Cover Picture

Lungfish Burrows in Dolomite of the Wellington Formation

The Permian Wellington Formation in north-central Oklahoma contains a rich variety of fossil forms that include vertebrates and arthropods such as insects, conchostracans, horseshoe crabs, and eurypterids. Fish, amphibian, and reptile remains from the Wellington have been cataloged by E. C. Olson in *Early Permian Vertebrates of Oklahoma* (1967, Oklahoma Geol. Survey Circ. 74, 111 p.).

Innumerable fragments of the lungfish *Gnathorhiza* have been found at Perry site 1 (SW¼ NE¼ sec. 10, T. 21 N., R. 2 W., Noble County) of Olson, who described the area as "one of the richest Permian vertebrate sites in the United States." The cover photograph shows an example of the lungfish burrows in a dolomite sample from the Wellington Formation at Perry site 1. In the photograph, vertical order has been reversed to show the cylindrical, downward-extending burrows, which in the field are as much as 6 inches in diameter and 1 foot in length. The burrows, in red clayey dolomite, project downward into red shale, and lungfish fragments are abundant in the burrows. Apparently, in order to escape desiccation during dry seasons, lungfish burrowed downward in muddy flats of supratidal or flood-basin ponds. According to K. J. Carlson (Jour. Geology, 1968, v. 76, p. 641-663), the lungfish used its mouth in burrowing and stood on its tail in the burrow during estivation.

—*John W. Shelton*

(Photograph by Robert L. McCulloh)

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(Photograph by Robert L. McCulloh)

Clay Petrology and Zonation of the Uppermost Shale Member of the Ada Formation (Pennsylvanian) Seminole and Pontotoc Counties, Oklahoma

Assad Iranpanah[1]

INTRODUCTION

The Ada Formation of Late Pennsylvanian age crops out in a north-south belt 1-4 miles wide in Seminole and Pontotoc Counties, Oklahoma. In this area it has been divided into a lower sandstone member, a middle conglomerate member, an upper sandstone member, and an uppermost shale member. Typical shale of the uppermost member crops out on the north side of the Canadian River bridge on State Highway 99 (measured sec. B, fig. 1; fig. 2) and consists of dark-gray, yellow-gray, pale-red, and grayish-orange shales interbedded with fine-grained calcareous sandstones.

The uppermost shale member of the Ada Formation is itself divisible into four distinctive units, based on clay mineralogy: a lowermost shale unit, a lower shale unit, an upper shale unit, and an uppermost shale unit. The shale units are poorly fissile to nonfissile and platy to nodular bedded.

The petrographic investigation of these shale units of the uppermost shale member shows that they are composed of nonoriented clays containing microscopic clay galls and some silicified fossil fragments. Except for the lower shale unit, which is slightly cemented by calcite, the rest of the shale units are moderately to well cemented by calcite and some dolomite. The shale units contain appreciable amounts of silt-sized detrital quartz and are moderately to poorly indurated. The shale units also contain some marl and limestone locally.

The mineralogical composition of the clay-mineral content of the Ada shales was determined by X-ray diffraction. Supplemental data were obtained by differential thermal analyses. These analyses show that the Ada shales have gradations in clay-mineral content. The clay-size fraction of the shales consists of five major clay minerals: montmorillonite, illite, mixed-layer illite-montmorillonite, chlorite, and kaolinite.

CLAY MINERALOGY OF SHALE UNITS

Lowermost shale unit.—Montmorillonite predominates in the lowermost unit (B-13, fig. 2) of the uppermost shale member and is associated with some kaolinite and minor to trace amounts of illite. Chlorite is essentially absent in this unit, and carbonate impurities occur in trace amounts.

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[1]Associate professor and research assistant to the director, Department of Geology, The University of Tehran, Tehran, Iran. This paper is taken from a Ph.D. dissertation completed in 1966 under the direction of Dr. Charles J. Mankin, School of Geology and Geophysics, The University of Oklahoma.

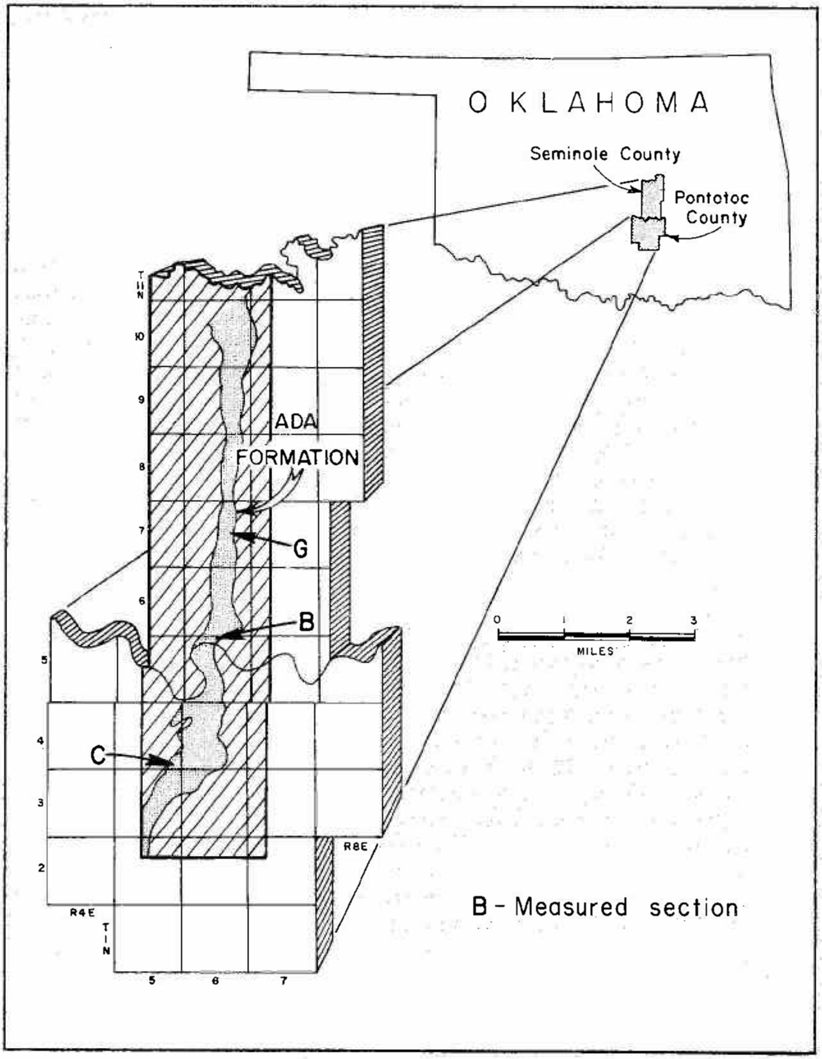

Figure 1. Index map showing generalized outcrop of Ada Formation in Seminole and Pontotoc Counties, Oklahoma.

Lower shale unit.—This is a transition unit (B-14, fig. 2) composed of more illite and kaolinite and associated poorly crystalline Na-montmorillonite. It contains little or no chlorite in its clay-mineral suite.

Upper shale unit.—This unit consists of illite, chlorite, a lesser amount of kaolinite, and some mixed-layer illite-montmorillonite. The

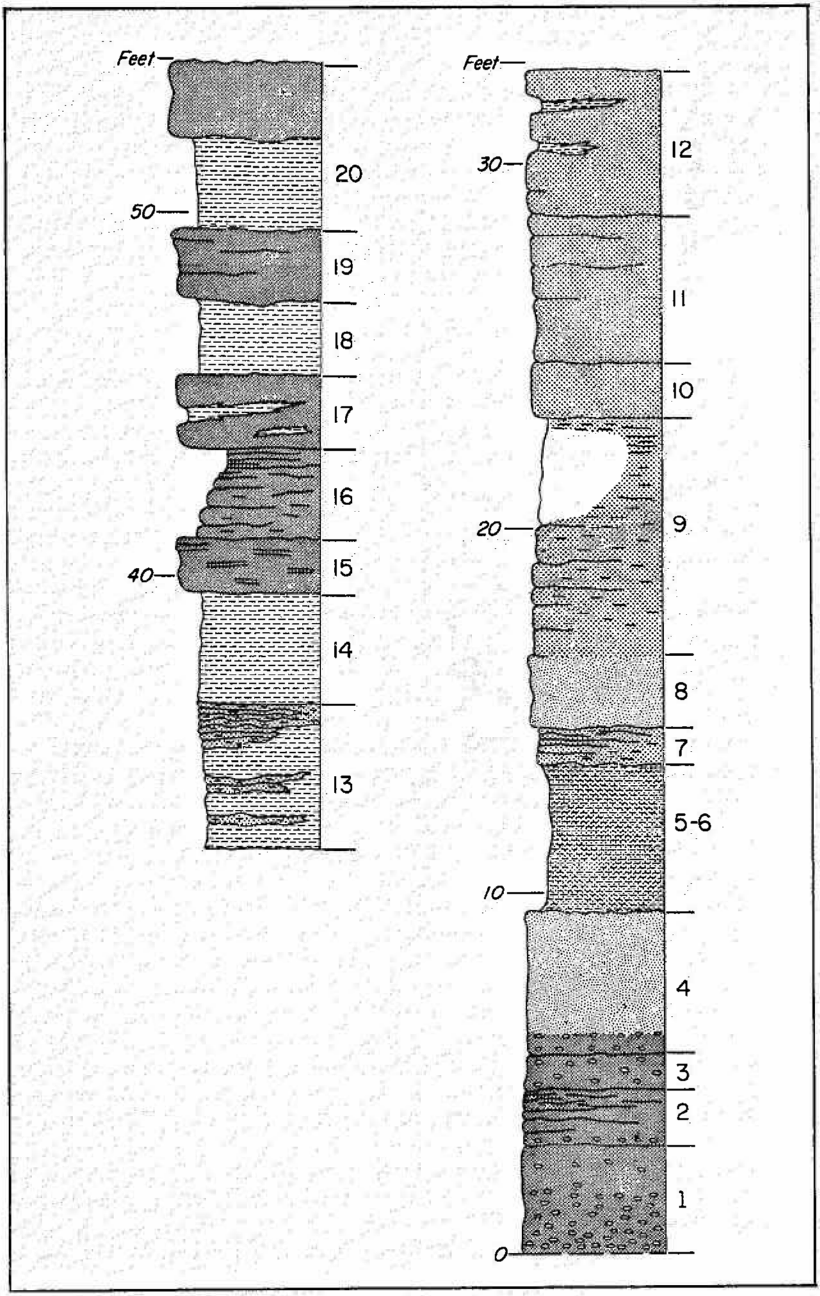

Figure 2. Measured section B of Ada Formation, sec. 4, T. 5 N., R. 6 E. Shale units 13-20 constitute the uppermost shale member.

amount of chlorite and illite increases appreciably from the lower shale unit (B-14, fig. 2) to the upper shale unit (B-16, fig. 2), and montmorillonite decreases. Apparently, in the higher units of the uppermost shale member the coarser clays, such as chlorite, illite, and some kaolinite, predominate and the finer clays (montmorillonite) disappear.

Uppermost shale unit.—The stratigraphically highest unit is well exposed at the top of measured section B (fig. 2) and consists predominantly of mixed-layer illite-montmorillonite, abundant chlorite, and some kaolinite. Examination of the X-ray-diffraction pattern of this unit from measured section G (fig. 1) reveals that chlorite and illite are the major clay constituents.

INTERPRETATION OF CLAY-MINERAL ZONATION

The two main hypotheses concerning the origin and geographic distribution of clay minerals as suggested by many workers are as follows: (1) diagenesis is the primary factor controlling the clay-mineral assemblage; (2) the contribution from the source area is the primary factor.

Distribution of the various clay-mineral constituents in the uppermost shale member of the Ada Formation was examined vertically and laterally along a north-south section. Montmorillonite occurs predominantly in the lowermost unit of the shale member and decreases upward. Illite and chlorite increase toward the top of the shale member. Montmorillonite occurs predominantly in the shales collected from the southern outcrops (measured sec. C, fig. 1). In the northernmost outcrops the clay-mineral suite consists mainly of illite and chlorite.

Assuming that the source materials were the primary factor in determining the character of the marine-clay suite, we have to accept the fact that most of the clay minerals were not altered to any extent in a marine environment. In such a case, the vertical and lateral variation of the clay-mineral suite must have been controlled by the site of active sedimentation, which was shifting to the north and was advancing to the northwest. The clay-mineral suite of the outer neritic environment, which is dominantly composed of montmorillonite (B-13, fig. 2), is overlain by a clay-mineral suite formed dominantly of kaolinite, which is a characteristic suite of nearshore and fluvial environments. This is overlain by clays that commonly are deposited in an inner neritic environment and that are composed of nearly equal amounts of kaolinite, mixed-layer montmorillonite-illite, and chlorite. The chlorite content increases toward the top of the shale member, which is also characteristic of nearshore environments because of the coarse particle size.

Montmorillonite commonly occurs in much smaller particle size than either kaolinite, illite, or chlorite and can be kept in suspension by much weaker agitation. Consequently, kaolinite, illite, and chlorite settle out before montmorillonite if all four are introduced into the depositional environment together from the source area. The process of flocculation, which is controlled by salinity, is also an important factor. Whitehouse (1952) and Whitehouse and Jeffrey (1955) have demonstrated that kaolinite and illite form large floccules in relatively low salinity immediately upon entering the marine environment, whereas montmorillonite requires high salinities and then will only flocculate slowly.

Grim and others (1949) concluded that diagenetic changes were the most important factors in clay-mineral distribution. In this context marine diagenesis was perhaps the most important factor and may be used to explain the variation of the clay-mineral suite in a single environment. However, Grim and Johns (1955), on the basis of their work on the Mississippi delta, concluded that diagenesis was much less important. Montmorillonite, which is one of the clay minerals most susceptible to alteration, is present in the Ada shales in substantial quantity. If diagenesis was the main factor in alteration, the montmorillonite would have been the first to be altered. The examination of the clay-mineral suite of the Ada shales suggests to the writer that the factor of source area is perhaps the most important in determining the mineralogical composition of the clays in the marine environment but that the process of diagenesis must not be neglected. During diagenesis the chemical composition of clays can be modified as a result of chemical equilibration (Degens, 1965). The process of alteration is kinetically slow, but the result is significant when environmental conditions favor alteration over peroids of geologic time. Factors such as increase in weight of overburden (water or rock) and temperature (geothermal gradient) would probably accelerate the reactions (Degens, 1965).

Interpretation of provenance clay petrology indicates that the lateral and vertical distribution of the clay-mineral suite in the uppermost shale member of the Ada Formation was mostly controlled by the source area and was partially related to the process of diagenesis.

The lithologic distribution of the clay minerals in the Ada Formation suggests a shift in active depositional sites during the period of deposition.

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Ham Library Donated to School of Geology and Geophysics

Elizabeth A. Ham, widow of William E. Ham, research geologist and specialist in carbonate rocks and industrial minerals at the Oklahoma Geological Survey, recently donated her late husband's entire library and research and teaching collection of rocks, minerals, thin sections, and color slides to the OU School of Geology and Geophysics. In his expression of gratitude for this material, Charles J. Mankin, director, recognized that this "invaluable collection of earth science materials is a significant addition to our academic program, and we gratefully accept these collections to be held in trust for use by current and future faculty and students."

An evaluation of these materials shows that the entire collection is worth over $16,000, with the library collection amounting to over $3,000 and the research and teaching collection, over $13,000.

The research and teaching collection contains 713 processed and unprocessed rock and mineral specimens, 247 rock thin sections, 1,228 color slides, and 245 color photographs. Coming from the United States, Canada, Bahama Islands, Europe, Africa, Australia, and New Zealand, this is the most complete collection of carbonate rocks in the world.

The library collection consists of many items that are out of print. The following list is a breakdown by general category.

Books	48
Periodicals	16
Professional societies	160
Federal surveys	68
State surveys	217
Foreign	20
Other societies	64
Theses	11

Two Staff Members to Retire This Summer

Planning to retire this summer are two staff members of the Oklahoma Geological Survey.

Lucy Hart Finnerty, librarian for the Geology and Geophysics library, will retire in July. She has served the library, which is maintained jointly by the Survey and the OU School of Geology and Geophysics, for 23 years and will be sorely missed by faculty, staff, and students. In fact, no longer having her detailed knowledge of the shelves readily available will force many of us to depend heavily on the card catalog for the first time! But she has assured us she will be on hand to help train her replacement and to help us individually from time to time.

Odus M. (Bill) Abbott, geological technician for the Survey since January 1967, is planning to retire in August. At that time he and his wife will move to Tulsa, where their two sons are living. The Survey staff wishes him well and will miss his quiet, efficient service.

Monument Dedicated at Midwestern SEG Meeting

A highlight of the 24th Annual Meeting of the Midwestern Societies of the Society of Exploration Geophysicists, held in Oklahoma City, April 1 and 2, was the dedication of a monument commemorating the 50th anniversary of the first successful test of the reflection seismograph, one of the most important exploration tools the petroleum industry has ever known. The monument, erected at the site of the successful field experiment of June 4, 1921, is located now on the grounds of the Belle Isle Library near May Avenue and Northwest Expressway in northwest Oklahoma City.

Present at the dedication ceremony were J. C. Karcher, one of the four principals of the original experiment; W. R. Wolfe, president of the Geophysical Society of Oklahoma City, the host society for the meeting; and W. B. Robinson, national president of SEG and an Oklahoma City geophysicist.

Two Oklahoma Geological Survey geologists, Kenneth S. Johnson and Robert O. Fay, played an important part in supplying blocks for the monument from Arbuckle Mountain outcrops of formations used as principal mapping units in the subsurface. These units include the Sycamore, Hunton, Viola, and Arbuckle. Fittingly, the base of the monument is made of Tishomingo Granite, the well-known basement of the subsurface.

Trace-Fossil Study of Ouachita Geosyncline Published

The results of an Oklahoma study by C. Kent Chamberlain were published in the January 1971 *Bulletin* of The American Association of Petroleum Geologists (p. 34-50); the paper is entitled "Bathymetry and Paleoecology of Ouachita Geosyncline of Southeastern Oklahoma as Determined from Trace Fossils." Among the findings of the report were that trace-fossil assemblages from rocks of the Ouachita Mountains define a basin-to-shoal bathymetric profile, and in the central Ouachitas trace-fossil assemblages are persistent through approximately 25,000 feet of Mississippian-Pennsylvanian rocks, attesting to the continuous hospitability of a flysch environment.

The Oklahoma Geological Survey paid for field expenses and research materials for the project in 1967 and 1968. The late Lewis M. Cline, professor of geology at The University of Wisconsin, acted as field-area advisor.

New Theses Added to OU Geology Library

The following master's theses have been added to The University of Oklahoma Geology Library recently:

Master of Science Theses

Subsurface stratigraphic analysis, Lower "Cherokee" group, portions of Alfalfa, Major and Woods Counties, Oklahoma, by Garth M. Lyon.

A comparison of waterflood performance characteristics for Pennsylvanian sands, by Thomas N. Miller.

Highway Geology Symposium Held in Norman

The Oklahoma State Highway Department and the Oklahoma Geological Survey cosponsored the 22nd Annual Highway Geology Symposium, which was held in Norman at the Oklahoma Center for Continuing Education on The University of Oklahoma campus April 22 and 23. The symposium attracted some 110 geologists, engineers, and other interested participants from points throughout the country and as far away as Puerto Rico.

A highly successful field trip was conducted on April 22 through the geologically complex Arbuckle Mountains and steeply dipping beds of the Ardmore basin to study related engineering problems in road and bridge construction on I-35 and U.S. 77. Field-trip leaders were Robert O. Fay, Kenneth S. Johnson, and L. R. Wilson, Oklahoma Geological Survey; Gerald J. Petzel, graduate student, OU School of Geology and Geophysics; and Curtis Hayes, Willard McCasland, and

Stuart Ronald, Oklahoma State Highway Department. A limited number of copies of the guidebook prepared for the trip will be available from the Survey for a distribution charge of 50 cents.

The annual banquet followed the field trip, at which the featured speaker was Newell J. Trask of the Branch of Astrogeologic Studies of the U.S. Geological Survey, Menlo Park, California. His topic was "Lunar Geology: The First Billion Years" and dealt mainly with attempts to unravel the stratigraphy of those moon rocks that are older than any known rocks on earth, both from photogeological studies and from study of returned lunar samples.

The meeting on April 23 comprised morning and afternoon technical sessions in the OCCE Forum Building, presided over by the meeting cochairmen, Mitchell D. Smith, physical science engineer with the Highway Department, and Charles J. Mankin, director of the Survey. The morning session began with a welcome from Chester Brooks, director of the Highway Department. The technical papers covered a wide range of subjects and dealt with problems encountered not only in the United States but also in Africa and South America. The proceedings will be printed by the Highway Department and distributed to the participants later this year.

Next year's meeting has been planned for Charlottesville, Virginia, and will be under the chairmanship of Michael A. Ozol, head of the Geology Section, Virginia Highway Research Council. Detailed arrangements will be announced later.

OKLAHOMA ABSTRACTS

University of Nebraska

Stratigraphy of the Everton Formation (Early Medial Ordovician) Along the Buffalo-White River Traverse, Northern Arkansas [Simpson Group equivalent]

RAYMOND W. SUHM, University of Nebraska, Ph.D. dissertation, 1970

The Everton is spectacularly exposed and ranges in thickness from 350 to 650 feet along the walls of the great gorges formed by the Buffalo and White rivers in north-central Arkansas, at the south

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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.

edge of the Ozark region. It rests unconformably upon the Powell Dolomite (Canadian) and is overlain by the so-called "St. Peter" Sandstones ("Chazy"), so it may be considered as of about "Early Chazy" age. Since the Everton seems to be a complex fully as complicated as the "St. Peter", it probably required about equivalent time for its deposition. In any case, the Everton has been largely ignored in standard classifications, and it essentially fills the great hiatus usually considered to occur at the major unconformity between the Sauk and Tippecanoe Sequences. Perhaps the Everton and "St. Peter" eventually should be ranked as Substages of the "Chazy" in the southern Midcontinent.

Twenty-four geologic sections have been measured and plotted for the 75-mile west-east traverse along the gorges, and eight members defined. These are, from oldest to youngest: (1) Sneeds Dolomite; (2) Kings River Sandstone; (3) Unnamed Limestone-Sandstone Member A, perhaps a lateral equivalent of the Kings River; (4) Calico Rock Sandstone, also perhaps laterally equivalent to the Kings River; (5) Unnamed Limestone-Sandstone and Dolomite Members B, B′, and B″; (6) Newton Sandstone, mostly younger than the preceding; (7) Unnamed Dolomitic Sandstone-Dolomite Member C; and (8) Jasper Limestone-Sandstone and Dolomite.

Everton lithology may be described in terms of a triangular plot of three end-members: *sandstone, limestone,* and *dolomite,* with the latter dominating. Additionally, *stromatolites, conglomerates,* and *breccias* are minor constituents.

The *sandstones* are considered to be of two types: (1) massive to thin-bedded, of "St. Peter" type, well described by Giles (1930); and (2) medium- to thick-bedded dolomitic sandstone. The former is characteristic of the Kings River, Calico Rock, and Newton, as well as of sandstones in Members A and B and at the base of the Jasper. The latter is essentially confined to the Sneeds and to Members B″ and C and seems to be unlike sandstone in other formations of the region.

The *limestones* likewise can be divided into two groups, both of which resemble the Plattin in that they are light gray and break with a conchoidal fracture, but may contain quartz grains: (1) calcarenite, which would be at first mistaken for sublithographic limestone if not immersed in acid or water, and characterized by pellets, intraclasts, oolites, or ostracodes; and (2) calcilutite, including both lithographic and sublithographic types.

The *dolomites* may be classified into five groups, some of which are like those of the Joachim: (1) medium-crystalline ("sucrose"); (2) dolarenite; (3) well-laminated and mud-cracked; (4) very-fine to finely-crystalline, the most important dolomitic lithology in the Everton; and (5) cherty dolomite.

Less common lithologies found in the Everton include *stromatolites,* which occur in limestone, dolomite, and sandstone, and *conglomerates,* as well as *breccias.*

Most of these sediments seem to have accumulated in relatively shallow water, and possibly beach sand may be present, but principal sedimentation was probably offshore, marginal to the Ouachita geosynclinal belts and cratonic edge. Disconformities occur throughout the

Everton, but in addition to the unconformities at bottom (base of Sneeds) and top (base of "St. Peter"), there are five others, at the base of each of the following, at least in places: Members A and B, Calico Rock, Newton, and Jasper. It now seems likely that these divisions can be traced into Oklahoma and Missouri, developing a regional picture for the Everton similar to that presented by Dapples (1955) for the "St. Peter" Sandstones.

GSA ANNUAL MEETING, NORTH-CENTRAL SECTION
LINCOLN, NEBRASKA, APRIL 29-MAY 1, 1971

The following abstract is reprinted from the North-Central Section Program of The Geological Society of America and Associated Societies, v. 3, no. 4. Page numbers are given in brackets below the abstract. Permission of the author and of Mrs. Jo Fogelberg, managing editor of GSA, to reproduce this abstract is gratefully acknowledged.

Phylloid Algal-Mound Complexes in the Ervine Creek Limestone (Late Pennsylvanian) in Southeastern Kansas

ALLAN D. GRIESEMER, University of Nebraska State Museum, Lincoln, Nebraska 68508

The Late Pennsylvanian (Virgil Series) Ervine Creek Limestone is a member of the Deer Creek Formation of the Shawnee Group. The Ervine Creek is directly underlain by the Larsh-Burroak Shale and overlain by the Calhoun Shale from southeastern Nebraska to correlative beds in Oklahoma.

Previous workers, primarily in Missourian age rocks of eastern Kansas and northeastern Oklahoma, have noted the presence of phylloid algal mounds which produce exaggerated unit thicknesses up to four times that normally expected. Although such algal mound complexes appear to have been less common in the Midcontinent in Virgilian time, a study of the Ervine Creek revealed extensive algal mounds in Greenwood and Elk Counties of southern Kansas. In the area of Hilltop, Kansas, in northern Greenwood County, the mounds developed over previously formed megaripples in the underlying Larsh-Burroak Shale. The troughs and crests of the megaripples were accentuated rather than masked by the subsequent algal growth; in fact, the troughs may have served to move tidal waters on and off the elevated mounds.

Apparently, the most prominent mound complexes in Ervine Creek rocks were restricted to the Greenwood and Elk County region where up to double normal member thicknesses developed.

[263-264]

GSA ANNUAL MEETING, SOUTHEASTERN SECTION
BLACKSBURG, VIRGINIA, MAY 5-8, 1971

The following abstracts are reprinted from the Southeastern Section Program of The Geological Society of America and Associated Societies, v. 3, no. 5. 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.

Dissepimental Coral Zonation of Upper Pennsylvanian Rocks of Oklahoma

J. M. COCKE, L. D. HAYNES, and J. L. MOLINARY, Department of Geology, East Tennessee State University, Johnson City, Tennessee 37601

The dissepimental corals *Neokoninckophyllum, Dibunophyllum* and *Geyerophyllum* occur abundantly in Missourian limestones of Kansas and Oklahoma. Four zones based on these genera have recently been recognized in Kansas; two of these, Zones 1 and 4, are definitely identified in northeastern Oklahoma. Zone 2 has not been identified in Oklahoma. Recognition of Zone 3 is not centain but corals related to its enclosed fauna are present.

Diagnostic of Zone 1 is *Neokoninckophyllum tushanense*. This species is abundant in the Lost City Limestone of Oklahoma. Further, this limestone contains an undescribed species of *Dibunophyllum* which is morphologically intermediate between *D. bourbonense* and *D. hystricosum* of Zone 1.

Geyerophyllids from the Oklahoma Dewey and Avant Limestones resemble *G. patulum* which occurs in the upper part of Zone 1; however, they show affinities to corals of Zone 3 and 4. Dewey dibunophyllids may be ancestral to *D. valeriae* of Zone 4. The lower limit of Zone 4 in Kansas is marked by the first occurrence of *D. parvum;* this species evolved to *D. dibolium* in the upper part of the zone. *Dibunophyllum parvum* has been collected in Oklahoma from an unidentified limestone. A limestone lentil in the Oklahoma Wann Formation contains *D. dibolium* and *D. valeriae,* a species which ranges through Zone 4.

[303-304]

Structure of the Buried Southwestern Appalachian System Beneath the Gulf Coastal Plain

WILLIAM A. THOMAS, Department of Earth and Environmental Sciences, Queens College, City University of New York, Flushing, New York 11367

Appalachian structures extend from the outcrop southwestward beneath Mesozoic coastal plain beds in western Alabama and eastern Mississippi. Subcrop data from exploratory wells outline major components of the structural system and generally define the strike. Southwest-trending parallel belts include metamorphic rocks to the southeast in Alabama; low-grade metasedimentary rocks in the middle; and, on the northwest, sedimentary rocks in at least three elongate folds or thrust blocks. The boundary between metasedimentary rocks and deformed unmetamorphosed sedimentary rocks extends southwestward along strike into western Alabama from the exposed Talladega metamorphic front in central Alabama. Strike of the sedimentary rocks is parallel with the metamorphic front; but, in eastern Mississippi, where a major depression crosses the system, strike apparently curves to the west.

Much of the subsurface pre-Mesozoic sequence is lithologically similar to formations of the Alabama Appalachian outcrops; however, tongues of rocks comparable to the Arkansas Ouachita facies are progressively prominent toward the west in Mississippi. The few wells west of central Mississippi have penetrated only fine clastic rocks of the Ouachita sequence. Slaty cleavage in some rocks of the Ouachita facies extends farther north than the projected strike position of the most northerly Appalachian structures of eastern Mississippi. (Approved for publication by the State Geologist, Geological Survey of Alabama.)

[351-352]

Lower Ordovician Stratigraphy at Smithville, Arkansas, and Adjacent Areas

O. A. WISE, JR., Arkansas Geological Commission, Little Rock, Arkansas 72201, and E. L. YOCHELSON, U.S. Geological Survey, Washington, D. C. 20242

At Smithville, Arkansas, the Smithville Formation is now known to be the lateral equivalent of the Black Rock Formation. Previously the Black Rock had been considered to be an overlying unit of youngest Early Ordovician age. The fauna of the Smithville is predominantly one of vagrant mollusks, whereas the Black Rock fauna is primarily one of sessile colonial organisms. In spite of these profound differences, intermixing of forms is sufficient to support the conclusion of contemporaneity based on physical stratigraphy. One species of the gastropod *Ceratopea* is particularly useful in identifying the Smithville; the occurrence of other species establishes trend lines of older units which parallel the outcrop pattern of combined Smithville-Black Rock. The Smithville fauna is correlated with that of the upper part of the West Spring Creek Formation in Oklahoma and also shows some similarity to that of the Odenville Limestone in Alabama.

[361]

AAPG-SEPM Annual Meeting, Rocky Mountain Section Billings, Montana, May 2-5, 1971

The following abstract is reprinted from the March 1971 issue, v. 55, of the *Bulletin* of The American Association of Petroleum Geologists. The page number appears in brackets below the abstract. Permission of the author and of A. A. Meyerhoff, managing editor of AAPG, is gratefully acknowledged.

Depositional Patterns in Middle Permian Strata of Central Western United States

FRED F. MEISSNER, Shell Oil Co., Denver, Colorado

Sedimentary strata of Middle Permian age (Guadalupian—uppermost Leonardian?) in the central western United States (Montana-North Dakota to Arizona-West Texas) contain a variety of rock types,

including carbonates, evaporites, and terrigenous clastics. These strata include such group or formational units as Phosphoria, Park City, Goose Egg (Wyoming); Taloga, Whitehorse, Blaine (Kansas, Oklahoma); Artesia, San Andres (West Texas, New Mexico); and Kaibab (Arizona). These sediments were deposited on a broad cratonic shelf which underwent differential subsidence and which was bounded by a continental upland on the east and by deep-water seas on the west and south. Lithologic patterns within the strata are characterized by profound lateral facies changes and cyclical repetitions in vertical sequence. Lateral lithofacies changes are related to a broad range of depositional environments and processes, many of which may be identified. These lithofacies changes control the accumulation of major quantities of oil and gas. Cyclic repetitions of lithology in vertical sequences of the strata are related to periods of transgression and regression produced by changes in sediment productivity and sea level. These changes may have been controlled by both global tectonic instability and polar glaciation. Regional correlations based on the cyclicity of the strata seem reasonable and suggest that several of the major depositional cycles identified in widely scattered parts of the central western United States may be synchronous.

[539]

OKLAHOMA GEOLOGY NOTES

Volume 31 June 1971 Number 3

IN THIS ISSUE

Page

Clay Petrology and Zonation of the Uppermost Shale Member of the Ada Formation (Pennsylvanian), Seminole and Pontotoc Counties, Oklahoma
ASSAD IRANPANAH 51

Lungfish Burrows in Dolomite of the Wellington Formation 50
Ham Library Donated to School of Geology and Geophysics 56
Two Staff Members to Retire This Summer 56
Monument Dedicated at Midwestern SEG Meeting 57
Trace-Fossil Study of Ouachita Geosyncline Published 58
New Theses Added to OU Geology Library 58
Highway Geology Symposium Held in Norman 58
Oklahoma Abstracts 59
University of Nebraska 59
GSA Annual Meeting, North-Central Section 61
GSA Annual Meeting, Southeastern Section 61
AAPG-SEPM Annual Meeting, Rocky Mountain Section 63