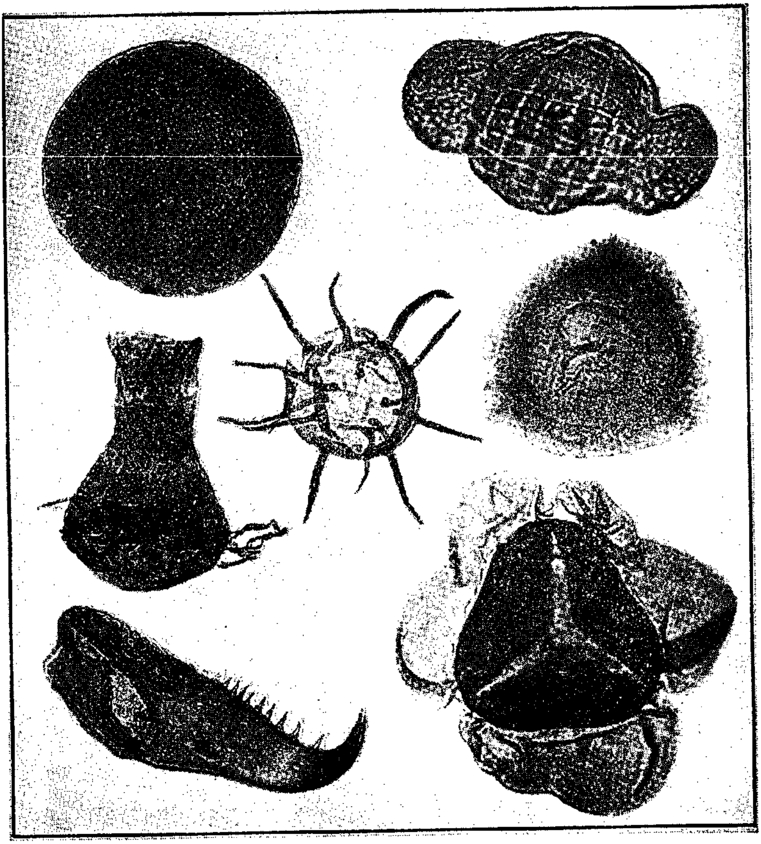
OKLAHOMA GEOLOGY NOTES



OKLAHOMA GEOLOGICAL SURVEY

NORMAN, OKLAHOMA

VOLUME 20, NUMBER 10

OCTOBER, 1960

SUBSCRIPTION $2.00

SINGLE NUMBER $0.25

Paleobotanists Visit Oklahoma

In conjunction with the 11th Annual Meetings of the American Institute of Biological Sciences, held at Stillwater in August, the Paleobotanical Section of the Botanical Society of America sponsored a paleobotanical field trip through Oklahoma on August 26-27. The trip was organized by the Oklahoma Geological Survey, under the leadership of Dr. L. R. Wilson. The group was composed of 35 people, representing 7 oil companies, 11 universities, 3 geological surveys, and 1 private laboratory.

The group is pictured here on the occasion of its visit to the palynology laboratory of the Oklahoma Geological Survey, the first stop of the 580-mile, two-day trip. The Survey presented each member of the group with a guidebook containing a short description of the physiography, geology, and botanical history of Oklahoma as well as road logs of the route followed from Stillwater, through Norman, Davis, and Madill to Lake Texoma (first day) and from Lake Texoma, through Ada, Eufaula, Muskogee, and Tulsa to Stillwater (second day). A few extra copies of the guidebook are available for purchase from the Survey at $1.00 each.

Standing (left to right)

Harry Leffingwell—Jersey Production Research Company
Harold Cousminer—Gulf Oil Company
Delbert Potter—Sinclair Research Laboratory
Mrs. Gilbert Leisman—visitor
Glenn Rouse—Univ. of British Columbia
Robert Page—Stanford University
Theodore Delevoryas—Yale University
Gilbert Leisman—Kansas State Teachers College
Charles Beck—University of Michigan
Clara Hires—Mistaire Laboratories
David Dilcher—Indiana University
Robert Baxter—University of Kansas
Virginia Page—Stanford University
Luther Norem—Richfield Oil Co.
Arthur Cridland—University of Kansas
Chester A. Arnold—University of Michigan
Thomas Fetters—Indiana University
Uttam Prakash—Birbal Sahni Institute of Paleobotany, India
Byard Hires—student
James Schopf—U. S. Geological Survey
Alex. Nicholson—Oklahoma Geol. Survey
L. R. Wilson—University of Oklahoma
Robert Kosanke—Illinois Geol. Survey
Donald Englehardt—Indiana University

Kneeling (left to right)

Alfred Traverse—Shell Development Co.
Richard Rezak—Shell Development Co.
Frank Staplin—Imperial Oil Company
John Morris—University of Kansas
Tom Rothwell—Richfield Oil Company
Maxine Abbott—University of Cincinnati
John Grayson—Magnolia Oil Company
Alan Graham—University of Michigan
W. S. Hoffmeister—Jersey Production Research Company
C. J. Smiley—Macalester College

THE POSTERIOR INTERRADIUS OF CARBONIFEROUS INADUNATE CRINOIDS OF OKLAHOMA

HARRELL L. STRIMPLE

The number of anal plates, and their arrangement, is one of the main factors used in the identification of various Mississippian, Pennsylvanian, and Permian inadunate crinoids. In 1948, I published a study of variations of the anal plates of *Phanocrinus* Kirk (1937), from the Fayetteville formation, Chester series, Mississippian of northeastern Oklahoma. My findings were remarkably similar to those of Wright (1926) for *Phanocrinus* from the Scottish Lower Carboniferous (Mississippian). There are several examples of variability within a genus, or even a given species, but those based on appreciable numbers of specimens have been summarized under the discussion of *Perimestocrinus hexagonus* Strimple (1952c) from the Wann formation, Ochelata group, Missouri series, Pennsylvanian of northeastern Oklahoma. The statistics known at that time for *Ureocrinus* Wright and Strimple (1945), for *Zeacrinites* Troost (1858), and for *Phanocrinus* disclosed that the dominant variant was "Advanced Type," wherein RA continued to contact the RPB but had migrated to contact LPR.* As anticipated, the next major divergence was loss of contact between RA and RPB, which was termed "Advanced Type A."

In *Phanocrinus calyx* (McCoy, 1849) there is also a strong tendency toward retention of contact between anal X and PB, yet with RA pulling away from the RPB, which is termed "Normal Type A," shown herein under Developmental Trend A (text-fig. 1c). In *Perimestocrinus* Moore and Plummer (1938), a large percentage of the specimens showed a strong tendency toward "Advanced Type A" and a considerable percentage toward "Advanced Type."

Based primarily on known factors disclosed by variability of certain species, the author (1948) proposed the probability of three trends which are: Developmental Trend A, dealing primarily with the early resorbtion of RA and elimination of RX from the dorsal cup; Developmental Trend B, wherein RA becomes the dominant anal plate but may eventually be resorbed; and Developmental Trend C, wherein RA becomes the only anal plate left in the cup. There is now considerably more material for comparisons than had been available previously and I propose to demonstrate the soundness of these earlier conclusions. The illustrations are sketches based on described Mississippian and Pennsylvanian crinoids which are known to occur in Oklahoma. Several new "Type" designations are proposed for readier reference in subsequent studies.

TEXT-FIGURE 1. DEVELOPMENTAL TREND A.

a. *Primitive Type (Normal)*. Example, *Phanocrinus alexanderi* Strimple (1948). A large number of Carboniferous genera have this arrangement of anal plates as a normal characteristic. A few are *Perimestocrinus*, *Plaxocrinus* Moore and Plummer (1938), *Zeacrinites*

* The abbreviations or symbols used here are those recommended by Moore and Laudon (1941). Such terms as "Advanced Type" and "Advanced Type A" are those used by Wright (1926) but are inadequate for more comprehensive studies. They have been used by the author where necessary for comparative purposes.

Troost, *Bronaughocrinus* Strimple (1951c), *Alcimocrinus* Kirk (1938), etc. Anal X is bordered by LPR to the left, RX to the right above, RA to the right below and rests solidly on PB. Anal X extends above the summit of the cup and RX to the right extends even higher. RA is in oblique position, bordered below by the left shoulder of RPB and the right shoulder of PB, to the right above by the lower left side of RPR, directly above by the proximal side of RX and to the left above by the lower right lateral side of anal X.

b. *Special Type B.* Example, *Texacrinus progressus* Strimple (1952a). The RA has established contact with LPR so that anal X is no longer in contact with PB. RX has lost contact with RA, but is still a calyx element. A highly specialized condition is the confluent upper surface formed by anal X and RX. This same type of structure, but with RX still in contact with RA, is illustrated as Extreme Type (1), text-figure 3b.

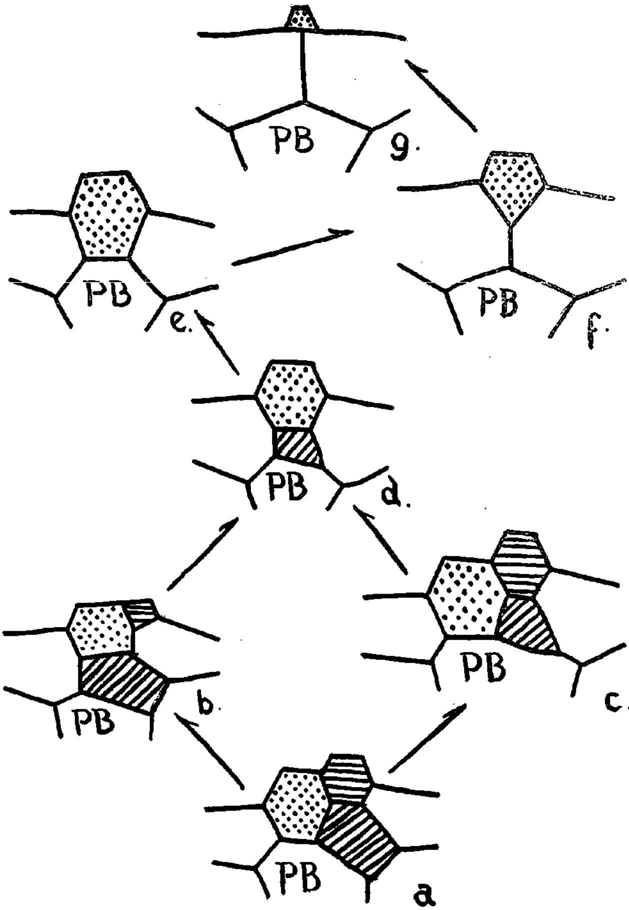
c. *Normal Type A.* Example, *Phanocrinus alexanderi.* This form is a variant wherein the only change is in loss of contact of RA with RPB. The variation is found in *Perimestocrinus*, et al., but has not been used as a specific or generic characteristic to date.

d. *Special Type D (2).* Example, *Phanocrinus irregularis* Strimple (1951b). RA has moved to dominantly posterior position, but is a small plate, and RX has been entirely eliminated from the calyx. This is an example of the early elimination of RX and tendency toward resorbtion of RA. Together with other characteristics, the structure was used as a specific characteristic for *Phanocrinus irregularis* because all specimens of the species found agreed in this respect. The condition has been observed in variants of *Perimestocrinus, Zeacrinites*, et al.

e. *Ultimate Type A.* Example, *Delocrinus subhemisphericus* Moore and Plummer (1940). Anal X is the only anal plate left in the calyx. It is truncated above for the reception of a single tube plate and is in solid contact with PB below. This condition is a generic characteristic for *Delocrinus* Miller and Gurley (1890), *Endelocrinus* Moore and Plummer (1940), et al. Although the upper portion of the anal X in *Apographiocrinus* Moore and Plummer (1940) carries two tube plates it is considered to belong to Developmental Trend A.

f. *Ultimate Type A (1).* Example, *Paradelocrinus dubius* (Mather, 1915). The holotype of this species has an anal plate as illustrated here, but as pointed out by Moore and Plummer (1938), the species normally has only a rudimentary element as found in Symmetrical Type, text-figure 1g. A more typical example is *Euerisocrinus waysidensis* Strimple (1939) from the Stanton limestone formation, Missouri series, Pennsylvanian of southeastern Kansas.

g. *Symmetrical Type.* Example, *Erisocrinus typus* Meek and Worthen (1865). The rudimentary anal plate normally does not enter into the outer lateral walls of the calyx. This condition is characteristic of *Erisocrinus* Meek and Worthen (1865), *Paradelocrinus* Moore and Plummer (1938), *Stuartwellercrinus* Moore and Plummer (1938) et al.

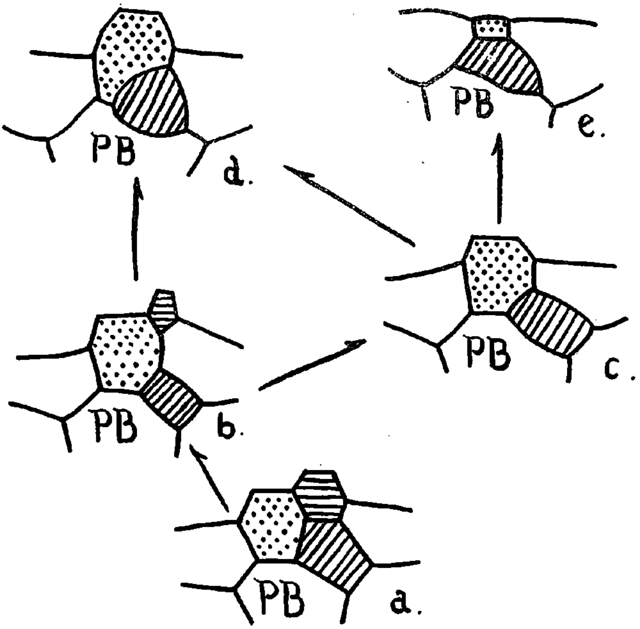


TEXT-FIGURE 1. Developmental Trend A. Stippling indicates anal X, horizontal lines RX, and diagonal lines RA. Arrows indicate probable trends.

TEXT-FIGURE 2. DEVELOPMENTAL TREND B.

a. *Primitive Type (Normal).* Same as text-figure 1a.

b. *Special Type.* Example, *Phanocrinus alexanderi.* This is a variant of the species and is also found in *Perimestocrinus*, et al. Conditions are normal except that RX is being pushed out of the dorsal cup.



TEXT-FIGURE 2. Developmental Trend B. Stippling indicates anal X, horizontal lines RX, and diagonal lines RA. Arrows indicate probable trends.

c. *Special Type C.* Example, *Ethelocrinus plattsburgensis* Strimple (1938). Same as Special Type except that RX is absent. This condition is found in variants of *Phanocrinus, Perimestocrinus,* et al.

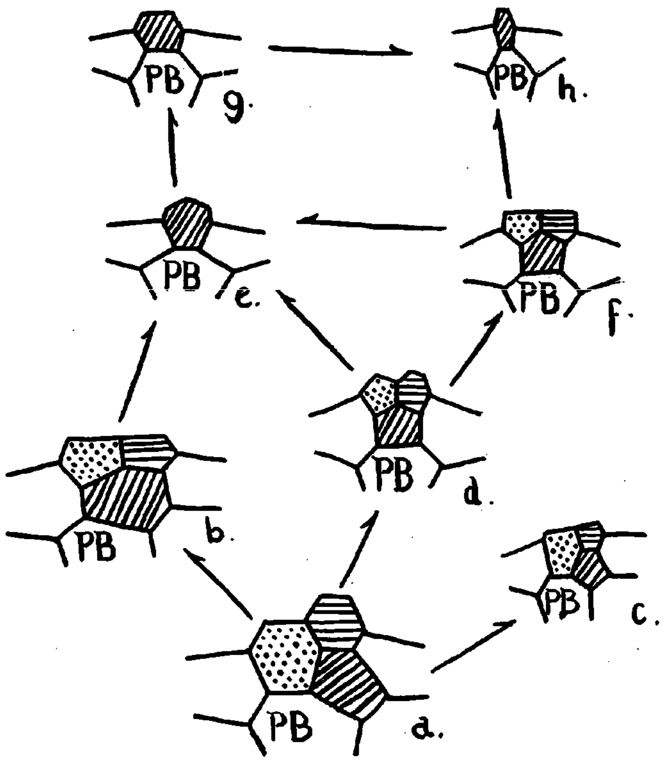
d. *Special Type D.* Example, *Ulocrinus buttsi* Miller and Gurley (1890) after Wright and Strimple (1945). Same as Special Type C, except for loss of contact of RA with RPB. In this case RA is pushing toward contact with LPR but apparently is also being resorbed.

e. *Special Type D-1.* Example, *Ulocrinus buttsi* as reflected by the holotype. Here the RA has established contact with LPR and anal X has become a very small element. Most evidence indicates that this is an unusual condtion for *Ulocrinus.*

TEXT-FIGURE 3. DEVELOPMENTAL TREND C.

a. *Primitive Type (Normal).* Same as text-figures 1a and 2a.

b. *Extreme Type (1).* Example, *Haerteocrinus turbinatus* Strimple (1952b). Same as Extreme Type (text-fig. 3d) except that a confluent, subhorizontal plane is formed by upper extremities of anal X and RX. The structure is typical for most species of *Texacrinus* Moore and Plummer (1940).



TEXT-FIGURE 3. Developmental Trend C. Stippling indicates anal X, horizontal lines RX, and diagonal lines RA. Arrows indicate probable trends.

c. *Primitive Type B.* Example, *Melbacrinus americanus* Strimple (1939). The only change from Primitive Type is the confluent, subhorizontal plane formed by upper extremities of anal X and RX. This same structure is found in *Hydriocrinus pusillus* Trautschold (1867), from the Upper Carboniferous (Pennsylvanian) of Russia, and is usually found in *Elibatocrinus* Moore (1940).

d. *Extreme Type.* Example, *Phanocrinus formosus* (Worthen, 1873). This is a variant of the species wherein RA is in dominant posterior position with anal X and RX as subequal elements above. The condition has been observed in *Perimestocrinus*, et al.

e. *Ultimate Type B (1).* Example, *Aesiocrinus twinensis* (Strimple, 1939). Anal X and RX are entirely eliminated from the dorsal cup, but there are two facets on the remaining anal plate (RA) for the reception of two tube plates. This same structure is found in *Polusocrinus* Strimple (1951a); however, the apex is much lower.

f. *Extreme Type (2).* Example, *Exocrinus multirami* Strimple (1949). This is the same as Extreme Type except that anal X and RX form a confluent, common plane above. This structure is also typical of *Stellarocrinus* Strimple (1940).

g. *Ultimate Type B (2).* Example, *Moundocrinus osagensis* Strimple (1939). It is the same as Ultimate Type B (1) except that the upper extremity of the single anal plate (RA) is truncated for the reception of a single tube plate. In effect it is therefore the same as Ultimate Type A under Developmental Trend A (text-fig. 1e).

h. *Ultimate Type B (3).* Example, *Oklahomacrinus regularis* Strimple (1951a). This is the same as Ultimate Type B (2) except that anal plate (RA) is a very narrow element.

Relationship between the various forms illustrated must not be inferred, although there are some related forms involved. The purpose here is to show the trends involved and to demonstrate the utility of the various manifestations in taxonomic studies.

I have purposely illustrated a few forms wherein a highly specialized condition exists, i. e., anal X and RX are of subequal height and/or form a confluent, subhorizontal plane. This appears to have substantial generic importance and has been observed in the following genera: *Haerteocrinus* Moore and Plummer (1940), *Melbacrinus* Strimple (1939), *Hydriocrinus* Trautschold (1867), *Galateacrinus* Moore (1940), *Exocrinus* Strimple (1949), *Elibatocrinus* and *Stellarocrinus* Strimple (1940). Close affinity between *Haerteocrinus* and *Texacrinus* has previously been suggested by the author (1925b). *Melbacrinus*, *Hydriocrinus* and possibly *Elibatocrinus* appear to be related. *Galateacrinus*, *Exocrinus* and possibly *Stellarocrinus* appear to be related.

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Dr. Motts Joins Survey Staff

On August 23, 1960, Dr. Ward S. Motts became Ground-Water Geologist for the Oklahoma Geological Survey. He graduated from Columbia University in 1949, took his Master's at Minnesota, and his doctorate at Illinois. Dr. Motts worked as a mining geologist in Chihuahua in 1949, as engineering geologist in Chico, California, for the U. S. Bureau of Reclamation from 1951 to 1953, and as ground-water geologist with the U. S. Geological Survey in New Mexico from 1953 to 1960.

Ward has published on ground water of the Carlsbad area, on geomorphology in the Sacramento Mountains, on geology of Pajarito Mountain, and he has completed a paper on the geology of the West Carlsbad quadrangle, and six other papers. He is already busily engaged on Oklahoma ground-water problems.

Tulsa Rock Show

Mr. William O. Proctor, President of the Tulsa Rock and Mineral Society, has announced the forthcoming first big show of that organization. The Tulsa Rock Show will be held on October 21, 22, and 23, 1960, in the Women's Building at the Tulsa State Fair Grounds. The Show, under the chairmanship of Mr. Jim Slack, will have many outstanding exhibits and dealers' displays.

Further information may be obtained by writing to Mr. Slack, 1320 W. Marshall, Tulsa 27, Okla., or to Mr. Proctor, 1224 S. Gary Place, Tulsa 4, Okla.

MAGNETITE-PYROXENE TEXTURES IN BASIC ROCKS FROM THE WICHITA MOUNTAINS

W. L. Hiss and H. E. Hunter

Precambrian or Early Cambrian basic layered accumulative rocks crop out in the core of the Wichita Mountain igneous complex. The rocks comprise anorthosite, feldspathic gabbro, olivine gabbro, and troctolite, and are unquestionably the result of accumulation through gravity settling of crystals from a cooling magma. This has been recognized by several previous investigators (Chase, 1950; Huang and Merritt, 1952, 1954), and has been confirmed by the more recent work of Hiss (1960) and Gilbert (1960). Evidence in support of the accumulative character of the rocks includes rhythmic layering, igneous lamination resulting from planar orientation of minerals, and gravity stratification in which mafic zones grade upward into less mafic zones. The relatively simple mineralogy and textural relationships of primary and interprecipitate minerals are features which characterize layered basic accumulative rocks in many parts of the world.

Clinopyroxene is present throughout the layered series and in most places occurs as coarse ophitic crystals, ranging from 5 cm to 20 cm in diameter. Pyroxene grains, ranging from 0.5 to 50 cm, have been observed. Without exception the clinopyroxene occurs in interstices among subhedral plagioclase grains. The texture ranges from subophitic, where small wedge-shaped grains lie between plagioclase laths, to ophitic, where numerous plagioclase grains are enclosed in a single large grain of pyroxene. Clinopyroxene crystals appear to have uniform composition and, with few exceptions, the plagioclase is unzoned.

Black, opaque oxides, referred to collectively as "magnetite" in this paper, occur sporadically in all parts of the basic rock. Magnetite lies interstitially between the silicate minerals, and in most specimens the magnetite-plagioclase and pyroxene-plagioclase textural relationships are strikingly similar. Magnetite crystals range from small, wedge-shaped grains between laths of plagioclase to masses 20 cm in diameter enclosing plagioclase grains. The term "skeletal" has been used for this texture. Similarity between magnetite-plagioclase and pyroxene-plagioclase texture is illustrated in plate I. Gilbert (1960, p. 22) reports that the largest skeletal magnetite crystals occur in rocks that contain the largest ophitic pyroxene grains.

Similarity of textures suggests a similar genetic history for magnetite and clinopyroxene. Both appear to have crystallized from pore fluid in a plagioclase crystal mush. Lack of zoning in plagioclase or pyroxene indicates that equilibrium was maintained during crystallization and therefore suggests that cooling proceeded slowly. The remarkable size of the pyroxene grains also suggests slow crystallization with the formation of relatively few crystal nuclei in the pore fluid.

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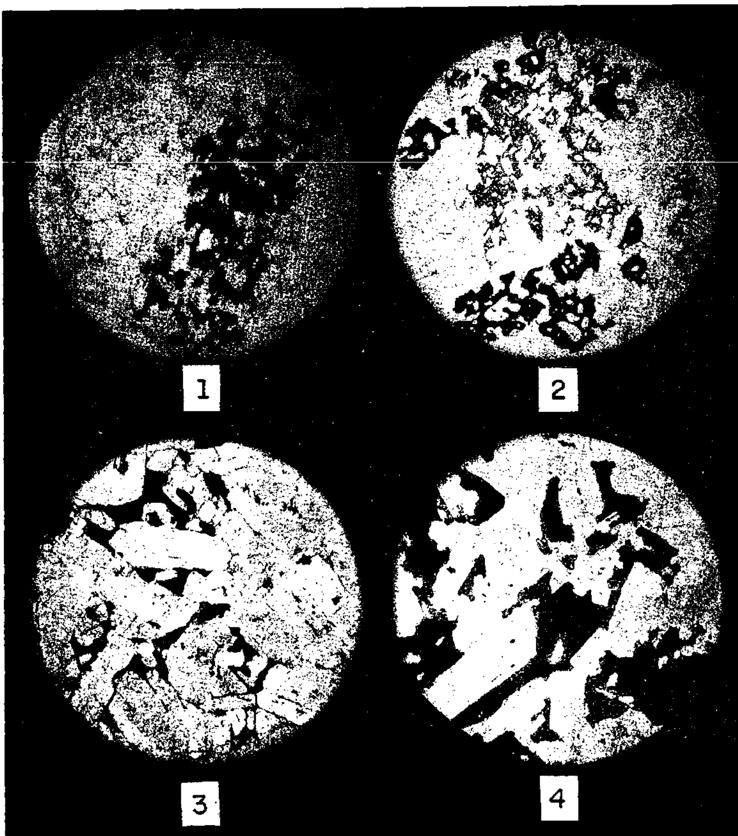

PLATE I

Photomicrographs showing similarity of texture of skeletal magnetite and ophitic clinopyroxene. Width of field 10 mm, x5.

FIGURES 1, 2. Skeletal magnetite in juxtaposition with ophitic clinopyroxene. Magnetite-plagioclase and pyroxene-plagioclase textural relationships are alike.
FIGURE 3. Portion of a large skeletal magnetite crystal.
FIGURE 4. Portion of a large ophitic clinopyroxene crystal. Note textural similarity between figures 3 and 4.

THE "PORES" OF STEPHANOCRINUS CONRAD

ROBERT O. FAY

In order to understand the systematic position of echinoderms belonging to the order Coronata Jaekel, one must understand the nature of the "pores" reported to be present in specimens of this group. Jaekel (1921) erected the order Coronata, which includes six genera (*Mespilocystites* Barrande 1887, *Paracystis* Sjöberg 1915, *Rhombifera* Barrande 1867, *Stephanoblastus* Jaekel 1918, *Stephanocrinus* Conrad 1842, and *Tormoblastus* Jaekel 1927), ranging from Middle Ordovician through Middle Silurian, with the following common characteristics. All have three basal plates, with the azygous one invariably in the right anterior interradial position, five radials with limbs entering into coronal processes above the plane of the peristome, five interradials (?deltoids of some authors) which also extend aborally into the coronal processes and are bordered adorally by five large oral plates, and an anal opening on the inside of the coronal process at the junction of the interradial with the adjacent limbs of two radials (pl. I).

Of the six genera of this order, only specimens of *Stephanocrinus* are well-enough preserved to show detailed morphology, and even in this group it is difficult to find perfect specimens. The specimens selected for this study are those of *Stephanocrinus gemmiformis* Hall, from the Waldron shale, Newsom, Tennessee, and belong to the geology department of the University of Illinois. In this suite of specimens it is possible to see all stages of "pore" development, from those with no pores through those with pores in some interradial areas to those with pores in all interradial areas. Plate I is an illustration of the latter type.

One specimen was selected in which the coronal processes were complete and therefore exhibited no pores. A series of seven parallel transverse sections was prepared through a coronal process, beginning at the top (pl. II, figs. 1-7). The first section shows that a small opening exists immediately below the outer wall of the theca, at the junction of an interradial plate with two adjacent limbs of radial plates (pl. II, fig. 1). The second section reveals two openings, one in the substance of the radial limbs and the other in the substance of the interradial plate at the junction with the radial limbs. In sections 3 and 4 these openings are seen to be larger, and in section 5 they join to form one large elongate opening. In section 6 the opening is larger and is elliptical, and in section 7, below the level of the interradial plate, the opening is seen to be part of the coelomic cavity.

Thus, in reconstructing sections, it is revealed that the "pores" in *Stephanocrinus* are part of the coelomic cavity which bifurcate for a short distance in each coronal process and unite again near the tips of the coronal processes. These extensions of the coelomic cavity do not reach the outer surface except in weathered specimens, in which types "pores" are reported to be present. In some specimens (pl. I), a small opening is present on the anal interradial aboral to the oral opening. This is also an extension of the coelomic cavity and is absent in other specimens. Thus it is possible to read descriptions of pores in specimens of one species in which the pores are reported to be absent or present, varying from none to nine or more, depending upon the state of preservation. In specimens of *Stephanocrinus* the only

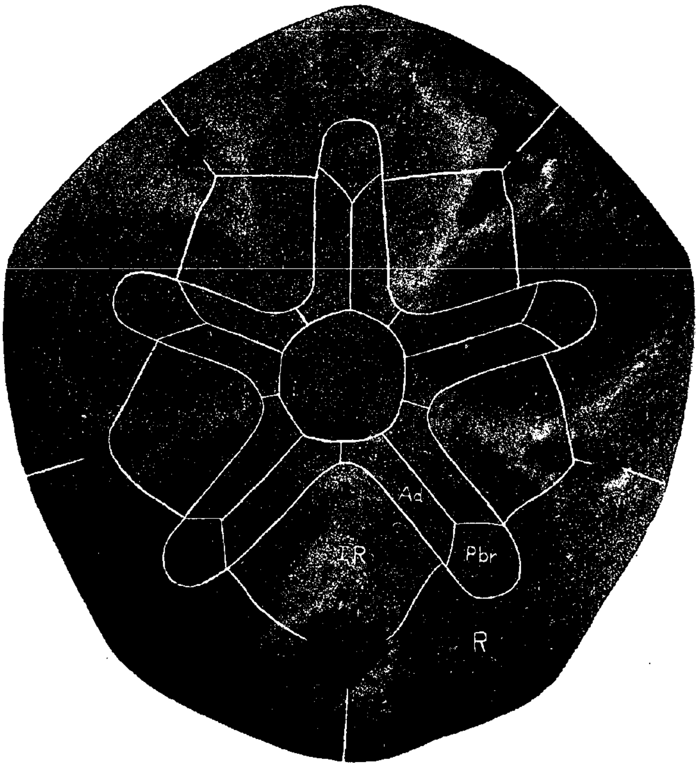

PLATE I

Oral view of *Stephanocrinus gemmiformis* Hall (x17.9), showing "pores" in weathered coronal processes. Anal opening is toward bottom of page. From Waldron shale, Newsom, Tennessee. Ad—adambulacral plate, IR—interradial plate, Pbr—primabrachial plate, R—radial plate. Specimen from the Department of Geology, University of Illinois.

true openings are apparently the oral and anal ones, which is a normal characteristic of this group.

The taxonomic position of the order Coronata is based upon two anatomical features: the pores and the arms. On the basis of pores it is apparent that the Coronata are not related to cystoids, which have diplopores and pore-rhombs, and are not related to blastoids, which have hydrospires. It is a group of stemmed pelmatozoans, closely related to the crinoids, with a thecal structure similar to the blastoids.

Apparently only one specimen has been found in which the arm structures are discernible (Springer, 1926), and if this is correctly illustrated, it

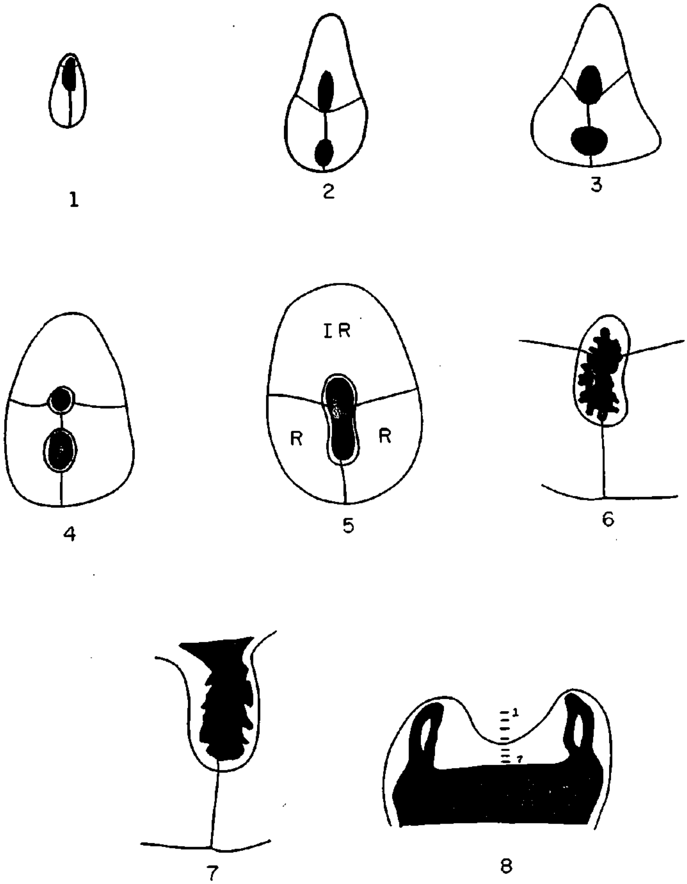

PLATE II

Serial sections through a coronal process of *Stephanocrinus gemmiformis* Hall

FIGURES 1-7. Successive transverse sections through a coronal process, x21.5 R—radial, IR—interradial.

FIGURE 8. Longitudinal section through two "pores," showing positions of successive sections, x6.45.

is evident that the Coronata must be a separate order of the class Crinoidea. The primabrachial is deeply imbedded in the radial sinus, on the ventral cup, followed by a primaxial, with two secundaxials on top. Each of these has a biserial arm extending laterally from one lateral face, with the upper face of each supporting a tertaxial. Each tertaxial has a biserial arm similar to the one below, and each supports a quartaxial, similarly arranged. The last plates are two quintaxials, each with one biserial arm. Thus, according to this interpretation, the arms are similar to those of a crinoid, with ten biserial arms in each ambulacral area, the bases of which are attached to axial plates. The axial plates adjoin each other medially and proximally, and are free above the primabrachial. This type of structure is odd for the known groups of crinoids and for this reason, among others, it seems proper to place the Coronata as a separate order of the Crinoidea, of equal rank with the Inadunata, Camerata, Flexibilia, and Articulata.

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A RESTRICTED BIOFACIES

CARL C. BRANSON

Many fossiliferous rock units are known in which there is an overwhelming predominance of one fossil species in the fauna. The abundance of *Atrypa* in some Devonian formations, of *Composita* in some Pennsylvanian formations, and of *Orthostrophia strophomenoides* in the Haragan marlstone are some examples. Most of these assemblages contain large numbers of specimens of a variety of other forms in addition to the dominant species. A fine collecting locality is currently available in the waste heaps of the Peerless Stone Company quarry in sec. 31, T. 28 N., R. 16 E., Nowata County, 1½ miles north of Lenapah and east of U. S. Highway 169. The quarry face in the Lenapah limestone is stripped back to eliminate the Sni Mills limestone, 7 feet thick. The Perry Farm shale, 13 inches thick, is the fossil-bearing bed, and it is hauled to the waste heaps where weathering frees the fossils. Below the Perry Farm shale is the Norfleet limestone member, 20 feet thick, which is the quarry rock.

In the course of more than one hour of collecting I recently recovered a faunule consisting of 143 specimens of *Desmoinesia muricatina* (Dunbar and Condra) and of specimens of a few other organisms. The collection did not include five species reported by Cade (1952). It did not include specimens of one species collected by L. R. Wilson, who accompanied me, nor of another species collected by me on an earlier occasion, nor of fusulinids found by an oil-company geologist.

The faunule collected by me consisted of:

Crinoidea	
stem ossicles	5
Brachiopoda	
Desmoinesia muricatina	143
Leiorhynchus rockymontanum	1
"*Dictyoclostus*" sp.	1
Juresania nebraskensis	1
Chonetes sp.	5
Composita subtilita	12
Cleiothyridina sp.	4
Lophophyllidium sp.	1
Crurithyris sp.	1
Hustedia mormoni	1
Cephalopoda	
Metacoceras sp.	1
Total	176

In addition to the above, the following seven species have been collected by others and by me, at an earlier time:

Foraminifera	
primitive fusulinids	by an oil-company geologist
Porifera	
Girtycoelia typica	by Cade
Crinoidea	
Erisocrinus sp.	by Branson
Brachiopoda	
Neospirifer texanus	by Cade
Dielasma bovidens	by Cade
Punctospirifer kentuckyensis	by Cade
Trilobita	
Griffithides sp.	by Cade
Griffithides sp.	by Wilson

The predominance of *Desmoinesia* and the scant representation of other species is striking. Of the 14 known brachiopod species only one specimen of each of six species was found, and three found by Cade were not seen. Only five crinoid stem segments were collected to represent that group, although a crown was collected in 1951. The cephalopods are represented by a single specimen of a nautiloid, and the sponge and the trilobite were not in the collection. The shells accumulated in the mud which covered and filled in between the calcareous algae which made up most of the lower part of the member, or of the top of the Norfleet member as Cade supposed.

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CHLORITE, VERMICULITE, AND TALC FROM WEBSTER, NORTH CAROLINA

C. J. MANKIN AND M. M. CASSIDY

During the first week in April 1960, The University of Oklahoma, School of Geology sponsored a spring field trip to the Southern Appalachian Mountains. One stop on this trip was the dunite deposit at Webster, North Carolina. This deposit, in the Blue Ridge Mountains, is a part of the peridotite belt which extends for about 300 miles from northern Georgia through western North Carolina.

The first comprehensive work on the peridotite belt was by Pratt and Lewis (1905), but Williams (1890), in a publication on the basic rocks of Maryland, described some samples from the Webster locality to which he gave the name websterite (a basic igneous rock composed essentially of ortho- and clinopyroxenes). In 1925 Ross and Shannon described a waxy green alteration product of the dunite. They interpreted this mineral as being a nickeliferous variety of deweylite (p. 445). In a later paper (1926) they described the occurrence of nickeliferous vermiculite from the same locality. Gruner (1934) in a comprehensive study of the vermiculite structure included samples from the Webster deposit. The most recent comprehensive paper on the peri-

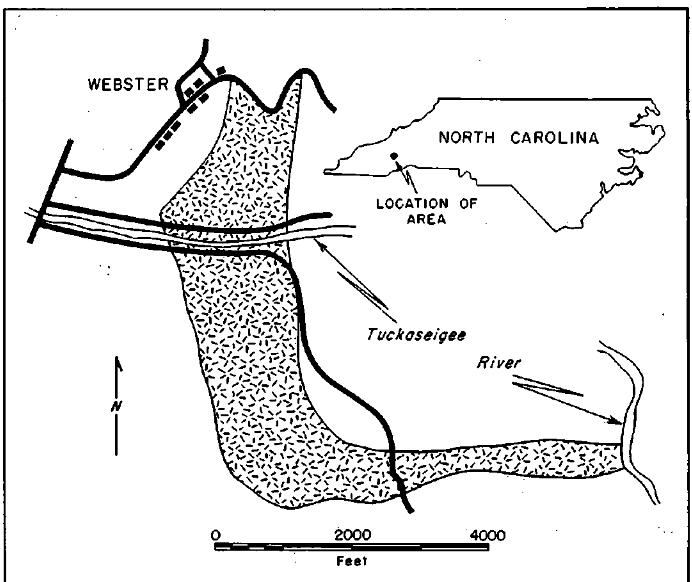

FIGURE 1. Webster dunite deposit, Jackson County, North Carolina. (Modified from C. E. Hunter, 1941)

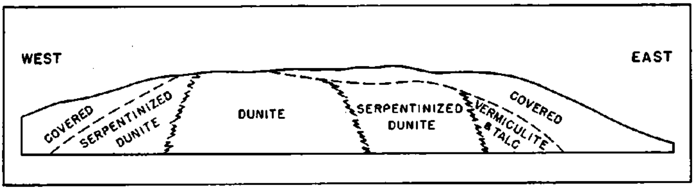

FIGURE 2. Idealized east-west cross section through Webster dunite deposit. Cross section along road south side of Tuckaseigee River (fig. 1).

dunite belt is by Hunter (1941). Much of the background information contained herein is from his report.

The Webster dunite deposit is located in the west-central part of Jackson County at the community of Webster (fig. 1). An investigation of exposures along a north-facing escarpment south of the Tuckaseigee River revealed a central core of relatively unaltered olivine (fig. 2). This grades laterally into serpentinized dunite and into a thin zone of vermiculite and talc at the contact with the surrounding country rock. Websterite was not found at this locality. Samples collected from the serpentinized dunite and from the contact zone reveal associations of chlorite, vermiculite, and talc.

Chlorite and vermiculite.—The sample was collected from material derived from the outer edge of the serpentinized dunite (fig. 2). Megascopically the sample resembles a normal bright-green chlorite. Individual crystals can be readily distinguished by hand lens observation. A petrographic examination reveals that there are essentially two major mineral components present; a dark-green, fibrous to platy mineral and a yellow-green to gray, platy mineral. The latter seems to be the most abundant. Both are biaxial negative with a 2V of 1-5 degrees. The intermediate index of refraction for the dark-green mineral is 1.54 ±0.005. The yellow-green to gray mineral has an intermediate index of 1.53 ±0.005.

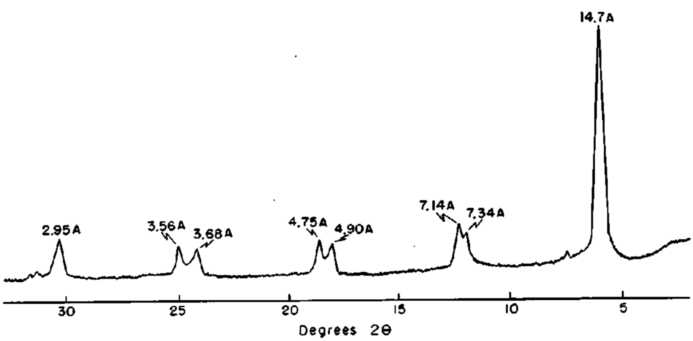

FIGURE 3. X-ray diffractogram of untreated sample of chlorite and vermiculite (Cu radiation; Ni filtered).

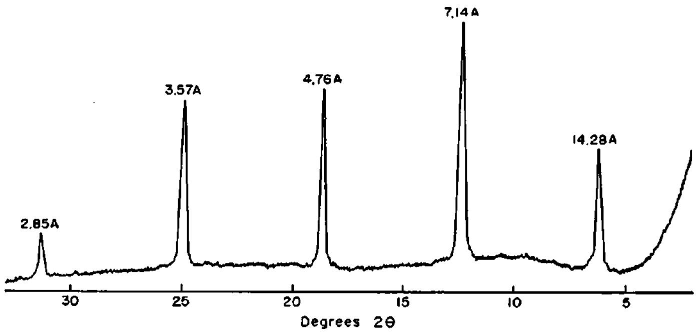

FIGURE 4. X-ray diffractogram of chlorite and vermiculite sample treated in hot, 1N HCl for one hour (Cu radiation; Ni filtered).

X-ray diffractograms were obtained by dispersing the material in distilled water in a Waring blender and sedimenting a thin layer of the suspended material on a glass slide. The source unit was a Norelco (North American Philips) generator and recorder using nickel-filtered, copper radiation (lambda=1.5418 A) at a setting of 35 kilovolts and 18 milliamps. The diffractograms shown in figures 3, 4, 5, 6, and 7 are reduced tracings from the original patterns.

The untreated sample gave a double set of second, third, and fourth order diffraction peaks at integral orders of about 14 A (fig. 3). The high 14 A peak and the subsequent less intense orders more closely resemble a typical vermiculite than a chlorite. Treatment of the clay in hot, 1N HCl for one hour destroyed one set of integral orders (fig. 4). This procedure is reported as a standard test for the presence of chlorite in which the result should be the destruction of the chlorite (Brindley, 1951, p. 188). But the diffractogram

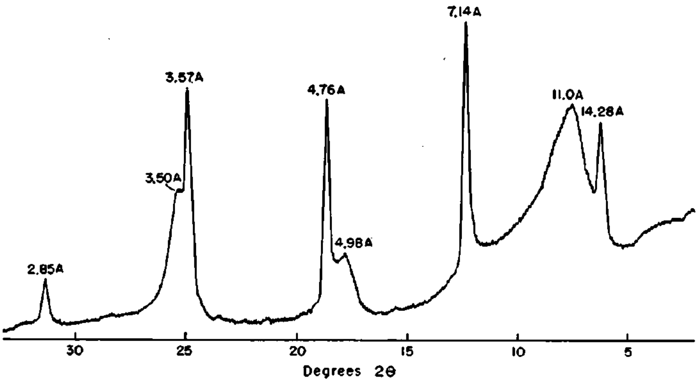

FIGURE 5. X-ray diffractogram of chlorite and vermiculite sample boiled in a solution of NH_4Cl for five minutes (Cu radiation; Ni filtered).

obtained from the material after the acid treatment more closely resembles a chlorite than a vermiculite.

A test for the presence of vermiculite is dispersal of the sample in a solution of NH_4Cl boiled for five minutes. The result should be the formation of an ammonium vermiculite which has a first order spacing of about 10.5 A (Brindley, 1951, p. 203). A sample of the original material that was treated with NH_4Cl gave two first order peaks, one at 14.3 A and one at about 11 A, suggesting the presence of both chlorite and vermiculite (fig. 5). A comparison of the diffractograms obtained from the acid treatment and the NH_4Cl treatment indicates that in each case the same set of integral orders was affected while the orders of the 14.3 A remained unchanged. In order to further test the determination that the same set of integral orders were affected by both the acid and the NH_4Cl treatments, a sample of the material was first treated with hot, 1N HCl for one hour and then boiled in a solution of NH_4Cl for five minutes. The resulting X-ray diffractogram gave integral orders 14 A with relative intensities corresponding to the acid-treated sample. Thus the NH_4Cl treatment had no effect upon the acid-treated material.

Another test for the distinction between vermiculite and chlorite is heating a sample to 700° C for about 10 hours (Brindley, 1951, p. 203). This will intensify the 14 A spacing of the chlorite and change the vermiculite to talc with a corresponding change in the peak to 9.3 A. A pattern resulting from the above described treatment gave a 14 A and a 9.3 A spacing (fig. 6). In addition, an acid-treated sample was heated to 700° C for 10 hours and the X-ray diffractogram obtained from the sample showed no talc lines.

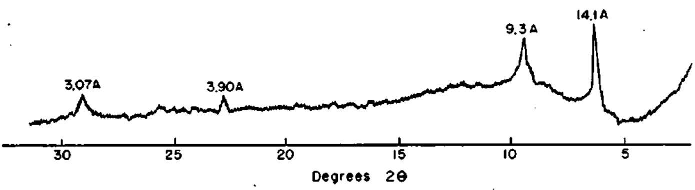

FIGURE 6. X-ray diffractogram of chlorite and vermiculite sample heated to 700°C for 10 hours (Cu radiation; Ni filtered).

It can therefore be concluded that this sample is a mixture of vermiculite and chlorite. The less intense first and third and more intense second and fourth order spacings of the chlorite suggest an iron-rich variety. But this is not probable because the HCl treatment is particularly effective in destroying iron-rich chlorite. The diffraction spacings suggest a penninite variety but the index of refraction (1.54) is too low to fit in the range of the reported penninites (1.57). Previous work by Ross and Shannon (1925, 1926) describing the high nickel content of the alteration products from the Webster deposit suggests the possibility that the chlorite could be high in nickel. Semiquantitative emission spectrometer data obtained in the geochemistry laboratory of the Oklahoma Geological Survey by Mr. John Schleicher does not reveal significant amounts of nickel in the chlorite. Further, these data indicate only minor amounts of aluminum and iron with significant amounts of silicon and magnesium. This would suggest that the chlorite is a normal, magnesium-rich, trioctahedral variety with magnesium filling all the available octahedral positions.

Vermiculite and talc.—The sample was collected from the contact zone. The exact location within this zone is uncertain because the outcrops are poor. The material is gray to rust-brown and coarse grained. Some crystals are larger than 2 mm in diameter. Petrographic studies reveal two mineral components; a pale yellow-brown to pale olive-green mineral with an intermediate index of refraction of 1.61±0.005 and a colorless mineral with an intermediate index of refraction of 1.59±0.005. Both are biaxial negative with a 2V of 1-5 degrees.

X-ray diffractograms obtained by the method previously described reveal diffraction peaks corresponding to a mixture of vermiculite and talc (fig. 7). Proof of the presence of vermiculite was obtained by boiling the sample in a solution of NH_4Cl for five minutes and obtaining an X-ray diffractogram of the results.

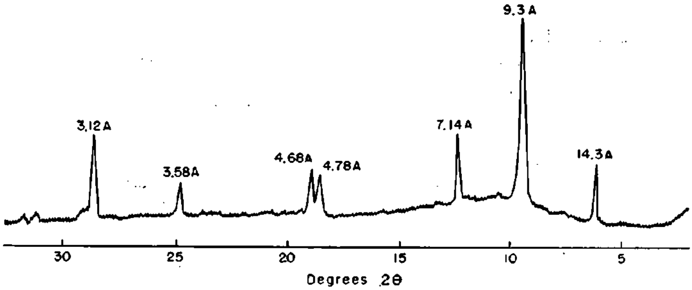

FIGURE 7. X-ray diffractogram of untreated sample of vermiculite and talc (Cu radiation; Ni filtered).

Semi-quantitative emission spectrometer data show that the vermiculite does contain nickel as has been previously reported by Ross and Shannon (1926). In addition the vermiculite contains traces of vanadium, titanium, zirconium, strontium, calcium, chromium, and a significant amount (several percent) of manganese.

The results of the present investigation show the occurrence of an apparently normal, high-magnesium chlorite with the anomalous property of non-destruction by the acid treatment. The reason for this anomaly is not known. In addition the investigation confirms the presence of nickel-bearing vermiculite, which may contain almost as much manganese as nickel. The mineral deweylite, previously described from the Webster deposit by Ross and Shannon (1925), was not found.

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IMPREGNATION OF SANDS WITH "BIO-PLASTIC" FOR GRAIN ORIENTATION STUDIES

L. M. Young and C. J. Mankin

Several procedures for in situ cementation of sediments have been described in the literature. Brown and Patnode (1953) describe a means of impregnating sediments with "Selectron 5001," a commercial low-viscosity liquid plastic which quickly sets to a stiff gel with the addition of a suitable catalyst and accelerator. Curray (1956) successfully utilized Brown and Patnode's method to study the dimensional orientation of beach and aeolian sands.

"Glyptol," a liquid resin, is in current use as an impregnating material for both dimensional orientation analysis and thin-section preparation (T. J. van Andel and Rudolf von Huene, personal communication, 1960).

A recent investigation of dimensional grain orientation in fine sands from the Canadian River required an impregnating medium to preserve the grain orientation. Unfortunately, the long setting time required for "Glyptol" made it difficult to use in this investigation. Consequently "Bio-Plastic," a clear liquid resin distributed by Ward's Natural Science Establishment, was used. "Bio-Plastic" is readily available and can be obtained upon short notice.

Preliminary tests have shown that, when "Bio-Plastic," with the proper amounts of catalyst and accelerator, is poured into sand, a stiff, rubbery gel results within two or three hours. The procedure is effective even when the sand is damp. This gel is sufficiently rigid to allow removal of the sand to the laboratory without disrupting grain orientation.

Six-ounce fruit-juice cans are satisfactory coring devices and molds for the plastic. Little disruption of grain orientation will result if the rim is cut away from the end which is to be inserted into the sand.

A detailed procedure for collecting oriented cores is as follows:

1. Insert the can perpendicularly into the feature to be sampled. The can should not be forced into the sand more than two inches in order to avoid unnecessary disruption of the grain orientation.

2. Prepare a mixture of "Bio-Plastic," catalyst, and accelerator. The best proportions are five drops of accelerator and eight drops of catalyst per 25 ml of "Bio-Plastic."

3. Slowly pour the mixture of "Bio-Plastic" into the can, allowing it to soak into the sand.

4. After the plastic has been poured, the can should be marked, with either paint or grease pencil, with respect to current direction, compass direction, and feature trend.

5. The plastic will harden into a stiff gel and the core may then be removed. The rigidity of the gel may be tested by gently probing the thin layer of plastic on the top surface of the core. Experience has shown that at least two hours is necessary for the plastic to set.

6. Cores brought into the laboratory should be left in the cans. The hardening process is completed by baking the cores for several hours at 140° F.

7. Finally, the metal can is cut away from the hardened core. Before removing the can, orientation marks are transferred from the metal can to the core itself. The core is now ready for cutting and thin-sectioning.

This method has been used primarily for sampling recent, small-scale sedimentary features. Undoubtedly the procedure could be extended, with modification, to include older sedimentary deposits.

The main advantage of this procedure is in the absence of elaborate equipment necessary to obtain good samples. The method described by Brown and Patnode involves the use of an elaborate vacuum system which is not necessary in the method just described.

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Boktukola Syncline Bulletin Issued

Oklahoma Geological Survey Bulletin 88, *Geology of the Boktukola syncline, southeastern Oklahoma*, by Orville B. Shelburne, Jr., was issued in September, 1960. The document consists of 84 pages, 18 figures, and one plate, a colored geologic map of the Boktukola syncline area. The area covered by this study comprises approximately 316 square miles in north-central and northwestern McCurtain County and in southeastern Le Flore and east-central Pushmataha Counties.

The document may be purchased from the Survey office for $3.25, cloth bound, or $2.50, paper bound. The map may be purchased separately for $1.00.

A CHAZYAN FAUNULE FROM THE LOWER TYNER, NORTHEASTERN OKLAHOMA

George G. Huffman and John M. Starke, Jr.

Introduction—The Tyner formation was named by Taff (1905, p. 2) for outcrops near the town of Proctor along Tyner Creek, a tributary of Barren Fork, in northern Adair County. The formation as originally defined included all units between the Burgen sandstone and the Chattanooga formation. Cram (1930, p. 20-22) restricted the term "Tyner" to the beds below the Fite and Fernvale limestones and above the Burgen sandstone.

The Ordovician system in northeastern Oklahoma now contains six recognized formations; in ascending order these are: Cotter dolomite, Burgen sandstone, Tyner shales and dolomite, Fite limestone, Fernvale limestone, and Sylvan shale. The Cotter dolomite is assigned to the Canadian series, the Burgen-Tyner-Fite sequence to the Chazyan and Black River, and the Fernvale-Sylvan to the Cincinnatian. Precise correlation of the Burgen-Tyner-Fite sequence with the Simpson section of the Arbuckle region has been conjectural. Recent discovery of a Chazyan faunule in the lower part of the Tyner formation provides new information which makes more precise correlation possible.

Tyner Formation—*Character and thickness*: The Tyner formation is characterized by lithologies of shale, sandstone, and compact dolomite. The shales are dominantly olive-green to dark blue-green, but range from yellow to mottled brown. Some of the shales are compact, calcareous, and dolomitic and grade laterally into sandy dolomite. Tyner dolomites are tan to buff, massive, sandy, and compact but locally they grade to soft, thin-bedded, earthy dolomite. Light-gray chert nodules, chert fragments, and crystalline quartz form a conspicuous zone in the uppermost part of the Tyner formation.

Cram (1930, p. 16-17) divided the Tyner formation into three parts: (1) a lower Tyner dolomite and green shale, (2) a middle Tyner green

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Explanation of Plate I

Fossils from the lower part of the Tyner formation, northeastern Cherokee County, Oklahoma.

Figure 1. Worn cast of *Maclurites* sp. collected on section line, secs. 22 and 23, T. 19 N., R. 23 E., xl.

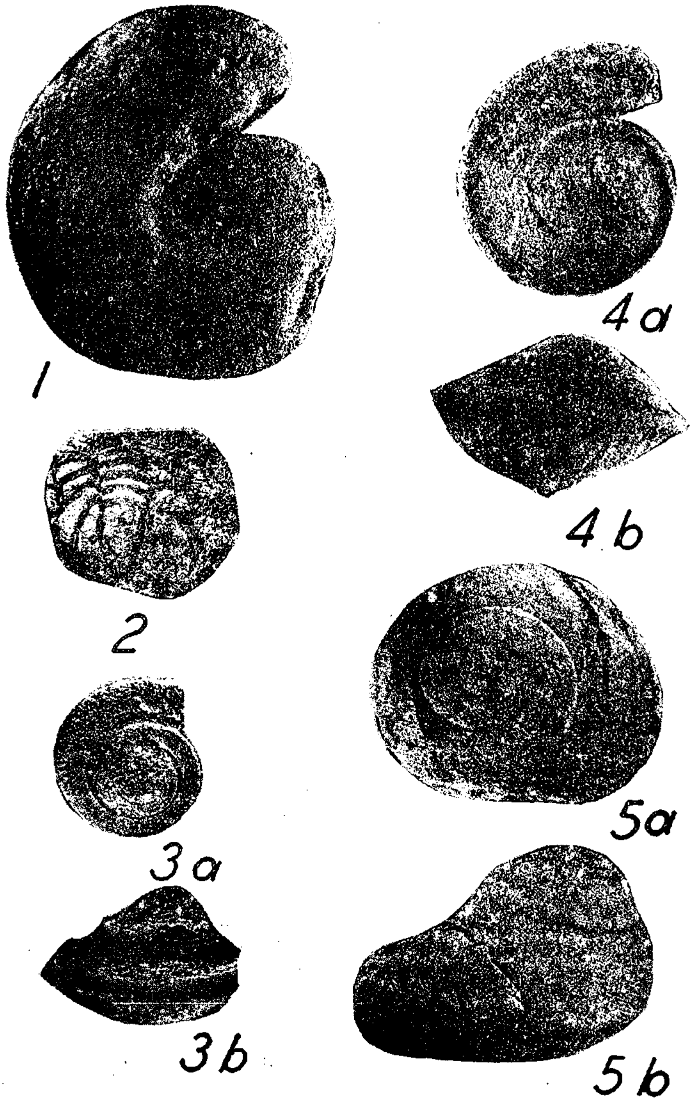
Figure 2. *Pseudomaria* (*Pliomerops*) *nevadensis* (Walcott), west-central part of sec. 24, T. 19 N., R. 23 E., xl.

Figure 3. Apical and side views of *Trochonema* sp. cf. *T. umbilicatum* Hall, NW¼ sec. 3, T. 18 N., R. 23 E., x2.

Figure 4. Apical and side views of *Raphistoma* sp. cf. *R. denticulatum* Ulrich, west-central part of sec. 24, T. 19 N., R. 23 E., x2.

Figure 5. Apical and side views of *Clathrospira* sp. cf. *C. subconica* Hall, west-central part of sec. 23, T. 19 N., R. 23 E., x2.

Plate I



shale, and (3) an upper Tyner cherty, dolomitic limestone. These subdivisions are recognizable throughout much of northeastern Oklahoma.

The thickness of the Tyner formation ranges from zero to approximately 100 feet. A total of 79 feet is present near Qualls, Oklahoma (sec. 35, T. 15 N., R. 21 E.), 90 feet on Cornshell Mountain (sec. 25, T. 16 N., R. 22 E.), and 100 feet along the Illinois River at Eagle Bluff (sec. 13, T. 18 N., R. 22 E.). The Tyner thins to extinction northward from T. 18 N. by truncation and overlap of the Chattanooga formation, which lies upon the Burgen and Cotter north of T. 19 N.

Distribution: The Tyner formation is exposed along the west bank of Spring Creek, sec. 12, T. 19 N., R. 20 E.; along Cedar Creek in secs. 30 and 31, T. 18 N., R. 20 E.; near Qualls in sec. 35, T. 15 N., R. 21 E., and in sec. 2, T. 14 N., R. 22 E.; along the Illinois River in secs. 30 and 31, T. 16 N., R. 23 E.; in Deep Hollow at the junction of secs. 17, 18, 19, and 20, T. 16 N., R. 23 E.; and on Cornshell Mountain, sec. 25, T. 16 N., R. 22 E.

Excellent exposures of the Tyner formation occur along the Illinois River and its tributaries northeast of Tahlequah near Ellerville, Scraper, and Chewey; in Baumgartner Hollow, secs. 34 and 35,, T. 18 N., R. 23 E.; and along Barren Fork near Proctor, T. 17 N., R. 24 E. (Starke, 1960).

Stratigraphic Relations: The Tyner formation rests conformably upon the Burgen sandstone. It is normally succeeded conformably by the Fite limestone with which it is gradational. Where the Fite limestone has been removed by pre-Chattanooga erosion, the Chattanooga rests unconformably upon the Tyner or upon older rocks.

Paleontology: A fauna collected by Taff (1905) and identified by Ulrich included *Camarocladia rugosa* Ulrich, *Hesperorthis tricenaria* (Conrad), *Liospira americana* Billings, *Lophospira* sp. cf. *L. perangulata*, *Hormotoma gracilis* (Hall), *Leperditia* sp. cf. *L. fabulites*, *Ceraurus pleurexanthemus* Greene, *Psiloconcha inornata* Ulrich, *Psiloconcha sinuata* Ulrich, *Psiloconcha* sp. cf. *P. subovalis* Ulrich, *Rhytimya* sp. and *Whiteavesia* sp.

Cram (1930) listed, in addition, *Streptelasma* (?), *Eurydictya*, *Ctenodonta*, *Hormotoma* sp. cf. *H. salteri*, *Pterygometopus*, and *Leperditella*. A faunule consisting of *Rafinesquina*, *Ctenodonta*, *Hormotoma*, *Leperditia fabulites*, *Leperditia* sp., *Leperditella*, and *Lophospira* was reported by Montgomery (1951, p. 152). These fossils came from the upper part of the Tyner formation from exposures along the Illinois River northeast of Tahlequah.

Starke (1960, p. 23) collected and identified the following forms from the lower Tyner dolomites in Tps. 18 and 19 N., R. 23 E., northeastern Cherokee County, Oklahoma: *Clathrospira* sp. cf. *C. subconica* Hall, *Hormotoma* sp., *Hormotoma gracilis* (?) (Hall), *Maclurites* sp., *Pseudomaria* (*Pliomerops*) *neveadensis* (Walcott), *Raphistoma* sp. cf. *R. denticulatum* Ulrich, and *Trochonema* sp. cf. *T. umbilicatum* Hall (plate I).

Harris (personal communication, 1960) collected *Drepanodus arcuatus* Pander from the lower part of the Tyner at Eagle Bluff (SW¼ sec. 13, T. 18 N., R. 22 E.).

Age and Correlation: Precise age and correlation of the Tyner formation are questionable. Taff (1905, p. 2) assigned the Tyner to the Lorraine (Upper Ordovician), Trenton, and Black River on the basis of fossils. Edson (1927, p. 975) correlated the Tyner with the "post-Wilcox" beds in the Mid-Continent and the Bromide in the Arbuckle Mountains. According to Cram (1930, p. 19) the upper part of the Tyner can be traced into the Bromide of the subsurface; the middle part of the Tyner is gradually replaced by the "Wilcox" sand to the west; and the lower part of the Tyner occurs far down in the Simpson section. Huffman (1958, p. 24) compared the upper part with the dolomite development in the upper part of the Bromide and the green shales with similar shales in the Marshall zone and possibly in the Tulip Creek of subsurface.

Starke (1960, p. 25) correlated the lower part of the Tyner with the Oil Creek formation on the basis of the faunule listed above. *Pseudomaria nevadensis* is present in the Oil Creek of the Arbuckle region (Decker and Merritt, 1931, p. 20) and *Drepanodus arcuatus* Pander is a definite Oil Creek form (Harris, personal communication, 1960). This assignment places the Burgen sandstone in the stratigraphic position of the Oil Creek sandstone as has been suggested by Cram (1930, p. 12) and by Disney and Cronenwett (1958, p. 21).

Summary and Conclusions—The faunule collected by Starke from the lower part of the Tyner formation suggests a Chazyan age for the lower Tyner and for the underlying Burgen sandstone, and establishes their equivalency to the Oil Creek formation of the Simpson group of south-central Oklahoma. The upper part of the Tyner contains a Black River faunule and is believed to be equivalent to the Bromide, overlying Fite limestone resembling the Bromide "dense" or Corbin Ranch formation. The middle part of the Tyner occupies the stratigraphic position of the Tulip Creek formation and possibly of the McLish formation. The latter may be missing if there is a hiatus at the base of the middle part of the Tyner, as was suggested by Cram (1930, p. 19).

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Northeastern Oklahoma Field Conference

The Kansas Geological Society, in cooperation with the Oklahoma Geological Survey and the University of Wichita, held a field conference on the geology of northeastern Oklahoma, September 16 and 17. The field conference was the twenty-fifth for the Kansas Geological Society. Jack G. Blythe, of the University of Wichita, was the director; Carl C. Branson was the leader for the Pennsylvanian portion of the tour; and George C. Huffman., The University of Oklahoma, was the leader for the pre-Pennsylvanian portion. Dr. Huffman also gave a review of pre-Pennsylvanian geology at a briefing session previous to the trip. Some 135 geologists participated in the conference and several service companies liberally furnished many of the amenities of the trip.

Transportation on the first day was by means of four air-conditioned busses, departing from Sequoyah State Park on Fort Gibson Reservoir and following a route through Tahlequah, Stilwell, Marble City, Vian, Gore, and Fort Gibson, and returning to Sequoyah State Park. At Marble City a visit was made to the underground limestone mine of the St. Clair Lime Company where a washed and illuminated wall exposure of St. Clair limestone (Silurian) in contact with Frisco limestone (Devonian) was examined by the group.

On the second day the group traveled in a caravan of more than 70 cars from Sequoyah State Park through Wagoner, Chouteau, Salina, and Spavinaw to Vinita, where the conference disbanded.

The Guidebook, Twenty-Fifth Field Conference includes, in addition to the road logs, the following articles of interest to Oklahoma geologists:

Carboniferous problems of the Mid-Continent area, by C. C. Branson, p. 44-47, 2 charts.

Regional relations of pre-Desmoinesian rocks, central Mid-Continent region, by G. G. Huffman, p. 48-71, tectonic map, paleogeologic map, 10 isopach maps.

Atoka formation in northeastern Oklahoma, by J. G. Blythe p. 72-81, 6 figures.

Geology of the Oklahoma Ozark region, by G. G. Huffman (condensed from Okla. Geol. Survey Bull. 77, p. 82-109, 5 figures.

Silurian and Devonian strata in the Marble City area, Sequoyah County, Oklahoma, by T. W. Amsden, p. 110-112, 2 figures.

Paleozoic deposition in northern Arkansas, by J. C. Maher, p. 113-117, 2 figures.

The lakes of northeastern Oklahoma, by G. G. Huffman, p. 118-122.

Copies of the guidebook may be obtained from the Kansas Geological Society, 508 East Murdock, Wichita. Kansas.