyan strata extend upward into the El Reno Group (Permian), most of these are also present below in the Missourian and Virgilian Series (Pennsylvanian). The preponderance of Gearyan palynomorphs is distributed widely through Pennsylvanian rocks, as low stratigraphically as the middle portion of the Desmoinesian Series. Palynological evidence, therefore, supports an assignment of the Gearyan Series to the Pennsylvanian System.

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