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A DISSERTATION

SUBMITTED TO THE GRADUATE FACULTY

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degree of

DOCTOR OF PHILOSOPHY

BY

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BIOSTRATIGRAPHIC INTERPRETATION AND CORAL FAUNA OF THE WAPANUCKA FORMATION OF OKLAHOMA

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PART I - INTRODUCTION

The Wapanucka Formation (Morrow Series, Lower Pennsylvanian) was described by J. A. Taff (1901) from exposures in the vicinity of the settlement of Wapanucka, Johnston County, Oklahoma. The formation was further defined by B. F. Wallis (1915), who referred to this area as the intended type locality for the formation.

The writer's interest in this formation stems from a petrographic study done for the master's degree at Tulane University (1959). The spiculiferous shales and limestones of the Wapanucka were studied at that time at the excellent exposures of this formation at Limestone Gap, Atoka County, Oklahoma. Reconnaissance study of the Wapanucka at that time suggested the suitability of this highly fossiliferous unit for a biostratigraphic study. Preliminary field work for this study was begun during the summer of 1959, and the study has been completed as a doctoral dissertation at the University of Oklahoma. Financial support for the field work was provided by the Oklahoma Geological Survey.

Age and Distribution

The Wapanucka Formation is partially equivalent to the Morrow Formation of northwestern Arkansas and to the Hale and Bloyd Formations of northeastern Oklahoma. Wapanucka equivalents in the Ardmore Basin may include the Jolliff and Otterville Members of the Golf Course Formation, and in the central Arbuckle Mountains the lower part of the Dornick Hills Group. The present study demonstrates a close correspondence between the coral fauna of the Wapanucka and that of the Marble Falls Formation of Texas.

The Wapanucka Formation is exposed at the surface as discontinuous ridges which extend along the northeastern and eastern flanks of the Arbuckle Mountains in south-central Oklahoma and along the frontal belt of the Ouachita Mountains in southeastern Oklahoma. These ridges extend to the Oklahoma-Arkansas boundary, but Wapanucka equivalents in Latimer and Le Flore Counties are not well established.

The westernmost exposures of this formation occur in sec. 6, T. 1 N., R. 7 E., Pontotoc County, Oklahoma, where the Wapanucka and Atoka Formations are truncated by the onlapping basal series of the McAlester Formation. Isolated exposures of Wapanucka age are present about 10 miles north of this area, which extend from sec. 33. T. 3 N., R. 7 E. southeastward to sec. 2, T. 2 N., R. 7 E., also in Pontotoc County. These exposures are terminated at their southern end by the Stonewall Fault at the northern margin of the Franks Graben. Although overlain by shales of the Boggy Formation and underlain by the Union Valley Formation, the fauna from localities in this area (PO 7, PO 8) corresponds most closely to that of the lower part of the formation in the main exposures to the south (see faunal chart, fig. 7, in pocket).

The outcrop of the Wapanucka in the Arbuckle Mountains extends across parts of southeastern Pontotoc County, southwestern Coal County, northeastern Johnston County and southwestern Atoka County (see index map, fig. 1, in pocket). The maximum exposed thickness in this area occurs at Canyon Creek (locality PO 3), where a measured section of 181 feet was recorded. The outcrop forms a single ridge in this region, and about six miles southeast of the town of Wapanucka the low ridge is covered by flat-lying beds of Cretaceous age.

Exposures of this formation occur in northeastern Atoka County, about 15 miles from the nearest outcrop in the Arbuckle area, in sec. 21, T. 1 N., R. 12 E. The trend of the Wapanucka ridge now conforms to the main structural trend of the frontal Ouachitas, and is northeast-southwest. In the northeastern part of T. 2 N., R. 13 E., multiple repetition of the section by faulting is characteristic.

The northernmost Wapanucka ridge in the southwestern Ouachita Mountains is locally called "Limestone Ridge". This ridge extends from sec. 21, T. 1 N., R. 12 E. to sec 2, T. 3 N., R. 15 E., a distance of about 25 miles. In this township another Wapanucka ridge appears still farther to the north and is also called "Limestone Ridge"; the latter ridge extends to sec. 11, T. 4 N., R. 17 E., where faulting displaces the ridge to the north. The single ridge extending eastward from this area is also known by the regionally popular name of "Limestone Ridge".

Structure and Physiography

In the Arbuckle Mountains the Springer, Wapanucka and Atoka Formations form an essentially conformable sequence whose attitude is closely related to the major structural features of this region. Ridges formed by the comparatively resistent strata of the Wapanucka Formation are locally prominent, but seldom have more than 50-60 feet of relief. Faulting, except for minor cross-faults, is restricted to the axes of major anticlinal and synclinal structures. Dips in this region commonly range between 15 and 30 degrees. The drainage pattern is superposed, and the best exposures of the Wapanucka are invariably associated with water-gaps.

In the frontal Ouachita Mountains the upper resistent strata of this formation form narrow, subparallel strike-ridges which stand from 40 to 250 feet above intervening wide valleys in the shales of the "Pennsylvanian Caney" Formation and the Atoka Formation, respectively. Dips are typically high, and locally, as at locality A 19 in sec. 15, T. 1 N., R. 12 E., the section is vertical to slightly overturned. All Wapanucka ridges in this region lie south of the Choctaw Fault and are therefore part of the Ouachita structural salient. Imbricating strike-faults are the dominant structural features, but cross-faults due to strike-shortening also occur. The drainage forms an incompletely-adjusted superposed pattern, and Wapanucka ridges are intersected by numerous wind-gaps and water-gaps. During the summer months most creeks can be forded on foot.

History of Previous Investigations

The Wapanucka Formation was named and described by Joseph A. Taff (1901, 1902), a geologist for the United States Geological Survey. Taff's original description (1901, p. 3) follows:

> Wapanucka limestone.-The Wapanucka limestone crops as a narrow band along the eastern border of the Caney shale in the southeastern and southwestern corners of the quadrangle. This formation is an extensive but relatively thin lentil, reaching beyond the limits of this quadrangle. It produces ridges, except in those places where the beds have been upturned to a vertical position, thereby permitting the soft shales to be eroded from both sides, leaving the limestone unprotected. The abrupt ending of the formation at the south end of Limestone Ridge is due to its displacement by an extensive fault. Southward the fault follows approximately the strike of the rocks, and the limestone does not come again to the surface in the quadrangle. At Boggy Depot, in the Atoka quadrangle, the Wapanucka limestone emerges from beneath the covering of Cretaceous rocks bearing toward the northwest, and continues in that general direction to the area in the southwest corner of the Coalgate quadrangle.
>
> The beds at the top of this formation are white, massive and often oolitic. Cherty sandy limestones and shales occur in the central part of the formation. Below these variable beds, a massive white limestone occurs, but it is not constant in thickness and character and in places could not be found. At the base of the formation there are calcareous and cherty sandstones which grade into shales on the one hand and into nearly pure ferruginous sandstones on the other. In Limestone Ridge the lowest strata are thin cherts and flint plates, interbedded with siliceous limestones. In the vicinity of Wapanucka, about 10 miles south of the quadrangle, sandstone beds occur at the base.
>
> The whole formation grows thinner westward, until but little else but massive oolitic limestone can be found. In Limestone Ridge the thickness is estimated to be nearly 200 feet. At the western border of the quadrangle it probably does not exceed 30 feet.

A type section is not specifically designated by Taff in this description; however, the exposures near the town of Wapanucka, Atoka County, Oklahoma, have been generally regarded as a "type area" for the Wapanucka Formation.

Charles N. Gould stated (1959, p. 148) that in the summer of 1908 Key Wolf, a field assistant of the newly formed Oklahoma Geological Survey, attempted to trace out the surface exposures of the Wapanucka Formation in the southeastern part of the state. Wolf's investigation apparently did not result in a written report.

The first extensive geological study of the Wapanucka was made under the direction of Benjamin F. Wallis, a geologist for the Oklahoma Geological Survey. The purpose of the study was stated by Wallis (1915, p. 11) to be chiefly economic, and the field work was designed "primarily to determine the nature and extent of the oolitic stone so admirably exposed near the town of Bromide." The resulting geological report is the only published study which describes the Wapanucka Formation in any detail. Wallis divided the exposures in the frontal belt of the Ouachita Mountains into eight members, and the exposures in the Wapanucka area into several less well-defined members. His report includes measured sections, evidence of unconformities within and at the top of the Wapanucka Formation, and an analysis of its potential economic value. This early study provided a firm basis for subsequent work, and Wallis' observations have been substantiated, with few exceptions, by field work done for the present study.

George D. Morgan (1924, p. 56-62) described a section measured where Canyon Creek crosses the outcrop of the Wapanucka Formation in Pontotoc County, Oklahoma (loc. PO 3, this report) as follows:

	Feet
Yellowish-white limestone Very fossiliferous.........	13
Shale...	30
Yellowish white limestone.........................	5
Shale with thin layers of limestone...............	50
Oolitic limestone.................................	3
Blue and gray-blue calcareous shale. Very fossiliferous............................	50
	151

Morgan observed (1924, p. 57):

> That the Wapanucka has a greater downward extension than is here given, and that all the underlying strata which have been referred to the upper or Pennsylvanian Caney are in reality to be considered a part of the Wapanucka is suggested by the position of the oolite which occurs only 50 feet above the base of the Canyon Creek section. In the region to the southeast...an oolitic member of the Wapanucka becomes quite prominent. On Delaware Creek near Bromide it has a thickness of 70 feet...In the Canyon Creek section, however, the yellowish-white limestone which occurs 83 feet above the oolite carries a characteristic Wapanucka fauna... the conclusion is drawn, that the oolitic members of the two localities are not the same, the Canyon Creek stratum being lower in the formation than the one at Delaware Creek.

In a footnote Morgan (1924, p. 58) made a proposal which was to have far-reaching effects on subsequent geological studies of the Lower Pennsylvanian of Oklahoma, as follows:

> Note: After completing a study of the Caney and Wapanucka faunas it appears that it would be desirable to restrict the term Caney to the Mississippian part of the formation and to describe as a new formation the upper or Pennsylvanian part. Time, however, is not available to make the necessary changes in mapping so that this undertaking will have to be left to the future.

In this manner the controversies regarding the age and stratigraphic position of the "Upper Caney", "Pennsylvanian Caney", "Ouachita Caney", and Johns Valley Formation arose. These problems require discussion here only insofar as the stratigraphic position of the lower boundary of the Wapanucka Formation is affected. One of the more remarkable results of the inevitable confusion was the suggestion by R. C. Moore (1934, p. 451) that the base of the Pennsylvanian System should be drawn at the base of the Johns Valley Formation, the base of the Atoka Formation, the base of the Cherokee Formation, and at the base of the Deese Formation. However, after subsequent investigations, Moore abandoned his assignment of the Wapanucka Formation to the Mississippian System (1934, p. 452, footnote).

R. V. Hollingsworth (1933, p. 7), in a study of the Lawrence Uplift, defined the "Union Valley sandstone member of the Wapanucka Formation" as follows:

> ...that series of sandstones occurring below the main body of the limestones and shales of the Wapanucka formation, from which it is usually separated by an unconformity. At the base it is limited by the lower shales of the Wapanucka formation or by the Caney shale (restricted).

This name was proposed to replace the "Lyons-Quinn", "Papoose", "Cromwell" and other subsurface designations of this horizon. The type locality is stated to be near the Union Valley schoolhouse, Pontotoc County, Oklahoma. A measured section is recorded for an exposure of "Union Valley" south of the Lawrence Uplift (sec. 15, T. 1 N., R. 7 E.) as follows (1933, p. 10):

WAPANUCKA FORMATION:	Thickness feet.
Upper shale member	15 plus
Unconformity	
Union Valley sandstone member	140
Yellowish, cherty, impure limestone	5
Sandstone	35
Blue-gray, finely crystalline, hard limestone	3 inches
Sandstone	100
Lower shale member	
Shale	?

A consequence of his definition of a sandstone member in the middle part of the Wapanucka section was the division of the Wapanucka into three parts; this Hollingsworth proposed (1933, p. 24) as follows:

> The Wapanucka formation, of the subsurface as well as of the surface, is thus divisible into three members. These members are: first, an upper member of limestone, limestone and shale, or, more rarely, shale alone; second, the Union Valley sandstone member consisting of sand, or a series of two or three sands separated by thinner intervals of shale; and, third, a lower shale member.

On the basis of microscopic fossils (primarily ostracods and conodonts) Hollingsworth proposed a correlation of the arenaceous limestone at the top of the Union Valley with the lower part of the section at Limestone Gap (loc. A 18, units A-M, this report).

In 1934 B. H. Harlton proposed the ill-fated "Bendian" System, which was to include the Wapanucka Formation. In this paper Harlton observed (1934, p. 1024) that:

> . . .by recognition of the varying characteristics of the profuse upper Bendian micro-fauna, it is definitely established that the Hale formation is a correlative of the Union Valley sandstone and the middle Springer formation, and therefore older than the Wapanucka. The Wapanucka limestone (middle Wapanucka) is found to be contemporaneous with the Otterville limestone of the Ardmore basin, which is definitely older than the Marble Falls of Texas. Previously all these formations were considered contemporaneous. . . . Detailed field investigations indubitably will reveal the equivalents of the middle Dornick Hills in the area north of the Arbuckles as well as in the Ozarks. A reconnaissance study indicated to the writer that these are present north of the Arbuckle Mountains and that at least part of them are present in the Ozarks. These sediments have at least in part been mapped with the lower Atoka formation, but due to the lithologic and faunal characteristics of the Wapanucka, the writer includes these Upper Bendian beds in the Wapanucka formation, using the term upper Wapanucka.

Harlton's observations at this time apparently formed the basis of his subsequent (1938, p. 908) definition of the "Barnett Hill" Formation, in which the following proposals were made: (1) subdivision of the "Bendian system" into two series, a lower Pushmataha Series and an upper Morrow Series. The Pushmataha Series was to include the Stanley Group and most of the Jackfork Group. The upper 400-500 feet of sediments, previously called Jackfork, Johns Valley, Wapanucka, and Barnett Hill, were to comprise the Morrow series. (2) restriction of the Wapanucka Formation, as a consequence of the proposal and definition of the "Primrose" Formation (1938, p. 900), the "Limestone Gap" Shale (1938, p. 901) and the "Barnett Hill" Formation (1938, p. 908). The correlations proposed by Harlton can be best summarized in tabular form (adapted from Harlton, 1938, fig. 1, p. 854):

SOUTH OF ARBUCKLES	NORTH OF ARBUCKLES	FRONTAL OUACHITAS
Lester, Bostwick	Barnett Hill	Barnett Hill
Otterville Jolliff	Wapanucka	Wapanucka
Limestone Gap Shale	Limestone Gap Shale (Penn. Caney)	Limestone Gap Shale
Primrose	Primrose (Union Valley Sandstone)	
Lake Ardmore Overbrook Rod Club	Union Valley Sandstone	Union Valley Sandstone
Wesley	Wesley	Wesley

M. H. Kuhleman, who studied the geology of the Atoka and Stonewall quadrangles, defined four members of the Wapanucka Formation in these areas, as follows (1948, p. 32):

> (1) lower fossiliferous, calcareous shales and thin sandy limestones, (2) gray, clay shales and an overlying gray, oolitic limestone, (3) gray, clay shales and a crinoidal, oolitic limestone, (4) gray, clay shales and a calcareous sandstone.

Field and subsurface evidence is cited by Kuhleman in this study which suggests (1) a local unconformity above the oolitic limestone (1948, p. 32), and (2) the equivalence of the Union Valley limestone of the Lawrence Uplift to the lower oolitic limestone of the Wapanucka Formation (1948, p. 36). Two measured sections are recorded in Kuhleman's study, and a small collection of invertebrate fossils was made.

Charles J. Barker (1950) made a geological study of a portion of the Lawrence Uplift, based in part upon faunal collections from the Wapanucka. Barker mapped as separate units a lower "Union Valley sandstone" and an upper "Union Valley limestone".

Maxim K. Elias (1956, p. 99), in a review of Mississippian and Pennsylvanian stratigraphy in Oklahoma, proposed the "Gene Autry" Shale as a unit of formational rank roughly equivalent to Harlton's "Limestone Gap" Shale of the frontal belt of the Ouachita Mountains. Elias makes this reservation (1956, p. 101-102):

> Harlton's name "Limestone Gap shale," if understood as it appears in the column for "South of the Arbuckles". . . approximately corresponds to the Gene Autry, because he applies it to the interval between the "Primrose" and the "Jolliff" in the Ardmore basin. However, when introducing the name Limestone Gap formally in the text. . . Harlton defines it as a shale in the "frontal belt of the Ouachitas," resting upon the "largely siliceous limestones and

shales" and to which "the Ardmore basin term Primrose is applied". By his further definition, it is overlain by the Wapanucka in a restricted sense, "retained for the main lower massive limestone as Taff undoubtedly intended the usage".

Correlations proposed by Elias are summarized as follows (adapted from Elias, 1956, Table II, p. 70):

NORTH AMERICAN SERIES	NORTHERN ARBUCKLE MOUNTAINS	SOUTHERN ARBUCKLE MOUNTAINS
	Wapanucka Limestone	Otterville Limestone
	Shale	Shale
	Sandy Limestone	Jolliff Ls. and Conglomerate
MORROW	Shale	Gene Autry Shale
	Union Valley Fm.	Upper Primrose Ss.
	(lower part probably	Shale
	includes "Cromwell Ss.)	Lower Primrose Ss.

C. L. Rowett (1959) made a petrographic study of the exposures of the Wapanucka Formation at Limestone Gap (loc. A 18, this study). The upper limestone beds described by the writer at that time included the "Barnett Hill" Formation, as defined by Harlton in 1938.

The writer has insufficient first-hand experience in the northeastern Ouachita Mountains upon which to base a meaningful review of the stratigraphy of that area. Field work done under the direction of L. M. Cline since 1953 has resulted (Cline, 1956, Cline and Shelburne, 1959, Cline, 1960) in a much clearer picture of the field relationships of many of these units. Cline's contentions are based on an abundance of field and faunal evidence accumulated during this period. Of consequence to this summary is the recognition by Cline (1960, p. 85) of a zone of spicular siliceous shale in the basal Atoka Formation which he believed to correspond to one of the spiculite beds in the upper part of the Wapanucka Formation at Limestone Gap in Atoka County, Oklahoma.

The reader is referred to the following additional references: Flawn (1959); Goldstein and Hendricks (1953); Goldstein and Flawn (1958); Hendricks (1958); Honess (1924); Miller (1955); Miser (1929, 1934, 1954); Miser and Honess (1927); Miser and Hendricks (1960); Misch and Oles (1958); Moore et al. (1944); Powers (1928); Ulrich (1911, 1927); White (1934, 1937, 1937a).

Definition of the Wapanucka Formation

The subdivisions by Wallis (1915), Hollingsworth (1933) and Barker (1950) have no effect on formational boundaries and may be locally useful.

Harlton's restriction of the Wapanucka, definition of the "Barnett Hill", and proposal of the "Bendian" System (1934, 1938) are rejected for the following reasons: (1) coral zones established in this study indicate the equivalence of the upper limestones in the Ouachitas to the section exposed in the Arbuckles; (2) faunal evidence invalidates the "Barnett Hill" at its type locality in Coal County and suggests that this unit is a local sandstone body in the lower Atoka Formation; (3) use of the term "Wapanucka" (unrestricted) by geologists in this state has continued, notwithstanding Harlton's proposals, and (4) the "Bendian" System has failed to gain acceptance and usage.

The boundaries of the Wapanucka Formation as originally defined by Taff (1901) and by Wallis (1915) seem most reasonable and therefore are followed here.

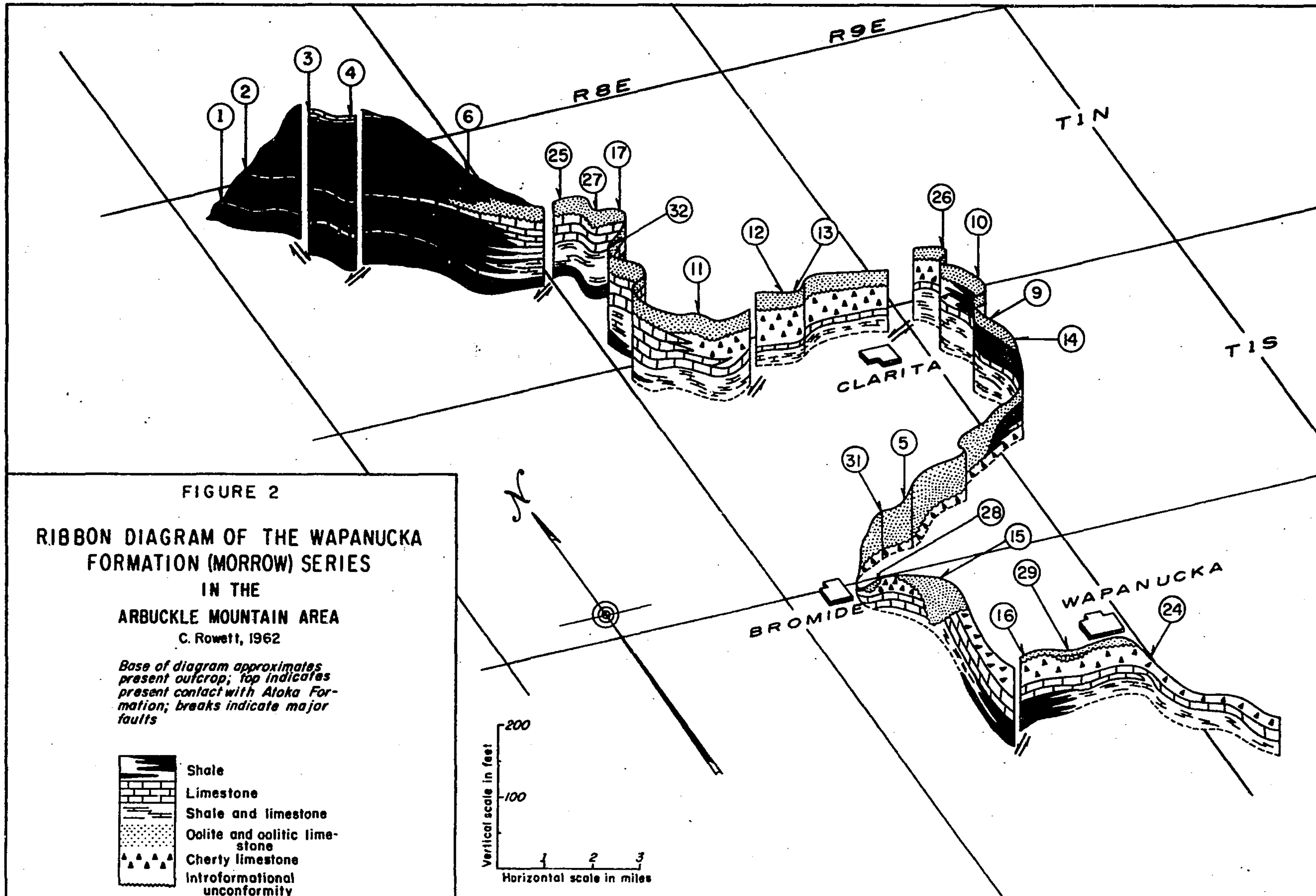

FIGURE 2

RIBBON DIAGRAM OF THE WAPANUCKA FORMATION (MORROW) SERIES IN THE ARBUCKLE MOUNTAIN AREA

C. Rowett, 1962

Base of diagram approximates present outcrop; top indicates present contact with Atoka Formation; breaks indicate major faults

PART II - BIOSTRATIGRAPHY

Paleontology

The fauna of the Wapanucka Formation is more abundant and varied than any fauna yet recorded from formations of similar age in Oklahoma or adjacent states. A total of 80 genera and 129 species has been identified from the Wapanucka, from collections made over a period of several years. Additional forms are undoubtedly present.

Preliminary collection of fossils by the writer indicated that a taxonomic study of all groups would be beyond the scope of this study, and would of necessity result in superficial descriptions of many species. A detailed study was therefore made of the rugose corals, whose stratigraphic value in rocks of Morrowan age had previously been demonstrated in the Marble Falls Formation of Texas by Moore and Plummer (1945). The zonal occurrence of coral species in the Wapanucka Formation has subsequently been established, and this group has proved to be of great value in stratigraphic interpretation and correlation. Preliminary identification and evaluation of the occurrences of other fossil invertebrates has failed to indicate a similar zonal distribution for any other group.

The Wapanucka fauna is dominated by corals, brachiopods, and crinoids. Corals are represented by 15 genera and 32 species, which includes a new genus (assigned to the Permian Family Timorphyllidae), and six new species. Twenty-one coral species are reported for the first time from the Wapanucka Formation.

The brachiopod fauna is poorly preserved, but is largest in terms of abundance and variety; 25 genera and 46 species have been identified from this unit. The distribution of brachiopods appears to be controlled primarily by lithofacies.

Crinoids are common at most horizons and are particularly abundant and well-preserved in the lower calcareous shales at Canyon Creek (locality PO 3). Approximately 355 identifiable dorsal cups and several complete and partial crowns have been collected, of which slightly more than one-half are referable to various species of Paragassizocrinus. A special study has been made of this unusual unattached form, which will be published separately. The collected crinoid fauna consists of 10 genera and 19 species, but indications are that several times this number are present in the formation. Only one blastoid genus has been collected, Pentremites.

Pelecypods and gastropods are ubiquitous, and include 18 genera and 18 species. Ammonoids and nautiloids are referred to seven genera and eight species.

Minor faunal elements, including arthropods and scyphozoans, include four genera and four species. Bryozoans were collected, but have not been studied.

The occurrence of all identified species are tabulated by locality and unit on the faunal chart (fig. 7, in pocket). The complete stratigraphic collection, including the rugose corals and several hundred thin-sections, will remain at the University of Oklahoma where it will be available for future biostratigraphic study of Morrowan formations in this region. All figured specimens, holotypes, and paratypes will be deposited in the Paleontological Repository at this University.

Paleoecology

Data of paleoecologic interest were recorded during all phases of this study, with the result that some general interpretations can be made. It is hoped that this preliminary consideration of the paleoecology will provide a framework for additional study.

The physical environment is reflected by both the physical stratigraphy and by the composition and texture of the sedimentary rocks. Information of a general nature can be derived from field descriptions, but detailed petrographic study is essential. Over 100 petrographic thin-sections were therefore prepared and studied for this discussion. Thin-section data are tabulated in Appendix III.

Paleoenvironments are also indicated by the fossil content of the rocks. In most carbonates, fossils and fossil debris constitute a large proportion of the rock and thereby influence texture, composition and classification. Fossil invertebrates were collected zonally from all localities and the coral fauna has been studied in detail. Stratigraphic reference collections of Morrowan fossils from other areas in this region were available to the writer for study and comparison.

A synthesis of physical and biological data requires the recognition of persistent faunal and lithologic associations. A special effort was made to record information of this type. Terminology used in this section follows the classification of marine environments proposed by Hedgpeth (1957) except where otherwise defined. The limestone terminology is that defined by Folk (1959a). All interpretations are the writer's.

Environments of Deposition

The Wapanucka Formation in the Arbuckle Mountains is composed primarily of limestones and shales. The carbonate petrology is varied, and includes all major categories of limestones as well as several unusual limestone types. Allochemical constituents include fossils, intraclasts, oolites, superficial oolites, pellets, and sponge spicules. Chemical cements (orthochemical constituents) include microcrystalline calcite ooze (micrite) and sparry calcite (spar). Recrystallization of micrite to microspar and to sparry calcite is common. In addition, pure micrite and dismicrite rocks occur, as well as spicular, pellet, and intraclast rocks. Shale types include highly fossiliferous calcareous shales, unfossiliferous, black shales, and spiculiferous shales. Lateral facies changes are common, and unconformities occur within and above the formation.

Stratigraphic and faunal control in the eastern Arbuckle Mountains is sufficient to reconstruct the history of the deposition of the Wapanucka in this area. Major lithofacies*, unconformities, and the locations of key stratigraphic sections are indicated by fig. 2. Similar regional interpretations were not possible in the frontal belt of the

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*This term is used here as defined by Moore (1949, p. 32), as meaning the rock record of any sedimentary environment, including both physical and organic characters.

Ouachita Mountains, which is characterized by intense structural deformation, poor exposures, and replacement of the rocks by chert.

In the Arbuckle Mountains the following lithofacies are recognized in this study: (1) littoral and sublittoral; (2) shallow, well-oxygenated neritic; (3) anaerobic lagoonal; (4) carbonate shelf; (5) tidal inlets or bores; and (6) oolite banks. Also, it is possible to postulate the location of fringing reefs and areas of subaerial erosion.

A description of these sedimentary facies will be presented in the following order: (1) discussion of the paleoecologic implications of the physical stratigraphy, petrology, and paleontology; and (2) a summary of the history of deposition.

<u>Neritic, lagoonal and sublittoral lithofacies</u>. The interfingering of neritic, lagoonal and sublittoral deposits indicates rapid temporal shifts in the margins of these environments. A record of these areas is partially preserved in the outcrop of the Wapanucka which trends from northwest to southeast across T. 1 N., R. 7 E. (see Ribbon Diagram, fig. 2). The area is best studied at the sections exposed at Canyon Creek (PO 3) and adjacent localities (PO 1, PO 2, PO 4).

A thick calcareous shale which occurs at the base of the section at the Canyon Creek locality contains a large fauna which includes solitary and colonial corals, crinoids, brachiopods, blastoids, bryozoans, pelecypods, gastropods, and trilobites. Preservation is excellent, except for slight compression of some forms. Solitary corals are commonly found attached to the substratum or to bryozoans and algae, and pelecypods have been encountered in the living position in the shale. It is clear that this fauna is primarily a life-assemblage, and occupied a shallow neritic zone characterized by near-optimum conditions of aeration, temperature and food supply. The substratum apparently consisted of relatively soft silt and clay in which attachment surfaces for the sessile population was provided by massive bryozoan colonies, algal colonies, and possibly sea-grasses. The presence of shifting bottom sediments precludes the existence of most sessile marine organisms (Osborne, 1957, Duncan, 1957), but the moderate energy level of this environment evidentally did not disturb the bottom sediments.

According to Newell _et al_. (1951, p. 18, 1959, p. 221-222), the presence of numerous pelecypods and gastropods in the neritic zone indicates proximity to the littoral and sublittoral zone. Water depth can not be determined, but the physical evidence indicates that the substratum was not disturbed by wave action. Although Elias (1937, p. 410-411) concluded that modern encrusting algae occupy depths ranging from 75 to 110 feet, algae of this type occur in very shallow water in the Bahamas (Illing, 1954, p. 70). The writer has observed solid clay substrates at depth of 25 to 40 feet off the southwest coast of Mexico which support numerous marine invertebrates. Illumination and aeration diminish rapidly below 40 feet, with a corresponding decrease in the numbers and variety of the fauna.

This fossiliferous shale is overlain by thin beds of oolitic limestone. This rock has been studied from thin-sections of samples collected at an adjacent locality (PO 4, thin-section B-1, B-2).

Allochems are large, concentrically formed oolites in a matrix of microspar and micrite, which indicates a marked decrease in the energy-level. The oolites were apparently washed into the area by onshore surface currents, or waves, and settled into a microcrystalline calcite ooze. Numerous intact tests of Millerella and Paramillerella are scattered throughout the rock which also suggest very low energy-level at the sea floor.

Correlative beds are exposed about one mile to the northwest of Canyon Creek (PO 1, thin-section A-1) which consist of numerous well-preserved valves of chonetid brachiopods in a matrix of micrite and microsparite. Finely divided organic matter and angular quartz silt are also present. Low-energy conditions are also indicated for this area.

This unit is overlain by a thick sequence of unfossiliferous black fissile shale (unit C at Canyon Creek). Casts of scyphozoan medussae, which are floating forms, are the only fossils known from these shales. Deoxygenation associated with current restriction and/or much deeper water may account for the absence of fossils. The lack of non-indigenous fossil debris also suggests weak surface currents. The environment is interpreted as a restricted lagoonal area.

These shales are overlain by oolitic biosparrudite (unit D at Canyon Creek) which consists primarily of broken and abraded fossil debris. The oolites in this rock (thin-section D-4) are believed to have been derived from carbonate sediments in a shelf area to the east or southeast. Most of the fossil debris was probably derived from the littoral and sublittoral zone to the west. Vigorous currents and shallow water are indicated by the large size of allochems and by the presence of sparry calcite cement.

A reversion to a restricted lagoonal environment is recorded by an overlying sequence of black shales (unit E) which are lithologically and faunally similar to unit C.

The highest beds preserved at Canyon Creek (unit F) are bioclastic limestones (biosparrudites) which contain zones of brachiopod shell coquina. These beds provide good evidence of a final phase of vigorous current and wave activity. Bedding is thin and irregular, and bedding planes show local scouring and concentrations of fossil debris. Shell material is fragmental but is not worn, which indicates rapid transportation from a nearby source, presumably the sublittoral zone. Petrographic study of this rock (thin-section F-10) indicates the presence of a few oolites, which are believed to have been derived from a nearby shelf area. Large fossil fragments, primarily echinoderms, are well-rounded and also have thin oolitic rims, which suggests a similar source. The chemical cement is sparry calcite.

In summary, the excellent exposures at Canyon Creek illustrate a well-aerated, comparatively shallow neritic zone which was subject to sporadic restriction of wave and current activity, resulting in deep, poorly oxygenated lagoons not suited to most invertebrate life. This area also periodically received deposits of bioclastic material from the littoral and sublittoral zones, as well as oolites and superficial oolites from an offshore area of carbonate deposition.

To the southeast of Canyon Creek, this facies can be traced a distance of about six miles, to locality C 27 in Coal County, where similar faunal associations occur in calcareous shales at the base of this section, and at locality J 16 in Johnston County, where there is also a correspondence of lithology and fauna. The fauna is characterized by small species of Lophophyllidium, several species of Barytichisma, and a new genus described herein as genus M. The crinoid genera Paragassizocrinus, Cibolocrinus, Ethelocrinus and Diphuicrinus are also common in these rocks, and the brachiopods Chonetes, Desmoinesia, Antiquatonia, and Krotovia. Pelecypods and gastropods are common.

The carbonate shelf lithofacies. The Wapanucka Formation in Coal and Johnston Counties (T. 1 S., 2 S., and 1 N., R. 8 E.) was deposited as a carbonate shelf. As used here, this term implies a broad, shallow offshore marine area in which deposition consists primarily of carbonate sediments.

By analogy to modern areas of carbonate deposition, the general range of shelf characteristics can be established. The physical stratigraphy, lithology, and fauna of the Wapanucka in these areas correspond to that of both modern shelf areas and "fossil" carbonate shelves. (See descriptions of localities C 25, C 27, C 17, C 12, C 26, C 9, C 14, J 16, and J 29, Appendix I).

Over 80 percent of the section in this area is composed of carbonate rocks. Typical shelf limestones lie immediately below a widespread intraformational unconformity (fig. 2) and are predominately biosparrudites and biosparites. Crinoid skeletal debris, algae, bryozoans, and brachiopod valves are the chief allochems, with minor percentages of foraminifers, fecal pellets, ostracods, and coral debris. Crinoid parts are the most important rock-formers and are abundant in thin-sections.

The chemical cement is invariably sparry calcite. Terrigenous admixtures are absent from these rocks, and quartz occurs only as small authigenic grains. True oolites are uncommon, but superficial oolites (fossil fragments with oolitic rims) are locally present. Intraclasts occur at many horizons, which indicate that deposition was in comparatively shallow water. Thin-sections of typical shelf limestones are as follows: C 12 (A-7); C 17 (A-10); J 16 (F-1); and J 29 (B-2, C-17).

Deposition in shallow water is indicated by the presence of intraclasts, abrasion and fragmentation of fossils, oolites and superficial oolites, current bedding, local concentration of fossil debris, and the large average size of allochems. The presence of sparry calcite as the chemical cement requires a high energy level, as microcrystalline calcite ooze is quickly winnowed out by brisk current activity (Folk, 1959a). The physical stratigraphy of this area also is typical of a shelf area, as beds are of uniform thickness and are widespread in distribution.

Modern carbonate shelves are characterized not only by specific assemblages of marine invertebrates, but also by widespread lateral dispersal of species due to uniformity of ecologic conditions. Shelf faunas and distribution of species have been described by numerous authors, including the following: Cumings and Shrock (1928); Ginsberg and Lowenstam (1958); Johnson (1943, 1945, 1952); Newell, Purdy, and Thurber (1959); and Wolfendam (1958). Widespread distribution of species is considered to be an indicator of shelf conditions by these authors, and in this respect the Wapanucka fauna is similar to both modern and fossil shelf faunas. Species of <u>Koninckophyllum</u> and <u>Pseudozaphrentoides</u>, for example, occur in a zone which can be traced at approximately the same horizon over a distance of more than 25 miles in the Arbuckle area. This zone has also been recognized in the frontal belt of the Ouachita Mountains, where these corals occur at several localities up to 45 miles distant from the shelf area in Coal County. The zonal distribution of these genera was recognized by Plummer (1945) in a report on the Marble Falls Formation (Morrow Series) of Texas.

Biohermal reef development has not been observed in the Wapanucka, but there is indirect evidence that fringing reefs existed locally during the early stages of the development of the shelf. The development of restricted lagoons, for example, suggests the presence of fringing reefs along the seaward edge of the shelf. Accumulations of fenestrate bryozoans at localities C 17 and C 27 support this hypothesis, because fenestrate bryozoans are thought to be restricted to reef or biohermal structures (Duncan, 1957, p. 784; Osborne, 1957, p. 1109). It is probable, therefore, that this material was derived from nearby reef structures. These beds occur at the same horizon as the lower black unfossiliferous shales at Canyon Creek (loc. PO 4, unit C). Reef structures, if present, were destroyed by post-Wapanucka erosion, or are not now exposed at the surface.

Inlets and tidal channels. The culmination of shelf development was followed by an eustatic shift which resulted in: (1) widespread formation of oolites, and (2) erosion and dissection of the shelf by wave and tidal activity.

Tidal channels are best observed at locality J 15, where the

Wapanucka ridge is cut by Delaware Creek. At this locality the upper shelf limestones and the underlying interbedded limestones and shales are truncated by a thick basin-shaped deposit of oolitic limestone. (See description of locality J 15, Appendix I). The original depth of this channel is not known, as the base of the oolite is not exposed. The deepest part of the channel is believed to have coincided with the present course of Delaware Creek, and had a minimum depth of 70 feet. Smaller channels occur both to the north and wouth of this area (e.g., locality J 28) at the crest of the ridge and have a maximum relief of only 11 feet.

The large quarries at Delaware Creek expose a succession of well-developed cross-beds in the oolite up to 8 feet in thickness. These indicate that the source of the oolite was from the northwest. Many beds consist of lenticular layers which thicken rapidly to the southeast, toward the axis of the channel. Intervening thinner cross-bedded units, up to 1.5 feet in thickness, indicate a source to the southeast. It is difficult to explain these relationships except by unusually high-energy conditions created by tidal activity across unconsolidated or weakly consolidated carbonate sediments.

Petrographically, this rock consists of concentrically layered oolites which comprise from 35 to 55 percent of the rock. The average diameter of the oolites is about 0.8 mm. Zones containing fossil debris, primarily small pelmatozoan parts (superficial oolites), occur in the oolite, but comprise less than 5 percent of the rock. The chemical cement is sparry calcite. The uniform composition of this oolite is indicated by the following thin-sections: J 15 (A-20, A-70; J 28 (B-1); J 29 (D-10); C 5 (B-1); C 12 (C-15); and C 17 (B-2).

The fauna contained in the Wapanucka oolite is poorly preserved and is not easily studied. The brachiopod fauna is dominated by robust species such as Buxtonia, Rhynchopora, and Schizophoria; spine-bearing productid brachiopods occur only in infrequent shaly zones. The abundant specimens of Paragassizocrinus at locality C 26 are thought to represent a life-assemblage, from which these unattached crinoids were dispersed into the lagoonal areas. Large cephalopods (Cravenoceras, Owenoceras) are restricted to the oolite, whereas the smaller goniatites (Eoasianites, Gastrioceras) occur in the lower shales of the neritic zone.

History of Deposition

Four stages are recognized in the history of the deposition of the Wapanucka Formation in the Arbuckle Mountains, as follows: early shelf development (stage I); culmination of shelf development and the development of restricted lagoons (stage II); shelf erosion, dissection, and development of oolite banks (stage III); deposition of oolites over the entire shelf (stage IV). The last stage was followed by the transgression of post-Wapanucka seas. The history of deposition is shown in figs. 3-6.

Stage I. The early development of the carbonate shelf is recorded by the interbedded calcareous shales and limestone in the shelf area. These beds are poorly exposed at the base of the escarpment slopes in the present Wapanucka ridges. The contact between the Wapanucka Formation and the underlying shales of the Springer Formation has not been observed in the field.

Deposition during this stage consisted of silts, clays, and lime muds throughout the Arbuckle area. Nearshore neritic areas, such as that at Canyon Creek (unit A), were inhabited by numerous invertebrate organisms. Regular thin bedding suggests uniform energy levels and gentle bottom slopes. The formation of oolites was restricted to a few areas, and these oolites are larger and contain a higher percentage of organic material than those subsequently formed. General uniformity of depositional conditions is reflected by the generalized lithofacies map (fig. 3).

<u>Stage</u> <u>II</u>. The restriction of lagoonal areas characterizes this stage of deposition. Current restrictions may have been due to fringing reefs at the edge of the shelf or to the growth of the shelf itself. The thick unfossiliferous black shales at Canyon Creek (units C and E) are an example of deposition in a poorly oxygenated area. The littoral and sublittoral zone had by now shifted to a position closer to localities PO 3 (Canyon Creek) and J 16. The proximity of this zone is reflected by the lithology of units D and F at Canyon Creek and by unit D at locality J 16.

Shelf development culminated during this time, and shelf limestones occur below the intraformational unconformity (see fig. 2). This stage of deposition is shown in fig. 4.

<u>Stage</u> <u>III</u>. This stage is marked by the erosion and dissection of the shelf and the formation of oolites. These events may have been brought about by a shift in the relative level of the shelf and sea-level. The unconsolidated shelf sediments were subjected to shallow marine and possibly subaerial erosion during this interval. The

resulting intraformational unconformity has little relief at most localities, but deep tidal channels and minor channeling can be observed in some areas.

Optimum conditions developed during this time for the formation of oolites. It is possible that in eroding the shelf limestones, sea-water saturated with calcium cafbonate accumulated in shallow areas where warming and agitation resulted in precipitation. Tidal channels, such as these described above, were filled with cross-bedded oolites. The approximate distribution of lithofacies at the end of this stage is shown in figure 5.

Stage IV. The final stage recognized in this study is marked by the deposition of oolitic sediments over the entire shelf. With the exception of a thin limestone sequence which overlies the oolite at locality J 15, younger beds of the Wapanucka Formation have not been recognized. Subsequent deposition was destroyed by post-Wapanucka pre-Atoka erosion. Evidence for a period of subaerial erosion before the incursion of transgressive Atokan seas is inconclusive. At Delaware Creek (locality J 15) the Wapanucka Formation is overlain by a limestone conglomerate which contains clasts up to cobble-size. This rock is interpreted as a basal transgressive conglomerate of Atokan age. Petrographic study (thin-sections D-1, D-2) indicates a lower Paleozoic (Ordovician) age for many clasts. The direction of the source may have been to the northwest, where the Arbuckle Formation is now exposed. Many clasts are composed of oolites derived from the Wapanucka Formation.

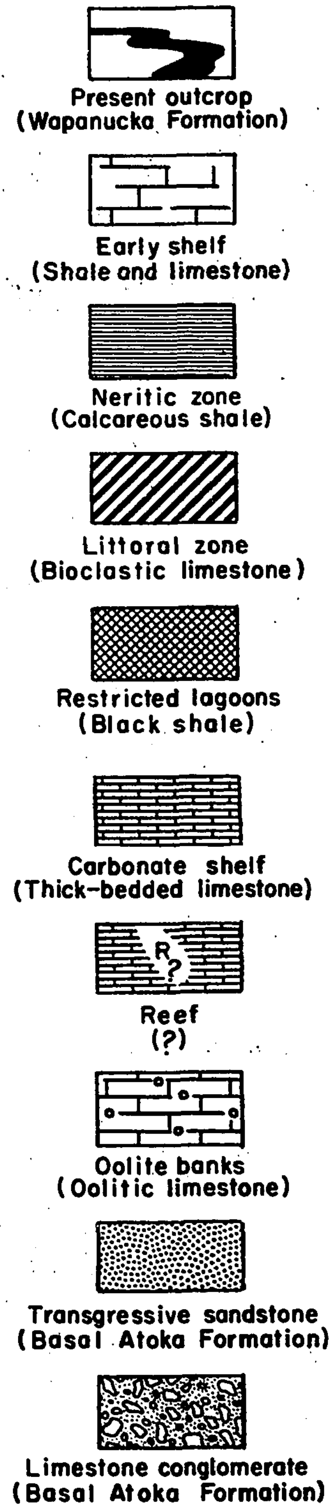
At locality C 5 a basal conglomerate of Atokan age (thin-section

D-1) contains oolitic clasts identical to the underlying oolitic beds at this locality (unit B). Basal conglomerates are present at localities C 17 and C 27 (thin-section E-1) which contain fragments of the underlying oolitic limestone. At locality C 26, the upper oolitic beds of the Wapanucka Formation are overlain by cross-bedded quartzose sandstones which represent the basal part of the Atoka Formation. At locality PO 3 the upper surface of unit F is oxidized and undulatory.

Post-Wapanucka pre-Atoka erosion was extensive, and locally the entire Wapanucka Formation may have been removed. This appears to have been the case in the present axis of the Wapanucka Syncline, although faulting may be partially responsible for the absence of the Wapanucka in this area. Progressive overlap and truncation of both the Wapanucka and the Atoka Formations is evident in T. 1 N., R. 7 E. At Canyon Creek (locality PO 3), the combined thickness of these two formations is in excess of 450 feet; within one mile to the northwest, however, both formations are absent. In the bed of Sheep Creek, about 100 yards to the northwest of locality PO 1, basal cross-bedded sandstones of the McAlester Formation rest directly upon shales of the Springer and possibly Caney Formations. The present position of the erosional surface at the base of the Atoka Formation is shown diagrammatically by the ribbon diagram (fig. 2). The distribution of major lithofacies during the initial stage of transgression and erosion is shown in fig. 6.

DEPOSITIONAL HISTORY OF THE WAPANUCKA FORMATION

C. Rowett - 1962



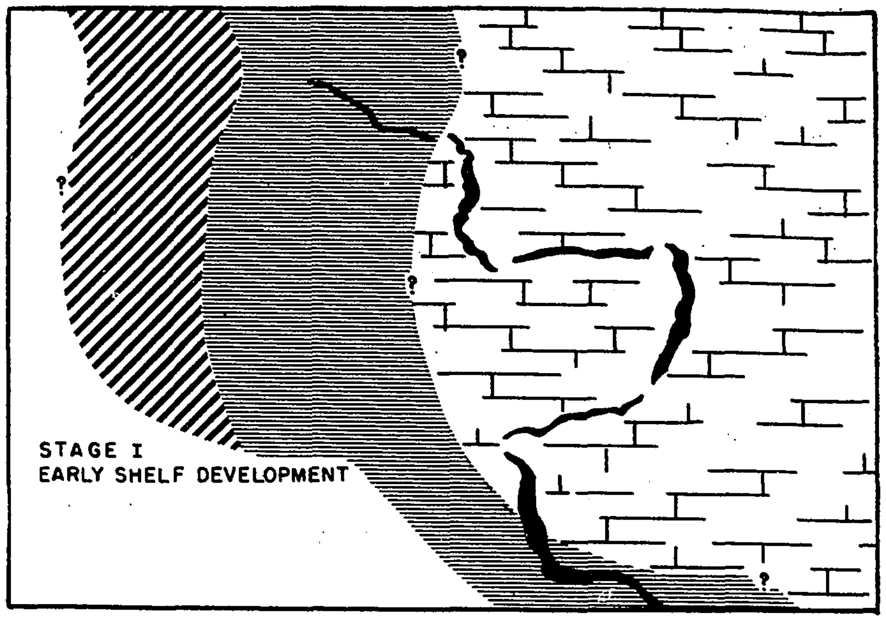


FIGURE 3

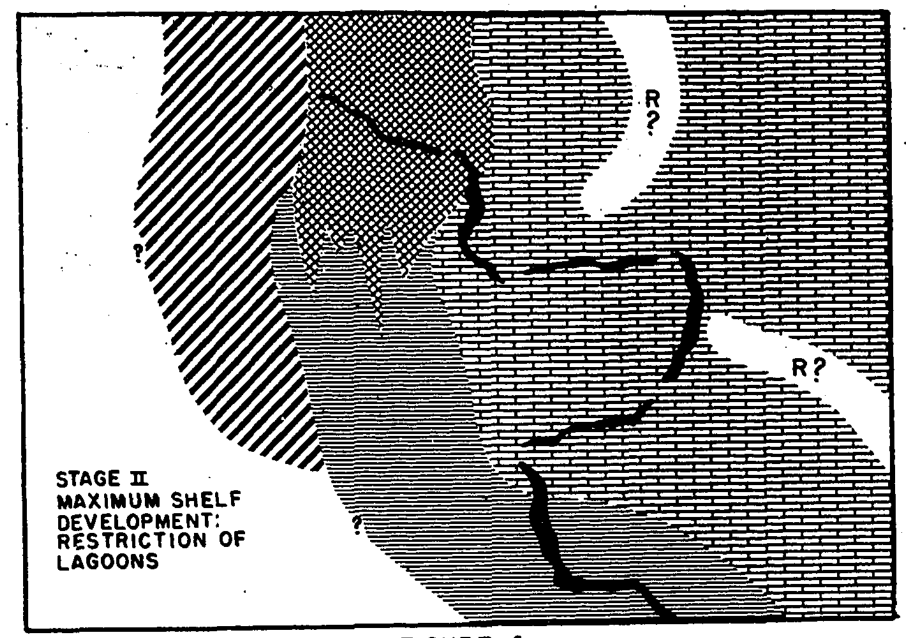


FIGURE 4

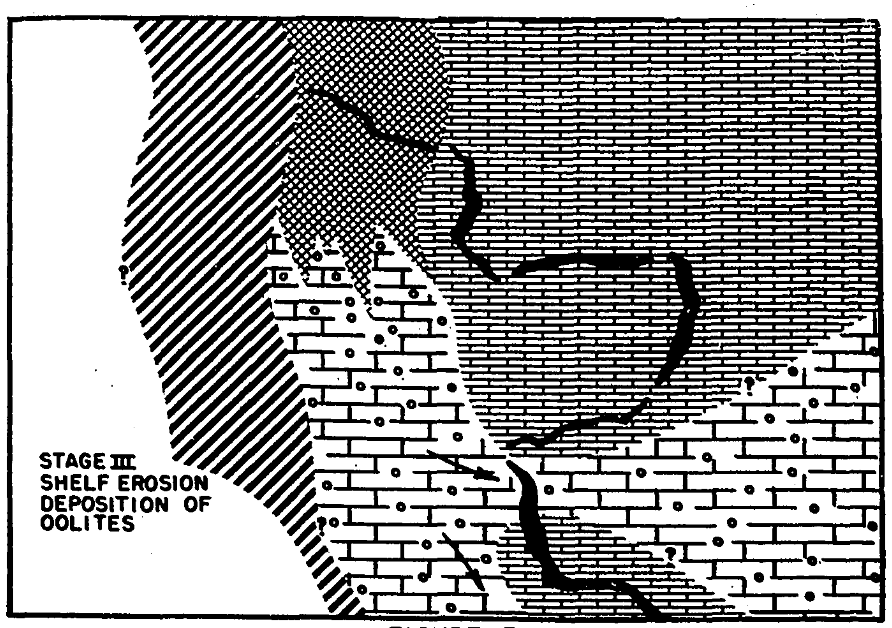


FIGURE 5

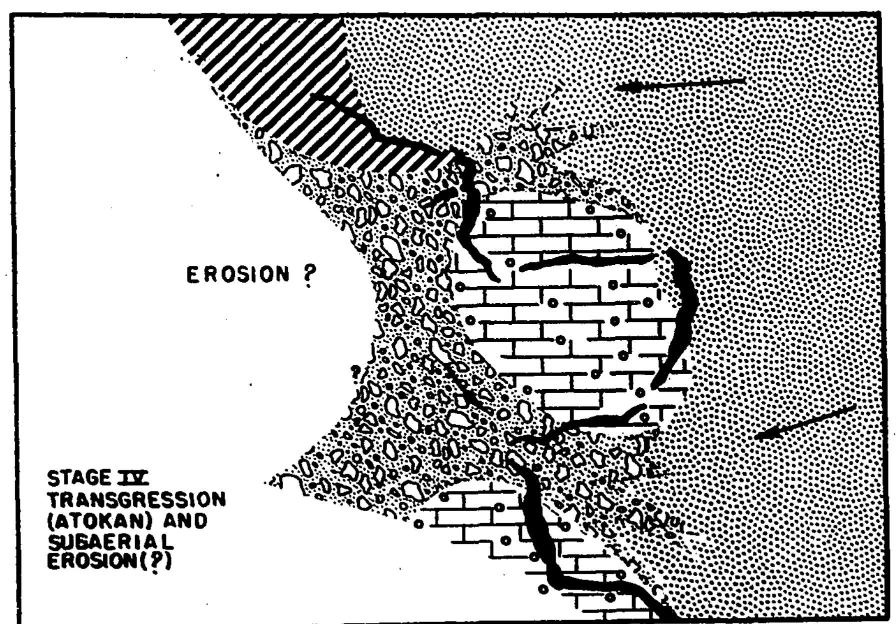


FIGURE 6

Zonation and Correlation

Comparison of the coral fauna of the Wapanucka Formation to the described coral faunas of the Marble Falls Formation of Texas and of the Hale Formation of northeastern Oklahoma shows a significantly high percentage of species which are common to these three formations. Moreover, the degree of correspondence of the Wapanucka coral fauna to the Lower, Middle and Upper Marble Falls (Sloan, Big Saline, and Lemons Bluff Members, respectively) is similar in magnitude. These comparisons are shown diagrammatically below (fig. 8).

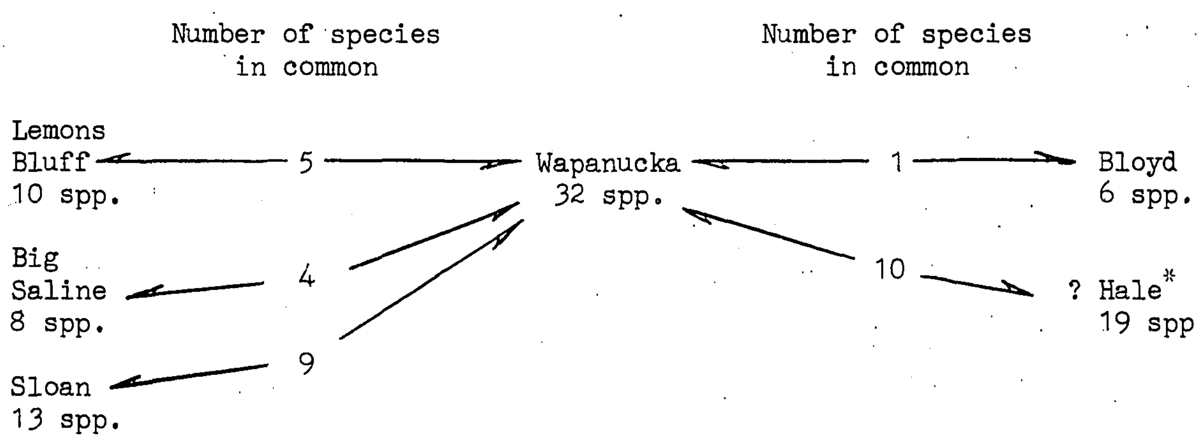


Fig. 8. Coral Species Common to the Marble Falls, Hale, Bloyd, and Wapanucka Formations of Oklahoma and Texas. *See discussion below.

These figures indicate that between 50 and 69 percent of the coral species described from each of the three Members of the Marble Falls are also present in the Wapanucka Formation, and 53 percent of the described species from the Hale Formation are also present in the Wapanucka. As is shown in this figure, however, only one species is common to both the Bloyd Formation and Wapanucka Formation. This does not agree with correlations based on other groups of invertebrates, such as the cephalopod faunas, which indicate at least a partial equivalence of these two units. The discrepancy is almost certainly due to the assignment by Moore and Jeffords (1945) of the fossiliferous strata below the spillway at Greenleaf Lake to the Hale Formation. A re-study of the stratigraphic relationships of the Hale and Bloyd Formations is beyond the scope of this study, but it is nevertheless true that conclusive correlation of the Wapanucka with the Morrowan of northeastern Oklahoma must be delayed until this problem is resolved. The most recent mapping in this area suggests that Huffman (1958, plate IV) regards the strata below the spillway at Greenleaf Lake as belonging to the Bloyd Formation. If this proves to be the case, the correspondence of the Wapanucka coral fauna to that of the Bloyd is significantly higher, with 11 of 25 described species common to the two formations.

The occurrences of all described species of corals from these formations, as reported in the literature, and from the Smithwick Formation of Texas, is shown in the accompanying table (table 1).

Coral Zones in the Marble Falls Formation were established by Plummer (1945) on the basis of the coral studies of Moore and Jeffords (1945). Two of these zones, one of which is characterized by species of *Koninckophyllum*, *Pseudozaphrentoides*, and *Amplexocarinia* and the other by species of *Barytichisma*, have now been recognized in the Wapanucka Formation. These zones can not only be traced through distances of up to 45 miles in the Wapanucka, but also occur in the same stratigraphic sequence as in the Marble Falls; i.e., the Barytichisma zone invariably occurs lower in the section than the Koninckophyllum-Amplexocarinia-Pseudozaphrentoides zone. This relationship is shown in fig. 9.

As is shown by this figure (fig. 9), there is a geographic shift in the distribution of some species between northeastern Oklahoma and central Texas. For example, K. simplex and P. nitellus are limited to the Hale (or Bloyd?) and Wapanucka Formations, and K. arcuatum and P. lepidus are restricted to the Marble Falls Formation. It is interesting to speculate that the Wapanucka may not only occupy an intermediate geographic position but may also contain some intermediate coral species. As an example of this, corals described in this study as Dibunophyllum sp. (plate 9, figure 4) seem to be intermediate in morphology to Koninckophyllum arcuatum (Moore and Jeffords) from the Marble Falls and Dibunophyllum inauditum Moore and Jeffords from the Hale Formation. Also, several specimens of Pseudozaphrentoides nitellus (cf. plate 9, figure 2) approach P. lepidus, a Marble Falls species, in morphology.

The zone of Barytichisma occurs in the Middle and Lower Marble Falls Formation and in the lower part of the Wapanucka Formation in the Arbuckle Mountain area. This zone has not, however, been recognized in the Wapanucka outcrops in the frontal belt of the Ouachita Mountains of Oklahoma. Barytichisma is a large and easily-recognized form, and it is probable that the distribution shown may represent the actual limits of this genus.

In summary, the evidence from the distribution of corals suggests that the thin shelf limestones of the Wapanucka are essentially

Species (Rugosa)	Southern Oklahoma	Texas				Northeast Oklahoma	
		Marble Falls					
	Wapanucka	Sloan	Big Saline	Lemons Bluff	Smithwick	Hale (?)	Bloyd
Lophophyllidium ignotum Moore and Jeffords	X						
Lophophyllidium new species A Rowett	X						
Lophophyllidium new species B Rowett	X						
Lophophyllidium mundulum Jeffords	?						
Lophophyllidium extumidum Moore and Jeffords	X	X					
Lophophyllidium idonium Moore and Jeffords	X	X				X	
Lophophyllidium angustifolium Moore and Jeffords	X					X	
Lophophyllidium minutum Moore and Jeffords	X					X	
Lophophyllidium exile Moore and Jeffords						X	
Lophophyllidium metum Moore and Jeffords						X	
Lophophyllidium conoideum Moore and Jeffords				X			X
Lophophyllidium blandum Moore and Jeffords						X	
Lophophyllidium coaptum Moore and Jeffords							X
Lophophyllidium adapertum Moore and Jeffords		X					
Amplexizaphrentis tumidum (Moore and Jeffords)	X				X		
Amplexizaphrentis retusum (Moore and Jeffords)					X		
Amplexizaphrentis crassiseptatum (Moore and Jeffords)	?				X		
Empodesma imulum Moore and Jeffords	?				X		
New genus M new species D Rowett	X						
New genus M new species E Rowett	X						
Lophamplexus captiosus Moore and Jeffords					X		
Lophamplexus new species C Rowett	X						

Table 1. Occurrences of Described Coral Species in Oklahoma and Texas

Species (Rugosa)	Southern Oklahoma	Texas				Northeast Oklahoma	
		Marble Falls					
	Wapanucka	Sloan	Big Saline	Lemons Bluff	Smithwick	Hale (?)	Bloyd
Lophotichium vesicum Moore and Jeffords							X
Lophotichium improcerum Moore and Jeffords						X	
Lophotichium densum Moore and Jeffords						X	
Lophotichium amoenum Moore and Jeffords						X	
Dibunophyllum sp.	X						
Dibunophyllum inauditum Moore and Jeffords						X	
Koninckophyllum simplex (Moore and Jeffords)	X					X	
Koninckophyllum gracile (Moore and Jeffords)	X			X			
Koninckophyllum arcuatum (Moore and Jeffords)			X				
Koninckophyllum new species F Rowett	X		X				
Pseudozaphrentoides nitellus Moore and Jeffords	X					X	
Pseudozaphrentoides lepidus Moore and Jeffords		X	X				
Pseudozaphrentoides spatiosus Moore and Jeffords		X					
Paracaninia? sana Moore and Jeffords				X			
Rodophyllum texanum Moore and Jeffords			X				
Stereocorypha annectans Moore and Jeffords	?	X					
Stereocorypha spissata Moore and Jeffords	X						
Barytichisma callosum Moore and Jeffords	X	X	X				
Barytichisma crassum Moore and Jeffords	X	X					
Barytichisma repletum Moore and Jeffords	X	X					
Zaphrentoides excentricus Moore and Jeffords					X		
Amplexocarinia corrugata (Mather)	X	X	X			X	

Table 1. (continued)

Species (Tabulata)	Southern Oklahoma	Texas				Northeast Oklahoma	
		Marble Falls					
	Wapanucka	Sloan	Big Saline	Lemons Bluff	Smithwick	Hale (?)	Bloyd
Cumminsia aplata (Cummins)					X		
Chaetetes subtilis Moore and Jeffords			X	X			
Chaetetes favosus Moore and Jeffords			X	X			
Chaetetes eximus Moore and Jeffords				X		X	
Striatopora religiosa Moore and Jeffords	X			X			
Striatopora immota Moore and Jeffords							X
Striatopora oklahomensis (Snider)							X
Acaciapora subcylindrica (Mather)	X					X	
Acaciapora ventusa Moore and Jeffords		X					
Cladochonus fragilis Mather	X	X				X	
Cladochonus texasensis Moore and Jeffords	X			X			
Michelinia scopulosa Moore and Jeffords	X					X	
Michelinia spissata Moore and Jeffords	X						X
Michelinia tenuicula Moore and Jeffords	X					X	
Michelinia latebrosa Moore and Jeffords	X		X				
Michelinia referta Moore and Jeffords	X	?			X		

Table 1. (continued).

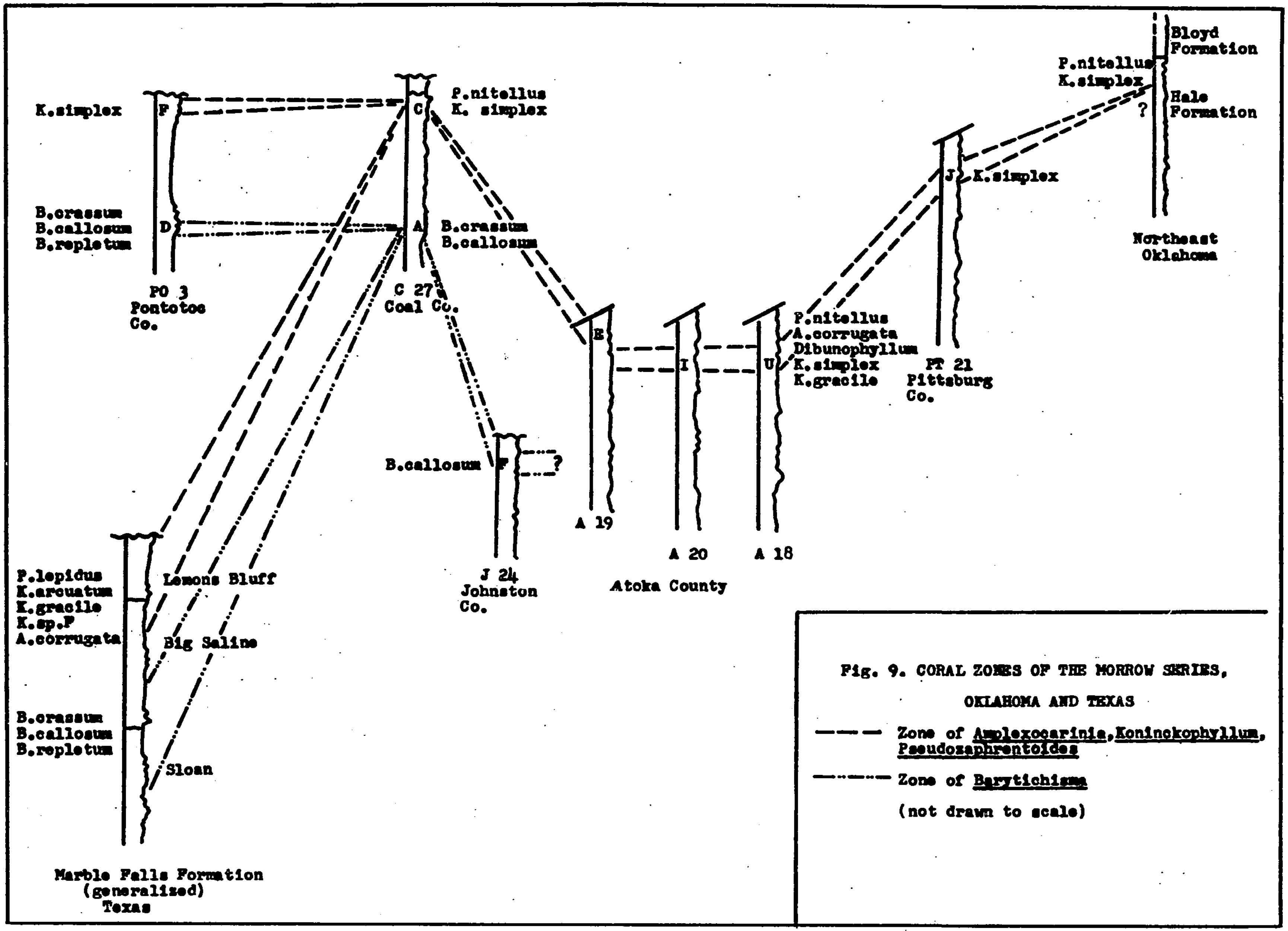


Fig. 9. CORAL ZONES OF THE MORROW SERIES, OKLAHOMA AND TEXAS

equivalent in age to the upper part of the Marble Falls Formation (Lemons Bluff Member) and the lower part of the Wapanucka is a correlative of the middle and lower parts (Big Saline and Sloan Members, respectively) of the Marble Falls. Paleontological evidence from other groups of invertebrates and recent mapping of the physical stratigraphy suggests that coral species referred by Moore and Jeffords (1945) to the "Hale" Formation at Greenleaf Lake were actually collected from the lower part of the Bloyd Formation. In the writer's opinion this conclusion will be supported by future biostratigraphic studies of the Morrow Series in this area. Reliable interregional coral zones are now established, and there is evidence that some coral species described from the Wapanucka may be morphologically intermediate between species described from the Morrow of northeastern Oklahoma and of central Texas.

PART III - SYSTEMATIC TAXONOMY

Introduction

Identification of solitary corals upon the basis of external form has been a common practice in the past, and is still occasionally done. Recent taxonomic studies of corals have, however, been based primarily upon internal morphology, and identification by other methods is consequently unreliable. This is particularly true of the lophophyllidid corals, for these reasons: (1) most lophophyllidid species are generally similar in external form; (2) the epitheca is commonly deeply eroded, and the upper cylindrical portion of conical-cylindrical forms may be missing; (3) variations in local environmental conditions and accidents of attachment may influence the shape of individuals of a species; and (4) large collections will invariably include both juvenile and adult specimens of a species.

In the present study of the rugose corals of the Wapanucka Formation, preliminary sorting of species was made on the basis of obvious external differences. Photographs of the exteriors of selected specimens were then taken. Transverse and longitudinal thin-sections were then prepared in order to study and illustrate the internal morphology. In a suprisingly large number of instances, study of the internal features showed the preliminary groupings to be incorrect, for one or more of the reasons listed above. It was often necessary to prepare serial sections to show changes in the relationships of septa, tabulae, and axial structures. Comparatively simple species could in some cases be identified from cut and polished surfaces, but this procedure was followed only after the specific characters were well established by thin-section study.

Type specimens for most species described by Jeffords (1942) and by Moore and Jeffords (1945) were borrowed from the University of Texas (Bureau of Economic Geology) and the University of Kansas. These authors illustrated their species by inking and bleaching enlarged photographs of cut and oiled surfaces. This method, while having the advantage of reducing costs of reproduction, in many instances fails to illustrate adequately all morphological features. Species which are thickened internally by stereoplasm are especially susceptible to poor reproduction by this procedure, and details of internal structure are invariably lost. A more serious consequence of Moore and Jeffords' system is the resulting condition of the type material, which consists of disarticulated, unpolished, and saw-marked chips. This material could be re-studied only with great difficulty, and was in no case accompanied by thin-sections.

This experience prompted the use of unretouched photographs of thin-sections in the present study, which have the advantage of unbiased reproduction and also allows all types to be accompanied by thin-sections to provide permanent record for subsequent studies.

Specimens borrowed from the University of Kansas are designated in the coral descriptions by the prefix UK before the catalog number; types from the University of Texas are designated by the prefix UT; and specimens to which Oklahoma catalog numbers have been assigned are designated by the prefix OU.

As noted in the discussion of zonation and correlation, occurrences of species reported by Moore and Jeffords from the "Hale" Formation below the spillway at Greenleaf Lake (and so recorded herein under "Range and Distribution") were almost certainly collected from the Bloyd Formation in that area.

Morphological terms used in the coral descriptions agree in most cases with the definitions given by Moore, Hill, and Wells (in Hill, 1956). Other good summaries of coral terminology are given in Hill (1935), Jeffords (1942, p. 192-201, 1947, p. 12-13) and Moore and Jeffords (1945, p. 81-83). Common terms, and terms which require a specific definition as used herein, are defined in Appendix V. Appendix IV contains the statistical parameters of coral species from the Wapanucka Formation.

ORDER RUGOSA

Family METRIOPHYLLIDAE Hill, 1939

The Metriophyllidae are defined by Hill, (1956, p. F257) as follows:

> Small, solitary Rugosa with marginarium a very narrow stereozone. All major septa unite at the axis with axial end of counter septum swollen laterally in some

> forms; cardinal fossula on the convex side of corallum and false counter fossula opposite; minor septa short; the septa may be flanged parallel to their calical edges. Tabulae distant. Ord.-Perm.

Genus Empodesma Moore and Jeffords, 1945

Generic diagnosis by Hill (1956, p. F258):

> Calice very oblique, septa dilated except distally, metriophylloid in arrangement only just above tabulae, withdrawing from the axis between into a calophylloid arrangement with the cardinal, counter, and 2 alar septa longer than others; cardinal and counter septa remain in contact longer. . .Penn., N. Am.

Type species: Empodesma imulum Moore and Jeffords, 1945

Remarks: Moore and Jeffords (1945) referred both Empodesma and Stereocorypha to the Streptelasmaidae Nicholson and Lydekker, 1889. They stated (1945, p. 86) that in the genotype species of Stereocorypha (S. annectans) the cardinal septum is normally on the concave side of the corallite. Similarly, Moore and Jeffords stated (1945, p. 90) that in the genotype species of Empodesma (E. imulum) the cardinal septum is inconsistent in position. Both genera are nevertheless assigned to the Metriophyllidae by Hill, (1956, p. F258), presumably on the basis of their metriophylloid septal arrangement. Material representative of these genera from the Wapanucka Formation is limited and poorly preserved, and does not provide an adequate basis for an opinion as to the correct taxonomic position of either genus. In the interest of standardization the writer therefore follows the classification adopted by Hill in the Treatise on Invertebrate Paleontology.

Empodesma aff. *imulum* Moore and Jeffords, 1945

Plate 1 figure 1.

DESCRIPTION: A single poorly preserved corallite from the Wapanucka Formation is referred to the genus *Empodesma* (Moore and Jeffords, 1945), but differs in several respects from the only described species, *E. imulum*. The corallite is moderately large, conical, and only slightly curved. Total original length was in excess of 45 mm; the calyx is crushed, and varies in diameter from 14 mm to 22 mm. The cardinal-counter plane does not correspond to the plane of the curvature, but lies in an intermediate position. The epitheca is thick, up 1.3 mm at the calyx, and is marked externally by shallow septal grooves and low interseptal ridges. Deep weathering and abrasion have removed most of the epitheca in earlier stages of growth, but it appears to have been thick also. Rugae and growth-lines are absent due to weathering. Attachment rootlets are absent.

Transverse sections show 32 major septa in sections near the base of the calyx. These are remarkably variable in both length and thickness. Typically, septa of the cardinal quadrants are longer, and uniformly thick throughout their length, while those of the counter quadrants are unequal in length (but generally shorter), and are rhopaloid only at their exial ends. The inequality of septal lengths varies somewhat through successive stages of growth, due to a slightly amplexoid tendency of septa; septa are slightly longer immediately above tabulae, and withdraw slightly thereafter until the appearance of the next tabulum. In the calyx, septa withdraw from the axial region, and are uniformly short through a distance of 10 - 15 mm above the floor of the calyx. Although the thick septa are in many specimens in contact laterally with adjacent septa, particularly in the cardinal quadrants, they are not joined by secondary deposits of stereoplasm. The cardinal and counter septa are united in the early growth-stages to form a prominent medial bar which separates the corallite into bilaterally symmetrical halves; in later stages of growth, both the cardinal and counter septum withdraw from the axis; thereafter, the cardinal septum is thin, and occupies a closed fossula and the counter septum extends to the edge of the open axial area. Alar septa are normally slightly longer than adjacent metasepta, and are readily identified. The number and distribution of septa in this specimen is indicated by the formula K 9 A 5 C 5 A 9 K, which shows moderate acceleration of septal insertion of the counter quadrants. No axial structure is present. Tabulae are common, and generally complete; in transverse sections tabulae appear as concentric rings connecting septal edges. Minor septa and dissepiments are absent.

Longitudinal sections have an irregular appearance due to local thickening of tabulae, obliquity of internal structures, and intersection of numerous septal ends. In general, tabulae are subhorizontal or slightly convex upward in the peripheral portion of the corallite, and sag strongly in the axial region. Longitudinal sections confirm the absence of a continuous axial structure, and show neither axial nor apical thickening by stereoplasm.

DISCUSSION: The generic characters of Empodesma are clearly present in this specimen, but there is not agreement to all details of morphology of the genotype species, E. imulum. The genus Empodesma, as defined by Moore and Jeffords (1945, p. 89) is characterized by (1) absence of dissepiments, (2) absence of an axial column, (3) obliquity of the calyx floor, and (4) juncture of the cardinal and counter septum in the early growth-stages. These features are present in the corallite here described, which also agrees with the genotype species in the number and attitude of tabulae, development of cardinal fossula, shortening of the cardinal septum, unequal lengths of major septa, and absence of minor septa. The septal formula of E. imulum does not differ significantly from that of the present corallite. The Wapanucka specimen also corresponds closely to the genotype species in the absence of stereoplasm, amplexoid nature of septa, and position of the protosepta. It differs, however, in having a noticeably thicker epitheca and in bearing distinct septal ridges and interseptal grooves. Illustrations of the holotype (Moore and Jeffords, 1945, p. 91, fig. 10) show somewhat thicker septa than those of the Wapanucka corallite, although the septa of paratypes (ibid., p. 91, figs. 11, 12) compare more closely in this aspect. Because of the direction in which longitudinal sections were made (approximately in the plane of the alar septa), the obliquity of the calyx floor is not evident; in transverse sections, however, the unequal length of septa in cardinal and counter quadrants reflect this feature.

RANGE AND DISTRIBUTION: Empodesma imulum was described by Moore and Jeffords (1945, p. 90) from the Marble Falls Limestone (Lower Pennsylvanian) of Lampasas County, Texas. The genus Empodesma has not previously been reported from the Wapanucka Formation.

MATERIAL AND OCCURRENCE: One specimen; locality J 24, unit F.

Genus Stereocorypha Moore and Jeffords, 1945

Generic diagnosis by Hill (1956, p. F258):

> Like Metriophyllum but with fossula on concave side and septa without flanges. . .Penn.,N.Am.

Type species: Stereocorypha annectans Moore and Jeffords, 1945.

Remarks: For clarity, Hill's diagnosis of Metriophyllum is included here, as follows (Hill, 1956, p. F257):

> Straight thick septa bearing horizontal flanges usually with upturned edges; axial edge of counter septum not swollen nor produced into a columella but union of septa at axis forms a solid axial pillar. . .M.Dev.-U.Dev.,N.Am.-Eu.-Austral.

To this diagnosis of Stereocorypha may be added a comment by Moore and Jeffords (1945, p. 84): "Other characters, such as the lack of strongly marked cardinal, counter, and alar septa. . .the rather steeply arched tabulae, absence of minor septa, and very deep calyx, aid in identification of the genotype species, but probably have less value for generic diagnosis."

The writer has examined the original description and illustrations of the genotype species of Metriophyllum Milne-Edwards and Haime (M. bouchardi Milne-Edwards and Haime, 1850, pl. 7, figs. 1,2) and the holotype specimen of Stereocorypha annectans (UT no. P-11931c). In addition, the holotype of S. spissata (UK no. 7060-22a) has been closely examined. The Wapanucka specimens show a slight degree of variation from S. annectans and are assigned provisionally to this species, with the following observations: (1) the position of the cardinal fossula with respect to curvature in the rugose corals has not been firmly established as being invariably useful in taxonomy above the sub-generic level (cf. discussion by Easton, 1951, p. 387, and discussion of Barytichisma, this report); and (2) minor septa may or may not be present in species of Stereocorypha. Although minor septa are stated to be lacking in the generic diagnosis by Moore and Jeffords (above), their illustrations and descriptions of S. spissata indicate their presence. Rudimentary minor septa are also present in the genotype species, S. annectans (see Moore and Jeffords, 1945, p. 85, fig. 1c, 4c, 4d).

Material representative of Stereocorypha from the Wapanucka Formation is fragmentary and poorly preserved. Specimens of S. spissata, which was described by Moore and Jeffords from the Wapanucka Formation at Limestone Gap, Atoka County, Oklahoma, (loc. A 18, this report), were not found by the writer.

Stereocorypha cf. annectans Moore and Jeffords, 1945

Plate 1 figure 2.

DESCRIPTION: Four solitary corallites from the Wapanucka Formation are assigned provisionally to this species. The nature of the exterior of the specimens and their complete lengths are not known, as the corallites are imbedded in limestone. Study of transverse sections indicates that septal grooves and interseptal ridges are of about equal width but are not prominent. The length of one corallite, in which the apical part is missing, is 27.0 mm. Maximum diameter occurs at the top of the calyx, and is 15.2 mm. The corallite is inferred from transverse sections to be slightly curved in the cardinal-counter plane. The cardinal septum lies on the concave side of the corallite.

Transverse sections through the upper part of the calyx show 39 major septa which are thin and short, extending a distance of 2 mm or less axially. Transverse sections at the base of the calyx show long, straight major septa which extend nearly to the open axial area. The septal formula is K 11 A 6 C 6 A 11 K, which indicates strong acceleration of septal insertion in the counter quadrants. Below the base of the calyx the major septa are united in the axial region by stereoplasm. The thickness of septa and the degree of thickening of the axial region by stereoplasm increases apically; it is probable that the apical one-third of the corallite, missing in all available specimens, is filled with stereoplasm. The septal arrangement in the lowest transverse section made is shown by the formula K 10 A 6 C 6 A 10 K. In the mature growth-stages the cardinal septum is long, thin, and extends into the axial region; it lies in a narrow fossula. Alar pseudofossulae are also narrow, but are prominent in all growth-stages. A solid axial column is lacking, but the coalescing axial ends of septa and intervening deposits of stereoplasm form a more or less open axial structure which does not project above the floor of the calyx. Dissepiments and minor septa are absent.

It was not possible to make longitudinal sections of these corallites. In transverse sections a few thin tabulae were observed to rise steeply toward the axis.

DISCUSSION: The corallites described above were collected from the Wapanucka Formation at the type locality (A 18, this report) of Stereocorypha spissata. However, study and comparison of these corallites with the type specimen of S. spissata (UK 7060-22a) and the type of a similar species, S. annectans (UT P-11931c) indicates closer affinities to the latter species. Both S. spissata and S. annectans were described by Moore and Jeffords (1945, p. 86-89). However, under the species descriptions, S. annectans is listed only from two Marble Falls localities in Texas; conversely, in the register of localities Moore and Jeffords (1945, p. 198) represent this species as occurring in the Wapanucka Formation (loc. KU-2747) on Coal Creek in Pontotoc County, Oklahoma.

The corallites from the Wapanucka Formation differ significantly from S. spissata in their smaller size, fewer tabulae, thinner epitheca and prominent alar pseudofossulae. In these characters, the Wapanucka specimens compare more closely to the morphology of S. annectans. Comparison with the holotype of this species, however, indicates that the Wapanucka corallites have less numerous tabulae and less pronounced acceleration of septal insertion in the counter quadrants than the type. Additional specimens will be needed before these variations can be evaluated.

RANGE AND DISTRIBUTION: Stereocorypha annectans was described by Moore and Jeffords (1945, p. 86) from the Marble Falls Limestone of San Saba County, Texas. This species may also have been collected by these authors from the Wapanucka Formation in Pontotoc County, Oklahoma.

MATERIAL AND OCCURRENCE: Four poorly preserved specimens have been collected from locality A 18, unit U. Serial sections were made from the most complete specimen, OU 4802.

Family LACCOPHYLLIDAE Grabau, 1928

The Laccophyllidae are defined by Hill (1956, p. F258) as follows:

> Small, solitary Rugosa with axial ends of major septa united at an aulos which divides horizontal inner tabellae from inclined outer tabellae; minor septa contratigent, dissepiments absent. Sil.-Perm.

Genus Amplexocarinia Soshkina, 1928

Generic diagnosis by Hill (1956, p. F258):

Septa and aulos thin. . .Perm., Eu.

Type species: Amplexocarinia muralis Soshkina, 1928.

Remarks: The range of the genus Amplexocarinia is restricted by Hill (1956) to the Permian of Europe. However, the range of this genus was extended to include the Lower Pennsylvanian of North America by Moore and Jeffords (1945, p. 142), who referred specimens from the Hale Formation of Oklahoma and the Marble Falls Formation of Texas (Morrow series, Lower Pennsylvanian) to Amplexocarinia, describing them as A. corrugata (Mather). Hill's position regarding this assignment is not made clear in the Treatise.

This taxonomic problem arises from the misuse of "Amplexus" as a generic name for Upper Paleozoic corals of this general type in North America and in Europe. Recently the amplexoid trend in corals has been recognized as an advanced evolutionary tendency which may occur in unrelated groups. Moore and Jeffords, in their discussion of Amplexocarinia (1945, p. 142), also note that:

> These corals are in close accord with the original description of Amplexus corugatus. Mather (1915, p. 90) states that the septa extend slightly more than one-half the distance to the axis in the mature region, but the single illustrated transverse section shows septa shorter than this. It is the counter septum, rather than the

> cardinal, that is distinguished by its longer length. Dissepiments, mentioned as rarely present near the periphery, seem to have been misidentified tabulae.

The genus Amplexocarinia is similar to Amplexus Sowerby, 1814. The genotype species of Amplexus (by monotypy) is A. coralloides, but this species has not been restudied. Final conclusions here pertaining to this genus are therefore unwarranted, but the writer agrees with Moore and Jeffords, who state (1945, p. 141) that : "The mature parts of Amplexus, interpreted from illustrations of A. coralloides, are readily distinguished from those of Amplexocarinia, however, by the absence of down-bent margins of the tabulae in the former." Moreover, the writer observes that illustrations of the exterior of A. coralloides (cf. Hill, 1956, Fig. 179, 11) show septal grooves and interseptal ridges to be absent. This agrees with the description of A. coralloides given in an earlier description by Hill from the collections of James Thomson and specimens in the Sedgwick Museum at Cambridge. Relative to these specimens, Hill (1940, p. 148) stated:

> The thin epitheca shows fine growth-annulations, but no longitudinal striation; in specimens from the reef knolls the septa can be seen through the semi-transparent calcite of the epitheca, and also where this is weathered off.

Amplexus coralloides Sowerby was described and illustrated by Milne-Edwards and Haime (1850-1854) in their monograph on British fossil corals. Their illustrations of this species (Tab. XXXVI, fig. 1, 1a, 1b, 1c, 1d, 1e) confirm the absence of septal grooves and interseptal ridges on the epitheca, and also support the contention by Moore and Jeffords (1945, p. 141, quoted above) that tabulae in the mature parts are not down-bent at the margins. In the description of

A. coralloides by Milne-Edwards and Haime (1952, pt. 3, p. 173) the authors stated that

> . . .but by their general form it is evident, that this corallum is very long, cylindrical, and irregularly bent; it presents, as usual, some circular accretion swellings; its epitheca is in many places worn away, so as to leave uncovered the outer edge of the septa, which form equidistant vertical lines.

This is in contrast to the description and illustrations of corals described by Mather (1915) as Amplexus, who noted (1915, p. 90) that the epitheca of A. corrugatus is thin, but longitudinally ribbed and concentrically striated. Moore and Jeffords are equally specific in recording the presence of septal grooves and interseptal ridges in Amplexocarinia.

In the present study of the corals of the Wapanucka Formation, several small cylindrical corallites have been collected which agree closely to the description of Amplexus corrugatus Mather. Because the assignment of these corals to Amplexocarinia Soshkina appears to be well-founded, the Wapanucka specimens are referred to this genus.

Amplexocarinia corrugata (Mather), 1915

Plate 1 figures 3 - 5.

DESCRIPTION: Corallites from the Wapanucka Formation referred to this species are small cylindrical forms which are conical only near the apex. Curvature appears to be due primarily to rejuvenescence, and in many cases is abrupt. All specimens are imbedded in limestone, but transverse sections show the calices to be deep and straight-sided. The epitheca is marked externally by narrow septal grooves and broad, low interseptal ridges. The largest corallite (OU 4804) has a length of slightly over 32 mm and a maximum diameter of 5.5 mm. In other specimens length varies from 13.0 mm to 17.5 mm and diameter ranges up to 5.0 mm. Hollow attachment rootlets are present at the apex of most corallites.

Transverse sections through the mature cylindrical portions of the corallites show a thin epitheca and a maximum of 21 short straight major septa. Septa have an average length equal to about one-third the radius, but are somewhat longer immediately above tabulae, where they may extend nearly one-half the distance to the axis. In the calyx, septa become progressively shorter and have an average length of about one-quarter to one-fifth the radius. An "inner wall", or aulos, connecting the axial ends of septa is simulated by the peripheral portions of tabulae, which are deflected strongly downward. The cardinal and counter septa project into the axial region a distance of about 1 mm in most sections; other septa may also extend slightly beyond the tabulae and into the axial area. Alar septa can not be identified with certainty. The septal formula of a typical corallite (OU 4804) appears to be K 6 A? 3 C 3 A? 5 K, which shows strong acceleration of septal insertion in the counter quadrants. Minor septa and dissepiments are absent. There is no axial structure.

In longitudinal section, the tabulae rise steeply from the epitheca for a distance of 3 to 4 mm, and in some cases may be subparallel to the epitheca through part of this interval. Tabulae are subhorizontal in the open axial region, and this portion of many tabulae makes an angle of almost 90 degrees with the steeply sloping peripheral parts. Tabulae are complete, and occur at intervals of about 3 mm in the mature growth-stages.

Transverse sections of the early stages of growth (within a few millimeters of the apex) show long septa which extend to the axis of the corallite; thereafter septa shorten gradually to produce a subcircular open axial area in all later growth-stages.

DISCUSSION: Several corallites from the Wapanucka Formation correspond closely to the described morphology of corals described by Mather (1915, p. 90) as Amplexus corrugatus and subsequently described by Moore and Jeffords (1945, p. 142) as Amplexocarinia corrugata (Mather). The principal distinguishing features of this species are: (1) short, slightly amplexoid septa in the mature growth-stages which are connected near their axial ends by tabulae; (2) long septa in the early stages of growth which unite at the axis of the corallite; and (3) complete tabulae which slope steeply downward in the peripheral portion of the corallite.

Mather stated that tabulae are spaced at intervals of about 1.5 mm, but his illustrated longitudinal section (1915, pl. I, fig. 8) appears to be through only the immature growth-stages. Also, Mather's statement (1915, p. 91) that "septa. . .in the mature region. . .extended slightly over half way to the center" is not supported by the illustrated transverse section (pl. I, fig. 9).

The writer follows Moore and Jeffords in assigning corals of this type to the Permian genus Amplexocarinia. A summary of the relationship of this genus to "Amplexus" is given in the discussion of the genus Amplexocarinia in this study.

RANGE AND DISTRIBUTION: Amplexus corrugatus was described by Mather (1915, p. 90) from the Brentwood Limestone of Arkansas and Oklahoma, and from the Morrow Formation near Fort Gibson, Oklahoma. Corals described as Amplexocarinia corrugata by Moore and Jeffords (1945, p. 142) were collected from the Hale Formation (Morrow Series, Lower Pennsylvanian) near Fort Gibson, Oklahoma, and from "Morrowan beds" south of Hulbert, Oklahoma. Two corallites from the Lower Marble Falls Limestone (Morrow Series, Lower Pennsylvanian) of San Saba County, Texas, were also referred to this species by Moore and Jeffords. Amplexocarinia has not been previously reported from the Wapanucka Formation in published literature.

MATERIAL AND OCCURRENCE: Four corallites here referred to Amplexocarinia corrugata were collected during the present study, from locality A 18, unit U (lower 6 feet).

Family LOPHOPHYLLIDIIDAE Moore and Jeffords, 1945

The Lophophyllidiidae are defined by Hill (1956, p. F264) as follows:

> Small solitary corella without dissepiments and with conical tabulae; septa long, arranged in quadrants in young stages, meeting enlarged counter septum at the axis; columella formed by swollen, vertically produced axial edge of the counter septum which may be reinforced by vestigial axial ends of other septa; cardinal septum shortened and other septa withdrawn from the axis in adult stages, commonly rhopaloid. Carb.-Perm.

Genus *Lophophyllidium* Grabau, 1928

Generic diagnosis by Hill (1956, F265):

> Columella wide, typically with radial lamellae conjoined to median lamella but not tabellate, may be separated from counter septum in adult stages; axial edges of other septa, except cardinal, may be thickened and fused to one another in a collar around the columella. . .Penn.-Perm.,N.Am.-Eu.-Asia

Type species: *Cyathaxonia prolifera* McChesney, 1860

Remarks: The history of the taxonomy of most Upper Paleozoic coral genera is as complex as that of any group known to the writer. In particular, the nomenclature of the lophophyllidid corals is a veritable morass of revision and redefinition. The taxonomic history of these corals has been reviewed elsewhere, in places at great length. The interested reader will find histories of the taxonomy of this group in papers by Moore and Jeffords (1941, p. 28-83) and Jeffords (1942, p. 201-213; 1947, p. 13-22). Further review of the early studies of these corals will therefore not be undertaken here.

Comparatively recent studies of Upper Paleozoic rugose corals of North America began with a detailed study of Permian corals of the midcontinent by Moore and Jeffords (1941). As a result of this investigation three new genera were defined from the Lower and Middle Permian of western Texas: *Leonardophyllum*, with *L. distinctum* as the type species; *Lophamplexus*, with *L. eliasi* as the type species; and *Heritschia* for which *H. girtyi* was designated as the type species. This study is of particular importance because the authors demonstrated the stratigraphic value of the coral faunas in this region. Less happily, they also established therein a method of description and illustration which influenced their subsequent coral studies. For example, Jeffords (1942) published on Pennsylvanian corals of Kansas and Oklahoma belonging to the genus *Lophophyllidium*. Although this study resolved several taxonomic problems, it created others. As an example, *Lophophyllidium*, as defined by Jeffords at that time (1942, p. 211), included a group of small corals (which he subsequently referred to as the *Lophyllidium newelli* group) which were characterized by (1) restriction of the immature characters to the very early growth-stages, (2) scarcity or absence of tabulae, and (3) large alar pseudofossulae. Jeffords noted (1942, p. 213) the similarity of these corals to *Malonophyllum*, but concluded that the significance of the variation from the type species of *Lophophyllidum* could not then be evaluated.

A more extensive study of Lower Pennsylvanian corals of the Texas and adjacent states by Moore and Jeffords (1945) resulted in the description of 22 genera and 62 species. One additional lophophyllidid genus was described as *Lophotichium* (1945, p. 111), with *L. vescum* designated as the type species from the Morrow series of eastern Oklahoma.

The "*Lophophyllidium newelli*" group again was retained in the genus *Lophophyllidium*.

In 1947 Jeffords made a study of the lophophyllidid corals from the Des Moines, Missouri, and Virgil Series of the midcontinent. Of consequence to this discussion is Jeffords' restriction of the genus (1947, p. 21), as follows:

> . . . Lophophyllidium is here restricted to species having a relatively large axial column that contains radiating laminae and commonly a much thickened apical portion. The curved elongate conico-cylindrical shape is characteristic of all but the spinose species.

Consequently, many coral species previously referred to *Lophophyllidium*, but which lack radial and concentric elements in the column, were transferred by Jeffords (1947, p. 40) to a new genus, *Stereostylus*, with *S. lenis* (Missouri Series) as the genotype species. The criteria for the subdivision of *Lophophyllidium* are discussed by Jeffords (1947, p. 38) as follows:

> Corals here referred to *Stereostylus* were included in *Lophophyllidium* in earlier studies (Moore & Jeffords, 1941, 1945; Jeffords, 1942), inasmuch as the significance of many lophophyllidid features was incompletely understood. Additional investigations now have furnished data that will permit the recognition of at least two generic lines--*Lophophyllidium* and *Stereostylus*. The latter genus may be distinguished generally from *Lophophyllidium* by examination of external features of the corallite. The form of the corallite referred to *Stereostylus* varies, but generally they are conical and bear low wrinkles. *Lophophyllidium*, on the other hand, is characterized by the more elongate conico-cylindrical, smoothly curved form of the corallites, absence of prominent transverse wrinkles, and in some species by an abundance of large radicles. Sections of species of *Stereostylus* are distinguished by their smaller apical areas filled by stereoplasm, thinner or more rhopaloid septa, laterally compressed axial

> column, and lack of radiating and circumscribing laminae in the column. Also, the septa in the upper portions of corallites belonging to _Stereostylus_ are shorter in relation to the diameter than in _Lophophyllidium_. . . .

The writer does not agree with this restriction of _Lophophyllidium_ for the following reasons: (1) Jeffords' argument that _Stereostylus_ "can be distinguished generally from _Lophophyllidium_ by examination of external features of the corallite" is shown to be tenuous by the most casual examination of the exteriors of representative species (e.g., Jeffords 1947, pl. 10, pl. 20; text Fig. 6, and Fig. 7); (2) the contention by Jeffords that "the septa in the upper portions of corallites belonging to _Stereostylus_ are shorter in relation to the diameter than in _Lophophyllidium_. . ." is unsupported. Jeffords' Fig. 4 (1947, p. 12), which purports to verify this statement graphically, shows only the relationship between "_Stereostylus_" _lenis_ and _Lophophyllidium_ _coniforme_, which is not a representative sample. Moreover, comparison was made between a conico-cylindrical representative of "_Stereostylus_" (_S_. _lenis_), in which a "breviseptal" stage is to be expected, and a decidedly conical representative of _Lophophyllidium_ (_L_. _coniforme_), in which the "breviseptal" stage is predictably brief or absent. Similar graphical treatment of comparable forms (i.e., conical, or conico-cylindrical) would probably fail to show this relationship; (3) Jeffords stated that ". . .species of _Stereostylus_ are distinguished by the smaller apical area filled with stereoplasm, thinner or more rhopaloid septa (_sic_), laterally compressed axial column, and lack of radiating and circumscribing laminae in the column." Only the last part of this statement need be discussed, inasmuch as the degree of internal thickening in rugose corals is known to be highly variable, even within a species. Pertaining to the radiating and circumscribing laminae of the column, it is the writers' opinion that these elements are gradational in their development, and do not provide a sound basis for the subdivision of Lophophyllidium. This opinion is not without support; the fauna of the Wapanucka Formation includes most of the lophophyllidid species described by Jeffords (1942) and Moore and Jeffords (1945). Variation in the complexity of the column has been observed in most species. The type material of most of Jeffords' species has been examined by the writer, with the same result. The development of radial and concentric skeletal elements in the column of lophophyllidid corals varies not only from one species to another, but throughout the ontogenetic development of many species as well.

Therefore, it is here considered that "Stereostylus" should be regarded as a junior synonym of Lophophyllidium. Species described herein which were originally referred to Lophophyllidium but which were subsequently transferred to "Stereostylus" by Jeffords are retained in the former genus; these include L. minutum, L. angustifolium, and L. mundulum.

Lophophyllidium idonium Moore and Jeffords, 1945

Plate 1 figures 6 - 9, Plate 2 figure 1.

DESCRIPTION: This species is represented in the Wapanucka Formation by conical corallites which are typically uncurved. The corallites range in length from 18 mm to 36 mm and in maximum diameter, which occurs at the top of the calyx, from 9 mm to 13 mm. Most of the specimens are deeply weathered, but in several examples a moderately thick epitheca is preserved, which is marked externally by narrow septal grooves and rounded interseptal ridges of approximately the same width. Rugae are absent and growth-lines are faint. In unbroken specimens the calyx is broad, deep, and contains a prominent axial boss.

Transverse sections show from 24 to 28 long, strongly rhopaloid major septa, which are united axially by dense deposits of stereoplasm. The cardinal fossula and alar pseudofossulae are well-developed. The cardinal septum is short and thick in all growth-stages, and has a length of less than 2 mm. A narrow, compressed axial column is formed by the distended axial end of the counter septum. Sections of well-preserved corallites indicate that the column is composed of concentric lamellar layers of calcite. Radial elements within the column are absent. A characteristic feature of this species, seen in most transverse sections, is an unusually wide interseptal space between the counter septum and the counter-lateral septa. This narrow open area extends into the thickened axial region of the corallite. The septal formula of a typical corallite from the Wapanucka Formation is K 7 A 3 C 3 A 7 K. which shows strong acceleration of septal insertion in the counter quadrants. The septal formula of another specimen (OU 4808) is K 8 A 4 C 4 A 8 K. Tabulae are few or absent in this species. In transverse sections tabulae are sometimes intersected, and appear as narrow concentric rings connecting septal edges. In a few specimens, several tabulae appear in a single transverse section.

Longitudinal sections of Lophophyllidium idonium are usually obscured by internal deposits of stereoplasm. Occasional sections show one or two thin tabulae rising steeply to the thickened axis. The lower one-quarter of the corallites sectioned are filled with this material.

DISCUSSION: Comparison of the Wapanucka corallites to the holotype of Lophophyllidium idonium (UK no. 7151-21a) shows only slight intraspecific variation. From L. confertum (Jeffords, 1942) the present species is distinguished by its lack of minor septa, narrower axial column, and well-developed alar pseudofossulae. From L. distinctum (Jeffords, 1942) this species differs in having more strongly rhopaloid major septa and a more elongate and uncurved form. Also, L. distinctum is characterized by a prominent subrectangular cardinal fossula, which differs in shape from the fossula of L. idonium. From most other Lower Pennsylvanian corals described by Jeffords (1942) and Moore and Jeffords (1945), such as L. conoideum, L. extumidum, and L. blandum, the present species is distinguished by its well-developed pseudofossulae and the characteristic development of wide interseptal spades adjacent to the counter septum. This feature, plus the presence of a few tabulae, separates L. idonium from L. minutum (Jeffords, 1942).

RANGE AND DISTRIBUTION: Lophophyllidium idonium was described from the Wapanucka Formation by Moore and Jeffords (1945, p. 96). The locality at which the holotype specimen and several paratypes were collected corresponds to loc. J 16 of this study. Moore and Jeffords also figured specimens from the basal Marble Falls Limestone near San Saba, Texas.

MATERIAL AND OCCURRENCE: Wapanucka material consists of 18 specimens, of which eight were thin-sectioned and the remainder cut and polished for study. Five specimens, including two figured specimens (OU 4807 and OU 4808) are topotypes. L. idonium has been identified from five localities in the Wapanucka Formation, as follows: PO 3, unit D; PO 4, unit A; C 26, unit A; C 27, unit A; J 24, unit F; and J 16, unit D (type locality).

Lophophyllidium minutum Jeffords, 1942

Plate 2 figures 2 - 4

DESCRIPTION: This species is represented in the Wapanucka Formation by small, broadly conical corallites few of which exceed 16 mm in length and about 7 mm in diameter. Curvature is restricted to the apical portion of the corallites and is variable in degree. In the sixteen specimens assigned to this species the position of the cardinal septum clearly is on the convex, or longer, side of the corallite. The epitheca is thick, in some specimens comprising as much as one-third the radius of the corallite, and is marked externally by narrow septal grooves and broad interseptal ridges. Transverse markings of the epitheca include inconspicuous low rugae and fine growth-lines. The calyx is wide, deep, and contains a prominent axial boss. The apex of most examples bears small attachment rootlets.

Transverse sections at the base of the calyx show from 21 to 24 long rhopaloid major septa extending into the axial region of the corallite, where they are united to the column by stereoplasm. These deposits increase apically, and the apical one-third of the corallites is solidly filled with this material. It is nevertheless possible to identify septa in all growth-stages by the positions of the dark median lamellae of the septa. Study of septal arrangement indicates that the septa and column are not united, except by stereoplasm. The major septa are rhopaloid in the calyx, but are separated by distinct inter-septal spaces due to the absence of stereoplasm above the base of the calyx. The cardinal septum is short, typically less than 1 mm in length, and lies in a prominent closed fossula in all mature growth-stages. Unusually large alar pseudofossulae are present in all stages of growth and are characteristic of this species. The column is formed by the thickened axial end of the counter septum. It is compressed laterally, and contains a dark median lamella which is continuous with that of the counter septum. Radially disposed elements within the column are not present. In the calyx, the column gradually diminishes in width, but remains attached to the long counter septum. The septal arrangement of a typical corallite (OU 4811) is indicated by the formula K 5 A 4 C 4 A 5 K; that of another specimen is K 6 A 4 C 4 A 6 K. Acceleration of septal insertion in the counter quadrants is also moderate in other corallites. In one corallite, however, the formula is K 6 A 3 C 3 A 7 K, which indicates comparatively strong acceleration. Dissepiments are absent. Minor septa were not observed.

Longitudinal sections show little more than the thick epitheca and the thickened apical and axial regions. Tabulae are unknown in this small species.

DISCUSSION: Lophophyllidium minutum was originally described by Jeffords (1942, p. 246) and was redescribed by Moore and Jeffords (1945, p. 107). In a subsequent paper by Jeffords (1947, p. 40) this species was tentatively assigned (as part of the L. newelli group) to the genus "Stereostylus". Corallites from the Wapanucka Formation belonging to this species are here assigned to the genus Lophophyllidium (see discussion of this genus).

The diagnostic features of L. minutum are as follows: (1) absence of tabulae, (2) prominent alar pseudofossulae, (3) rarity or absence of minor septa, (4) rhopaloid septa, (5) thick epitheca, and (6) small size. The specimens from the Wapanucka Formation were compared to the holotype of this species (UK no. 7385-21c) and agree closely to the morphology of the type. A paratype from the Wapanucka Formation figured by Jeffords in his original description (1942, pl. 7, fig. 2a-c) also compares in all details of morphology to the writer's specimens. In a later paper, however, Moore and Jeffords described and figured (1945, p. 105, fig. 56) another corallite from the Wapanucka (UK no. 1221-21a) which differs somewhat in having distinct minor septa and radiating lamellae within the axial column. These features were not observed in the collected material.

Lophophyllidium minutum differs from L. newelli in lacking a prominent subrectangular cardinal fossula. L. distinctum is characterized by large subrectangular alar pseudofossulae which are not present in L. minutum. Lophophyllidium minutum is distinguished from L. new species A by its lack of tabulae, thicker epitheca, and more prominent alar pseudofossulae. (see also description of L. new species A).

RANGE AND DISTRIBUTION: Lophophyllidium minutum was described by Jeffords (1942, p. 246) from the Brentwood Limestone Member of the Bloyd Formation (Morrow Series) at Greenleaf Lake, southwest of Braggs, Oklahoma. Paratypes were collected from the Otterville Limestone north of Berwyn, Oklahoma, and from the Wapanucka Formation on Coal Creek, Pontotoc County, Oklahoma. In the redescription of this species, Moore and Jeffords list (1945, p. 107) additional occurrences from the Hale Formation (Morrow Series) at Greenleaf Lake, Oklahoma, and the Wapanucka Formation at Limestone Gap (Atoka County, Oklahoma) and west of Clarita (Coal County, Oklahoma.)

MATERIAL AND OCCURRENCE: Sixteen corallites, of which six were thin-sectioned and the remainder were cut and polished for study. All are from locality PO 4, unit A.

<u>Lophophyllidium</u> <u>ignotum</u> Moore and Jeffords, 1945

Plate 2 figures 5 - 6.

DESCRIPTION: Solitary corallites from the Wapanucka Formation belonging to this species are medium in size, conical, and typically almost straight. The corallites range in length from 18.0 mm to 24.9 mm and in maximum diameter from 9.9 mm to 10.9 mm. The epitheca is unusually thick and is covered externally by a veneer of dark carbonaceous and calcareous material. Study of transverse sections indicates that septal grooves and interseptal ridges are poorly developed. The calyx is broad, deep and contains a prominent axial boss. Rootlets for attachment are preserved at the apex of the corallites.

Transverse sections through the upper part of the calyx show about 24 thick (but non-rhopaloid) major septa, whose length is equal to about one-third the radius of the corallite. Transverse sections at the base of the calyx show about 25 major septa cf subequal length. Septa extend into the axial region, but are not in contact with the column. In lower sections, septa become progressively thicker, and, with the column, fill the interior of the corallite except for small peripheral interseptal spaces. The cardinal septum is long and thin in all but the latest growth-stages. Its length normally approximates four-fifths that of adjacent metasepta. The cardinal fossula is small but prominent, and in most corallites can be distinguished in the thickened immature growth-stages. Alar pseudofossulae are narrow, but are also distinguishable in most transverse sections. The axial column is formed by the distended axial end of the counter septum. In the mature stages of growth it is compressed and narrower than the thick septa. The column contains a thin median lamella which is continuous with that of the counter septum. Radially-disposed elements within the column are not in evidence. In the calyx the column becomes irregular in outline and persists into the upper calyx as an independent structure. The epitheca is thick in all growth-stages, often having a width equal to one-third the radius of the corallite. Septal lamellae penetrate the epitheca and extend through about four-fifths its width. The septal arrangement of a typical corallite is indicated by the formula K 7 A 3 C 4 A 7 K, which shows strong acceleration of septal insertion in the counter quadrants. Tabulae are present, and appear in transverse sections as thick concentric rings connecting septal edges. Minor septa are present in the upper part of the calyx but are rudimentary. Dissepiments are not present.

DISCUSSION: The above description of <u>Lophophyllidium</u> <u>ignotum</u> is based upon topotype material which has been compared with the holotype (UK no. 7134-21b) of this species. Moore and Jeffords incorrectly stated (1945, p. 108) that the cardinal septum of <u>L</u>. <u>ignotum</u> is short in all growth-stages. In the holotype, and in the topotypes collected by the writer, the cardinal septum is short only in the calyx.

Diagnostic features of this species are: (1) the irregularity of the axial column in the calyx; (2) the thick epitheca; and (3) the long cardinal septum in all but the latest stages of growth.

<u>Lophophyllidium</u> new species <u>B</u>, an externally similar species, occurs at the same locality and horizon in the Wapanucka Formation. <u>L</u>. <u>ignotum</u> differs from this new species in having a much narrower column in all growth-stages, larger alar pseudofossulae, and fewer septa. Also, the column in <u>L</u>. new species <u>B</u> does not become irregular in the calyx and is short throughout all stages of growth.

RANGE AND DISTRIBUTION: <u>Lophophyllidium</u> <u>ignotum</u> was described by Moore and Jeffords (1945, p. 108) from two corallites from the Wapanucka Formation at a locality (KU loc. 7134), which corresponds to loc. PT 23 of this report.

MATERIAL AND OCCURRENCE: Three topotypes, from locality PT 23, unit B.

<u>Lophophyllidium</u> <u>extumidum</u> Moore and Jeffords, 1945

Plate 2 figure 7.

DESCRIPTION: Two corallites from the Wapanucka Formation are assigned to this species. The corallites are conical, straight, or slightly curved. The figured specimen (OU 4816) has a length of 19.3 mm and a maximum diameter of 11.0 mm. The upper part of the calyx is not preserved in either specimen. The epitheca is thick, and in some sections comprises slightly more than one-fourth the radius of the corallite; it is marked externally by shallow septal grooves and broad, low interseptal ridges. Growth-lines are faint, and rugae are low and inconspicuous. The calyx contains a prominent axial boss.

Transverse sections at the base of the calyx show 24 long, strongly rhopaloid major septa which are in contact with adjacent septa in the axial one-half of their length. Minor amounts of stereoplasm are present in the axial region, but the thickened appearance of the axial region of this species is due primarily to the strongly rhopaloid septa. The cardinal septum is slightly thinner than other septa, and lies in a closed fossula. The length of the cardinal septum is typically between one-third and one-half that of adjacent metasepta. Alar septa are identified with difficulty because of pronounced radial symmetry; alar pseudofossulae are narrow, and in most sections obscure. The axial column of this species is large, suboval, and prominent in all transverse sections. It is formed by the thickened axial end of the long counter septum and is reinforced by concentric deposits of stereoplasm. The column remains attached to the counter septum as high as the floor of the calyx, above which it persists as an independent structure into the calyx. The number and arrangement of septa in the figured specimen is indicated by the formula K 7 A 3 C 3 A 7 K; that of the second corallite is similar. Acceleration of septal insertion in the counter quadrants is strong. Tabulae appear in transverse sections as numerous thin concentric rings connecting septal edges. Commonly from 3 to 5 tabulae are intersected by transverse sections. Minor septa were not observed in these corallites, but the upper calyx is not present. Dissepiments are absent.

Adequate longitudinal sections could not be obtained from the limited material available. A longitudinal section of the juvenile and early mature growth-stages shows complete tabulae which rise steeply to the column; the apical one-fifth of the corallites are thickened by stereoplasm.

DISCUSSION: Lophophyllidium extumidum is a distinctive species and is easily distinguished from other lophophyllidid corals. From L. angustifolium (Moore and Jeffords, 1945), this species differs in having a more prominent axial column, more numerous tabulae, and in lacking well-developed alar pseudofossulae. L. blandum (Moore and Jeffords, 1945) has a narrower column, fewer tabulae, and less rhopaloid septa.

The corallites from the Wapanucka Formation described above were compared to the type specimen of L. extumidum (UT no. P- 9536a) and to the described and figured paratypes. All significant aspects of morphology compare closely. Slight differences in preservation obscure the "superposed cones" which form the column of the holotype and several paratypes, but the concentric lamellar structure of the column is visible in transverse sections. Short minor septa, incorrectly stated by Moore and Jeffords to be lacking in this species (1945, p. 93), are present in several paratypes figured by these authors (1945, figs. 16b, 21a, p. 94). Minor septa are not present in the preserved portions of the corallites from the Wapanucka Formation.

RANGE AND DISTRIBUTION: Lophophyllidium extumidum was described by Moore and Jeffords (1945, p. 93) from the Marble Falls Limestone of San Saba

County, Texas, and is here reported for the first time from the Wapanucka Formation.

MATERIAL AND OCCURRENCE: Two corallites, from locality Pt 23, unit B, and J 24, unit F.

<u>Lophophyllidium</u> cf. <u>mundulum</u> Jeffords, 1942

Plate 2 figures 8 - 10.

DESCRIPTION: Solitary corallites from the Wapanucka Formation which may represent this species are conical forms of medium size. The largest corallite is 24.4 mm in length, and the maximum diameter recorded is 16.3 mm. Curvature is slight, or absent. The thin epitheca is marked externally by narrow septal grooves and broad, low interseptal ridges. Fine growth-lines comprise the transverse markings of the epitheca. The calyx is broad, deep, and contains a spine-like axial boss. Attachment rootlets are lacking, or are not preserved.

Transverse sections through the upper calyx show up to 30 long, straight major septa which are markedly unequal in length, and non-rhopaloid. The septa in this growth-stage are free at their axial ends. Short minor septa are present in the calyx, but are rudimentary or absent in lower sections. The cardinal septum is short and thin in all stages of growth, and lies in an open fossula. In length, the cardinal septum approximates one-half the length of the adjacent metasepta, which in turn are somewhat shorter than other septa of the cardinal quadrants; this feature is consistent in the specimens here described. Transverse sections made through the base of the calyx show from 24 to 26 major septa which do not extend to the axial column, but are joined in their axial portion to other septa of the same quadrant. In lower sections the axial ends of the septa thus united may be joined to the column by narrow extensions of stereoplasm. In the juvenile stages of growth, major septa are joined to the column by stereoplasm in all four quadrants, with the exception of the cardinal septum and the two last-inserted septa of the cardinal quadrants. Alar septa are readily identified due to strong tetameral symmetry and prominent alar pseudofossulae. The counter septum is long, and is expanded axially to form a narrow column. Counter-lateral septa typically are parallel to the counter septum except in the axial region, where they curve away from the column. The septal arrangement of a typical specimen (OU 4817) is indicated by the formula K 7 A 4 C 4 A 7 K, which shows moderate acceleration of septal insertion of the counter quadrants. In the calyx the major septa withdraw slightly, and the axial column persists for several millimeters as an independent structure. Tabulae were not observed.

It was not possible to make adequate longitudinal sections of this species because of the limited material.

DISCUSSION: Described Lower Pennsylvanian lophophyllidid corals in which tabulae are rare or absent include Lophophyllidium minutum, L. distinctum, L. newelli, and L. mundulum. These species were described by R. M. Jeffords (1942). Subsequently, L. *minutum* was redescribed by Moore and Jeffords (1945). The corallites from the Wapanucka Formation were compared to the holotypes of these species (UK nos. 7385-21c, 5210-21a, 2562-21b, and 68-21a, respectively). From *L. minutum*, *L. distinctum* and *L. newelli*, the present corallites differ primarily in lacking the thickened axial region and prominent fossulae (cardinal and alar) which characterize these species. In addition, *L. minutum* and *L. distinctum* have a maximum of 24 major septa, whereas the number of major septa in the Wapanucka corallites ranges from 26 to 30 in the mature growth-stages. *L. distinctum* is also distinguished by its prominent axial column. *L. newelli* has a comparable number of major septa, but the septa of that species are moderately rhopaloid and subequal in length, while the septa in the Wapanucka specimens are nonrhopaloid and of distinctly unequal lengths. Although comparison to the holotype of *L. mundulum* suggests tentative assignment to this species, the morphology of *L. mundulum* is incompletely known, as the mature portion of the type was not thin-sectioned. The Wapanucka corallites correspond closely to the morphology of the type (Jeffords, 1942, pl. 2, figs. 1a-d, p. 225) insofar as it is shown, but comparison with the mature growth-stages was not possible.

RANGE AND DISTRIBUTION: *Lophophyllidium mundulum* was described by Jeffords (1942, p. 223) from the Lower Pennsylvanian of the Ardmore basin of Oklahoma. The locality is given by Jeffords (1942, p. 224) as follows: "Pumpkin Creek limestone, 220 feet above Lester limestone, Dornick Hills group, of Lampasas age, Pennsylvanian. . .southwest of the Country Club, about 3 miles north of Ardmore, Oklahoma."

MATERIAL AND OCCURRENCE: Three corallites; all were thin-sectioned for study and comparison. Corallites were collected at locality J 16, unit D.

<u>Lophophyllidium</u> cf. <u>angustifolium</u> Moore and Jeffords, 1945

Plate 2 figures 11 - 12, Plate 3 figures 1 - 2.

DESCRIPTION: Solitary corallites from the Wapanucka Formation here tentatively assigned to this species are medium in size, conical, and typically almost straight. In length the corallites range from 18.0 mm to 20.5 mm, but the calyx is in no case preserved. Maximum diameter ranges from 8.6 mm to 12.5 mm. The epitheca is of moderate thickness, and bears narrow septal grooves and low, rounded interseptal ridges. These are crossed by fine growth-lines and inconspicuous rugae.

Transverse sections show from 24 to 26 long, slightly rhopaloid major septa which are commonly joined to adjacent septa by stereoplasm. Major septa do not extend to the column, nor are they united to it by stereoplasm. Septa are typically joined to each other by quadrants, which accentuates the strong tetameral symmetry of this species. The septal arrangement of typical corallites is indicated by the following formulae: K 6 A 4 C 4 A 6 K (OU 4820); K 7 A 4 C 4 A 6 K (OU 4823); and K 7 A 4 C 4 A 7 K (OU 4821). Moderate acceleration of septal insertion in the counter quadrants is indicated by these formulae. Minor septa are present as low rounded ridges in the uppermost part of only one corallite. The cardinal septum is short, in all specimens less than 1 mm in length, and lies in an open fossula. Alar pseudo-fossulae are present but are not prominent. The axial end of the counter septum is distended to form a narrow column which contains a median lamella continuous with that of the counter septum. A few tabulae are intersected by transverse sections, and appear to be incomplete. Dissepiments are absent.

Longitudinal sections of the corallites from the Wapanucka Formation show the tabulae to rise steeply to the column; their attitude is variable, but in general they are convex downward near the periphery of the corallite and become convex upward as they near the axis. The apical portion of the corallites is slightly thickened by stereoplasm.

DISCUSSION: The writer has not examined the type material of _L. angustifolium_, and the morphology of this species is not clearly illustrated by Moore and Jeffords (1945, p. 102, figs. 44-46). Identification of the corallites from the Wapanucka Formation is therefore tentative, although the present specimens correspond to the stated characters of the species. A similar species is _L. idonium_ (Moore and Jeffords, 1945) which has wide interseptal spaces adjacent to the counter septum which extend into the axial region. Because of the thickened axial region of _L. idonium_, however, these spaces are more prominent than in L. angustifolium. Also, the present species has more tabulae and a more open apical region than observed in L. idonium. The lack of thickened internal structures also separates L. angustifolium from L. extumidum (Moore and Jeffords, 1945), L. metum (Moore and Jeffords, 1945), L. minutum (Jeffords, 1942), and L. conoideum (Moore and Jeffords, 1945). From L. blandum (Moore and Jeffords, 1945) the present species is distinguished by its narrower conical form and recognizable alar pseudofossulae in the mature growth-stages.

RANGE AND DISTRIBUTION: Lophophyllidium angustifolium was described by Moore and Jeffords (1945, p. 103) from a single corallite collected from the Hale Formation (Morrow Series) 1 mile south of Morrow, Arkansas, and two paratypes collected near Greenleaf Lake, southeast of Braggs, Oklahoma. This species has not previously been reported from the Wapanucka Formation.

MATERIAL AND OCCURRENCE: The present material consists of six corallites, five of which were thin-sectioned for study, from locality PO 4, unit A.

Lophophyllidium new species A

Plate 3 figures 3 - 5.

DESCRIPTION: Diagnosis of this species is based on solitary corallites which are small and typically conical in form. A few specimens tend to become cylindrical in the upper part of the corallite. Curvature is restricted to the apical one-quarter of the corallites. The cardinal septum lies on the convex, or longer, side of the corallite. The corallites are relatively uniform in length, ranging from 15.4 mm to 16.5 mm. Maximum diameter ranges from 7.0 mm to 9.7 mm. The epitheca is of moderate thickness and is marked by narrow septal grooves and interseptal ridges. Low rugae and fine growth-lines are present, but are not prominent. A pronounced axial boss projects above the floor of the calyx in well-preserved specimens.

Transverse sections at the base of the calyx show from 21 to 25 long major septa, which are joined to the axial column by thick deposits of stereoplasm. The cardinal septum is short, ranging from 0.5 mm to 1.0 mm in length, and occupies a closed fossula. Alar pseudofossulae are well-developed in all growth-stages. The counter septum is thickened axially to form a compressed column. Radiating lamellae are not present, but the column contains a dark median lamella which is continuous with that of the counter septum. The septal arrangement in the mature portion of the type specimen (OU 4824) is indicated by the formula K 6 A 4 C 4 A 6 K. Moderate acceleration of septal insertion in the counter quadrants is also indicated. The formula of other specimens sectioned is similar. Transverse sections normally intersect one or two tabulae, which appear as thin concentric rings connecting septal edges. Transverse sections through the upper part of the calyx show long non-rhopaloid septa and a compressed, slightly irregular axial column. The column remains connected to the counter septum well into the calyx, and does not persist as an independent structure as in some species of Lophophyllidium (e.g., L. ignotum). Minor septa and dissepiments are lacking.

Longitudinal sections show the thickened axial region and a few thin tabulae which rise steeply from the periphery of the corallite to the column. The apical one-third of all specimens is solid stereoplasm, which condition makes the identification of tabulae difficult.

DISCUSSION: This new species is externally similar to Lophophyllidium minutum, a small form described by Jeffords (1942, p. 246) from the Wapanucka Formation. In addition, the two species occur at the same locality (PO 4) and horizon (unit A). Internally, the presence of tabulae in Lophophyllidium new species A distinguishes this species from L. minutum. Other internal differences, probably of less value, are as follows: (1) the epitheca of the new species is thinner than that of L. minutum at comparable stages of growth; (2) septa in the new species are thinner; (3) alar pseudofossulae are less prominent; and (4) the cardinal septum is consistently on the convex side of the corallite, whereas it is variable in position in L. minutum. Statistical plots of the populations of the two species have been made, which indicate that for a given growth-stage (= height) the new species consistently has a slightly lesser diameter than L. minutum, but the value of this is limited by the rather small sample.

From Lophophyllidium distinctum and L. newelli, also described by Jeffords (1942, p. 242, 243), L. new species A is also distinguished by the presence of tabulae. L. newelli is characterized in part by a large subrectangular cardinal fossula, which is not similarly developed in this new species; nor does this small form have the prominent subrectangular alar pseudofossulae present in L. distinctum.

Described lophophyllidid corals which correspond to the present species in having tabulae and in lacking minor septa include L. idonium, L. eastoni, and L. metum. These species were described by Moore and Jeffords (1945) from rocks of Morrowan age in Oklahoma and Arkansas. L. new species A differs markedly from L. eastoni in the nature of the axial column, and does not require further comparison here with that species. From L. idonium, which was described from the Wapanucka Formation, L. new species A can be distinguished by its lack of large interseptal spaces between the counter septum and counter-lateral septa, smaller size, and thickened apical region. In L. metum, tabulae are numerous and become horizontal about halfway to the axis of the corallite, rather than rising uninterrupted to the column as in the present species. L. metum is also characterized by poorly developed alar pseudofossulae and an unthickened axial region, whereas L. new species A has well-developed pseudofossulae and marked internal thickening.

The above discussion is based on study and comparison with the type specimens of all similar described Morrowan species of Lophophyllidium from Oklahoma and adjacent states, including the holotypes of L. metum (UK no. 4520-21a), L. distinctum (UK no. 5210-21a), L. minutum (UK no. 7385-21c), L. idonium (UK no. 7151-21a) and L. newelli (UK no. 2562-21b).

RANGE AND DISTRIBUTION: Wapanucka Formation (Morrow Series, Lower Pennsylvanian).

MATERIAL AND OCCURRENCE: Fourteen corallites, of which all were either thin-sectioned or cut and polished for study. All specimens are from locality PO 4, unit A.

<u>Lophophyllidium</u> new species <u>B</u>

Plate 3 figures 6 - 9.

DESCRIPTION: Solitary corallites here described as <u>Lophophyllidium</u> new species <u>B</u> are small to medium in size, conical, and typically straight. A few corallites are slightly curved in the plane of the alar septa. The type specimen (OU 4827) is 34 mm in length and 18 mm in diameter at the top of the calyx. Other specimens are slightly smaller, and average about 27 mm in length and 10 mm in diameter. Carbonaceous material covers the exterior of the epitheca of all specimens, but study of transverse sections indicates that septal grooves and interseptal ridges are poorly developed. Rugae are low and inconspicuous. Small attachment rootlets are preserved at the apex of one specimen. The calyx is broad, deep, and contains a prominent axial boss.

Transverse sections through the upper calyx show from 28 to 30 major septa which are of subequal length and are slightly rhopaloid. Minor septa are rudimentary, and are absent below the calyx. In transverse sections at the base of the calyx the major septa are more strongly rhopaloid and are laterally in contact in the axial region, but do not extend to the axial column. The epitheca is unusually thick, and in the mature corallite has a width equal to as much as one-third the radius. The cardinal septum is short and thick in all stages of growth, typically less than 1 mm in length, and lies in a small but prominent fossula. Alar septa can be identified only by the position of the short last-inserted septa of the counter quadrants. The axial column of this species is large and prominent in all transverse sections. It is oval to subcircular in outline, and is attached to the counter septum in all but the latest growth-stages. The median lamella of the column is continuous with that of the counter septum and distinct radiating septal lamellae are visible within the column in most sections. Lamellae are symmetrically arranged, and in some corallites the column has a hexagonal outline. The number and arrangement of septa in the holotype is indicated by the formula K 8 A 4 C 4 A 9 K, which shows strong acceleration of septal insertion in the counter quadrants. Paratypes have similar formulae. A few tabulae are present, and appear in transverse sections as concentric rings around the axial region. Tabulae are complete and of moderate thickness, but are not intersected by all transverse sections. Dissepiments are absent.

Longitudinal sections show little more than the thick epitheca, thickened axial region, and column. In some sections a few tabulae are intersected, which rise evenly to the column. The apical one-third to one-half of the corallites is filled with stereoplasm, but the cardinal fossula remains open almost to the apex of the corallites.

DISCUSSION: It is probable that this new species includes corals described by Moore and Jeffords (1945, p. 110) as Lophophyllidium sp. "A" from the Wapanucka Formation and the Hale Formation (Morrow Series) of Oklahoma. Moore and Jeffords' description was based on two specimens, one of which was collected at the same locality as the material here described. Comparison was made to both specimens (UK no. 7134-21a and 7385-21n). Only the immature growth-stages are preserved in these specimens, and to this portion of the corallites the Wapanucka specimens correspond closely. In view of the additional material now available, it is desirable to describe this form as a distinct species.

An externally similar species is L. ignotum Moore and Jeffords, which also occurs at the same locality and horizon in the Wapanucka Formation. L. new species B differs from this species in the following respects: (1) the column of the new species is more prominent and regular in outline in all stages of growth; (2) a greater number of septa are present in the mature growth-stages; and (3) the cardinal septum is short in all growth-stages.

Internally similar species are L. wewokanum Jeffords (= L. profundum Girty, 1915) and L. plummeri Jeffords (= L. profundum Plummer and Moore, 1921). From the former species, L. new species B differs in: (1) its broader conical form; (2) thicker epitheca; (3) rudimentary minor septa; (4) greater internal thickening by stereoplasm; and (5) lack of conical laminae in the axial column. From the latter species, L. plummeri, the new species is distinguished by: (1) its smaller size; (2) broader, uncurved conical form; and (3) stronger acceleration of septal insertion in the counter quadrants.

RANGE AND DISTRIBUTION: Wapanucka Formation, and possibly the Hale Formation (Morrow Series, Lower Pennsylvanian).

MATERIAL AND OCCURRENCE: Six corallites; the holotype (OU 4827) and four paratypes were collected at locality PT 23, unit B. One corallite was collected from locality PT 21, unit H.

Lophophyllidium sp. "X"

Plate 3 figures 10-11.

DESCRIPTION: Solitary corallites here described as Lophophyllidium sp. "X" are medium in size, conical, and slightly curved in the cardinal-counter plane. In the several specimens at hand, the cardinal septum lies on the concave, or shorter, side of the corallite. The corallites range in length from 26.0 mm to 30.5 mm, and in maximum diameter from 12.7 mm to 18.3 mm. The thick epitheca is marked externally by deep, narrow septal grooves and rounded interseptal ridges. Rugae are inconspicuous, and growth-lines faint or lacking. The axial column forms a prominent axial boss in the wide calyx. Attachment rootlets are not present, or are not preserved.

Transverse sections through the mature growth-stages show approximately 30 long major septa of subequal length. Septa are strongly rhopaloid, and are typically in contact axially with adjacent metasepta of the same quadrant, thereby forming an inner wall around the column. In some sections, narrow extensions of stereoplasm extend from this wall to the column, but in no growth-stage do the major septa extend to the column. The cardinal septum lies in an open fossula, and in the mature growth-stages is about one-third the length of adjacent metasepta. Alar septa are identified by the position of well-developed narrow pseudofossulae. The counter septum is long, and is distended axially to form a compressed axial column. In one specimen (OU 4832), the central portion of the column consists of a solid structureless rod which is oval in cross section; in other corallites, this feature is obscure. The septal formula of two of the corallites (OU 4831 and OU 4832) is K 9 A 4 C 4 A 9 K, indicating strong acceleration of septal insertion in the counter quadrants. In the third corallite the septal arrangement is indicated by the formula K 9 A 5 C 4 A 9 K. Tabulae are complete, and appear only in the latest growth-stages, between the counter and counter-lateral septa. Dissepiments are absent.

Longitudinal sections show numerous tabulae (4 to 6 per 10 mm) which are strongly convex upward in one corallite and moderately so in others. The axial column is narrow, solid, and slightly sinuous in longitudinal sections.

Transverse sections through the juvenile growth-stages show a slight increase in thickening by stereoplasm. Tetameral symmetry is pronounced, and septa join axially by quadrants. The cardinal septum is thinner than other septa and lies in a large fossula. Alar pseudofossulae are conspicuous.

DISCUSSION: The corallites described above do not agree in all aspects to any lophophyllidid species known to the writer. From the Morrowan species L. angustifolium Moore and Jeffords, these corallites differ in (1) their larger size, (2) greater number of septa in the mature growth-stages, (3) stronger acceleration of septal insertion in the counter quadrants, (4) more numerous tabulae, (5) more rhopaloid septa, and (6) slightly broader column. Lophophyllidium sp. "X" differs from L. adapertum Moore and Jeffords, also of Morrow age, in (1) having more numerous tabulae, (2) more strongly rhopaloid septa, and (3) much smaller size. L. elongatum is stated by Jeffords to range up to over 52 mm in length, a size which is improbable for the Wapanucka corallites. From L. radiatum Jeffords the present specimens differ in (1) having more rhopaloid septa, (2) rudimentary minor septa, and (3) a narrower column. Both L. radiatum and L. elongatum were described by Jeffords (1942) from the Missouri Series (Middle Pennsylvanian) of Kansas and Oklahoma.

Because of the few specimens available for study, a new species name is not proposed at this time.

RANGE AND DISTRIBUTION: Wapanucka Formation (Morrow Series, Lower Pennsylvanian).

MATERIAL AND OCCURRENCE: Three corallites, from locality PO 4, unit A.

Genus Lophamplexus Moore and Jeffords, 1941

Generic diagnosis by Hill (1956, p. F265):

> Like Stereostylus, but columella discontinuous or lacking in upper part of corallite. Penn. - L. Perm., N. Am.

Type species: Lophamplexus eliasi Moore and Jeffords, 1941.

Remarks: Hill's diagnosis of Stereostylus agrees with the original definition of the genus by Jeffords (1947, p. 38), and includes as part of the diagnosis the statement that the columella consists of a simple expansion of the axial end of the counter septum. Stereostylus, however, is considered to be a junior synonym of Lophophyllidium Grabau (see discussion of Lophophyllidium, this report). It is nonetheless true that the axial column of all described species of Lophamplexus is typically compressed laterally. The altered diagnosis of this genus is as follows:

> Like Lophophyllidium, but column discontinuous or absent in upper part of corallite; column formed by expanded axial end of long counter septum; cardinal septum long in early growth-stages, short above; counter septum often shorter than adjacent metasepta in mature stages of growth.

The essential part of this diagnosis, by which Lophamplexus is distinguished from Lophophyllidium, is considered by the writer to be the discontinuity of the axial column. This feature is clearly observable only in longitudinal sections, and care must be taken to avoid misidentification of species of Lophophyllidium as Lophamplexus because of poorly centered longitudinal sections.

The genotype species of Lophamplexus is L. eliasi, which was described by Moore and Jeffords (1941, p. 90) from the Lower Permian (Wolfcamp Series) of Kansas and Oklahoma. The similarity of the early growth-stages of this genus to Lophophyllidium is noted by these authors (1941, p. 90) who state that:

> The apical part of the corallite, representing youthful stages of growth, bears internal structures typical of Lophophyllidium, having an axial column that is composed mainly of vertical extensions of tabulae joined to the major septa that tend to form a stereozone.

On the basis of these observations, the authors stated (1941, p. 91) that "Lophamplexus is indicated to have been derived from an ancestor belonging to Lophophyllidium or a closely related genus."

Since the description of L. eliasi in 1941, however, corals referred to Lophamplexus have been described by Moore and Jeffords (1945) and Jeffords (1947) from all Pennsylvanian series in the mid-continent region. Of importance to this discussion are L. captiosus, described from the Hale Formation (Morrow Series) by Moore and Jeffords (1945), and L. new species C, here described from the Wapanucka Formation. The association of species of Lophamplexus and Lophophyllidium in rocks of Pennsylvanian age, and the absence of lophophyllidid corals in rocks of Mississippian age, is contrary to Moore and Jeffords' conclusions pertaining to the phylogeny of this genus. It is probable that Jeffords' evaluation of the phylogeny of Lophamplexus in a more recent (1947) paper represents a more realistic view of the origin of these corals. Jeffords stated (1947, p. 62, 64) that:

> Ontogenetic study of these corals indicates that the appearance of the breviseptal phase relates to the specialization of the species. Thus, advanced species are characterized by a restriction of the lophophyllidoid characters to a very small apical portion and by a strong development of the breviseptal phase. . . The degree of specialization, however, is not related to stratigraphic occurrence. Advanced species, such as L. brevifolius, n. sp., and L. phractus, n. sp. and L. vagus, n. sp., occur in Desmoinesian and Missourian rocks, whereas structurally less advanced forms, such as L. spanius n. sp., and L. eliasi Moore & Jeffords, occur in Virgilian and Lower Permian rocks, respectively. It seems probable, therefore, that the species included in Lophamplexus are polyphyletic in origin and developed independently and at different times from Stereostylus. Thus, the degree of specialization cannot be used reliably as an indication of stratigraphic horizon.

Jeffords referred to "Stereostylus" as the probable ancestral genus to the various species of Lophamplexus; this genus is considered by the writer to be a junior synonym of Lophophyllidium, as previously noted. Jeffords' reference to "Stereostylus" as having given rise---at various times during the Pennsylvanian and Lower Permian---to species of Lophamplexus is all the more strange in the light of the distinctly lophophyllidid nature of the axial column in the early growth-stages of these corals. This would be true even if Lophophyllidium were considered in the restricted sense, as including only corals with radially disposed elements within the column. With this reservation, Jeffords' appraisal of the phylogeny of Lophamplexus seems to be well-founded, within the limitations of our knowledge of the lophophyllidid corals and the perplexing "amplexoid" tendency observed in some groups.

<u>Lophamplexus</u> new species <u>C</u>

Plate 4 figures 1 - 4.

DESCRIPTION: Solitary corallites here described as <u>Lophamplexus</u> new species <u>C</u> are cylindrical forms, in which the conical portion is restricted to the earlier growth-stages. The epitheca is marked externally by narrow septal grooves and comparatively broad, rounded interseptal ridges. Growth-lines are fine, but distinct. Rugae are present, but are not prominent. In most specimens curvature appears to be due primarily to periodic rejuvenescence. The direction of curvature was observed to be inconsistent with respect to the position of protosepta. The holotype (OU 4834), which is incomplete, is 24.3 mm in length and has a maximum diameter of 9.0 mm. A paratype, also incomplete, 28.2 mm in length and has a maximum diameter of 11.1 mm. It is probable that complete specimens of this species attain lengths well in excess of 35 mm.

In the holotype there are 23 major septa at the base of the calyx which alternate with short minor septa. In other specimens major septa number 23 to 26 at this growth-stage. Major septa are thin, straight, non-rhopaloid, and are of approximately equal length at a given growth-stage. The cardinal septum has the same thickness as other major septa, but its length approximates one-half that of adjacent metasepta. The cardinal fossula is open, and is poorly developed in all growth-stages. The counter septum is long, thin, and in some sections extends as wavy lamella into the open axial region. Alar septa can not be identified with certainty in specimens in which the septal grooves and interseptal ridges are obscured or abraided. Alar pseudofossulae are absent. The septal formula of the holotype is K 7 A 3 C 3 A 6 K, indicating strong acceleration of septal insertion in the counter quadrants. A paratype (OU 4833) has the following septal arrangement: K 7 A 4 C 4 A 6 K. Minor septa in few cases exceed one-eighth the length of major septa. Tabulae appear in transverse sections as narrow, strongly curved bars near the periphery of the corallite or as discontinuous indistinct curved bands in the axial region. Dissepiments are absent. The axial column is discontinuous vertically.

Longitudinal sections show the septa of this species to be strongly amplexoid. Septa extend well into the axial region on the distal (upper) surfaces of tabulae, but progressively withdraw from the axis upward. A diagnostic feature of the genus *Lophamplexus*, best observed in longitudinal section, is the discontinuous axial column. In the present species, the column, when present, is formed by the thickened axial end of the counter septum and the axial ends of tabulae. The apical one-third of corallites is characterized by a distinct column which is formed by the axial end of the counter septum. It is similar in appearance to the axial column in many species of *Lophophyllidium*. In the mature growth-stages, however, the column is discontinuous and typically terminates from 5 to 10 mm below the base of the calyx. In several specimens, the column is interrupted at several earlier stages of growth. Tabulae range in number from 5 to 8 per 10 mm. In those portions of the corallites where the column is present, tabulae rise steeply from the epitheca, become subhorizontal about halfway to the axis, and are deflected sharply upwards (distally) as they near the column. Where the column is interrupted, or above the terminus of the column, tabulae are complete and cross the axial region in a horizontal or slightly sagging attitude. Commonly the axial end of a tabulum rests upon a subjacent tabulum.

DISCUSSION: Lophamplexus new species C differs from the type species of Lophamplexus, L. eliasi, as follows: the new species has (1) a thicker epitheca; (2) more numerous and stouter tabulae; (3) a more cylindrical form; and (4) a more complex axial column, which incorporates the axial ends of tabulae into its structure. L. eliasi was described by Moore and Jeffords (1941, p. 91) from the Permian (Wolfcamp Series) of Texas. A more nearly similar form is L. captiosus, described by Moore and Jeffords (1945, p. 120) from the Hale Formation (Morrow Series, Lower Pennsylvanian). Corallites from the Wapanucka were compared to the holotype of this species (UK no. 4520-21f) and differ in their more cylindrical form, lack of a well-developed cardinal fossula, more numerous tabulae, and more complex axial column. Lophamplexus new species C differs markedly from other described species of Lophamplexus and does not require further comparisons.

RANGE AND DISTRIBUTION: Wapanucka Formation (Morrow Series, Lower Pennsylvanian). The genus Lophamplexus has not previously been reported from the Wapanucka Formation.

MATERIAL AND OCCURRENCE: The description of this species is based on four corallites, all of which were thin-sectioned for study and comparison. All specimens were collected at localities PO 3, unit A, and PO 4, unit A.

Family TIMORPHYLLIDAE Soshkina in Soshkina, Dobrolyubova & Porfiriev, 1941

The Timorphyllidae are defined by Hill (1956, p. F266) as follows:

> Solitary coralla, typically without dissepiments; with an axial structure of median lamella, radial lamellae, and tabellae; with narrow peripheral stereozone and conical tabulae. L. Carb. - L. Perm. (Artinsk.).

Genus M n. gen.

Generic diagnosis:

> Corallite conical-cylindrical, marked externally by septal grooves and interseptal ridges; axial structure with median lamella, radial lamellae, and short tabellae; cardinal septum short, counter septum continuous with median lamella of axial structure; all major septa slightly amplexoid; tabulae convex distally, sharply upturned axially; minor septa short; dissepiments absent. L. Penn. (Morrow Series) Oklahoma.

Type species: Genus M new species D Rowett, 1962.

Remarks: Corallites from the Wapanucka Formation described in this study as new genus _M_ are placed in the Family Timorphyllidae, as defined in Hill (1956, p. F266-267). This assignment is made on the basis of the absence of dissepiments, attitude of tabulae, and the dibunophylloid-like axial structure of the Wapanucka corallites.

The axial structure of this new genus suggests comparison with _Dibunophyllum_ Thomson and Nicholson, 1876, and _Carcinophyllum_ Thomson and Nicholson, 1876. _Dibunophyllum_ has been recognized from the Lower Carboniferous of Europe, N. Africa, and N. America, and is assigned in Hill (1956, p. F286) to the Aulophyllidae. _Carcinophyllum_ was described from the Lower Carboniferous of Europe, and is assigned in Hill (1956, p. F308) to the Family Lonsdaleiidae.

Most authors agree that the presence or absence of dissepiments in the Rugosa is significant in the separation of genera. On this basis, new genus _M_ can be distinguished from _Clisiophyllum_, _Dibunophyllum_, _Carcinophyllum_, and _Zeliaphyllum_, which are characterized by dissepiments. In addition, the new genus differs from _Carcinophyllum_ in lacking sagging tabulae in the axial region; from _Zeliaphyllum_ in lacking thickened internal structures; from _Dibunophyllum_ in lacking the web-like axial structure characteristic of that genus; and from _Clisiophyllum_ in having a well-developed and complex axial structure.

Genera which correspond to new genus _M_ in the absence of dissepiments include _Cravinia_, _Verbeekiella_, _Timorphyllum_, and _Leonardophyllum_. The new genus differs from both _Cravinia_ and _Verbeekiella_ in the absence of an "inner wall" separating the axial structure and the outer area of tabulae, and in having a continuous median lamella connecting the axial structure with the counter septum. From Timorphyllum, the new genus is distinguished by the presence of septal grooves and interseptal ridges on the epitheca, strongly arched tabulae, and complex axial structure.

Leonardophyllum, described by Moore and Jeffords (1941, p. 85) from the Permian Leonard Series, is similar in internal morphology to the proposed genus and may well be phylogenetically related to these Morrowan corals. Careful study was made of the type material of the type species, L. distinctum (UK 75161) and of L. acus (UK 74162). The two genera agree in: (1) the absence of dissepiments; (2) nature of the axial structure; (3) presence of minor septa, (4) number and length of major septa; and (5) continuity of the counter septum with the median lamella of the axial structure. There is also a general similarity in the relationship of the sharply upturned axial ends of the tabulae to the radial elements of the column in both Leonardophyllum and the new genus. However, the proposed genus differs in several important respects from Leonardophyllum, as follows: (1) tabulae in the new genus M are much less steeply inclined from the horizontal; (2) there is no tendency for tabulae to "bundle" in the axial region; (3) well-developed septal grooves and interseptal ridges are present on the epitheca; and (4) the axial structure is distinctly more dibunophylloid-like due to the "tented" attitude of tabulae.

Genus _M_ new species _D_

Plate 4 figures 5-9, Plate 5 figures 1-3

DESCRIPTION: Description of this species is based upon medium to large conical-cylindrical corallites from the Wapanucka Formation. The cylindrical portion normally comprises more than three-quarters the total length. Curvature is variable in degree and in direction; some corallites are curved only near the apex, whereas others are gently curved throughout their length. Periodic rejuvenescence in the mature cylindrical portion commonly produces abrupt changes in the direction of growth. A few corallites are uncurved. The position of the protosepta bears no consistent relationship to the curvature. The epitheca is of moderate thickness and is marked externally by shallow septal grooves and low, rounded interseptal ridges of equal width. Growth-lines are fine, but distinct; rugae are conspicuous at stages of growth marked by rejuvenescence. The holotype (OU 4838), which is incomplete, is 30.3 mm in length and has a maximum diameter of 9.9 mm. Paratypes are between 35 mm and 45 mm in length. Rootlets for attachment are preserved at the apex of several specimens.

Transverse sections of the mature stages of growth show from 23 to 26 short, non-rhopaloid major septa which alternate with well-developed minor septa. Major septa are amplexoid and therefore are longer immediately above tabulae. A maximum length of 2.2 mm was recorded for the length of major septa, at a diameter of 10.0 mm; the average length of septa is about 1.5 mm. Major septa do not extend to the axial structure except in the early growth-stages. Minor septa average about 0.5 mm in length in the mature corallites and are rudimentary or absent in lower sections. The cardinal septum is short, typically approximating one-half the length of adjacent metasepta, and lies in an open fossula. Alar septa are identified with difficulty; alar pseudofossulae are not developed. The counter septum is long, thick, and extends to the periphery of the axial structure. In the upper calyx the counter septum withdraws from the column. The septal arrangement of the type specimen is indicated by the formula K 6 A 4 C 4 A 6 K. The formulae for other specimens assigned to this species is similar.

In this species the axial structure appears in transverse sections as a broad, open framework which comprises as much as one-third the radius of some corallites. It consists of a median lamella and up to 12 irregular radiating lamellae, which are connected by the axial edges of tabulae. Tabulae are numerous, and become vertical near the column, where their axial ends assume tentlike deflections over the radiating lamellae of the column. The net effect is a "cobweb" appearance similar to that of the dibunophylloid corals, but which is in general less complex and more irregular than the axial structure of that group. Dissepiments are absent.

Longitudinal sections show numerous tabulae, between 8 and 11 per 10 mm, which slope steeply upwards from the inner edge of the epitheca toward the column. At the periphery of the axial structure, tabulae become vertical and are incorporated as reinforcing elements into the open framework of the column.

The early growth-stages are similar in structure to the mature corallite, and are not thickened by stereoplasm. A characteristic feature of the early growth-stages is a parallelism of the counter septum and the counter-lateral septa; however, this feature is more pronounced in some corallites than in others. In the early tip the cardinal septum extends to the edge of the axial structure.

DISCUSSION: Species here described under new genus M have a high degree of individual and interspecific variation. However, scatter diagrams comparing length, diameter, septal increase, septal length, and septal ratios of these species do not show clear bimodal distributions. Nevertheless, the present species can be distinguished from M species E by its more numerous tabulae and broader, more complex axial structure. The complex axial structure is present in the early growth-stages of M species D, whereas the column in the early tip of M species E is narrow and lacks radial elements. Tabulae in the present species are more numerous, more anastomosing, and more steeply inclined than those of M species E. Features which are subject to individual variation and are less useful in separating these species are as follows: in the present species the epitheca and the septa are shorter, and somewhat thicker. Rarely, the axial structure is discontinuous (cf. plate 5, fig. 3) in this species.

RANGE AND DISTRIBUTION: Wapanucka Formation (Morrow Series, Lower Pennsylvanian).

MATERIAL AND OCCURRENCE: Description of this species is based on eight corallites which were thin-sectioned for study and comparison, and on approximately 40 additional specimens which were studied from cut and polished surfaces. The holotype (OU 4838) was collected at locality PO 4, unit A; paratypes were collected from this locality, and from locality PO 3, unit A.

New genus M new species E

Plate 5 figures 4 - 5.

DESCRIPTION: Diagnosis of this species is based upon medium to large solitary corallites from the Wapanucka which are conical-cylindrical or narrowly conical. Curvature is normally in the plane of the alar septa. The epitheca is marked by shallow septal grooves and low interseptal ridges. Growth-lines are fine. Rugae are inconspicuous or absent. In these specimens, rejuvenescence is absent. The holotype (OU 4846) lacks only the upper portion of the calyx; it is 51.0 mm in length and 13.6 mm in maximum diameter. Other specimens are smaller than the type. Rootlets for attachment are preserved at the apex of several corallites.

Transverse sections show from 24 to 26 major septa in the mature stages of growth, which alternate with short minor septa. Major septa are subequal in length at a given growth-stage, but are amplexoid. In length, major septa approximate one-fourth to one-third the radius. Septa do not extend to the axial structure at any stage of growth.

Minor septa are rudimentary or absent in immature growth-stages. The cardinal septum is short, normally about one-half the length of adjacent metasepta, and occupies an open fossula. Alar septa are identified with difficulty; pseudofossulae are not developed. The axial portion of the counter septum is expanded to form the thin, irregular median lamella of the axial structure. Transverse sections indicate that the counter septum withdraws during the late growth-stages, isolating the column as an independent structure. The septal arrangement of the holotype is K 7 A 4 C 3 A 7 K, which indicates acceleration of septal insertion in the counter quadrants. The formulae of paratypes are similar.

The axial structure in this species is less complex than that of the genotype species, M species D. This structure consists of an irregular median lamella and 2 or 3 short, radially disposed lamellae. Tabulae are draped over the radial elements of the column, and have a tented appearance in transverse sections. Dissepiments are absent.

In longitudinal sections the column appears as a persistent sinuous median lamella which is reinforced by the upturned axial ends of tabulae. Tabulae are widely spaced (4 to 7 per 10 mm), and are complete. The tabulae rise at about 45 degrees for a distance equal to approximately one-third the radius, but become subhorizontal in the axial two-thirds of their lengths. The axial extremities of the tabulae are deflected sharply upwards, and impinge upon the median lamella or radiating lamellae of the axial structure.

Early growth-stages of M species E are similar to many species of lophophyllidid corals; the column is simple, and consists only of the slightly expanded axial end of the counter septum. In the early tip, the cardinal septum has the same length as adjacent metasepta, and is only slightly thinner.

DISCUSSION: This species differs from the type species M species D in having fewer tabulae and a less prominent axial structure. Tabulae in the present species are in part subhorizontal and are widely spaced, whereas those of the type species are numerous, highly anastomosing, and steeply inclined. The axial structure of the present species comprises only one-fifth the radius, whereas that of the type species is much broader. In addition, this species is distinguished by the absence of numerous irregular radial elements in the axial structure, a slightly thinner epitheca, thinner septa, less prominent minor septa, and lack of strong rejuvenescence.

RANGE AND DISTRIBUTION: Wapanucka Formation (Morrow Series, Lower Pennsylvanian).

MATERIAL AND OCCURRENCE: The description of M species E is based on four corallites, all of which were thin-sectioned; an additional five specimens were studied from cut and polished surfaces. The holotype (OU 4846) and the figured paratype (OU 4845) were collected from locality PO 4, unit A; other specimens were collected at this locality, and at locality PO 3, unit A.

Family HAPSIPHYLLIDAE Grabau, 1928

The Hapsiphyllidae are defined by Hill (1956, p. F267) as follows:

> Small, solitary, ceratoid or trochoid coralla with fossula bounded laterally by cardinal lateral septa and axially (in younger stages at least) by a wall consisting of fused axial ends of major septa of the counter quadrants. The septa may withdraw from the axis. Tabulae incomplete, conical, with highest point at inner edge of the fossula. No dissepiments. Minor septa present or absent. L. Carb. - L. Perm. (Artinsk.).

Genus *Amplexizaphrentis* Vaughn, 1906

Generic diagnosis by Hill (1956, p. F267):

> Corallum large, may be subquadrate in section; fossula commonly oblique and septa wavy, arranged inequilaterally; withdrawl from axis may begin first in counter quadrants; minor septa very short; cardinal septum long at first, short later. . . L. Carb., Eu-Asia-N. Am., Penn., N. Am.

Type species: *Zaphrentis bowerbanki* Thomson, 1883

Remarks: No effort will be made in this report to review the long and confused history of the zaphrentid corals. An excellent summary of this history is given under the discussion of *Amplexi-Zaphrentis* (= *Amplexizaphrentis*) by Sutherland (1958, p. 44-50). The principal contributors to this group of corals are as follows: Billings (1875); Carruthers (1910); Easton (1944, 1951); Grabau (1928); Grove (1934-

1935); Hall (1884); Hill (1938-1940, 1956); Hudson (1941); Lambe (1901); Lang, Smith and Thomas (1940); Milne-Edwards and Haime (1850-1854); Moore and Jeffords (1945); Rafinesque and Clifford (1820); Schindewolf (1938); Simpson (1900); Stumm (1949); Stuckenberg (1895); Sutherland (1958); Vaughn (1906); Wang (1950); and Worthen (1890).

In this study a number of corallites have been collected from the Wapanucka Formation which correspond in part to corals tentatively described as species of _Hapsiphyllum_ by Moore and Jeffords (1945, p. 123-128). Pertaining to this assignment, the authors stated (1945, p. 125):

> Reliable information concerning the internal structure of the genotype species of _Hapsiphyllum_ is not at hand. . . Schindewolf's (1938, p. 445, pl. 44, figs. 3-5, pl. 45, figs. 1a-e) description and illustration of supposed specimens of _H. calcariforme_ are reported to have been based on material from the St. Louis limestone in Indiana. Several good transverse sections are given by Schindewolf, but they do not help very much to establish the characters of _Hapsiphyllum_, inasmuch as they probably represent a coral that is not _H. calcariforme_. Accordingly, assignment of any new species to _Hapsiphyllum_ must be made with reservation until authentic examples of the genotype species have been critically studied.

The original description of the type species, _Zaphrentis calcariformis_, is as follows (Hall, 1882):

> Corallum simple, conical or horn-shaped; calyx circular, comparatively deep, with thin margins; biareal. The outer area is bounded by the external epitheca; the inner area by a sub-vertical wall of horseshoe shape, open on the side of the septal fovea. Two larger septa connect with this wall in such a manner as to apparently be a continuation of it, and form a very distinct pyriform septal fova; septa alternating in size, the smaller ones continuing for a short distance into the cavity of the corallum, there coalescing with the larger ones, which continue to the inner wall, with which they coalesce, and in which they terminate. Tabulae and dissepiments are present.

The writer has examined the original descriptions and illustrations, and agrees with Sutherland (1958, p. 48) who made an extensive study of many zaphrentid genera in Canada, and who concluded (in part):

> The genus Hapsiphyllum, based on an inadequately known type species, is considered to include only forms having contratingent minor septa, no dissepiments and mostly with an inner wall developed around the cardinal fossula. It is not believed to be a subgenus of Zaphrentoides as proposed by Schindewolf (1938, p. 450).

The genus Hapsiphyllum was emended by Easton (1944, p. 42) to include forms with both contratingent minor septa and minor septa which are free at their axial ends. Two subgenera were proposed: Hapsiphyllum, which included corals with contratingent minor septa and cardinal fossula on the concave side of the corallite; and Homalophyllites, which included corals with shorter, free minor septa and the cardinal fossula on the convex side of the corallite. In a subsequent paper, however, Easton (1951, p. 389) restored the genus Hapsiphyllum to its original definition - i.e., to include only corals with long contratingent minor septa.

The present diagnosis of Hapsiphyllum by Hill (1956, p. F267) agrees with Sutherland's and Easton's conclusions pertaining to the presence of contratingent minor septa.

The corallites from the Wapanucka Formation have only rudimentary minor septa in the late growth-stages, or none. The presence of long contratingent minor septa is essential to the diagnosis of Hapsiphyllum, and the Wapanucka specimens are therefore assigned to Amplexizaphrentis Vaughn.

Amplexizaphrentis _tumidum_ (Moore and Jeffords) 1945

Plate 5 figures 6 - 8.

DESCRIPTION: Solitary corallites from the Wapanucka Formation belonging to this species are medium in size and conical. Curvature is inconsistent in direction with respect to the position of the protosepta. Specimens range in length from 20.0 mm to 31.0 mm, and in maximum diameter from 14.8 mm to about 18 mm. The epitheca is marked by narrow septal grooves and low, rounded interseptal ridges which are crossed by fine growth-lines and inconspicuous rugae. The calyx is broad and deep.

Transverse sections show from 28 to 30 long, rhopaloid major septa, whose axial ends are laterally in contact with adjacent septa or are united by thin deposits of stereoplasm. A prominent horseshoe-shaped inner wall is thereby formed around the open axial area, which opens into the cardinal fossula. The prominence of this wall is variable, as it is periodically reinforced by the axial ends of tabulae. The cardinal septum is short, thick, and lies in an open fossula. In length the cardinal septum in few cases exceeds one-half the length of adjacent metasepta. The cardinal fossula is present in all stages of growth, and is constricted by the axial ends of the metasepta of the cardinal quadrants. Alar septa are identified with difficulty, due to poorly developed pseudofossulae. The counter septum is slightly longer than the counter-lateral septa, and extends several millimeters into the open axial region. The septal arrangement in the mature region of a typical corallite (OU 4847) is indicated by the formula K 8 A 5 C 5 A 8 K, which shows moderate acceleration of septal insertion in the counter quadrants. The formula of another specimen (OU 4848) at an earlier growth-stage, is K 7 A 3 C 3 A 7 K. Tabulae are complete, and appear in transverse sections as thick concentric rings. Minor septa are not present except in one corallite in which they appear as rudimentary low ridges in the calyx. Dissepiments are absent. There is no axial column.

Longitudinal sections in the plane of the alar septa show complete tabulae (6 to 9 per 10 mm), which rise steeply from the periphery of the corallite for a distance equal to about one-half the radius, and are horizontal or slightly sagging as they cross the axial region. The axial part of the corallites is thickened by stereoplasm.

DISCUSSION: These corallites compare closely to corals described by Moore and Jeffords as Hapsiphyllum tumidum (1945, p. 125). However, contratingent minor septa are here considered to be an essential part of the diagnosis of this genus, and they are entirely lacking in both the Wapanucka corals and Moore and Jeffords' specimens.

Other described corals of similar morphology include "Hapsiphyllum" crassiseptatum and "H". retusum which have rudimentary or no minor septa. Amplexizaphrentis tumidum (Moore and Jeffords) differs from A. crassiseptatum in having more numerous septa, stronger acceleration of septal insertion in the counter quadrants, a comparatively large open axial area, and larger size. From A. retusum, the present species is distinguished by its narrower conical form and absence of minor septa. The identity of the Wapanucka corallites to _A. tumidum_ was confirmed by comparison to the holotype of that species (UT no. P-11799a).

RANGE AND DISTRIBUTION: Corals described by Moore and Jeffords (1945, p. 125) as _Hapsiphyllum tumidum_ (a species which is here assigned to the genus _Amplexizaphrentis_) were collected from the Smithwick Shale (Bend Series, Lower Pennsylvanian) of San Saba County, Texas. This genus has not previously been reported from the Wapanucka Formation.

MATERIAL AND OCCURRENCE: Four corallites, of which three were thin-sectioned for study and comparison, were collected from the following localities: PO 4, unit A; A 18, unit C; A 19, unit E.

Amplexizaphrentis cf. _crassiseptatum_ (Moore and Jeffords), 1945

Plate 5 figure 9.

DESCRIPTION: One narrowly conical corallite from the Wapanucka may belong to this species. The corallite is 14.1 mm in length, and has a maximum diameter of 9.0 mm. Curvature is slight, and is in the cardinal-counter plane. The cardinal septum is on the concave side of the corallite. The epitheca is thick, and is marked externally by narrow septal grooves and rounded interseptal ridges. Growth-lines are fine, and rugae are almost imperceptible. The calyx is crushed. Small but prominent attachment rootlets are preserved at the apex.

Transverse sections show a maximum of 30 thick major septa, which are joined axially by stereoplasm to form a prominent horseshoe-shaped inner wall around an open axial area. The cardinal fossula opens into the axial area, and is slightly constricted by the axial ends of metasepta of the cardinal quadrant. The cardinal septum is short in the mature stages of growth, but is long and thin in earlier growth-stages and extends to the axis of the corallite. Prominent pseudo-fossulae are developed in all but the apical one-third of the corallite, where interseptal spaces are reduced to narrow peripheral openings by the thick septa. The counter septum is similar in length and thickness to other septa of the counter quadrants, but can be identified by slightly wider interseptal spaces on the counter side of the counter-lateral septa. The number and arrangement of septa is indicated by the formula K 7 A 6 C 5 A 8 K. Slight acceleration of septal insertion in the counter quadrants is indicated.

The apical one-third of the corallite is greatly thickened by internal deposits of stereoplasm and thick septa. A few thin complete tabulae were intersected by transverse sections. Minor septa and dissepiments are absent. There is no axial structure.

DISCUSSION: The corallite described above was compared to the holotype of Hapsiphyllum (Amplexizaphrentis) crassiseptatum (UK no. 7744 21-b) from which it differs only in having a thinner epitheca, more prominent inner wall, and a longer cardinal septum in the early growth-stages. The range of specific variation of this species is not established, as the species description is based upon a single corallite described by Moore and Jeffords (1945, p. 128).

RANGE AND DISTRIBUTION: The corallite described by Moore and Jeffords as H. crassiseptatum was collected from the Hale Formation (Morrow Series), near Keough Quarry, north of Fort Gibson, Oklahoma. This species is here assigned to Amplexizaphrentis, and has not previously been reported from the Wapanucka Formation.

MATERIAL AND OCCURRENCE: One corallite, from locality J 16, unit D.

Amplexizaphrentis sp.

Plate 5 figure 10.

DESCRIPTION: One corallite from the Wapanucka Formation can only be referred to the genus Amplexizaphrentis. The corallite is conical, curved slightly near the apex, 18.0 mm in length, and 9.5 mm in diameter. The epitheca is covered by calcareous material, but septal grooves and interseptal ridges appear to be poorly developed. The calyx contains a prominent cardinal fossula which opens into a shallow subcircular central depression. There is no axial boss.

At the base of the calyx are 22 long major septa which are thick near epitheca and taper evenly toward the axis. A small open axial area is delimited by thin deposits of stereoplasm. The open fossula contains a short, thick cardinal septum. The fossula is constricted axially by the ends of metasepta of the cardinal quadrants. The counter septum is longer than the metasepta of the counter quadrants, and extends about 1 mm into the axial area. Pseudofossulae are poorly developed. The number and arrangement of septa is indicated by the formula K 6 A 3 C 3 A 6 K. Strong acceleration of septal insertion in the counter quadrants is indicated. Dissepiments and minor septa are absent.

It was not possible to prepare longitudinal sections of this corallite. Tabulae are not visible in transverse sections, and are not evident in lower cut and polished surfaces.

DISCUSSION: The corallite is assigned to Amplexizaphrentis on the basis of the configuration of the calyx, absence of axial structure, and horseshoe-shaped inner wall. It does not, however, correspond in all details to the morphology of any species of Amplexizaphrentis known to the writer. The most similar species is a form described as Hapsiphyllum crassiseptatum by Moore and Jeffords (1945, p. 128) from the Hale Formation (Morrow Series). The Wapanucka specimen differs from the holotype of this species (UK no. 7744-21b) in having fewer septa, less internal thickening, stronger acceleration of septal insertion in the counter quadrants, and in lacking tabulae.

RANGE AND DISTRIBUTION: Wapanucka Formation (Morrow Series, Lower Pennsylvanian).

MATERIAL AND OCCURRENCE: The single corallite described above was collected at locality PT 23, unit B.

Genus Barytichisma Moore and Jeffords, 1945

Generic diagnosis (abstracted from Moore and Jeffords, 1945, p. 131):

> Epitheca very thick, not penetrated by septa; zaphrentoid septal arrangement; major septa numerous, reaching axis immediately above tabulae only; tabulae numerous, subhorizontal; minor septa rudimentary or absent; dissepiments absent; no true axial structure. Penn., N. Am.

Type species: Barytichisma crassum Moore and Jeffords, 1945.

Remarks: Moore and Jeffords proposed the genus Barytichisma (1945, p. 131) to include corals described as B. crassum, B. repletum, and B. callosum. This genus has subsequently been questionably regarded by Hill (1956, p. F267) as a junior synonym of Amplexizaphrentis Vaughn. The writer believes, however, that these species constitute a valid generic group and they are so treated in this study.

Barytichisma can be distinguished from all other hapsiphyllid genera by its unusually thick epitheca, which is present in all stages of growth. In width, the epitheca is equal to about one-third the radius of the corallite, and approaches one-half the radius in some individuals. In addition, the epitheca in Barytichisma is not penetrated by the dark medial lamellae of the septa, indicating that the epitheca is a primary feature, and is not due to secondary deposition of stereoplasm. The septal arrangement, number and attitude of tabulae, and the amplexoid septa serve to distinguish species belonging to this genus.

The writer does not agree with the present division of the hapsiphyllid corals in Hill (1956, p. F267). Genera assigned to this family are divided into two "Groups" on the basis of the position of the cardinal fossula with respect to the direction of curvature of the corallite. "Group I" includes genera in which the fossula is on the concave side of the corallite, and "Group II" includes genera having the fossula on the convex side. On the basis, Amplexizaphrentis is assigned by Hill to "Group I". Barytichisma, however, cannot be thus classified as the curvature, while consistent for a particular species, varies within the genus. Although Hill's "Group" designations have no taxonomic status, it is nonetheless impossible to follow Hill's system in this instance.

Separation of genera on the basis of the position of the cardinal fossula (and hence the cardinal septum) with respect to curvature seems to lead in all cases to taxonomic difficulties such as the present one. The writer is in accord with Easton, who studied this matter in some detail and concluded that curvature is subordinate to septal arrangement in morphological and taxonomic significance. Easton summarizes his opinions as follows (1951, p. 387):

> It is a well-known fact that the counter quadrants of rugose corals usually contain more major septa than do the cardinal quadrants. Inasmuch as the rugose corals are commonly curved toward the cardinal septum, it naturally follows that the counter quadrants are potentially expanded. . . On the other hand, it can be observed among the corals studied herein

> that the counter quadrants are consistently accelerated no matter which side the cardinal fossula lies. This runs counter to the principal observed among rugose corals in general (which mostly have their cardinal fossulae on the concave side). If the coral is convex on the cardinal side, one would assume before observing the septa that they would not be accelerated on the counter side, or even that they might accelerated on the cardinal side. It is concluded, then, that as a general rule, the distribution of septa within the quadrants of a calyx results from a strong genetic requirement. . . .If these conclusions are valid, then one may further conclude that the distribution of septa within a calyx has been determined by long established genetic lines. In other words, the distribution of septa will tend to remain constant for a time even though the shape of the coral may begin to change. From these matters, the writer has concluded that the orientation of the cardinal fossula with regard to curvature is less important taxonomically than is the nature and degree of acceleration of the septa. Accordingly, the location of the cardinal fossula is assigned subgeneric status.

More recently, in a detailed study of zaphrentid corals of British Columbia, Sutherland reached similar conclusions regarding the advisibility of generic subdivision or separation on the basis of the position of the cardinal fossula. Sutherland stated (1958, p. 48):

> . . .several authors have at various times separated genera or subdivided them into subgenera on the basis of the position of the cardinal fossula in relation to the cruvature of the corallite. However, the consistency and value of this feature in taxonomy has not been adequately demonstrated. Although many forms appear to have the cardinal fossula located on either the concave or the convex side of the corallum, others have the fossula at varying positions in relation to the plane of curvature; and still other genera may be almost straight, without consistent curvature or may be somewhat twisted. For these reasons it is suggested that corals not otherwise distinguishable except for this feature should not be separated into different genera or subgenera.

The conclusions of both Easton and Sutherland are supported by the present study of the rugose corals of the Wapanucka Formation, and in particular by the morphology of the genus Barytichisma. The position of the cardinal septum is, however, a reliable basis of separation of species belonging to this genus. Preliminary identification on this basis has invariably been substantiated by thin-section study of other internal features. For the present, therefore, it seems advisable to regard Barytichisma as a valid and recognizable genus, and to disregard Hill's "Group" designations.

Barytichisma callosum Moore and Jeffords, 1945

Plate 6 figure 7.

DESCRIPTION: This species is represented in the collections from the Wapanucka Formation by large corallites of conical-cylindrical form. Curvature is in the cardinal-counter plane, and the cardinal fossula is located on the shorter, or concave, side of the corallites. The epitheca is unusually thick, and attains a width equal to one-third the radius of the corallite. The epitheca is marked by narrow septal grooves and by slightly wider rounded interseptal ridges. Transverse markings include faint lines of growth and subdued rugae. The early tip of the corallites, when preserved, bears small attachment rootlets. The calyx is deep and thick-walled. In length most specimens range from 60 to 70 mm; one corallite exceeds this, and is 89.5 mm in length. This is probably near the maximum for the species. Diameter at the top of the calyx varies from 25 mm to 33.3 mm.

Transverse sections through the base of the calyx show from 43 to 50 thick major septa which thicken slightly toward the axis. The septal formula indicates strong acceleration of septal insertion in the counter quadrants; the formula for one specimen (OU 4858) is K 12 A 7 C 8 A 12 K in a transverse section made at 38.8 mm from the apex. That of another specimen is K 14 A 9 C 9 A 14 K, at 36.0 mm from the apex. In the breviseptal stage, major septa withdraw from the axis and become short in the upper calyx. Below the calyx floor, septa are amplexoid. Some transverse sections therefore show long major septa extending to the axis of the corallite, whereas in others the septa are withdrawn, leaving a large open axial area. The cardinal septum is short in the mature stages of growth and occupies a prominent open fossula. The length of the cardinal septum varies, but does not exceed one-quarter the length of adjacent metasepta. Alar septa are identified with difficulty due to strong radial symmetry which obscures alar pseudofossulae. Minor septa are present only in the upper calyx. Dissepiments are absent. There is no true axial column.

The calyx is floored by subhorizontal or slightly sagging tabulae. Earlier stages of growth are characterized by numerous slightly anastomosing tabulae which rise from the inner edge of the epitheca for a short distance and cross the tabularium in a horizontal or slightly sagging attitude; from 6 to 10 tabulae occur per 10 mm. The upper surfaces of tabulae in the central part of the corallite are thickened by stereoplasm and extensions of septa. Oblique longitudinal sections (cf. fig. 7, Plate 6) show the amplexoid nature of the septa.

The apical one-third of the corallites is filled with stereoplasm, but individual septa can be identified. The epitheca is thick even in the juvenile stages of B. callosum. In transverse sections through the early tip, the cardinal septum extends as a thin lamella to the axis of the corallite.

DISCUSSION: From the two similar species, B. repletum and B. crassum (Moore and Jeffords, 1945, p. 131-134), the present species is distinguished by its relatively large size, more numerous major septa, and the position of the cardinal septum on the concave side of the corallite. Barytichisma callosum also lacks alar pseudofossulae, which characterize the early stages of growth of B. repletum, and has more numerous tabulae and more strongly amplexoid septa than that species. Corallites from the Wapanucka belonging to this species were compared to the holotype (UT no. P-11916a) of B. callosum and agree in all details with this specimen.

RANGE AND DISTRIBUTION: Barytichisma callosum was described by Moore and Jeffords (1945) from the basal Falls Limestone (Morrow Series) of San Saba County, Texas, and from the middle part of this formation in the same area. One specimen tentatively assigned to this species was collected from the Brentwood Limestone near Woolsey, Arkansas. This is the first recorded occurrence of this genus from the Wapanucka Formation.

MATERIAL AND OCCURRENCE: Eleven specimens; several were thin-sectioned and the remainder cut and polished for study. This species has been collected from the following localities: PO 3, unit D; PO 4, unit A; C 10, unit B; C 27, unit A; J 24, unit F; J 28, unit A.

<u>Barytichisma</u> <u>crassum</u> Moore and Jeffords, 1945

Plate 6 figures 1 - 4.

DESCRIPTION: Solitary corallites from the Wapanucka Formation assigned to this species are medium to large conical-cylindrical forms in which the concave side of the corallite coincides with either the cardinal septum, an alar septum, or is intermediate in position. The upper cylindrical portion of the corallites is missing in most specimens. Curvature is acute in one corallite, amounting to almost 90 degrees in the early stages of growth; in other specimens, curvature approximates 30 degrees. The epitheca is extremely thick and is marked by deep septal grooves and high, rounded interseptal ridges. Fine growth-lines and low inconspicuous rugae comprise the transverse markings. Attachment rootlets are poorly developed or absent. The calyx is broad, deep, and contains a prominent cardinal fossula. The corallites, mostly incomplete, range in length from 21.5 mm to 38.9 mm and in maximum diameter from 13.4 mm to 16.0 mm. Maximum diameter occurs at the top of the calyx.

Transverse sections at the base of the calyx show about 34 long major septa which extend into the axial region. Sections above the base of the calyx are characterized by shorter septa and a large open axial area. Septa are amplexoid, as is shown by most longitudinal sections (cf. Plate 6 fig. 4). In length the cardinal septum is commonly less than one-quarter that of adjacent metasepta, and lies in a prominent open fossula in all stages of growth. The counter septum is several millimeters longer than adjacent metasepta, but is not expanded axially. Alar septa are distinguished with difficulty due to well-developed radial symmetry. The septal formula of a typical specimen (OU 4854) is K 10 A 5 C 5 A 10 K; that of another specimen (OU 4853) is K 9 A 4 C 5 A 9 K. Strong acceleration of the counter quadrants is indicated. Minor septa are short, thick, and are rudimentary or absent below the calyx. In transverse sections tabulae appear as narrow curved bars joining the edges of septa in the peripheral part of the corallite and as broad, indistinct concentric rings in the axial region. Dissepiments are absent. There is no axial column.

Longitudinal sections show from 8 to 10 tabulae per 10 mm, which rise steeply from the inner edge of the epitheca and are horizontal or sagging in the axial area. The septal arrangement of the thickened early stages of growth are distinguishable in several specimens; in the early tip, the cardinal septum extends as a thin lamella into the axial region.

DISCUSSION: These corallites were compared to the holotype of Barytichisma crassum (UT no P-11908b) and B. callosum (UT no. P-11916a). They agree with the former species in all details of morphology.

Moore and Jeffords separate species of Barytichisma on the basis of the position of the protosepta with respect to curvature, as follows: in B. crassum, an alar septa is located at or near the concave, or shorter side of the corallite; in B. callosum, the cardinal septum occupies this position; and in B. repletum the cardinal septum lies on the convex, or longer, side of the corallite. Final identification is based on additional internal features, as discussed below.

Because all described species of Barytichisma may be present in the Wapanucka Formation, a test of the validity of this basis of separation was provided. Preliminary identification on this basis was shown to be consistently correct by subsequent thin-section study. Barytichisma crassum also differs from B. callosum in having fewer major septa, fewer and more commonly complete tabulae, and in its smaller size at maturity. From B. repletum, the present species is distinguished by its more numerous septa, absence of prominent alar pseudofossulae in the early stages of growth, and short cardinal septum.

Barytichisma is regarded by Hill (1956, p. F267) as a junior synonym for Amplexizaphrentis Vaughn. In this study, Barytichisma is retained as a valid generic name, for reasons given under the discussion of this genus.

RANGE AND DISTRIBUTION: Barytichisma crassum was described by Moore and Jeffords (1945, p. 131) from the lower part of the Marble Falls Limestone (Morrow Series) of San Saba County, Texas. This genus has not previously been reported from the Wapanucka Formation.

MATERIAL AND OCCURRENCE: Eleven specimens, of which nine were thin-sectioned for comparison to the type material. The specimens were collected from the following localities: PO 3, unit F, PO 4, unit A; C 17, unit A; and C 27, unit A.

Barytichisma cf. repletum Moore and Jeffords, 1945

Plate 6 figures 5 - 6.

DESCRIPTION: Two incomplete corallites from the Wapanucka Formation are here tentatively assigned to this species. The corallites are medium to large, conical in the lower one-third, and cylindrical in the mature stages of growth. The large specimen has a length of 31.4 mm and diameter of 21.3 mm at the base of the calyx. The calyx is broken, but appears to have been deep, and steep-sided. The dimensions of the smaller corallite are as follows: length, 20.6 mm, maximum diameter, 14.0 mm. In both specimens the epitheca is unusually thick, and comprises from one-fourth to one-third the radius of the corallites. External markings of the epitheca of the larger corallite are not well-preserved. In the smaller specimen, deep grooves alternate with high, rounded interseptal ridges of about equal width. Curvature is slight, but the cardinal septum is clearly on the convex side of the corallites. Prominent attachment rootlets are preserved near the apex.

There are 39 major septa near the base of the calyx of the large corallite. Transverse sections through the mature portion of the smaller specimen show 36 septa. Major septa are long, tapering, and extend into the axial region where they are united by stereoplasm. The cardinal septum is long, thin, and extends into the axial region. It lies in a large open fossula in all stages of growth. Alar septa are identified by the position of the shorter, last inserted septa of the counter quadrants. The septal formula of the larger corallites (OU 4857) is K 11 A 6 C 7 A 11 K, which shows strong acceleration of septal insertion in the counter quadrants. The formula of the smaller specimen, (OU 4856) in a slightly lower section, is K 10 A 6 C 6 A 10 K. Minor septa were not observed, but may have been present higher in the calyx. Tabulae appear in transverse sections as indistinct concentric rings in the axial region, and as narrower, curved bars in the peripheral part of the corallites. The attitude of tabulae could not be determined as it was not possible to make adequate longitudinal sections of these specimens. Tabulae appear to be subhorizontal in the axial region, and mostly complete. Dissepiments are absent, and there is no axial column.

The lower one-third of the corallites contain small interseptal spaces only near the periphery; small alar pseudofossulae are present in the early stages of growth of the larger corallite, but are obscure in the smaller specimen.

DISCUSSION: _Barytichisma_ _repletum_ is distinguished primarily from _B_. _callosum_ and _B_. _crassum_ by the position of the cardinal septum which is located on the convex side of the corallite in the present species. In addition, this species differs from _B_. _callosum_ in its smaller size, fewer septa, and long, thin cardinal septum which extends into the axial region in all growth-stages. Less reliable distinguishing features of this species are the presence of alar pseudofossulae in the early stages of growth and smaller size.

The two Wapanucka corallites agree with the stated characteristics of _Barytichisma repletum_. However, they are only tentatively assigned to this species bacause of the lack of adequate longitudinal sections.

RANGE AND DISTRIBUTION: _Barytichisma repletum_ was described by Moore and Jeffords (1945, p. 133) from a single specimen from the lower part of the Marble Falls Limestone (Morrow Series) of San Saba County, Texas. The genus _Barytichisma_ has not been previously reported from the Wapanucka Formation.

MATERIAL AND OCCURRENCE: Two incomplete corallites, both of which were thin-sectioned for study. They were collected at localities PO 3, unit D, and PO 4, unit A.

Family AULOPHYLLIDAE Dybowski, 1873

The Aulophyllidae are defined by Hill (1956, p. F286) as follows:

> Simple or less commonly compound Rugosa with numerous septa, a regular dissepimentarium, imcomplete conical

> tabulae, and generally an axial structure. Septa are equally spaced and seldom curved about the small, open cardinal fossula, which is marked by an extension of the tabularium into the dissepimentarium; major septa may be dilated in the tabularium, particularly in cardinal quadrants; minor septa may be degenerate. Dissepiments are small and globose, concentric, angulo-concentric, or inosculating, rarely lonsdaleoid. The axial structure normally consists of straight or curved septal lamellae, commonly with a columella or median plate, and an inner series of tabellae. Carb.-Perm.

Genus Dibunophyllum Thomson and Nicholson, 1876.

Generic diagnosis by Hill (1956, p. F286):

> Solitary, with inner parts of minor septa degenerate, leaving inner dissepiments insoculating; axial structure variable, typically one-third as wide as corallite, consisting of a median plate and 4 to 8 septal lamellae on either side; less typically, the lamellae may become curved, the median plate disappear, or the bilateral arrangement be lost. . . L. Carb., Eu.-N.Afr.-N.Am.; M.Carb.,Carpathians-Japan.

Type species: Dibunophyllum muirheadi Thomson and Nicholson, 1876.

Remarks: A single corallite from the large collections from the Wapanucka Formation may represent this genus. The assignment of this specimen to Dibunophyllum is based primarily upon the axial structure, which is well-developed and distinctly dibunophylloid in character. However, most diagnoses of Dibunophyllum include the presence of degenerate minor septa; in the corallite described below, minor septa are long, and extend through the dissepimentarium and a short distance into the outer tabulate area. The assignment to _Dibunophyllum_ is therefore tentative; it is possible that the Wapanucka corallite represents a variant of _Koninckophyllum arcuatum_ (Moore and Jeffords), 1945, or a related form.

The history of the taxonomy of dibunophylloid corals is long and involved. As is pointed out by Hill (1938, p. 66), _Rhodophyllum_ (_sic_), _Aspidiophyllum_, and _Cymatiophyllum_ are all generic names which were proposed earlier than _Dibunophyllum_. Any of these therefore has priority over _Dibunophyllum_ according to the International Rules of Zoological Nomenclature. _Rodophyllum_ Thomson (1874, p. 556) was proposed first and technically should be used. However, _Dibunophyllum_ is a familiar and well-established generic name and has been retained in general usage. The desirability of a formal ruling by the Commission in favor of retaining _Dibunophyllum_ has been noted (i.e., Sutherland, 1958, p. 84). The problem is far from simple, however. For example, Moore and Jeffords suggested (1945) that _Rodophyllum_ and _Dibunophyllum_ are distinct genera and recognized the validity of both. More recently, Hill (1956, p. F286) in the Treatise regarded _Rhodophyllum_ (_sic_) as a junior synonym of _Dibunophyllum_.

The taxonomic status of _Rodophyllum_, _Dibunophyllum_, and to a lesser degree _Koninckophyllum_ is uncertain. A revision of these genera is outside the scope of this study, and the affinities of the Wapanucka coral could be determined only if additional material were available.

<u>Dibunophyllum</u> ? sp.

Plate 9 figure 4.

DESCRIPTION: One corallite from the Wapanucka Formation may represent the genus <u>Dibunophyllum</u> (Thomson and Nicholson, 1876). Only the upper part of the corallite is preserved; this fragment is cylindrical, almost straight, and has a length of 18.9 mm. The complete length of the corallite is judged to have been in excess of 40 mm. The specimen is imbedded in limestone, which obscures the exterior of the epitheca. In transverse sections the epitheca is less than 1 mm thick and was probably marked by septal grooves and interseptal ridges. Rugae appear to have been subdued. The apex and early stages of growth are not known.

In transverse sections an open, dibunophylloid axial structure occupies the central one-third of the corallite. A peripheral zone of dissepiments has a width of about one-third the radius. Major septa are thin and crooked in this zone, but thicken abruptly at the boundary of the dissepimentarium and tabularium. Septa are straight in the tabularium, and taper evenly toward the axial region. The long cardinal and counter septa extend into the axial structure, where they unite to form a distinct medial lamella, or plate. Above the base of the calyx, the cardinal septum withdraws and is shorter than adjacent metasepta of the cardinal quadrant. In this stage of growth, the medial plate is formed only by the distended axial end of the long counter septum. Alar septa are identified with difficulty; no fossulae are developed. A maximum of 30 major septa is present. Septal arrangement is indicated by the formula K 8 A 5 C 5 A 8 K. Moderate acceleration of septal insertion in the counter quadrants is indicated. Dissepiments are small, and form an irregular herringbone pattern in transverse sections.

The axial structure is complex in all stages of growth. It consists of a distinct medial plate which bears from 4 to 6 radially disposed septal lamellae on either side. These are reinforced by numerous axial tabellae, which are so abundant as to have a vesicular appearance in some sections. The axial structure is suboval in the calyx and is distinctly spindle-shaped in lower sections. In all sections examined the axial structure is separated from the outer tabulate region by an open area.

Minor septa are well-developed, and extend through the zone of dissepiments to project slightly into the tabularium. In the dissepimentarium, minor septa are crooked, and have about the same width as the major septa. Because of closely spaced transverse sections, it was not possible to make longitudinal sections.

DISCUSSION: The presence of a distinct medial plate, septal lamellae, and axial tabellae within the axial structure of this corallite corresponds to that of the genus <u>Dibunophyllum</u> Thomson and Nicholson (1876). The corallite differs from this genus, however, in the presence of long minor septa.

A similar form was described from the Marble Falls Formation of Texas by Moore and Jeffords (1945, p. 161) as <u>Neokoninckophyllum arcuatum</u>. In the present study the writer follows Hill (1956, p. F286) in regarding most species of _Neokoninckophyllum_ as properly belonging to _Koninckophyllum_ Thomson and Nicholson (see discussion of _Koninckophyllum_, this report). The corallite described above differs from Moore and Jeffords' species in having a more complex axial structure and narrower dissepimentarium. In addition, the minor septa of this species extend into the tabularium, whereas they extend only two-thirds the distance through the dissepimentarium in _K. arcuatum_ (Moore and Jeffords).

The morphology of _K. arcuatum_ does not compare closely to that of the type species of _Neokoninckophyllum_ (_N. vesiculosum_ Fomichev, 1939), nor does it agree with the morphology of the type species of _Koninckophyllum_ (_K. magnificum_ Thomson and Nicholson, 1876). These corals should probably be assigned to _Dibunophyllum_ on the basis of their axial structure, but the relationship of this species to the Wapanucka corallite is not clear.

RANGE AND DISTRIBUTION: _Koninckophyllum arcuatum_ (Moore and Jeffords), which may be related to the form here described, was described from the middle Marble Falls Limestone (Morrow Series) of Kimble County, Texas. The genus _Dibunophyllum_ has not previously been reported from the Wapanucka Formation.

MATERIAL AND OCCURRENCE: One corallite, from locality A 18, unit U.

Genus Koninckophyllum Thomson and Nicholson, 1876

Generic diagnosis by Hill (1956, p. F288):

> Solitary or fasciculate; minor septa may be shortened axially in dissepimentarium; axial structure a columella, which may be supported by a few septal lamellae; tabulae tented and incomplete; if columella is absent, the tabulae flatten and may become complete. . .Carb., Eu.-Asia-N.Am.

Type species: Koninckophyllum magnificum (subsequent designation by Thomson, 1883).

Remarks: Two species of aulophylloid corals are described below which were originally described by Moore and Jeffords (1945) as species of Neokoninckophyllum Fomitchev. These authors stated (1945, p. 158-159) that this genus is distinguishable from Koninckophyllum Thomson and Nicholson, as follows:

> Koninckophyllum Thomson and Nicholson (1876, p. 297) and Lophophyllum Edwards and Haime (1850, p. lxvi) are closely related genera described from Lower Carboniferous rocks of western Europe that bear resemblance to Neokoninckophyllum in several features. . .Longitudinal sections of corals assigned to any of the three genera show no diagnostic features by which one can be separated from the others. Transverse sections, however, reveal differences; the column of Lophophyllum and Koninckophyllum is relatively dense and shows a distinct elongation in the plane of the counter and cardinal septa, whereas the columnar structure of Neokoninckophyllum is open and rather indefinite, and if a median lamella is distinguishable, it is not prominent.

The morphological variation observed within the genus Koninckophyllum seems to include corals later described by Fomichev

(1939) as Neokoninckophyllum. The contention by Moore and Jeffords that a distinct median lamella is not distinguishable, or not prominent, in Neokoninckophyllum is not supported by their descriptions and illustrated transverse sections of N. gracile and N. simplex (Moore and Jeffords, 1945, p. 160, Fig. 159). Also, there is no apparent difference in longitudinal sections of Neokoninckophyllum and Koninckophyllum. The writer accordingly follows Hill (1938-41, 1956) in regarding Neokoninckophyllum as a junior synonym of Koninckophyllum.

It must be recognized that there are grounds for contesting the validity of Koninckophyllum as a valid generic name. Discussions pertaining to Koninckophyllum and Lophophyllum are given by Hill (1938-41, p. 85-89), Jeffords (1942, p. 201-208), Moore and Jeffords (1945, p. 158-159) and Sutherland (1958, p. 74-76). This taxonomic problem can be summarized here as follows:

Lophophyllum was described by Milne-Edwards and Haime (1850, p. lxvi) from the Tournai district of Belgium. Carruthers (1913), believing the type specimens to be lost, recollected this area and concluded that L. tortuosum (Michelin) was a senior synonym of L. konincki Milne-Edwards and Haime, the type species. Carruthers also considered Koninckophyllum Thomson and Nicholson to be a junior synonym of Lophophyllum. Carruthers' views were supported by Lang, Smith, and Thomas (1940, p. 81), who examined material from Tournai, with the reservation that the types of L. konincki should be re-studied to settle the matter. Hill (1938-41), however, disagreed with Carruthers' proposal and stated:

> I cannot agree that _Lophophyllum_ _tortuosum_ Carruthers is synonymous with _Lophophyllum_ _konincki_ Edwards and Haime, and therefore do not regard _Koninckophyllum_ as synonymous with _Lophophyllum_. Carruthers' conclusion, . . . , is not necessarily true, nor can it be proved, for it is negative, and therefore insufficient as a reason for dropping a generic name. Stanley Smith, after an examination of the specimens presumably studied by Edwards and Haime. . . , thought it possible that specimen 3, on the card labelled _Lophophyllum_ _konincki_ in the Musee d'Histoire Naturelle, was Edwards and Haime's figured specimen. None of the specimens on this card shows dissepiments; they are trochoid, with deep calices, and the arrangement of the septa is as in _Zaphrentis_, but there is a columella.

Apparently these specimens have not yet been sectioned, but it is clear from Smith's description of the external features (as reported by Hill, 1938) that they cannot be representatives of _Koninckophyllum_. This genus must therefore be regarded as valid, at least until such time as re-examination of the types is undertaken.

Koninckophyllum _simplex_ (Moore and Jeffords), 1945

Plate 7 figures 1 - 2.

DESCRIPTION: Solitary corallites from the Wapanucka Formation identified as _Koninckophyllum_ _simplex_ are medium to large conical forms in which curvature is in the plane of the alar septa. Several specimens are almost straight. The thin epitheca is marked by shallow septal grooves and interseptal ridges, which are crossed by well-developed lines of growth and low rugae. Attachment rootlets are preserved at the apex of several corallites. In other specimens, the apex is flattened to form a broad attachment surface.

Transverse sections commonly show from 36 to 38 major septa, and as many as 47 septa are present in some specimens. Minor septa extend only to the first dissepiment in the calyx, and are absent in earlier growth-stages. Major septa are thin, and are crooked in the dissepimentarium; they thicken abruptly at the inner edge of this zone. In length, septa approximate two-thirds the radius of the corallite; each third or fourth septum extends as a wavy lamella into the axial area. The cardinal septum occupies an open fossula and is connected in most growth-stages to the counter septum. Alar septa are not identifiable in most sections; pseudofossulae are not developed. A broad band of dissepiments occupies the peripheral one-third to one-half of the corallites. This zone is set off from the tabularium by a poorly defined inner wall, which is formed by thickening of adjacent dissepiments and septa. The position of the cardinal fossula is usually indicated by a slight sag in the inner wall. The axial structure of _K. simplex_ consists of a medial lamella which joins the cardinal and the counter septum. This lamella is joined at irregular intervals by the wavy axial ends of septa. In transverse sections tabulae appear as closely spaced discontinuous concentric bands.

In longitudinal sections the median lamella appears as a persistent structure throughout all stages of growth, although it may be highly irregular. The axial ends of metasepta form discontinuous lamellae which are subparallel to the median lamella. Dissepiments are of unequal size and slope steeply downward toward the axis. Tabulae are closely spaced and highly anastomosing, from 16 to 25 typically crossing the tabularium per 10 mm. Tabulae are subhorizontal or slightly sagging in the central part of the corallite. The axial extremity of each tabulum is deflected sharply upward, and impinges upon the median lamella; in the peripheral part of the tabularium, the tabulae slope gently downward toward the dissepimentarium. The medial lamella protrudes a distance of several millimeters above the convex floor of the calyx. The subvertical inner walls of the calyx are formed by the dissepimentarium.

DISCUSSION: Corallites from the Wapanucka Formation belonging to this species show a considerable range of variation. This species was described by Moore and Jeffords (1945, p. 159) as belonging to the genus _Neokoninckophyllum_. Their material consisted of only two specimens, and some variation from the morphology of the holotype and paratype is therefore to be expected. The length of the incomplete holotype is stated as 28.2 mm, and maximum diameter at the calyx as 19.3 mm. Corallites from the Wapanucka Formation, some of which are complete, range in length from about 15 mm to 60 mm, and in maximum diameter from 17 to 26 mm. The holotype is stated to have 41 major septa in a mature stage of growth, whereas the present corallites have 36 to 47 major septa in comparable stages of growth. Tabulae are more nearly horizontal in the present corallites than those of the illustrated holotype and paratype, and the corallites here described also show more variation in the degree of development of the inner wall.

Koninckophyllum _simplex_ differs from _K._ _arcuatum_ (Moore and

Jeffords) in having a less complex axial structure and in lacking longer minor septa. From _K._ new species _F_ the present species is distinguished by a more simple axial structure, thinner inner wall, larger dissepiments, and narrower dissepimentarium. Corals which may represent a juvenile form of _K. simplex_ are described herein as _K. gracile_.

RANGE AND DISTRIBUTION: _Koninckophyllum simplex_ (Moore and Jeffords) was described by these authors (1945, p. 159) from the Hale Formation (Morrow Series) near Fort Gibson, Oklahoma. _Koninckophyllum_ has not previously been reported from the Wapanucka Formation.

MATERIAL AND OCCURRENCE: Approximately 45 corallites from the Wapanucka have been identified as belonging to this species. Most of the material is deeply weathered and fragmentary. Five comparatively well-preserved specimens were thin-sectioned and the remainder cut and polished for study. _Koninckophyllum simplex_ occurs at the following localities in the Wapanucka: C 27,unit C; C 32; A 18, unit U; A 19, unit E; A 20, unit I; PT 21, unit J.

Koninckophyllum gracile (Moore and Jeffords), 1945

Plate 8 figures 4 - 6.

DESCRIPTION: This species is represented in the Wapanucka Formation by broadly conical forms of medium size. All corallites except one are imbedded in limestone; in this specimen, the epitheca is preserved and is marked by well-developed rugae and distinct lines of growth. Septal grooves and interseptal ridges are inconspicuous. Curvature is slight, and in the plane of the alar septa. Attachment rootlets are small or lacking.

Transverse sections show from 30 to 34 long major septa at the base of the calyx, which extend through a narrow dissepimental zone and into the axial area of the corallites. The septa are thin and slightly crooked in the dissepimentarium but thicken slightly at its inner margin; in the tabularium septa thin axially. Dissepiments at the inner edge of the dissepimentarium are thickened by stereoplasm, forming an inner wall between the dissepimentarium and tabularium. The dissepimentarium of this species is narrow in comparison to other species of this genus and in few cases exceeds one-fifth of the radius of the corallites. Minor septa are rudimentary or absent. The cardinal septum lies in an open fossula, and is connected in most stages of growth to the counter septum by a thin medial lamella. Alar septa are normally not identifiable; alar pseudofossulae are not developed. Tabulae appear in transverse section as closely spaced discontinuous concentric bars. The axial structure consists of a persistent medial lamella which is joined at irregular intervals by septal ends and the axial ends of tabulae.

In longitudinal sections the axial structure appears as a single persistent medial lamella which extends several millimeters above the calyx floor. Tabulae are incomplete, highly anastomosing, and sub-horizontal except at the periphery of the tabularium, where they are inclined downward toward the dissepimentarium. The dissepimentarium becomes progressively narrower apically, and has a width of only one dissepiment in the early tip. The zone of dissepiments continues into the calyx, where the inner wall of the dissepimentarium forms the calyx wall. The floor of the calyx is typically convex upward, due to the attitude of the uppermost tabulae.

DISCUSSION: *Koninckophyllum gracile* is distinguished from other described species of this genus on the basis of its comparatively small size, narrow dissepimentarium, low number of major septa, and well-developed inner wall between the dissepimentarium and tabularium. The Wapanucka corallites compare closely to the description of the holotype and two paratypes by Moore and Jeffords (1945, p. 162). Although *K. gracile* is stated by these authors (1945, p. 162) to be a cylindrical form, the illustrated holotype (UK no. 7994-21a) is incomplete. Complete specimens from the Wapanucka are distinctly conical, and become cylindrical only in the upper portion. Described species of *Koninckophyllum* include *K. arcuatum* (Moore and Jeffords, 1945) and *K. simplex* (Moore and Jeffords, 1945). From the former species, *K. gracile* is distinguished by its lack of long minor septa and a complex axial structure. From the latter species, *K. simplex*, this species differs in having a narrower dissepimentarium, more widely spaced tabulae, and a less prominent inner wall. However, further study may show *K. gracile* to represent a juvenile stage of growth of *K. simplex*. On the basis of the limited material available no conclusion could be reached. When equivalent stages of growth are compared, the differences between the two species are slight. In the development of the inner wall and in the nature of the medial lamella there is also little difference between _K. simplex_ and the present species. The tabulae of _K. simplex_ are stated by Moore and Jeffords (1945, p. 161) to be more highly arched than those of _K. gracile_, but this feature is also difficult to evaluate as the attitude of tabulae in both species is variable. From _K._ new species _F_, _K. gracile_ differs in the width of the dissepimentarium, nature of the dissepiments, complexity of the axial structure, and number of septa (see also description of _K._ new species _F_).

RANGE AND DISTRIBUTION: _Koninckophyllum gracile_ was described by Moore and Jeffords (1945, p. 162) from the Marble Falls Limestone (Bendian, Lower Pennsylvanian) of Burnet County, Texas. _Koninckophyllum_ has not previously been reported from the Wapanucka Formation.

MATERIAL AND OCCURRENCE: Seventeen specimens, four of which were thin-sectioned and the remainder cut and polished for study and comparison. The corallites were collected from the following localities: A 18, unit U; A 19, unit E; A 20, unit I.

Koninckophyllum new species _F_

Plate 8 figures 1 - 3.

DESCRIPTION: Solitary corallites from the Wapanucka Formation here described as _Koninckophyllum_ new species _F_ are large conical-cylindrical forms. The holotype (OU 4861) is 58.2 mm in length and has a maximum diameter of 31.0 mm. The original length of several incomplete corallites is estimated to have been in excess of 70 mm. Curvature is slight and variable in direction. All corallites are poorly preserved. Small rootlets for attachment are present at the apex of several specimens; in others, the apex is flattened to form a broad attachment area.

Transverse sections at or near the base of the calyx show from 36 to 45 major septa. Septa extend through the wide dissepimentarium and into the tabularium. Each second or third septum is longer, and extends into the axial area; the shorter septa are subequal in length. Septa are thin and crooked in the dissepimentarium, and thicken abruptly at the inner margin of this zone. Dissepiments at the inner margin of the dissepimentarium are thickened, and an inner wall is thereby formed. In the tabularium, septa are straight, except for their wavy axial ends, and thin progressively toward the axis of the corallite. The cardinal septum is slightly shorter than adjacent metasepta and lies in a conspicuous open fossula. A sag in the inner wall marks the position of the cardinal fossula. Alar septa are difficult to identify, as pseudofossulae are not developed. The counter septum is long, and extends into the axial area in all stages of growth except in the calyx. All the septa withdraw slightly from the axis in the calyx. A medial lamella joins the cardinal and counter septum in some stages of growth, but this feature is not consistent. Forty-five major septa are present in the highest transverse section made of the holotype; its septal arrangement is represented by the formula K 11 A 9 C 9 A 12 K, which indicates slight acceleration of the counter quadrants. Tabulae appear in transverse sections as closely spaced discontinuous concentric bands. The dissepimentarium is wide, and in some corallites occupies the peripheral one-half of the corallite (one-half the radius). Dissepiments are small, and form a herringbone pattern in transverse sections. Minor septa extend only to the first dissepiment in the mature corallite and are absent in lower stages of growth.

The axial structure consists of a discontinuous medial lamella formed by the axial end of the long counter septum. Subparallel lamellae are formed by the ends of the longer septa. Numerous anastomosing tabulae contribute to the complexity of broad, irregular axial structure. From 18 to 24 tabulae originate at the inner margin of the dissepimentarium per 10 mm; many are horizontal, or slope downwards, for several millimeters adjacent to the inner wall, but thereafter they are inclined upward toward the axis of the corallite. Dissepiments are inclined downward toward the axis at about 45 degrees, and are in general markedly smaller than in other described species of Koninckophyllum. Sections through the juvenile stages of growth show the dissepimentarium to be well-developed and the inner wall to be proportionally as prominent as in higher sections.

DISCUSSION: Koninckophyllum new species F may include a corallite by Moore and Jeffords (1945, p. 163) as Neokoninckophyllum sp. A, from the Marble Falls Limestone (Morrow Series).

Other described species of Koninckophyllum of Morrow age are K. gracile, K. simplex, and K. arcuatum; all were described by Moore and Jeffords (1945). All of these but K. arcuatum have been identified from the Wapanucka Formation during the present study. From K. gracile, the present species differs in having a wide dissepimentarium, smaller dissepiments, more irregular axial structure, more highly anastomosing tabulae, and a stronger inner wall. K. simplex approaches this species in size, but also differs in the respects listed above.

RANGE AND DISTRIBUTION: Neokoninckophyllum sp. A was described by Moore and Jeffords (1945, p. 163) from a single corallite from the Marble Falls Limestone (Morrow Series) of Kimble County, Texas. Koninckophyllum has not previously been reported from the Wapanucka Formation.

MATERIAL AND OCCURRENCE: The above description was based upon seven corallites; the holotype (OU 4861) and the figured paratype (OU 4862) were collected from locality C 17, unit A; other specimens were collected from locality C 27, unit C; and PO 6, unit B.

Family CYATHOPSIDAE Dybowski, 1873

The Cyathopsidae are defined by Hill (1956, p. F291-292) as follows:

> Solitary or fasciculate Rugosa with an open tabular fossula; septa typically dilated and amplexoid in the wide tabularium; tabulae complete, domed or flat, with down-turned edges; marginarium a regular or (in some) a lonsdaleoid dissepimentarium; cardinal septum short, counter septum commonly elongate. L.Carb.-Perm.

Genus *Pseudozaphrentoides* Stuckenberg, 1904

Generic diagnosis (after Moore and Jeffords, 1945, Sutherland, 1958):

> Solitary corallites, trochoid to cylindrical; major septa reach axis only in immature growth stages, withdraw in mature growth stages; cardinal septum short, counter septum equal or very slightly longer than metasepta; acceleration of septal insertion in counter quadrants slight or absent; tabulae closely spaced, subhorizontal except at margins, where they are deflected downwards in an outer tabulate area; minor septa of various lengths; dissepiments well developed, but not lonsdaleoid; no axial column.

Type species: *Pseudozaphrentoides jerofeewi* Stuckenberg, 1904

(Genoholotype by monotypy)

Remarks: Hill (1939, p. 104, 1956, p. F292) regards *Pseudozaphrentoides* as a junior synonym of *Caninia* Michelin in Gervais, 1840. This is perhaps due to Hill's broad interpretation of *Caninia* (1939, p. 105-

106), which allows the inclusion in Caninia of small forms with few dissepiments, large forms with numerous (and even lonsdaleoid) dissepiments, and many intermediate forms.

Moore and Jeffords (1945, p. 145-146) suggested that many of the species regarded by Hill as "caninimorphs" be raised to the rank of genera, and proposed that: (a) The genus Caninia Michelin in Gervais be restricted to forms clearly similar to the type species, C. cornucopiae Michelin (in Gervais, 1840); (b) the genus Pseudozaphrentoides Stuckenberg be used for forms conforming to the above diagnosis, i.e., having long major septa in the immature stages of growth only, non-lonsdaleoid dissepiments, and an open cardinal fossula; and (c) the genus Siphonophyllia (Scouler, in McCoy, 1884), which has a type species S. cylindrica Scouler, be reserved for forms having a well-developed siphonofossula and lonsdaleoid dissepiments.

The genus Caninia has also been viewed in a restricted sense by Wang (1950, p. 209). Wang, however, regarded Pseudozaphrentoides as a junior synonym of Bothrophyllum Trautschold. This synonymy is clearly incorrect, as was subsequently pointed out by Sutherland (1958). Sutherland also followed Moore and Jeffords in restricting the genus Caninia to forms similar to the type species, with this reservation (1958, p. 63):

> This procedure is followed in this paper but with the realization that all our generic and even specific boundaries in the caniniids are highly artificial at present as we have little knowledge of their true phylogenetic relations. It has been suggested that there is probably continuous gradation between the above listed genera. Such features as the tendency in some forms for the dissepiments to become lonsdaleoid have probably appeared in various groups at different times.

Prolonged discussion of the taxonomic history of Caninia and Pseudozaphrentoides are beyond the scope of this study. In retaining the latter genus, the writer follows Moore and Jeffords (1945, p. 146) who summarized their views as follows:

> Interpreting Caninia as properly including only corals that have structural features like those of the genotype, C. cornucopiae, this genus may be differentiated from Pseudozaphrentoides by the very slight development of dissepiments in Caninia and perhaps also by the greater contrast in characters of the immature and mature regions in Caninia.

Pseudozaphrentoides nitellus Moore and Jeffords, 1945

Plate 9 figures 1 - 3.

DESCRIPTION: Solitary corallites from the Wapanucka Formation belonging to this species are medium to large in size and cylindrical in form. The exterior is irregular due to strong periodic rejuvenescence, which produces wrinkles and constrictions of the epitheca. External markings of the epitheca include well-developed lines of growth which cross faint septal grooves and interseptal ridges. The early tip of several corallites is preserved, and bears strong rootlets for attachment. Within these limits, this species is highly variable; specimens range in length from about 15 mm to 50 mm and in maximum diameter from 9 mm to 21 mm. Maximum diameter may occur at any point in the upper cylindrical portion, which normally comprises the upper two-thirds of the corallites.

Transverse sections at the base of the calyx show from 23 to 34 long thin major septa, which extend about two-thirds the distance to the axis of the corallites. These alternate with minor septa, whose length averages approximately two-thirds that of the major septa. Major septa are crooked in the dissepimentarium, and become noticeably straighter in the tabularium; they are thickened slightly at the inner edge of the dissepimental zone. Minor septa are thinner than the major septa, and extend only to the inner margin of the dissepiments. Protosepta are not distinguishable in transverse sections. In a few cases one major septum is slightly withdrawn from the axis, which may be the cardinal septum. A cardinal fossula is not developed at any growth-stage. The broad central area contains only arched tabulae. Two distinct orientations of the tabulae are visible in transverse sections, which are discussed below. No axial structure is present.

The diagnostic features of Pseudozaphrentoides nitellus are best seen in longitudinal sections, which show three distinct zones within the corallites. These zones are described by Moore and Jeffords (1945, p. 151-152) and are: (1) an inner tabularium, termed the inner tabulate area, which is devoid of septa but contains abundant closely spaced tabulae. The tabulae are slightly anastomosing, arched gently upwards, and crowded. From 10 to 12 tabulae occur per 5 mm in the mature corallites. (2) An outer tabulae area which approximates one-third the radius of the tabularium; in this zone the tabulae are deflected sharply downward and are anastomosing, averaging 12-14 tabulae per 5 mm. The axial ends of the septa coincide with the inner edge of this zone. (3) An outermost zone, which consists of a broad band of dissepiments. The width of the dissepimentarium is about one-third the radius of the corallite. It is separated from the outer tabulate zone by an inner wall which is produced by secondary thickening of dissepiments. Dissepiments are somewhat irregular in size, but in general are small, convex upward, and slope downward toward the axis of the corallite at about 45 degrees.

DISCUSSION: The three zones described above are diagnostic of this species. The strikingly abundant and closely spaced tabulae, and the nearly horizontal attitude of the tabulae, separate *Pseudozaphrentoides nitellus* from *P. verticillatus* (Barbour). *P. nitellus* also lacks calicular buds, stated to be present in the former species by Moore and Jeffords (1945, p. 152). From *P. lepitus* this species is distinguished primarily by the presence of long minor septa and well-developed internal zones. A similar species, *P. spatiosus* Moore and Jeffords, 1945, attains a larger size and also lacks the distinct internal zones observed in *P. nitellus*.

RANGE AND DISTRIBUTION: *Pseudozaphrentoides nitellus* was described by Moore and Jeffords (1945, p. 151) from the Hale Formation (Morrow Series) near Greenleaf Lake, Oklahoma. This is the first recorded occurrence of *Pseudozaphrentoides* from the Wapanucka Formation.

MATERIAL AND OCCURRENCE: A total of 39 specimens, of which four were thin-sectioned and the remainder cut and polished for study, have been collected from the following localities: PO 3, unit D, unit F; PO 7, unit A; C 9, unit B; C 10, unit B; C 14, unit B; C 17, unit A; C 27, unit C; and A 19, unit E.

ORDER TABULATA

Family FAVOSITIDAE Dana, 1846

The Favositidae defined by Hill (1956, p. F460) as follows:

> Massive, typically without coenenchyme; corallites slender, with mural pores; septa short, equal, spinose, variable in number; tabulae complete. . . U.Ord.-Perm., ?Trias.

The genus Striatopora Hall is assigned by Hill to the Subfamily Pachyporinae Gerth, 1921. This group is defined by Hill (ibid., p. F464) as follows:

> Tuberose or branching; walls of corallites thickened, with tunnel-like mural pores; calices opening normal to surface; septa spinose, tabulae thin, complete. Sil.-Perm.

Genus Striatopora Hall, 1851

Generic diagnosis by Hill (1956, p. F464):

> Ramose; walls thickened distally only; septa 12, with numerous trebeculae. Sil.,cosmop.;Dev.-Perm., N.Am.

Type species: Striatopora flexuosa Hall

Remarks: Considerable controversy has attended the taxonomic history of this genus. However, there is now general agreement that *Striatopora* is distinct from allied genera, such as *Favosites* and *Michelinia*, and can be consistently distinguished by the presence of a thickened peripheral region and sparse mural pores. A closely related genus is *Thamnopora* Steininger (1831), from which *Striatopora* differs in having less thickened mature and immature regions, more closely spaced tabulae, and smaller mural pores. The type species of *Thamnopora* (*T. madreporacea* = *Alveolites cervicornis* Blainville, 1830) is usually regarded as representing the generic characters of *Thamnopora*; this species has uniformly thick walls and corallites which attain a maximum diameter of little more than 1 millimeter.

Study of *Pachypora* Lindstrom (1873) has demonstrated that this genus is a junior synonym of *Thamnopora*. This view is followed by Lang, Smith, and Thomas (1940, p. 92), Wells (1944, p. 259), Moore and Jeffords (1945, p. 175) and Hill (1956, p. F464). Species originally assigned to *Pachypora* are now assigned to either *Thamnopora* or *Striatopora*.

The genera discussed above may represent a graded series marked by progressive thickening of the inner walls or the corallites. This sequence is presumably evolutionary, and according to Wells (1944, p. 259) is as follows: *Favosites*; *Thamnopora*; *Striatopora*; *Trachypora*. Although the validity of all these genera is recognized by Hill (1956), the close similarity of *Thamnopora* and *Striatopora* continues to be a taxonomic problem.

<u>Striatopora</u> <u>religiosa</u> Moore and Jeffords, 1945

DESCRIPTION: Several fragments of massive or ramose coralla from the Wapanucka Formation belong to this species. The largest fragment, which may represent a stage of growth broadened by branching, exceeds 70 mm in width. The average thickness of the fragment is about 20 mm, and the maximum thickness slightly exceeds 30 mm. The corallum is approximately oval in cross-section. A smaller specimen is subspherical in shape, and has a maximum diameter of about 45 mm.

The surfaces of both fragments contain numerous calices, which average about 3 mm in diameter. The maximum diameter observed is 6.5 mm, but calices of this size are few. Many calices are as much as 4 mm deep, but this may be due in part to the absence of the uppermost tabulae. Unweathered calices bear distinct narrow ridges and intervening grooves, which may represent degenerate septa. An average of 9 or 10 ridges occur per 3 mm around the calicular opening, and both ridges and grooves extend to the base of the calyx.

The internal structure of the larger fragment is poorly preserved and sections show little more than the thickened peripheral region, which is up to 6 mm in width. The immature region consists of numerous fragmented walls and tabulae. In the smaller specimen, peripheral thickening is not well-developed, and the thickened zone has a maximum width of 3 mm or less. Walls are thickest in the mature part of the specimen. The average thickness of walls is approximately 0.5 mm and the maximum about 1.0 mm. Mural pores are up to 0.25 mm in diameter, and occur only in the peripheral portions of the corallum. Tabulae are complete and incomplete, and are gently convex to slightly concave upward. Tabulae are crowded in the mature region, where as many as 5 to 6 occur per 5 mm.

DISCUSSION: Longitudinal ridges and grooves are not present in any species of _Striatopora_ known to the writer except in _S. religiosa_. This species was described from the Marble Falls Formation of Texas by Moore and Jeffords, who state (1945, p. 180): ". . .longitudinal low ridges and intervening grooves. . .are spaced two in 1 mm. on the average. . ." About the same number of ridges and grooves occurs in the present material, which also corresponds closely to this species in most other aspects. The Wapanucka specimens differ from _S. religiosa_ only in the smaller maximum size attained by some calices, but this variation amounts to less than 2 mm.

Coralla similar to this species were described as _Pachypora carbonaria_ by Mather (1915, p. 94), as _P. oklahomensis_ by Snider (1915, p. 72), and as _P. caneyana_ by Morgan (1924, p. 175). The spacing of tabulae appears to be slightly greater in _P. caneyana_, but is well within the range of variation of _P. oklahomensis_.

Pachypora is regarded in Hill (1956) as a junior synonym of _Thamnopora_ (see discussion of _Striatopora_, above). _P. carbonaria_ and _P. oklahomensis_ apparently are synonymous, and are correctly referred by Moore and Jeffords (1945) to _Striatopora oklahomensis_ (Snider).

To this synonymy the writer adds P. caneyana Morgan.

Moore and Jeffords' species, S. religiosa, can be readily distinguished from S. oklahomensis by the presence of distinct septal grooves and ridges and larger calices in the former species. This species does not require comparison with S. immota Moore and Jeffords (1945), in which the calices range in diameter from less than 1 mm to only 1.6 mm.

RANGE AND DISTRIBUTION: Striatopora religiosa Moore and Jeffords (1945) was described from the upper Marble Falls Limestone (Morrow Series), San Saba County, Texas. Striatopora oklahomensis (Snider) was described by Moore and Jeffords (1945) from the Brentwood Limestone (Morrow Series) of northwestern Arkansas, and from Morrowan strata of northeastern Oklahoma.

Pachypora caneyana Morgan (1924) was described from "one locality near the top of the Caney shale." (Morgan, 1924, p. 176). This locality (Morgan's no. 170), is now mapped as the Union Valley Formation (Morrow Series). Pachypora oklahomensis Snider (1915) was reported from the "Mayes" Formation (Morrow Series). Pachypora carbonaria Mather (1915) was described from the Brentwood Limestone (Morrow Series) near Brentwood, Arkansas, and from the Morrow Formation (Morrow Series) near Fort Gibson and Chouteau, Oklahoma.

MATERIAL AND OCCURRENCE: Three fragmentary specimens, from locality C 27, unit B.

Genus Acaciapora Moore and Jeffords, 1945

Generic diagnosis by Hill (1956, p. F464):

> Like Thamnopora but with squamulae. Penn., Texas - Okla.

Type species: Michelinia subcylindrica Mather, 1915.

Remarks: The genus Acaciapora was defined by Moore and Jeffords (1945, p. 181) to include small ramose coralla which are primarily distinguished by the presence of squamulae, i.e., incomplete tabulae which are free at one end and do not extend completely across the corallites. This feature alone serves to separate Acaciapora from other tabulate genera, including Thamnopora Steininger (1831), Michelinia de Koninck (1841), Striatopora Hall (1851), Cladochonus Hall (1851) and "Pachypora" (= Striatopora) Lindstrom (1873).

Described species of Acaciapora are separated principally on the basis of surface features, including the spacing and degree of overlap of calices. The genotype species, Michelinia subcylindrica Mather, is stated by Mather (1915, p. 97) to have a "wrinkled, concentrically striated epitheca which does not extend far upon the sides of the colony in any of the specimens at hand. . ." Specimens described by Moore and Jeffords as Acaciapora subcylindrica (Mather) and A. venusta in 1945, however, lack an epitheca. Moreover, there is no indication that an epitheca was present in any of the present specimens from the Wapanucka Formation. This variation from the type species is not considered to be significant by the writer. Although the outer surfaces of species of *Acaciapora* and *Michelinia* are superficially similar, particularly when comparison is made with small species of *Michelinia*, such as *M. tenuicula*, close examination shows distinct and significant differences in morphology. All species of *Michelinia* have polygonal, non-overlapping calices which are flush with the curved plane of the surface of the corallum. The apertures of *Acaciapora*, conversely, are obliquely oriented with respect to this surface because of the raised lower rim of the calyx, and are round. Internally, the squamulae of *Acaciapora* distinguish this genus from *Michelinia* and all other tabulate genera.

Acaciapora subcylindrica (Mather), 1915

DESCRIPTION: Coralla of this type are common in the Wapanucka Formation. The present material consists of eight incomplete specimens, including a branching portion of a corallum. The largest fragment has a length of 14 mm; the maximum diameter of any fragment is 6.4 mm. The basal attachment surfaces of several specimens are present, but an epitheca is absent, or is not preserved.

Closely spaced subcircular calices occupy the entire outer surfaces of the coralla. The lower rims of the calices are elevated slightly, so that a given calyx may appear to be overlapped distally by the adjacent (higher) calyx. However, if the corallum is viewed obliquely this interference is seen to be apparent rather than real. Calices are from 3 mm to 4 mm in depth and have a maximum diameter of about 1.5 mm; most are less than 1 mm across. Well-preserved calices show from 14 to 16 indistinct septal ridges and intervening grooves, and have slightly denticulate rims. Interspaces between apertures are small or absent.

Longitudinal sections show evenly expanding corallites which curve gently upward and outward toward the surface of the corallum. Numerous incomplete tabulae with free ends, or squamulae, occur at irregular intervals along the corallite tubes. A maximum of 2 or 3 of these plates occur over a distance of 1 mm along the corallites. In some corallites, squamulae originate on alternating sides of the tube. The free ends of squamulae are occasionally intersected by thin-sections and appear to float in the open axial area. Thickening of the inner walls by stereoplasm is limited to areas of branching. Corallite walls are 0.5 mm or less in thickness and are perforated by widely spaced large (0.5 mm to 0.15 mm) mural pores. Mural pores can also be observed in the walls of weathered calices at the surface of the corallum.

DISCUSSION: The closely spaced calices of this species, which appear to overlap adjacent calices, distinguish it from A. venusta Moore and Jeffords (1945), which was described from the basal part of the Marble Falls Formation (Morrow Series) of Texas. The present species also differs from A. venusta is having more closely spaced calices and a somewhat broader growth-form. Septal grooves were not reported to be present in *A. venusta*, but this may have been due to poor preservation. Internal differences between the two species are slight.

RANGE AND DISTRIBUTION: *Michelinia subcylindrica* Mather (1915) was described from the Morrow Formation, near Fort Gibson, Oklahoma. Moore and Jeffords' specimens, described as *Acaciapora subcylindrica* (Mather) were collected from the Hale Formation (Morrow Series) at Greenleaf Lake near Braggs, Oklahoma, and near Keough quarry, north of Fort Gibson, Oklahoma. *Acaciapora* has not previously been reported from the Wapanucka Formation.

MATERIAL AND OCCURRENCE: *Acaciapora* is commonly associated with small bryozoan fragments in the Wapanucka Formation. Because bryozoans were not systematically collected, many specimens were undoubtedly overlooked. The eight specimens described above were collected at locality PO 4, unit A.

Subfamily Micheliniinae Waagen and Wentzel, 1886

The Subfamily Micheliniinae are defined by Hill (1956, p. F466) as follows:

> Discoid or hemispherical, with large corallites, large mural pores, septal spines or ridges, and with or without tabulae. *Dev.-Perm.*

Genus *Michelinia* de Koninck, 1841

Generic diagnosis by Hill (1956, p. F466):

> Like Pleurodictyum but with numerous, incomplete, convex tabulae; may be thin-walled. U.Dev.-Perm., cosmop. .

Type species: Calamopora tenuisepta Phillips, 1836 (=Michelinia tenuisepta de Koninck, 1841; subsequent designation by Milne-Edwards and Haime, 1850)

Remarks: This genus includes tabulate coralla of highly variable form which are comprised of closely packed polygonal corallites. A holotheca may be present at the base of the corallum. Corallite walls are thin (typically less than 1 mm) and bear large mural pores which perforate the walls or, less commonly, lie in the plane of the walls. Tabulae are numerous to abundant, complete or incomplete, and in general are convex upward. Septal ridges are rudimentary or absent.

Michelinia differs from Pleurodictyum Goldfuss (1829), which has as its type species P. problematicum, in having much thinner corallite walls, smaller mural pores, and more numerous tabulae. Michelinia is distinguished from Striatopora Hall (1851) (type species, S. flexuosa) primarily by the absence of a thickened peripheral, or mature, region.

The Wapanucka Formation contains numerous representatives of Michelinia, and specimens can be collected at most localities. Representatives of this genus are referred to five species, M. scopulosa, M. spissata, M. referta, M. latebrossa, and M. tenuicula.

Michelinia referta Moore and Jeffords, 1945

DESCRIPTION: Two poorly preserved coralla from the Wapanucka Formation belong to this species. Each specimen is wider than it is high, and one corallum has a massive or encrusting form of growth. The larger specimen has a maximum height of about 21 mm and a maximum diameter of 57 mm. The smaller corallum is 66 mm across in one direction but does not exceed 10 mm in height. There is no holotheca.

Individual corallites are large, polygonal, and thin-walled. Calices with diameters of 6 mm are common, and a few are as much as 8 mm across. The depth of the calices is normally less than one-half the diameter, but this is due in part to weathering. Septal ridges are absent.

Longitudinal sections show numerous, thin, closely spaced tabulae, with up to 8 or 10 occurring per 10 mm along the corallites. Tabulae are gently convex upward and typically complete. Corallite walls are thin, usually less than 0.5 mm in width, and bear small, widely spaced mural pores in the peripheral portions of the coralla. The maximum diameter recorded from mural pores in this species is 0.3 mm, but most are less than 0.2 mm in diameter.

DISCUSSION: These coralla agree closely in morphology with Michelinia referta Moore and Jeffords (1945). The growth-form of M. referta, however, was described by Moore and Jeffords (1945, p. 174) as being massive, ovoid, and higher than wide. The present coralla, however, are wider than high. This difference is not considered to be significant in species characterized by massive form.

Michelinia referta differs from most species of Michelinia, such as M. scopulosa, M. tenuicula, M. spissata, and M. latebrosa, by its large corallites, thin corallite walls, and closely spaced tabulae. Michelinia referta is similar to M. eliximura, described by Mather (1915, p. 96, pl. II, figs. 2, 2a) from beds of Morrowan age near Chouteau, Oklahoma. M. referta differs from this species in having somewhat larger corallites and much more closely spaced tabulae.

RANGE AND DISTRIBUTION: Michelinia referta was described by Moore and Jeffords (1945, p. 174, text figs. 171, 172, 182) from beds thought to belong to the Marble Falls Limestone (Morrow Series) in San Saba County, Texas.

MATERIAL AND OCCURRENCE: Two coralla, from locality PO 8, unit B.

Michelinia scopulosa Moore and Jeffords, 1945

DESCRIPTION: Specimens of Michelinia scopulosa are common in the Wapanucka Formation. The coralla are variable in shape, but in general are subhemispherical. The maximum width recorded is about 40 mm; most specimens are less than 30 mm wide. In height, about the same range of values obtains. A few specimens have a strongly wrinkled holotheca at the base of the corallum, but in most examples the holotheca is rudimentary or absent.

Individual corallites are small, polygonal, and thin-walled. Calices are 3 mm or less in diameter, but a few occur which are up to 3.5 mm across. Calices are typically between 2.5 mm and 3.5 mm in depth. Septal ridges are present in well-preserved calices, but these are low, closely spaced, and almost imperceptible.

Longitudinal sections of several coralla show thin complete and incomplete tabulae. Tabulae are in general gently convex upward, and as many as 10 tabulae occur per 5 mm in the immature portions of some corallites. Corallite walls vary in thickness from 0.4 to 0.5 mm; at points where walls bifurcate to form new corallites they are somewhat thicker, but all are less than 1 mm in width. Mural pores are most common in the mature portions of the coralla and range in diameter up to about 0.3 mm.

DISCUSSION: Coralla of this type were described and illustrated by White (1884, p. 119, pl. 23, figs. 14-16) as Michelinia eugeneae. The exteriors of White's specimens, however, indicate that more than one species was represented. White's figure 14, for example, is probably a representative of M. scopulosa. No illustrations of internal structures were given by White, and M. eugeneae must therefore be regarded as an unrecognizable species until the type material is restudied. Specimens described and figured by Mather (1915, p. 96, pl. 1, figs. 17, 17a, pl. 2, fig. 1) as M. eugeneae are here referred to M. scopulosa, as are specimens illustrated by Morgan (1924, pl. 35, fig. 1, 1a). It has been the practice for several decades to assign all small tabulate corals from Pennsylvanian strata to

M. eugeneae White.

A smaller species of *Michelinia*, which also occurs in the Wapanucka Formation was described by Moore and Jeffords (1945, p. 172) from the Hale Formation as *M. tenuicula*. There is considerable overlap in form between *M. tenuicula* and the present species. *M. scopulosa* can be distinguished from *M. tenuicula*, however, by the greater diameter attained by many of its corallites, thinner corallite walls, less crowded tabulae, and more numerous mural pores.

Coralla described as *M. spissata* Moore and Jeffords (1945) are also associated with *M. scopulosa* at many localities in the Wapanucka Formation. *M. scopulosa* is distinguished from this species by its smaller size, lesser diameters of individual corallites, thinner more numerous tabulae, and smaller more widely spaced mural pores. Corallites of *M. scopulosa* also lack the thickened basal portion which characterizes those of *M. spissata*.

Two additional species of *Michelinia* which occur in the Wapanucka Formation are *M. referta* and *M. latebrosa*, both of which were described by Moore and Jeffords (1945). These species are much larger than the present species, both in the size of the coralla and in the diameters of individual corallites, and do not require detailed comparison.

The coralla described above differ from *M. scopulosa* only in the development of the holotheca, which is more rudimentary in the Wapanucka specimens.

RANGE AND DISTRIBUTION: The original description of Michelinia eugeneae by White (1884) includes one specimen which probably belongs to the present species. White's material was collected from several horizons in Pennsylvanian strata in Indiana and Illinois. Specimens assigned by Mather (1915) to M. eugeneae were from the Brentwood and Kessler Limestones (Morrow Series) in Arkansas and Oklahoma. Specimens illustrated by Morgan (1924) and listed as M. eugeneae were collected from the Wapanucka Formation at a locality which corresponds to locality PO 4 of this report. The description of M. scopulosa by Moore and Jeffords (1945) was based on specimens from the Hale Formation (?) (Morrow Series) at Greenleaf Lake, near Braggs, Oklahoma, and near Keough quarry, north of Fort Gibson, Oklahoma.

MATERIAL AND OCCURRENCE: Fifty-four specimens, from the following localities: PO 3, units A, D, F; PO 4, unit A; PO 7, units A, B; PO 8, unit B; C 9, unit B; C 17, unit A; C 26, unit A; PT 21, unit F; and PT 22.

Michelinia spissata Moore and Jeffords, 1945

DESCRIPTION: Numerous coralla from the Wapanucka Formation are assigned to Michelinia spissata Moore and Jeffords (1945). The material shows a greater range of variation, however, than is indicated in the description of this species. Coralla from the Wapanucka vary from small conical forms with a well-developed and prominent holotheca to large globose or subhemispherical colonies in which the holotheca is rudimentary. Most coralla are higher than wide, but in many specimens the reverse occurs. The height of the largest corallum is about 40 mm and the maximum diameter recorded is 35 mm. Average coralla are about 30 mm in height and from 25 mm to 30 mm in diameter. The holotheca of many specimens is remarkable for its degree of development and symmetry. In some elongate specimens, as much as four-fifths of the total height is covered by a strongly rugose holotheca; in subhemispherical coralla, the holotheca may be equally well-developed, but covers only the basal half of the colony.

Individual corallites have an average diameter of approximately 4 mm, but many are 5 mm across. Calices are deep, polygonal, and are separated by thick walls. In well-preserved calices closely spaced rudimentary septal grooves are visible.

Longitudinal sections of this species show numerous thick tabulae which are both complete and incomplete; tabulae are evenly spaced and are not crowded. From 5 to 6 tabulae occur per 5 mm in the mature corallites; in the immature portions tabulae are more closely spaced than this. Corallite walls are variable in thickness, and range from 1.3 mm in the immature parts of corallites to about 0.5 mm in mature portions. The average thickness of walls approximates 1 mm. Mural pores up to 0.2 mm in diameter are numerous throughout the coralla, and are closely spaced in the thickened walls adjacent to bifurcations.

DISCUSSION: The specimens described above agree closely to M. spissata in diameter, thickness of corallite walls, nature and attitude of tabulae, and in size and distribution of mural pores.

The number of specimens studied by Moore and Jeffords as the basis of their description of this species is not clear, but apparently only a few specimens were described. All illustrations (ibid., text figs. 170, 180) are of the holotype, and the presence of a holotheca is not noted. The development of a holotheca has been demonstrated to be highly variable within a species, and the prominent holotheca present in many of the coralla here described is therefore considered to be significant only as a further definition of this species.

Michelinia spissata is distinguished from other described species of this genus by the nature of its corallite walls, stout and evenly spaced tabulae, and numerous mural pores. The prominent holotheca observed in many of the Wapanucka specimens is also considered to be characteristic, but should be used with caution because of the variability present in its development.

RANGE AND DISTRIBUTION: A specimen of Michelinia stated to have been collected from the Boggy Formation (Des Moines Series) is illustrated by Morgan (1915, pl. xxxv, fig. 1b). This corallum is listed by Morgan (ibid., erroneously under the description of plate xxxiii) as Michelenia (sic) eugeneae White. The similarity of this corallum to M. spissata is strong, particularly with respect to the well-developed holotheca, but further study of the specimen is needed. The type specimen (UK no. 720) of M. spissata Moore and Jeffords was collected from the Brentwood Limestone (Morrow Series) at "Acorn Cut", northwest of Brentwood, Arkansas.

MATERIAL AND OCCURRENCE: The above description is based on 86 specimens, from the following localities: PO 7, unit A; C 25, unit F; C 26, unit A; J 16, unit D; J 24, unit F; A 18, unit U.

Michelinia tenuicula Moore and Jeffords, 1945

DESCRIPTION: Numerous representatives of this small species occur in the Wapanucka Formation. The coralla are uniform in size and shape, compared to other species of *Michelinia*. The largest corallum is about 25 mm in diameter, and in width most specimens fall between 15 mm and 20 mm. The maximum height of one corallum is 30 mm. The development of the holotheca is variable but in no specimen is the holotheca prominent.

Individual corallites are small, polygonal, and are separated by thin walls. Most are 2 mm or less in diameter, but a few exceed this by 0.1 or 0.2 mm. In depth, the calices are about equal to the diameter. Septal ridges are not present.

Longitudinal sections show numerous, closely spaced complete and incomplete tabulae which are gently convex upward. Tabulae in the immature portions of the corallites are crowded, with as many as 12 to 14 occurring per 5 mm. Corallite walls are 0.5 mm or less in thickness, except where they bifurcate to form new corallites. Walls are less than 1 mm in thickness even at these points. Mural pores up to 0.2 mm in diameter are numerous, evenly distributed throughout the coralla, and small.

DISCUSSION: *Michelinia eugeneae* White (1884) is here considered to be an unrecognizable species (see discussion of *M. scopulosa*) and includes at least one specimen which probably belongs to *M. tenuicula*. However, this can be confirmed only by restudy of White's material.

M. tenuicula is associated with *M. scopulosa* in the Wapanucka Formation. *M. tenuicula* is in general smaller and is comprised of corallites which are decidedly smaller than those of *M. scopulosa*. In addition, the present species has thinner and more crowded tabulae, and smaller and less numerous mural pores than *M. scopulosa*.

M. tenuicula does not require detailed comparison with larger forms, such as *M. spissata*, *M. latebrosa*, and *M. referta*.

RANGE AND DISTRIBUTION: White's type material for *Michelinia eugeneae* was reported to have been collected from Pennsylvanian strata in Indiana and Illinois. As noted above, one of his specimens (White, 1884, pl. 23, no. 15) is thought to represent the present species. Coralla described by Moore and Jeffords (1945, p. 172) as *M. tenuicula* were from the Hale Formation (?) (Morrow Series) at the Greenleaf reservoir, near Braggs, Oklahoma, and near Keough quarry, north of Fort Gibson, Oklahoma.

MATERIAL AND OCCURRENCE: The present description is based on 28 coralla from the following localities: PO 3, unit A; PO 4, unit A; PO 7, unit A; C 17, unit A; C 26, unit A.

<u>Michelinia</u> <u>latebrosa</u> Moore and Jeffords, 1945

DESCRIPTION: Several coralla from the Wapanucka Formation are referred to this species. The specimens are subhemispherical to subcylindrical in form. The largest corallum has an unequal "dumb-bell" shape. This specimen has an overall height of 102 mm and a diameter of 56 mm at the larger end; it is clearly anomalous and apparently was toppled over at an early stage of growth and subsequently grew in a new direction, thereby obscuring the original attachment area. A second corallum has a height of 63 mm and a maximum diameter of 44 mm. In this specimen the location of the attachment area is clear, although a holotheca is not developed. A third corallum is subhemispherical in form and is wider than high, measuring 45 mm and 29 mm, respectively. This specimen is poorly preserved but also appears to lack a holotheca.

Corallites are moderately large, with an average diameter of about 3.5 mm. A maximum diameter of 5 mm is attained by some corallites, and corallites 4 mm across are common. Polygonal calices cover the outer surface of the coralla, and are separated by well-developed walls. Most calices are slightly deeper than wide. Septal ridges are present in well-preserved calices and are about 0.3 mm in width.

Longitudinal sections show corallite walls to be straight, and uniform in thickness. Walls average 0.5 mm in thickness with a variation of less than 0.2 mm. Tabulae are commonly complete, stout, and evenly spaced along the corallite interiors. From 5 to 6 tabulae typically occur in a distance of 5 mm. Mural pores are small, up to 0.15 mm in diameter, and are common only in the peripheral portions of the coralla.

DISCUSSION: The coralla from the Wapanucka Formation differ from the description of Michelinia latebrosa Moore and Jeffords only in the diameter attained by some of the corallites, which exceeds the stated maximum by about 1 mm. M. latebrosa is similar only to M. referta Moore and Jeffords (1945), but can be distinguished from this species by its smaller corallites, thinner corallite walls, and stouter, more widely spaced tabulae.

RANGE AND DISTRIBUTION: Michelinia latebrosa was described by Moore and Jeffords (1945, p. 174) from the Jolliff and Otterville Limestones (Morrow Series) near Ardmore, Oklahoma; from two specimens "presumably from the middle Marble Falls limestone (Bendian) . . .southwest of Mason, Texas" (ibid., p. 175); and from two specimens from the Brentwood Limestone (Morrow Series) near Woolsey, Arkansas.

MATERIAL AND OCCURRENCE: Three coralla, from the following localities: PO 4, unit A; PO 7, unit A; J 24, unit F.

Family AULOPORIDAE Milne-Edwards and Haime, 1851

The Auloporidae are defined by Hill (1956, p. F469) as follows:

> Coralla compound, erect or repent and incrusting; corallites tubular, cylindrical or trumpet-shaped, increasing by lateral gemmation, in some forms

> connected by transverse stolons; walls solid, covered by transversely wrinkled epitheca. Septa represented by peripheral ridges or vertical rows of spines, lacking in some forms. Tabulae horizontal or distally concave, closely or widely spaced, broken up into tabellae in some forms, rare or absent in others. ?Sil., Dev.-Perm.

The genus Cladochonus McCoy is referred in Hill (1956, p. F469) to the Subfamily Auloporinae. Hill's diagnosis of this group follows:

> Small repent or erect coralla, typically with trumpet-shaped corallites that increase by lateral gemmation producing uniserial, biserial, multiserial, ramose, or web-shaped growth-patterns; transverse stolons absent. Septa represented by peripheral ridges or rows of spinules, absent in some forms. Tabulae widely spaced or lacking. ?Sil., Dev.-Perm.

Genus Cladochonus McCoy, 1847

Generic diagnosis by Hill, (1956, p. F472):

> Proximal corallites in repant (sic) ring from which free branches arise; individual corallites trumpet-or pipe-shaped, in contact only at points of origin, each giving rise to another by lateral increase through wall of expanded calice; each with a thick peripheral stereozone of laminar or reticulate sclerenchyme. Septal spines and tabulae lacking in the narrow lumen, but septal rings may appear in the calices. . .Dev.-Perm., N.Am.-Eu.-Asia-E.Indies-Austral.

Type species: Cladochonus tenuicollis McCoy, 1847 (subsequent designation by Milne-Edwards and Haime, 1850)

Remarks: _Cladochonus_ includes diminutive ramose coralla in which trumpet-shaped corallites alternatingly branch in opposite directions at intervals. Lateral increase through corallite walls produce individuals which are in contact with others only at their proximal end. Calices are wide, compared to the slender immature stages of growth, and are obliquely oriented with respect to the mid-line of the branch. The open axial tubes are narrow, except at the calyx, and walls are thick. Horizontal elements such as tabulae are absent.

Study of this genus by Hill and Smyth (1938) demonstrated that the basal portion of the corallum consists of a ring of corallites, commonly encircling some foreign object, which gives rise to branches. Prior to their study, the distal portions of these coralla were assigned to _Cladochonus_, and the proximal ring-like portions were referred by Nicholson and Etheridge (1879) to a separate genus, _Monilopora_. _Monilopora_ is now considered to be a junior synonym of _Cladochonus_.

Girty (1925, p. 23) designated _C. crassus_ (McCoy) = _Jania crassa_ McCoy, 1844, as the type species of _Cladochonus_. This assignment is invalid, as an earlier designation of _C. tenuicollis_ McCoy as the type was established by Milne-Edwards and Haime (1850, p. lxxvi) and has priority. Girty, however, correctly recognized the synonymy of _Monilopora_ and _Cladochonus_.

Hill (1956, p. F472) followed Nicholson (1879) and others in regarding the genus _Pyrgia_ Milne-Edwards and Haime (1851) as a junior synonym of _Cladochonus_. Examination of the illustrations of the type species of _Pyrgia_, _P. michelini_, leaves little doubt that their specimens were disarticulated corallites from one or more

Cladochonus coralla.

The alternating calices of Cladochonus serve to distinguish these corals from most other tabulate genera. Aulopora Goldfuss (1829) is similar in the form of individual corallites, but differs from Cladochonus in having a netlike growth-pattern, in which the lower side of corallites are adhered to an attachment surface. Virtually all the calices in Aulopora open in the same direction, i.e., away from the attachment surface.

Cladochonus fragilis Mather, 1915

DESCRIPTION: This species is represented in the Wapanucka Formation by small coralla consisting of slender trumpet- or funnel-shaped corallites which alternately branch in opposite directions. The outer surfaces of corallites are smooth except for almost imperceptible low lines of growth near the rims of the calices. The largest fragment consists of 3 corallites, and has a total length of about 12 mm. Most corallites are from 3 to 3.5 mm in length, but a few have lengths of almost 5 mm. Maximum diameter invariably occurs at the calyx. The average calyx diameter is about 2 mm; the largest calyx has a diameter of 2.8 mm.

Well-preserved calices are denticulate at their rims, and contain faint septal grooves and interseptal ridges. Up to four pairs of ridges and grooves occur in a distance of 1 mm. The average width of the ridges approximates 0.12 mm. Most calices have depths approximately equal to the diameter, and contain a narrow depression at the base.

These pits are laterally constricted by swelling of the inner wall of the calices and are parallel to the direction of growth. Those measured have lengths of about 1.2 mm and do not exceed 0.4 mm in width.

Growth of the coralla is by lateral increase, or gemmation. This occurs distally, between 0.5 and 1.5 mm from the rim of the calyx. Connecting pores between new corallites and their antecedents are not present, but the outer lamellae of the theca is absent at these points, and septal ridges are exposed. Tabulae are absent.

DISCUSSION: The specimens described above agree closely to the morphology of Cladochonus fragilis Mather (1915, p. 98, pl. I, figs. 3-5).

Cladochonus texasensis, which also occurs in the Wapanucka Formation, was described by Moore and Jeffords (1945, p. 187, pl. 14, fig. 4, text figs. 206 a, b) from the Marble Falls Formation of Texas. Moore and Jeffords' species, however, is a larger form and is marked externally by a reticulate pattern. The present species also differs from C. texasensis in having a different form of growth, in which new corallites do not arise in pairs from a single antecedent individual.

C. fragilis does not require detailed comparison to C. bennetti Beede (1898, p. 17; 1900, p. 24, pl. III, fig 1), which is characterized by a strongly wrinkled epitheca, or to C. americanus Weller (1909, p. 275, pl. 10, fig. 30), in which corallites are from 9 mm to 10 mm in length.

RANGE AND DISTRIBUTION: Cladochonus fragilis Mather (1915) was first described from the Morrow Formation (Morrow Series) near Fort Gibson, Oklahoma. Subsequently, a single specimen of C. fragilis from the Wapanucka Formation was illustrated by Morgan (1924, pl. xxxi, fig. 3). Morgan's specimen was collected at a locality which corresponds to locality PO 4 in this study. This species was recorded by Moore and Jeffords (1945, p. 186) from the Hale Formation (Morrow Series) near Fort Gibson and near Braggs, Oklahoma, and from the basal Marble Falls Limestone (Morrow Series) in San Saba County, Texas.

MATERIAL AND OCCURRENCE: A total of 23 specimens, from locality PO 4, unit A.

Cladochonus texasensis Moore and Jeffords, 1945

DESCRIPTION: One fragment of a Cladochonus corallum from the Wapanucka Formation is referred to C. texasensis. The specimen includes parts of 3 corallites, and has an overall length of 14.8 mm. The maximum diameter (7.4 mm) includes the diameters of 2 subparallel corallites and the basal portion of a third. Calices open in opposite directions and have subcircular rims which are parallel to the direction of growth. Septal grooves and interseptal ridges are present, but are low and indistinct. Each pair of ridges and grooves has a width of 0.8 mm to 1.0 mm.

Individual corallites, all of which are incomplete, appear to have had original lengths of 9 or 10 mm. The corallites range in diameter from about 3.0 mm in the immature region to 4.5 mm at the calyx. Corallite walls are thick, varying from 1.5 mm in the immature parts to 0.5 mm at the rim of the calyx.

Gemmation is by lateral increase, which typically occurs 2 to 3 mm from the distal ends of the corallites. In this species, two new corallites commonly arise from a single individual. The exterior of the corallites bears fine lines of growth and indistinct longitudinal ridges which correspond to the positions of septa. Weathering has removed most of these markings in the present material.

DISCUSSION: This specimen agrees in essential details to coralla described by Moore and Jeffords (1945) as Cladochonus texasensis. Diagnostic features include the bifurcating pattern of growth, width of septal ridges and interseptal grooves, and presence of a reticulate pattern on the exterior of the corallites. The Wapanucka specimen is somewhat smaller than Moore and Jeffords illustrated types, (ibid., pl. 14, fig. 4, text figs. 206 a, b), and may represent an early stage of growth of the colony.

Cladochonus texasensis differs from C. fragilis Mather (1915) in its larger size, ribbed exterior, and pattern of growth.

This species is also a larger form than C. americanus Weller (1909), from the Lower Mississippian of Missouri, and also differs from that species in growth form and external markings.

C. texasensis differs from C. bennetti Beede (1898) in lacking a strongly wrinkled epitheca and by its larger calices.

RANGE AND DISTRIBUTION: Clacochonus texasensis was described by Moore and Jeffords (1945, p. 187) from the upper part of the Marble Falls Formation (Morrow Series) of San Saba County, Texas. This species has not previously been reported from the Wapanucka Formation.

MATERIAL AND OCCURRENCE: One specimen, from locality PO 3, unit F.

PART IV

PLATES 1 - 9

PLATE 1

(All figures X2 unless otherwise stated)

Fig. 1. Empodesma aff. imulum Moore and Jeffords, 1945

1a-d. OU 4801, loc. J 24. a, longitudinal section, alar plane; b, transverse section at base of calyx; c, transverse section of ephebic stage; d, transverse section of early neanic stage; note joined cardinal and counter septa.

Fig. 2. Stereocorypha cf. annectans Moore and Jeffords, 1945

2a-d. OU 4802, loc. A 18. a, transverse section of upper calyx; b, transverse section at base of calyx (reflected light); c, transverse section of middle ephebic stage; d, transverse section of neanic stage (reflected light, reversed).

Fig. 3-5. Amplexocarinia corrugata (Mather)

3a-d. OU 4803, loc. A 18. a, transverse section of ephebic stage at point of rejuvenescence; note long septa; b, transverse section of neanic stage; c, transverse section of early neanic stage; d, enlargement of neanic stage, X 7.5.

4a-e. OU 4804, loc. A 18. a, longitudinal section, alar plane; b, diagram showing attitude of tabulae in (a); note steeply sloping peripheral portions; c, transverse section at base of calyx; d, transverse section of ephebic stage, above a tabulum; e, transverse section below a tabulum; note shortened septa.

5a. OU 4805, loc. A 18. a, exterior of deeply eroded and incomplete corallite, X1.

Fig. 6-9. Lophophyllidium idonium Moore and Jeffords, 1945

6a. OU 4806, loc. PO 4. a, exterior of typical corallite, X1.

7a-c. OU 4807, loc. J 16, a, exterior of topotype, X1; b, longitudinal section, alar plane; c, transverse section at base of calyx.

8a. OU 4808, loc. J 16. a, transverse section of topotype; note characteristic wide interseptal spaces between counter and counter-lateral septa.

9a-b. OU 4809, loc. J 24. a, longitudinal section, cardinal-counter plane; b, transverse section at base of calyx.

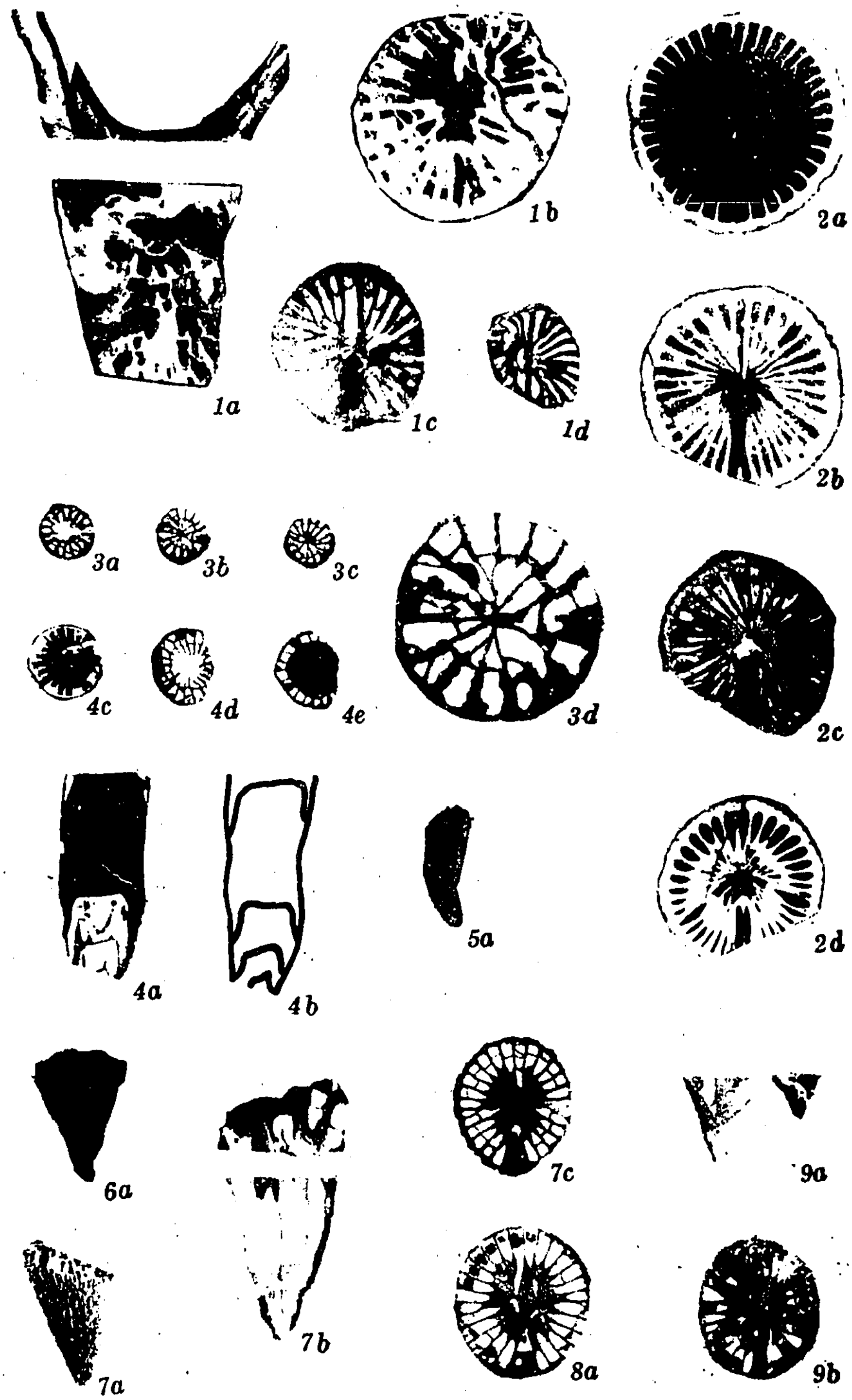

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PLATE 1

PLATE 2

(All figures X2 unless otherwise stated)

Fig. 1. Lophophyllidium idonium Moore and Jeffords, 1945

1a-b. OU 4810, loc. PO 4. a, transverse section of ephebic stage; interseptal spaces not typically developed; b, enlargement of axial area, X8.5.

Fig. 2-4. Lophophyllidium minutum Jeffords, 1942

2a-b. OU 4811, loc. PO 4. a, exterior of incomplete corallite, X1; b, transverse section at base of calyx; note prominent alar pseudofossulae and axial thickening.

3a. OU 4812, loc. PO 4. a, exterior of well-preserved corallite, X1.

4a-b. OU 4813, loc. PO 4. a, longitudinal section, alar plane; b, transverse section at base of calyx.

Fig. 5-6. Lophophyllidium ignotum Moore and Jeffords, 1945

5a-b. OU 4814, loc. PT 23. a, longitudinal section, alar plane; b, transverse section of early ephebic stage (topotype).

6a-b. OU 4815, loc. PT 23. a, transverse section at base of calyx; b, transverse section of early ephebic stage.

Fig. 7. Lophophyllidium extumidum Moore and Jeffords, 1945

7a-b. OU 4816, loc. PT 23. a, longitudinal section, cardinal-counter plane; b, transverse section of late ephebic stage; note concentric lamellar axial structure.

Fig. 8-10. Lophophyllidium cf. mundulum Jeffords, 1942

8a-c. OU 4817, loc. J 16. a, exterior of corallite, X1; b, transverse section at base of calyx; c, transverse section of neanic stage.

9a-c. OU 4818. a, transverse section through lower calyx; b, transverse section at base of calyx; c, transverse section of late ephebic stage.

10a-b. OU 4819, loc. J 16. a, longitudinal section, cardinal-counter plane; b, transverse section at base of calyx.

(PLATE 2, continued)

Fig. 11-12. Lophophyllidium cf. angustifolium Moore and Jeffords, 1945

11a-c. OU 4820, loc. PO 4. a, exterior of corallite, X1; b, longitudinal section, alar plane; c, transverse section at base of calyx.

12a-c. OU 4821, loc. PO 4. a, exterior of corallite, X1; b, longitudinal section, alar plane; c, transverse section at base of calyx.

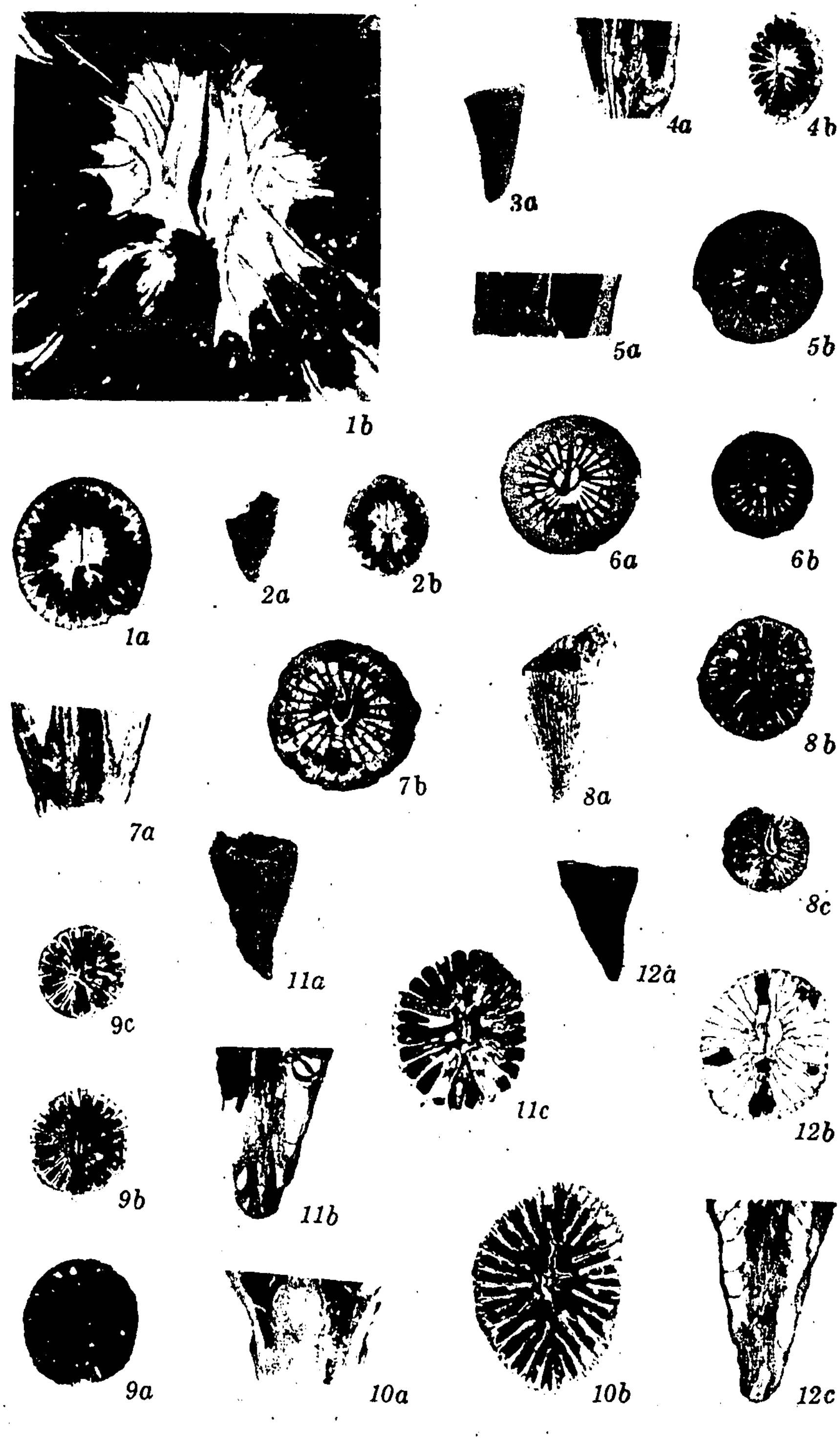

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PLATE 2

PLATE 3

(All figures X2 unless otherwise stated)

Fig. 1-2. Lophophyllidium cf. angustifolium Moore and Jeffords, 1945

1a-b. OU 4822, loc. PO 4. a, longitudinal section, alar plane; b, transverse section at base of calyx.

2a-b. OU 4823, loc. PO 4. a, longitudinal section, cardinal-counter plane; b, transverse section at base of calyx.

Fig. 3-5. Lophophyllidium new species A

3a-b. OU 4824, loc. PO 4. a, exterior of holotype, X1; b, transverse section at base of calyx; note presence of tabulae.

4a-c. OU 4825, loc. PO 4. a, exterior of incomplete paratype, X1; b, longitudinal section, alar plane; tabulae are almost imperceptible in this section; c, transverse section through upper calyx.

5a. OU 4826, loc. PO 4. a, transverse section of paratype at base of calyx.

Fig. 6-9. Lophophyllidium new species B

6a-d. OU 4827, loc. PT 23. a, longitudinal section of holotype, alar plane; b, transverse section through lower calyx; c, transverse section at base of calyx; d, transverse section of early ephebic stage.

7a. OU 4828, loc. PT 23. a, transverse section of paratype, ephebic stage.

8a. OU 4829, loc. PT 23. a, exterior of reconstructed corallite, X1.

9a. OU 4830, loc. PT 23. a, transverse section of paratype, at base of calyx.

Fig. 10-11. Lophophyllidium sp. "X"

10a-b. OU 4831, loc. PO 4. a, longitudinal section, alar plane; b, transverse section of early ephebic stage.

11a-d. OU 4832, loc. PO 4. a, longitudinal section, alar plane; b, transverse section at base of calyx; c, transverse section, neanic stage; d, enlargement of neanic stage X 9.5.

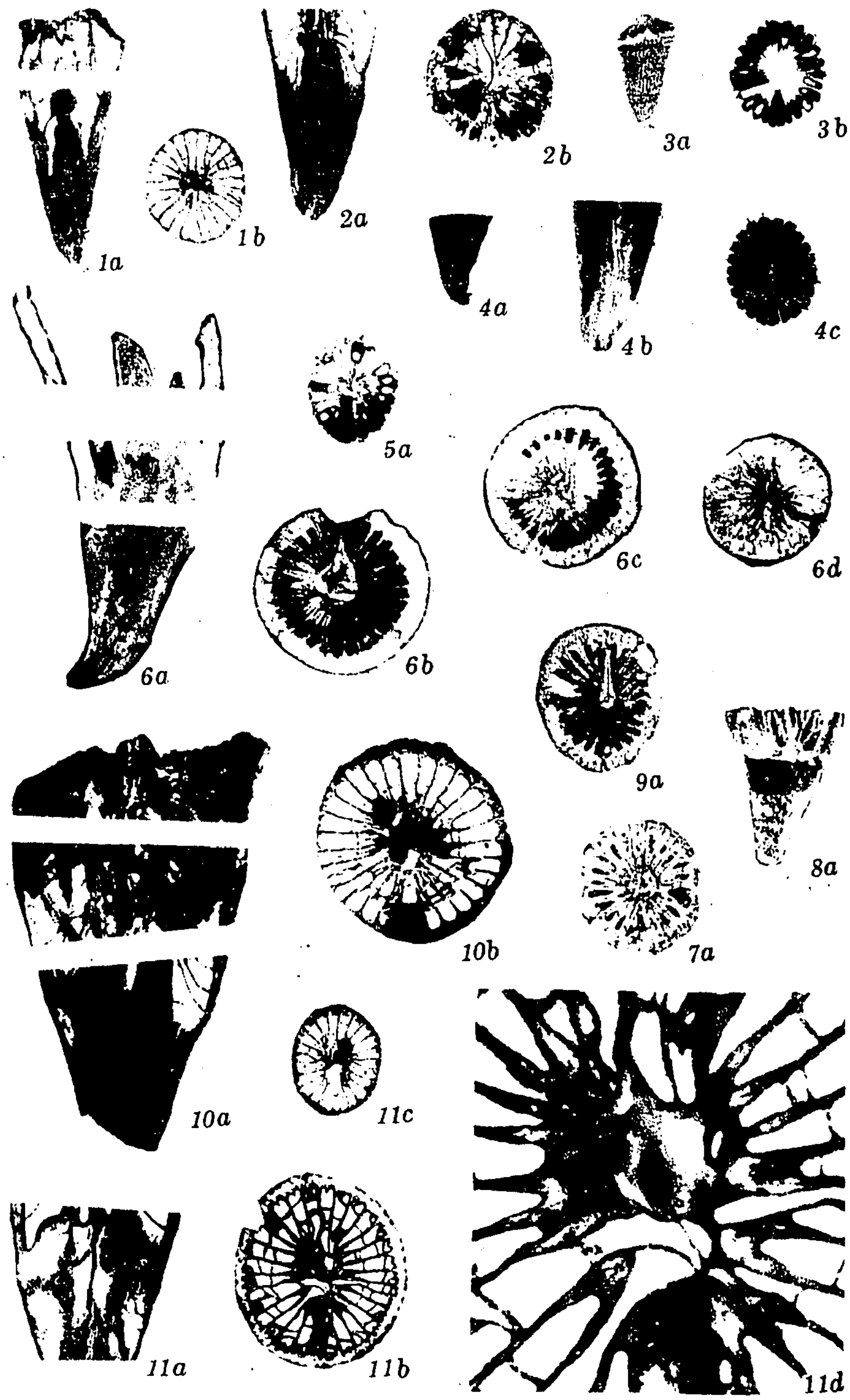
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PLATE 3

PLATE 4

(All figures X2 unless otherwise stated)

Fig. 1-4. Lophamplexus new species C

1a-c. OU 4833, loc. PO 4. a, longitudinal section of paratype, alar plane; note discontinuous column; b, transverse section of ephebic stage; c, transverse section of late neanic stage.

2a-c. OU 4834, loc. PO 3. a, exterior of holotype, X1; b, longitudinal section, cardinal-counter plane; c, transverse section of early neanic stage.

3a-b. OU 4835, loc. PO 3. a, longitudinal section of paratype, alar plane; b, transverse section of neanic stage.

4a. OU 4836, loc. PO 3. a, longitudinal section, alar plane; note terminus of axial column in lower part of section.

Fig. 5-9. New genus M new species D

5a. OU 4837, loc. PO 4. a, exterior of typical corallite (paratype), showing rejuvenescence, X1.

6a-d. OU 4838, loc. PO 4. a, longitudinal section of holotype, alar plane; b, transverse section of late ephebic stage; c, transverse section of neanic stage; d, enlargement (reversed) of neanic stage, X8.

7a-c. OU 4839, loc. PO 3. a, longitudinal section of paratype, alar plane; b, transverse section of neanic stage.

8a-d. OU 4840, loc. PO 4. a, longitudinal section of paratype, alar plane; b, transverse section of ephebic stage; c, transverse section of early neanic stage; d, enlargement of early neanic stage, X10.5.

9a. OU 4841, loc. PO 3. a, exterior of paratype, X1.

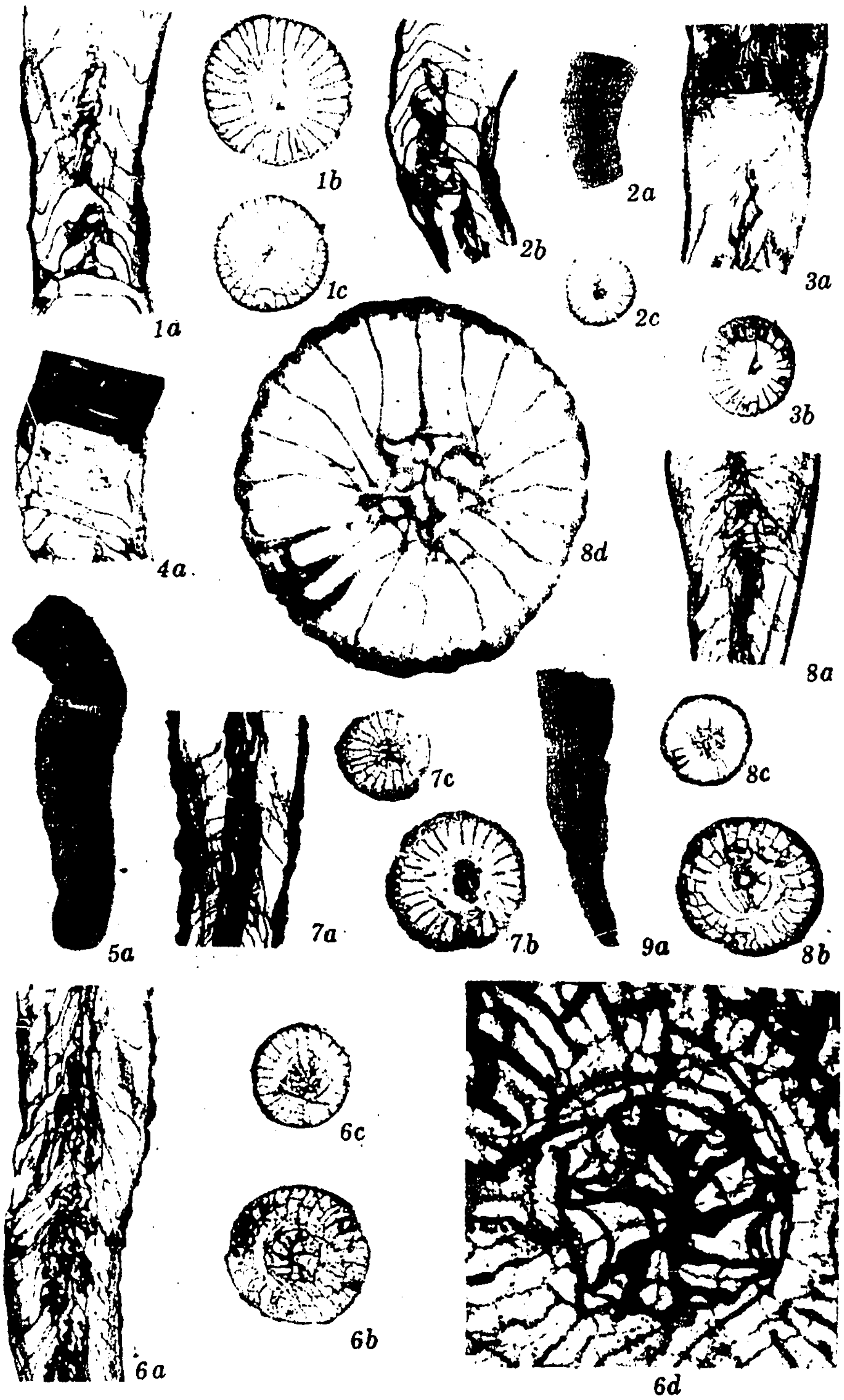

PLATE 4

PLATE 5

(All figures X2 unless otherwise stated)

Fig. 1-3. New genus M new species D

1a-c. OU 4842, loc. PO 4. a, longitudinal section of paratype, alar plane; b, transverse section of ephebic stage; c, transverse section of neanic stage; this corallite shows excessive thickening of all internal structures.

2a-c. OU 4843, loc. PO 4. a, exterior of incomplete paratype, X1; b, transverse section of ephebic stage; c, enlargement of early ephebic stage, X7.

3a-d. OU 4844, loc. PO 4. a, exterior of reconstructed paratype, X1; b, longitudinal section, cardinal-counter plane; note discontinuous axial structure in this corallite; c, transverse section of late ephebic stage; d, transverse section showing atrophied axial structure.

Fig. 4-5. New genus M new species E

4a-c. OU 4845, loc. PO 4. a, exterior of paratype, X1; b, longitudinal section, alar plane; c, transverse section of ephebic stage.

5a-f. OU 4846, loc. PO 4. a, exterior of holotype, X1; b, longitudinal section, alar plane; c, transverse section of late ephebic stage; d, transverse section of neanic stage; e, transverse section of earliest neanic stage; f, enlargement of this stage, X7; note compressed, lophophyllidid-like column in this stage of growth.

Fig. 6-8. *Amplexizaphrentis tumidum* (Moore and Jeffords), 1945

6a-c. OU 4847, loc. PO 4. a, exterior of corallite, X1; b, longitudinal section, cardinal-counter plane; c, transverse section at base of calyx.

7a-b. OU 4848, loc. A 19. a, exterior of incomplete corallite, X1; b, transverse section of early ephebic stage.

8a. OU 4849, loc. A 18. a, longitudinal section, alar plane; note characteristic sagging of tabulae in axial region.

(PLATE 5, continued)

Fig. 9. <u>Amplexizaphrentis</u> cf. <u>crassiseptatum</u> (Moore and Jeffords), 1945

9a-b. OU 4850, loc. J 16. a, transverse section of ephebic stage; b, transverse section of neanic stage.

Fig. 10. <u>Amplexizaphrentis</u> sp.

10a. OU 4851, loc. PT 23. a, transverse section at base of calyx.

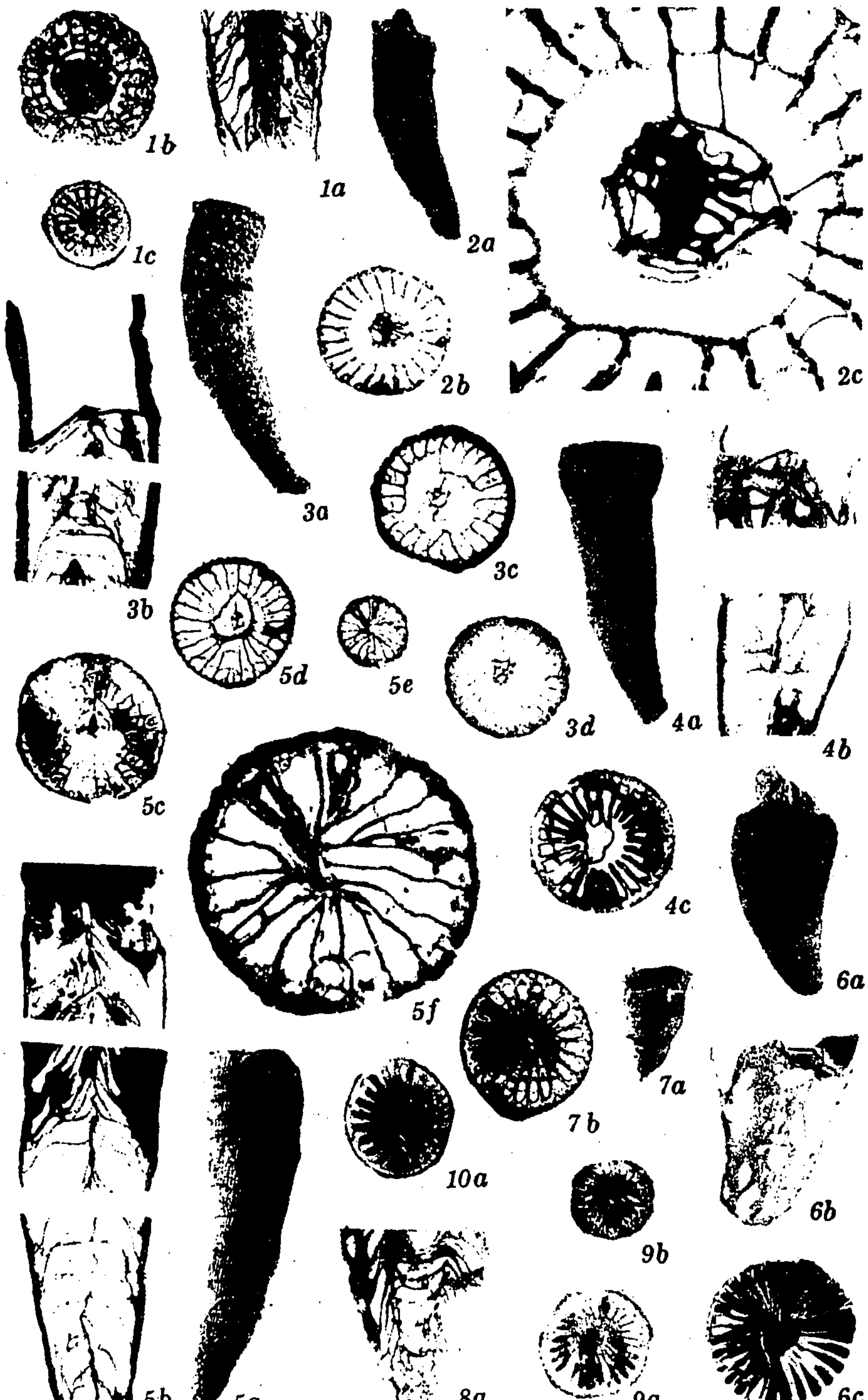
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PLATE 5

PLATE 6

(All figures X2 unless otherwise stated)

Fig. 1-4. Barytichisma crassum Moore and Jeffords, 1945

1a-d. OU 4852, loc. PO 4. a, exterior of corallite, X1; b, transverse section at base of calyx; c, transverse section of neanic stage; d, transverse section of brephic stage.

2a-e. OU 4853, loc. PO 4. a, exterior of corallite, X1; b, longitudinal section, alar plane; note amplexoid septa; c, transverse section at base of calyx; d, transverse section of ephebic stage; e, transverse section of neanic stage.

3a-b. OU 4854, loc. PO 4. a, exterior of corallite, X1; b, transverse section at base of calyx.

4a-b. OU 4855, loc. PO 4. a, longitudinal section, cardinal-counter plane; b, transverse section of early neanic stage.

Fig. 5-6. Barytichisma cf. repletum Moore and Jeffords, 1945

5a-b. OU 4856, loc. PO 3. a, exterior of corallite, X1; b, transverse section of neanic stage.

6a-b. OU 4857, loc. PO 4. a, transverse section of late ephebic stage; note thick epitheca, long thin cardinal septum; b, transverse section of brephic stage.

Fig. 7. Barytichisma callosum Moore and Jeffords, 1945

7a-d. OU 4858, loc. PO 3. a, exterior of corallite, X1; b, longitudinal section, alar plane; note the well-developed amplexoid septa in the ephebic stage, greatly thickened neanic and brephic stages; c, transverse section of ephebic stage, showing long septa immediately above a tabulum; d, transverse section of early neanic stage.

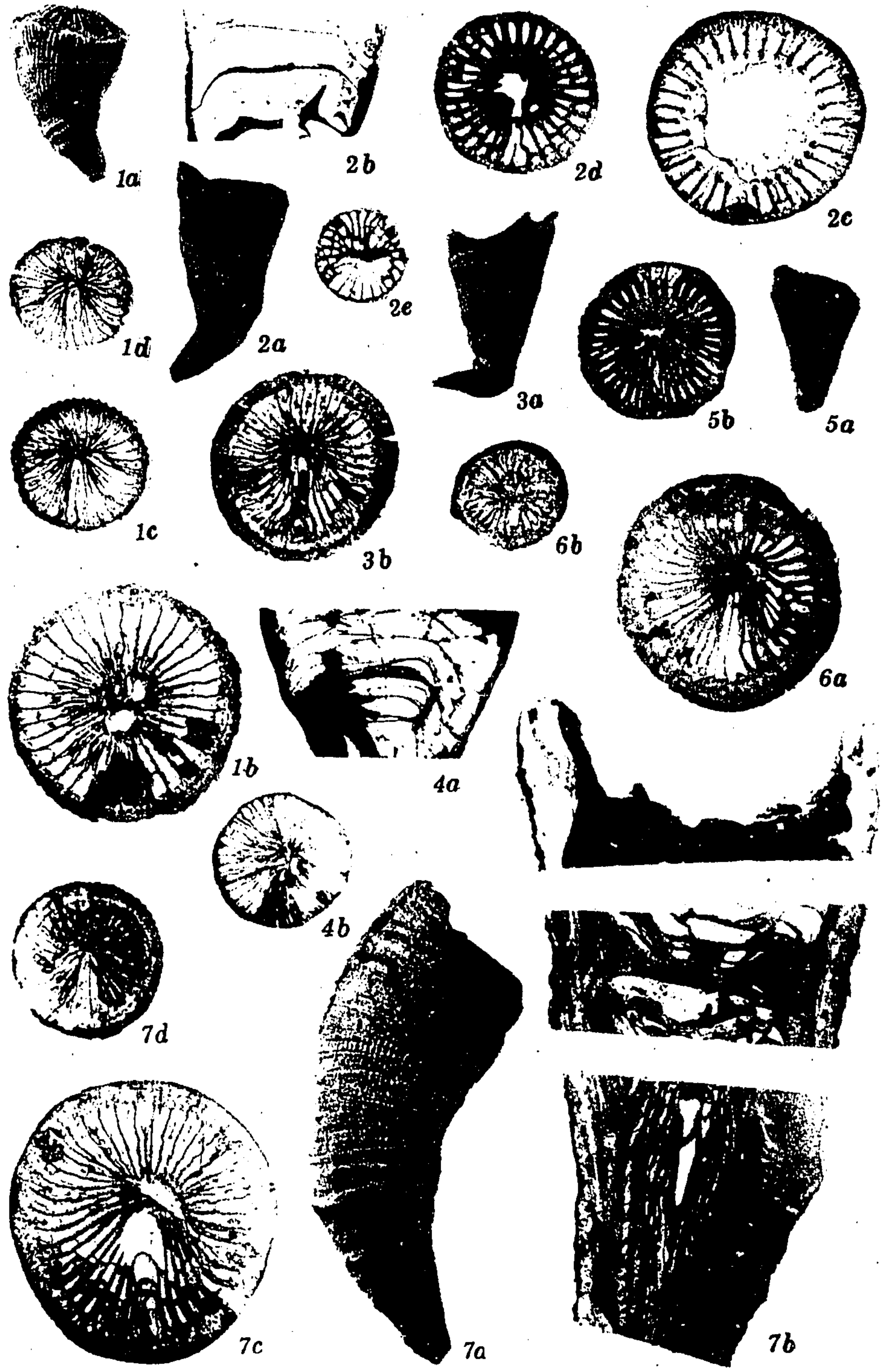

PLATE 6

PLATE 7

(All figures X2 unless otherwise stated)

Fig. 1-2. Koninckophyllum simplex (Moore and Jeffords) 1945

1a-e. OU 4859, loc. PT 21. a, exterior of corallite, X1; b, longitudinal section, alar plane; note the continuous medial lamella; c, transverse section of late ephebic stage; d, transverse section of early ephebic stage; e, transverse section of neanic stage.

2a-e. OU 4860, loc. PT 21. a, exterior of corallite, X1; b, longitudinal section, cardinal-counter plane; c, transverse section at base of calyx; d, transverse section of early ephebic stage; e, transverse section of neanic stage.

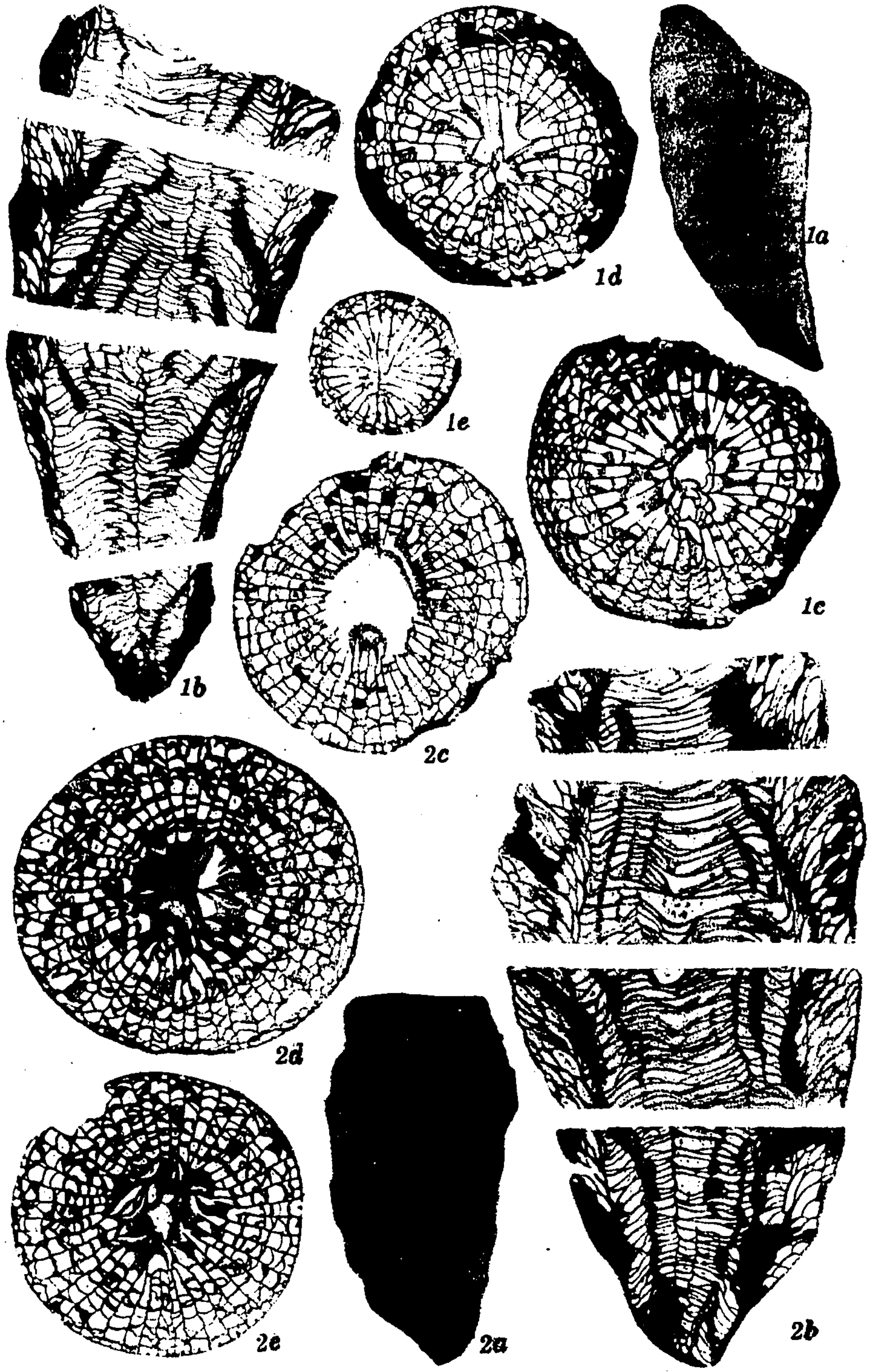

PLATE 7

PLATE 8

(All figures X2 unless otherwise stated)

Fig. 1-3. Koninckophyllum new species F

1a-e. OU 4861, loc. C 17. a, exterior of holotype, X1; b, longitudinal section, alar plane; c, transverse section near base of calyx; d, transverse section of neanic stage; e, transverse section of brephic stage.

2a-b. OU 4862, loc. C 17. a, longitudinal section of paratype, alar plane; b, transverse section of ephebic stage.

3a-b. OU 4863, loc. C 27. a, transverse section of paratype, ephebic stage; b, transverse section of neanic stage; in these figures, note the wide dissepimentarium, complex and irregular axial structure, small dissepiments.

Fig. 4-6. Koninckophyllum gracile (Moore and Jeffords) 1945

4a. OU 4864, loc. A 18. a, longitudinal section, alar plane.

5a. OU 4865, loc. A 18. a, transverse section of ephebic stage.

6a-b. OU 4866, loc. A 18. a, exterior of corallite, X1; b, longitudinal section, alar plane; in figs. 4-6, note narrow dissepimentarium, large dissepiments, continuous medial lamella.

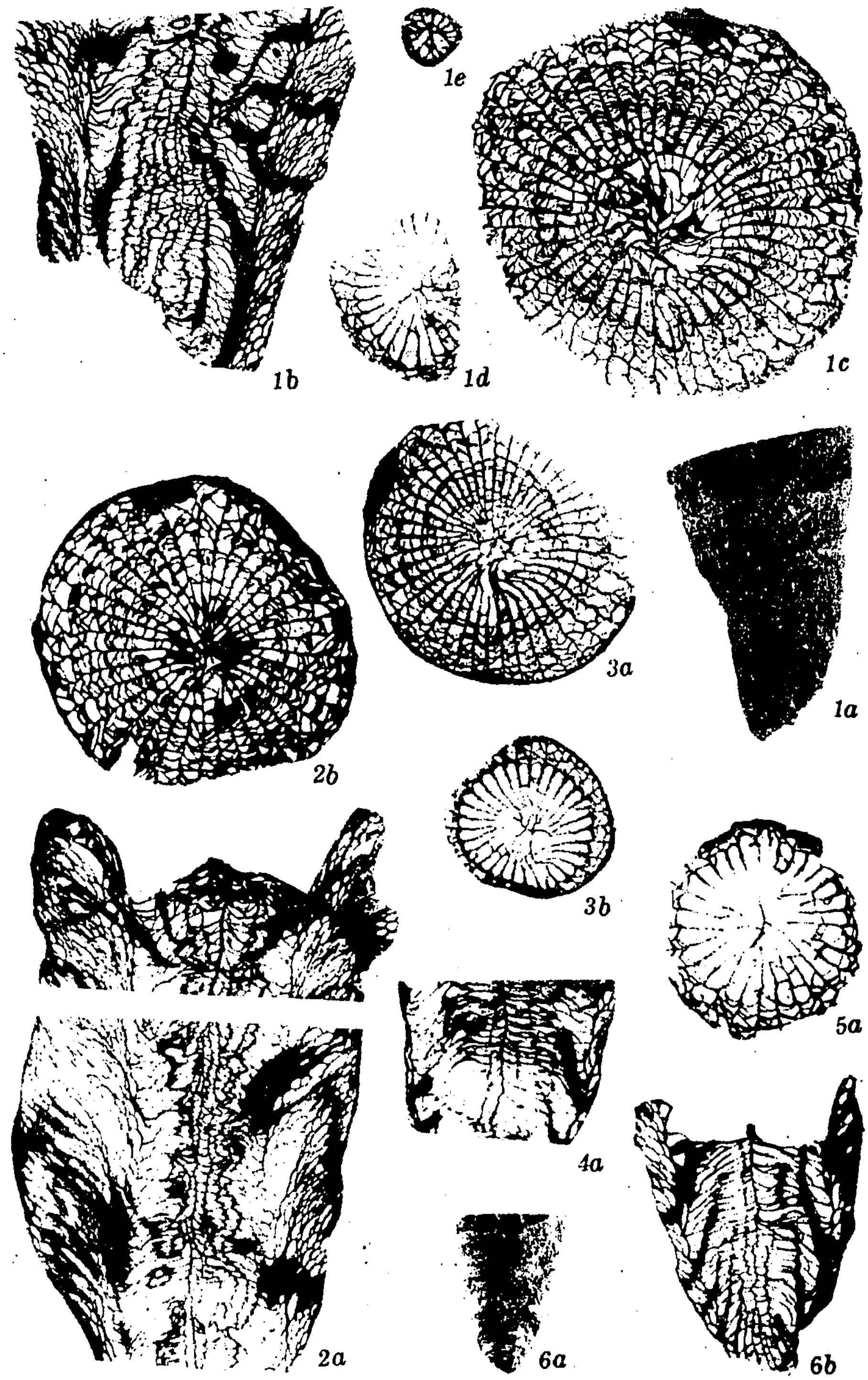

PLATE 8

PLATE 9

(All figures X2 unless otherwise stated)

Fig. 1-3. Pseudozaphrentoides nitellus Moore and Jeffords, 1945

1a-d. OU 4867, loc. C 17. a, exterior of typical corallite, showing moderate rejuvenescence, X1; b, longitudinal section, cardinal-counter (?) plane; c, transverse section of late ephebic stage; c, transverse section of early ephebic stage.

2a-b. OU 4868, loc. C 17. a, longitudinal section of unusually large specimen, cardinal-counter (?) plane; b, transverse section at base of calyx.

3a. OU 4869, loc. C 17. a, exteriors of two juvenile corallites in which the upper cylindrical portion has not yet developed; in figs 1-2, note the three well-developed internal zones in this species; a dissepimentarium, an outer tabulate area, and an inner tabulate area.

Fig. 4. Dibunophyllum sp.

4a-e. OU 4870, loc. A 18. a, transverse section of lower calyx; b, transverse section at base of calyx; c, transverse section of ephebic stage; d, transverse section of early ephebic stage; e, enlargement of the dibunophylloid axial structure of the early ephebic stage, X8.5. Note the long minor septa in this corallite.

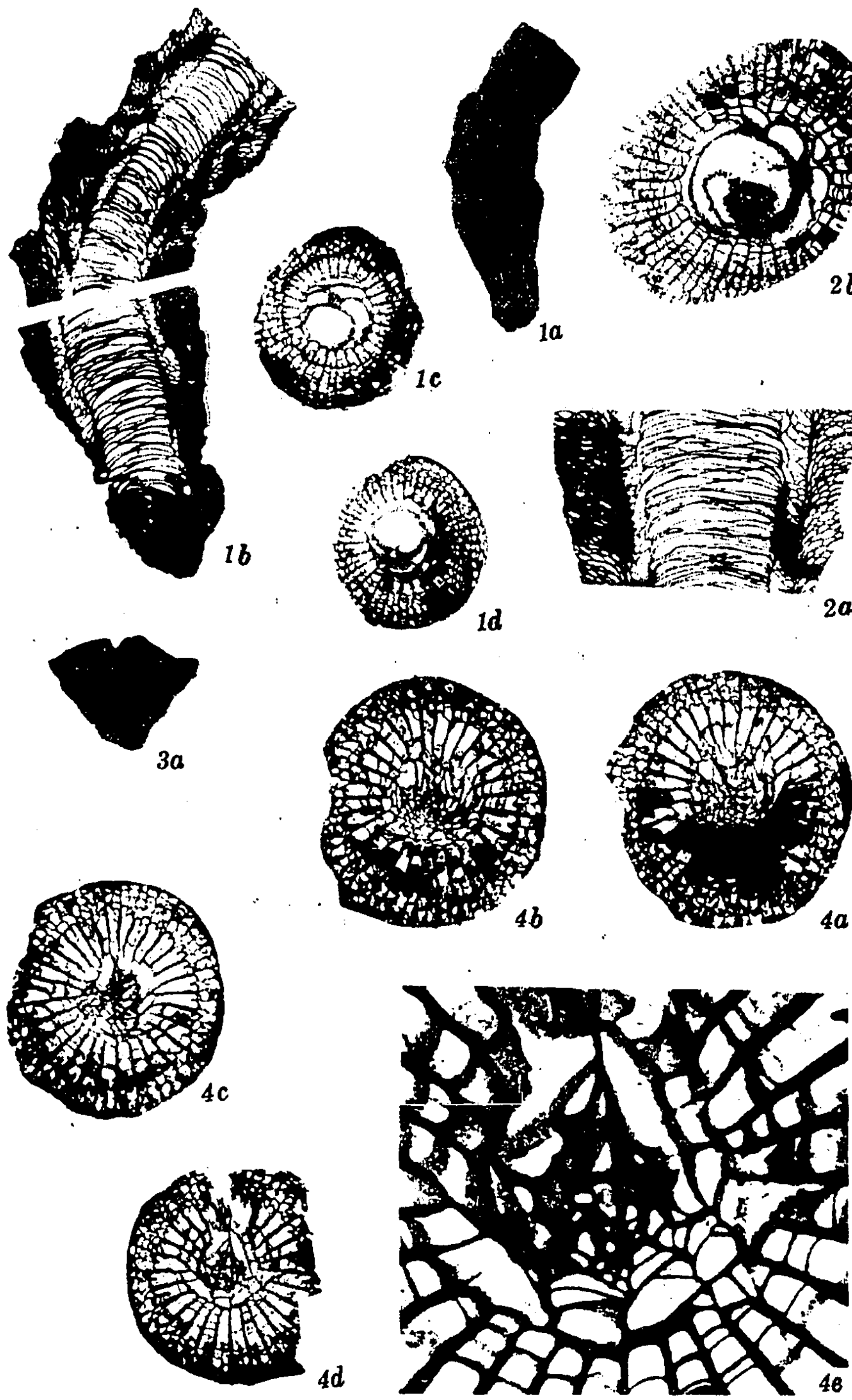

PLATE 9

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APPENDIX I

STRATIGRAPHIC SECTIONS

Field methods: Stratigraphic sections were measured with a metric steel tape. When topography or covered intervals prevented direct measurements, recourse was made to the Abney level and Jacob's staff.

Lithologic units are designated by a letter. For example, A 18 - U indicates unit "U", at locality 18, Atoka County, Oklahoma. A "unit", as used here, implies a distinct lithologic division; that is, one which is recognizable in the field and which can be distinguished lithologically from overlying and underlying units. In this sense, a unit may be of any thickness.

Field descriptions were complied at the outcrop. Record was made of the attitude of strata, bedding, lithology, fossil content, contacts, and weathering characteristics. Special note was made of features of possible value for interpretation of the paleoecology and the history of deposition of the Wapanucka Formation.

In the description of bedding, the writer follows the classification proposed by McKee and Wier (1953) as modified by Ingram (1954). It is here adapted as follows:

Massive bedding	no visible bedding
Very thick-bedded	over three feet
Thick-bedded.	from one to three feet
Medium-bedded	from four to twelve inches
Thin-bedded	from one to four inches
Laminated	less than one inch

Rock samples were collected from many localities and horizons in the Wapanucka Formation. Petrographic thin-sections have been prepared, and in many cases field descriptions are supplemented with a petrographic description of the rock. Thin-section numbers indicate the distance from the base of the unit (in foot-intervals) at which the rock was sampled. For example, "E-2" indicates that the thin-section was made from a sample collected from the second foot above the base of unit E. Because thin-sections show only a small portion of the rock, the petrographic designation does not always correspond to the description of the gross litholoty of the unit.

Fossils were collected on the initial visit to a locality, and on subsequent visits to several abundantly fossiliferous localities. The highly fossiliferous section exposed by Canyon Creek (loc. PO 3, this report), for example, was collected on numerous occasions during the past three years.

Stratigraphic sections are arranged in the order in which they occur along the outcrop of the Wapanucka Formation, beginning at the western extremity of the exposures in Pontotoc County and continuing eastward and southward across parts of Coal, Johnston, Atoka, and Pittsburg Counties, Oklahoma. Two localities (PO 7 and PO 8) which are in an isolated outcrop of the Wapanucka in Pontotoc County are described following the description of loc. PO 6. Wapanucka equivalents in Latimer County have not been clearly established. Localities at which the section was not measured are listed in the register of localities (Appendix II).

STRATIGRAPHIC SECTION PO 1

Description of locality: This locality is within 100 yards of the northwestern extremity of the outcrop of the Wapanucka Formation. Exposures of the lower part of the Wapanucka Formation here form a low tree-covered strike ridge in the NE $\frac{1}{4}$ SW$\frac{1}{4}$ sec. 6, T. 1 N., R. 7 E., Pontotoc County, Oklahoma.

Exposures are poor and only a partial section could be measured. Strike varies from N 40 W to N 65 W. The dip of the strata is also variable, from 35 to 45° N. The section is overlain by deeply weathered unfossiliferous calcareous sandstones tentatively assigned to the lower McAlester Formation and underlain by shales of the Springer Formation.

This locality is best reached by walking north along the east bank of a small tributary of Sheep Creek, which crosses the section-line road (State Highway 61) approximately 0.6 mile east from the southwest corner of this section. The small ridge terminates about 40 yards east of this stream.

This area corresponds to a locality described by Morgan (1924, loc. 19). Section measured by C. Rowett, November 8, 1959.

Unit No.	Description	Thickness (feet)
	Wapanucka Formation:	
B	Shale and limestone, interbedded: shale calcareous, grey, unfossiliferous; interbedded with thin (1-4 inches) calcareous and arenaceous limestone, locally conglomeratic. Thickness approximate. Remarks: These strata are unconformably overlain by calcareous sandstones of the McAlester Formation. The contact is abrupt and slightly undulatory.	16.0
A	Limestone, fossiliferous, finely crystalline, tan to brown on fresh and weathered surfaces; bedding thin, regular. Remarks: The contact with the overlying unfossiliferous unit is not exposed. Unit B contains abundant chonetid brachiopods which cover bedding planes. Base not exposed. Petrographic description: A - 1: Silty brachiopod biomicrosparrudite and biomicrudite	2.0
	Total thickness of exposures:	18.0

STRATIGRAPHIC SECTION PO 2

Description of locality: Fossiliferous limestones of the middle part of the Wapanucka Formation are exposed approximately 200 yards south and 30 yards east of the NW cor. sec. 8, T. 1 N., R. 7 E., Pontotoc County, Oklahoma.

Exposures are poor, and only one lithologic unit is recognizable.

These strata appear to be underlain by shales and thin limestones, but the lower part of the section is mostly covered. The strike is N 60 W; dip is variable, from 10 to 15 degrees, and to the north.

This locality was listed by G. D. Morgan (1924, loc. 41) and by M. H. Kuhleman (1948, loc. 9). Section measured and described for this study by C. Rowett, Nov. 8, 1959.

Unit no.	Description	Thickness (feet)
Wapanucka Formation:		
A	Limestone, oolitic in part, medium to coarsely crystalline, tan, weathers tan to yellow-brown; bedding thin to medium, regular; fossiliferous.	
	Remarks: Petrographic study suggests that this unit is equivalent to unit D at Canyon Creek (loc. PO 3). Upper and lower contacts covered. Thickness approximate.	
	Petrographic description:	
	A - 1: Oolitic biosparrudite	5.0
	Total thickness of exposures:	5.0

STRATIGRAPHIC SECTION PO 3

<u>Description of locality</u>: This is the most important exposure of the Wapanucka Formation in the Arbuckle Mountains. This locality was described by G. D. Morgan (1924, p. 57) and fossils were subsequently collected here by M. H. Kuhleman (1948, locs. 10 and 11) The locality is well-known and is often visited by both professional and amateur

fossil collectors. The section is well exposed and is highly fossiliferous. About thirty percent of the total collected Wapanucka fauna occur in these beds.

The exposures are located in the NE $\frac{1}{4}$ NW $\frac{1}{4}$ SE $\frac{1}{4}$ sec. 8, T. 1 N., R. 7 E., Pontotoc County, Oklahoma. The locality can be reached by walking south from a point 400 feet east of the center of the north line of this section, or by following Canyon Creek southwestward across the section to the point where it cuts a high ridge formed by the Wapanucka Formation and the overlying Atoka Formation. This ridge crosses the section from northwest to southeast; just northwest of this locality, however, the ridge is less prominent and is offset about 500 yards to the northeast by faulting. The Wapanucka Formation and the overlying strata of the Atoka Formation are exposed in the bed and banks of Canyon Creek. The strata dip 35-40° NE and strike N 70 W. Section measured by C. Rowett and D. Strong, August 8, 1960.

Unit no.	Description	Thickness (feet)
<u>Wapanucka Formation</u>:		
F	Limestone and brachiopod coquina: limestone arenaceous, medium crystalline, tan, weathers buff to yellow-brown; bedding thin, irregular; interbedded with zones of shell coquina, predominently brachiopod valves.	
	<u>Remarks</u>: Unit F forms a series of ledges which overhang the creek bed. Thickness of the unit varies, due to the irregular contact with the basal sandstones and shales of the Atoka Formation. The upper beds are oxidized to a depth of several inches and are deep red to maroon in	

color. Shell coquina consists primarily of crushed and disarticulated brachiopod valves. Fossils can be collected by washing this material through a screen in order to remove the matrix.

Petrographic description:

F - 10: Oolitic biosparrudite

10.2

E Shale, calcareous, blue to dark grey; mostly covered.

Remarks: The contact with the overlying limestone is exposed only for a short distance above the normal water level in the creek and is abrupt and regular. The upper 2 feet of the shale contain a few spiriferoid and productid brachiopods. The lower 1 foot contains fossils which have also been extracted by washing; these were probably derived from the upper surface of the underlying unit (D).

55.0

D Limestone, fossiliferous, medium to coarsely crystalline, light tan, weathers tan to brown; bedding thick and regular.

Remarks: Large blocks of this unit are displaced due to slumping. The contact with the overlying shale is covered. A small crack-out fauna was collected and several large solitary rugose corals (*Barytichisma*).

Petrographic description:

D - 4: Fossiliferous oosparrudite

4.5

C Shale, dark grey to black, fissile; unfossiliferous.

Remarks: The contact with the overlying limestone is abrupt and regular. Fresh exposures up to 10 feet in thickness were examined, but megafossils other than scyphozoans were not observed.

65.7

B Limestone, oolitic, fine to medium crystalline, grey on fresh surfaces, weathers grey to white; bedding thick, and regular.

Remarks: This unit forms a series of ledges in the bed of Canyon Creek. Oolites occur in the lower part of the unit. The upper surface is undulatory due to solution. Fossils include only small pelmatozoan parts.

2.5

A Shale, calcareous, blue to grey; highly fossiliferous.

Remarks: This shale is exposed in the bed of Canyon Creek where it is normally covered by 1 to 3 feet of water. About 200 square feet of the shale are exposed above the level of the water and form a low bank on the north side of the creek. The shale is alternately clayey and calcareous; fossils are not abundant but are exceptionally well-preserved in the clay zones. The calcareous zones are highly fossiliferous.

The fauna is dominated by spiriferoid and productid brachiopods, but includes pelecypods, cephalopods, gastropods, solitary corals, blastoids, and crinoids. The crinoid fauna is especially noteworthy for its variety; Cibolocrinus is common, and complete crowns of other genera occur in a thin clay zone near the top of the unit. Corals include Lophamplexus, Lophophyllidium, and forms described herein as a new genus belonging to the Family Timorphyllidae.

The base of the shale is not exposed, but is presumably underlain by shales of the Springer Formation. Contorted, black, highly fissile shales which contain conularids and goniatite cephalopods indicative of Caney age are exposed along Canyon Creek approximately 500 yards southwest of this locality.

43.5

Total thickness of exposures: 181.4

STRATIGRAPHIC SECTION PO 4

<u>Description</u> <u>of</u> <u>locality</u>: Exposures at this locality are limited to the lower part of the Wapanucka Formation, and include beds equivalent to the upper part of unit A and unit B at Canyon Creek (PO 3). The section is complicated by faulting, with an apparent right-lateral movement of about 400 yards to the northeast. An interpretation of the local structure, based on field work done by C. Rowett and J. Logan in May, 1960, is as follows: (1) The main ridge in this area is due to the resistant sandstones of the Atoka Formation, and trends northwest; strata dip to the northeast. Exposures of the underlying Wapanucka Formation should therefore occur on the southwest, or escarpment face, of the ridge. This relationship is observed at Canyon Creek, about one-half mile distant. The exposures at this locality, however, occur in the northeast side of the ridge, where they form a small knoll. (2) Strata dip 38° N at the eastern extremity of the exposures, but are vertical to slightly overturned about 50 yards to the west. (3) At the western extremity, the steeply dipping strata are in fault-contact with Atokan sandstones, which have a NE dip of less than 20°. (4) The strike was also observed to change through this interval, from N 90 W to N 70 W. The principal fault apparently trends NE, and is downthrown on the east. The main ridge terminates here and does not reappear for a distance of almost one mile to the southeast.

These exposures are located in the NE$\frac{1}{4}$ SE$\frac{1}{4}$ SE$\frac{1}{4}$ sec. 8, T. 1 N., R 7 E., Pontotoc County, Oklahoma. This locality was first described by George D. Morgan (1924, loc. 28); the crinoid fauna was subsequently collected and described by Mr. Harrel Strimple of Tulsa, Oklahoma, who directed the writer to the locality. The exposures occur near the west bank of a tributary of Canyon Creek, which enters the section at the SE corner. The exposures can be reached by following this small creek northward. Section measured by C. Rowett and D. Strong, August 9, 1960.

Unit no.	Description	Thickness (feet)
Wapanucka Formation:		
B	Limestone, oolitic, fine to medium crystalline, tan to blue, weathers tan to brown, bedding thin and irregular. Remarks: Oolites in these beds occur in local concentrations. Calcite veins and small joints are common. Fossils include pelmatozoans (crinoids and blastoids) foraminifera, and brachiopods. Petrographic description: B - 1: *Millerella* biomicrosparrudite B - 2: Oolitic, pelletiferous biomicrosparrudite	2.0
A	Shale, grey to brown, clayey, highly fossiliferous. Remarks: This shale is exposed over a large area, which is partly overgrown. The brachiopod, coral and crinoid faunas correspond closely to that of the basal shale at Canyon Creek (PO 3, unit A), but preservation is in general inferior. The upper part of the shale contains thin limestones. Crinoid cups are common in this upper zone, and have been collected by washing the shale through a screen. Crinoids include *Cibolocrinus*, *Morrowcrinus*, *Ethelocrinus*, and *Allocatillocrinus*; this is the type locality for several species of *Paragassizocrinus*. The coral fauna includes species of *Lophophyllidium*,	

<u>Amplexizaphrentis</u>, <u>Barytichisma</u>, <u>Lophamplexus</u>, and a new genus described in this report under the Family Timorphyllidae.
The base of the shale is not exposed.

	42.9
Total thickness of exposures:	44.9

STRATIGRAPHIC SECTION PO 6

<u>Description of locality</u>: The middle part of the Wapanucka Formation is exposed as a small knoll at this locality, which is located in the SE $\frac{1}{4}$ SE $\frac{1}{4}$ sec. 15, T. 1 N., R. 7 E. Exposures are in the southwest side of a ridge, about two miles south and one mile west of the town of Jessie, Pontotoc County, Oklahoma. The ridge is held up by resistant basal sandstones of the Atoka Formation. Strata of the Wapanucka Formation are exposed in this area only at or near points where this ridge is cut by streams.

The strike is N 45 W and dip is 30-35° N. The locality can be reached most easily from the north. The knoll is located about 200 yards southeast of the point where Coal Creek crosses the ridge.

Fossils were collected in this area by M. H. Kuhleman. The writer was not able to locate his locality, however, which he described as follows(1948, loc. 15):

> Oolitic, crinoidal limestone. Lower part of the Wapanucka Formation. West bank of Coal creek, 200' south of center sec. 15, T. 1 N., R. 7 E.

A typographical error may be involved, and Kuhleman's locality may correspond to the present one.

Section measured by C. Rowett and D. Strong, August 10, 1960.

Unit no.	Description	Thickness (feet)
Wapanucka Formation:		
C	Limestone, oolitic and argillaceous, yellow, weathers yellow to white; bedding thin and regular; fossiliferous. Remarks: These beds are exposed at the top of the knoll and dip to the north; about 30 feet northward, brown ferruginous sandstones occur that are typical of the basal part of the Atoka Formation. The contact forms a shallow gully, and is covered. Small brachiopods and a few other megafossils are common in the limestone.	4.0
B	Limestone, medium crystalline, tan, weathers yellow-brown; bedding thin to medium, regular; fossiliferous. Remarks: Unit B forms a series of ledges near the top of the knoll; the contact with the overlying limestone is regular. These beds contain numerous well-preserved specimens of *Composita*.	5.0
A	Shale, brown to grey, deeply leached; unfossiliferous. Remarks: This shale forms a gentle overgrown slope which grades imperceptibly into the valley formed in the underlying Springer and Caney Shales. Fossils which occur on this surface were derived from the overlying unit; none were encountered at depth in the shale.	10.0
	Total thickness of exposures:	19.0

STRATIGRAPHIC SECTION PO 7

Description of locality: The lower (?) part of the Wapanucka Formation is exposed at this locality, in the bed of a small creek and in a low hill: NE $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 33, T. 3 N., R. 7 E., Pontotoc County, Oklahoma.

This locality was listed by G. D. Morgan (1924, loc. 170-A), R. V. Hollingsworth (1933, loc. 8), and J. C. Barker (1950, locs. 28-A and 18-B), but the section here had not previously been measured.

These exposures occur about 10 miles north of the main exposures of the Wapanucka Formation in southeastern Pontotoc County, and are separated by a major structural feature, the Franks Graben. The Wapanucka is only slightly more resistant to erosion than the overlying shales of the Boggy Formation and the underlying Union Valley Formation, and exposures are consequently poor. An upper limestone in the Wapanucka forms a low, sinuous ridge which begins near the town of Stonewall (section 2, T. 2 N., R. 7 E.) and terminates near Union Valley (section 33, T. 3 N., R. 7 E.). The ridge has a relief of 20 feet or less, and is mostly overgrown. The Wapanucka Formation in this area is underlain by sandstones and shales of the Union Valley Formation, which, according to M. K. Elias (1956, p. 102) can be correlated with the Primrose Formation by goniatite cephalopods. This suggests that the entire sequence is lower in the Morrow series than the Wapanucka Formation is elsewhere. It is the writer's opinion that faunal and lithologic differences are due to environmental changes in an offshore facies which is equivalent to the lower part of the Wapanucka elsewhere. The stratigraphic position of these exposures is discussed at greater length elsewhere in this study. Strata strike N 45 W and dip 10-15° E.

Section measured by C. Rowett, August 11, 1960.

Unit no.	Description	Thickness (feet)
Wapanucka Formation:		
C	Limestone, fossiliferous, medium crystalline, tan to blue, weathers yellow-brown; bedding thin to medium; mostly covered. Remarks: These beds form the crest of a small knoll 150 yards south of the creek, where only the upper three feet are well exposed; below this horizon, the unit is mostly covered and only a few ledges crop out. Brachiopods, bryozoans, and cephalopods were collected from the weathered surfaces of these beds. Casts of scyphozoan medusae are common. Thickness recorded is approximate.	20.0
B	Shale, calcareous, grey; platy to nodular; silty to sandy in part; unfossiliferous. Remarks: The lower 12 feet of this shale is exposed in the south bank of the creek. Casts of scyphozoan medusae occur throughout the unit. Thickness approximate.	37.0
A	Limestone and shale: limestone medium crystalline, grey, weathers tan; bedding thin, irregular; moderately fossiliferous; interbedded with thin shales. Remarks: These beds form ledges in the bed of the creek. The contact with the overlying shale is abrupt. Fossils include small goniatite cephalopods, brachiopods, crinoids (*Paragassizocrinus*), and blastoids. The base of the unit is not exposed. Petrographic description: A - 1: fossiliferous oosparite	4.0
	Total thickness of exposures:	61.0

STRATIGRAPHIC SECTION PO 8

Description of locality: An undetermined part of the Wapanucka Formation is exposed as a prominent hill in the NE $\frac{1}{4}$ SE $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 34, T. 3 N., R. 7 E., Pontotoc County, Oklahoma.

Strata dip 0-15° E; strike is N 40 W. The section was measured from the edge of a small stock tank eastward to the crest of the hill, by C. Rowett and D. Strong, August 15, 1960.

Unit no.	Description	Thickness (feet)
	Wapanucka Formation:	
B	Limestone and shale: limestone fine to medium crystalline, tan, weathers brown to maroon; bedding thin to medium, regular; interbedded with shales 1 to 2 feet thick; mostly covered. Remarks: This resistant unit is responsible for the relief of the ridge; the limestones are oxidized to deep red or maroon, and are sparsely fossiliferous.	71.5
A	Shale and siltstone: shale calcareous, blue-grey, unfossiliferous; interbedded with thin (1 to 2 inch) layers of tan siltstone. Remarks: The siltstone layers within this unit are oxidized to deep shades of maroon and red; they contain numerous internal molds of goniatite cephalopods, which are typically compressed and not identifiable. The base of the unit is not exposed.	16.5
	Total thickness of exposures:	88.0

STRATIGRAPHIC SECTION C 25

Description of locality: The Wapanucka Formation is exposed at this locality as a narrow, steep-sided ridge. The outcrop is in Coal County, Oklahoma: SW $\frac{1}{4}$ SW $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 19, T. 1 N., R. 8 E. The section was measured about 30 yards west of the point where this ridge is cut out by Goose Creek, from the bottom of a small gully to the crest of the ridge. Strata dip from 25 to 70° N. and strike is NW. Changes in strike and dip indicate that the upper unit (D) is in fault-contact with the Atoka Formation.

This section was measured by B. F. Wallis (1915, p. 51) who described the entire section as being composed of oolite. Section measured for this study by C. Rowett, April 4, 1960.

Unit no.	Description	Thickness (feet)
Basal Atoka Formation:		
	Limestone, locally conglomeratic, medium to coarsely crystalline, grey to tan, weathers grey to brown; bedding thin to medium, irregular; fossiliferous in part. Remarks: These strata are deeply weathered to a rust-brown color and are extensively veined and chertified; they form the dip slope of the ridge and are overlain by ferruginous sandstones.	12.0
Wapanucka Formation:		
D	Limestone, oolitic, medium crystalline, grey to tan, weathers white; bedding medium to thick, regular. Remarks: Oolites are concentrated in the lower part of the unit, but the unit is oolitic throughout.	

The contact with the overlying Atoka Formation is abrupt.

19.5

C Limestone, medium crystalline, grey, weathers grey to white; bedding thin to medium, regular; partly covered.

Remarks: The contact with unit D is covered; the lower beds contain a crack-out fauna, predominately brachiopods.

33.0

B Limestone and shale: limestone fine to medium crystalline, blue-grey, weathers brown; bedding thin to medium, regular, partly covered; interbedded with shales of about equal thickness.

Remarks: Oolites were not observed in these beds. Slumping has covered the upper contact, and talus covers about 50% of the section.

50.0

A Limestone and shale: limestone fossiliferous, medium crystalline, tan, weathers brown; bedding thin and irregular; interbedded with thin shale partings throughout; mostly covered.

Remarks: Most of this unit is covered; the upper contact is not exposed, nor is the base of the unit. Bedding planes contain numerous fossils, mostly brachiopods.

13.0

Total thickness (Wapanucka Formation only): 115.5

STRATIGRAPHIC SECTION C 27

Description of locality: The Wapanucka Formation forms a steep ridge in this area which trends NW across the NE $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 30, T. 1 N., R. 8 E., Coal County, Oklahoma. Strata in the south side of the ridge are exposed along a fire-lane. Beds strike N 50 W and dip 10-15° N. Access to this locality is difficult, as water in Goose Creek frequently is several feet deep. The best mode of access is about one-half mile to the south, where an earth dam crosses Goose Creek, and forms a small artificial lake. A road leads eastward to the dam from the SW corner of the NW $\frac{1}{4}$ of this section. Permission to enter can be obtained at the Rhynes' ranch, two and one-half miles south and one-half mile west of East Jessie, Coal County, Oklahoma.

Fossils were collected in this area by M. H. Kuhleman (1948, locs. 22 and 23) but no section was measured at that time. Section measured for this study by C. Rowett, June 9, 1961.

Unit no.	Description	Thickness (feet)
<u>Basal Atoka Formation</u>:		
	Limestone conglomerate; clasts pebble-to cobble-size; locally oxidized. Thickness variable along strike.	
	<u>Petrographic description</u>:	
	Fossiliferous, oolitic limestone conglomerate. Thin-section study of this rock ("E"-1) indicates that many clasts contain oolites of same size and type as those which occur in the underlying oolitic unit of the Wapanucka Formation (unit D).	3.0
<u>Wapanucka Formation</u>:		
D	Limestone, oolitic, grey to white, weathers white; bedding thin to medium, regular; partly covered.	
	<u>Remarks</u>: The basal part of this oolite carries a small crinoid fauna, including species of <u>Delocrinus</u>, <u>Ethelocrinus</u>, and <u>Paragassizocrinus</u>. Near the base of the dip slope, the oolite is overlain by a thin (2 to 3 feet) limestone conglomerate. The contact is not well exposed, but field relationships indicate that the conglomerate represents the basal part of the	

Atoka Formation. The conglomerate is in turn overlain by typical red-brown ferruginous sands of the Atoka Formation. This conglomerate is composed of both limestone and oolite clasts, with ferruginous and calcareous cement. It is discontinuous laterally, and is replaced along strike about 200 yards east of this locality by a conglomeratic brown limestone at loc. C 17. Thickness recorded for the oolite is maximum.

20.0

C Limestone, fossiliferous, medium crystalline, tan to blue, weathers grey-blue; bedding medium to thick, regular except near top; thin shaly partings and cherty zones in upper part.

Remarks: These beds are exposed at the crest of the ridge at this locality; the contact with the overlying oolitic limestone is irregular, and appears to be unconformable. Solitary corals (Koninckophyllum, Pseudozaphrentoides) occur throughout the unit but typically weather flush with the surfaces of the beds. Crinoids and blastoids are common.

31.0

B Limestone and shale: limestone fine to medium crystalline, fossiliferous, weathers yellow-brown; bedding thin to medium, regular; interbedded shales mostly covered by soil and vegetation.

Remarks: The lower 10 feet of this unit is exposed in a small wash located about 40 yards WSW from the foot of the ridge; the beds are highly fossiliferous, but fossils do not weather free; fenestrate bryozoans, brachiopods, and crinoid parts are abundant. Thickness calculated.

65.0

A Shale and thin limestones: shale calcareous, concretionary, grey-green to olive in color, fossiliferous; interbedded with thin (2 to 6 inches) shaley limestones.

Remarks: This shale is dissimilar in appearance to basal shales of the Wapanucka Formation observed elsewhere, but its age is confirmed by the presence of species of Paragassizocrinus and the coral Barytichisma. Brachiopods and sand casts of scyphozoan medusae are common. The shale contains numerous limonite concretions and thin calcite veins. The base of the shale is covered by stream alluvium. Thickness calculated. 20.0

Total thickness (Wapanucka Formation only): 136.0

STRATIGRAPHIC SECTION C 17

Description of locality: The Wapanucka Formation in this area forms a narrow ridge which crosses the NE $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 30, T. 1 N., R. 8 E., Coal County, Oklahoma. Best access to this locality is described in the description of loc. C 27, which is located about 200 yards to the west. At the present locality, the ridge is cut by a small tributary of Goose Creek. Strata dip 19° N and strike N 20 W. Section measured in the bed and along the banks of the creek, by C. Rowett and D. Strong, August 19, 1960.

Unit no.	Description	Thickness (feet)
Basal Atoka Formation:		
	Limestone conglomerate, tan, weathers dark grey to brown; bedding thick, irregular; sparsely fossiliferous.	
	Remarks: The lower part of these beds contain thin shale lenses and reworked fossil debris; they are overlain by ferruginous red-brown sandstones of the lower Atoka Formation. The lower contact appears to be regular at this locality, but evidence from nearby localities (C 25, C 27) indicates that an unconformity is present at this horizon.	24.0
Wapanucka Formation:		
B	Limestone, oolitic, grey to white, weathers white; bedding thin to medium, regular; sparsely fossiliferous in lower part.	

Remarks: This oolite forms the dip slope of the ridge. The lower part carries a crinoid fauna.

Petrographic description:

B - 2: Fossiliferous oosparite

19.0

A Limestone, medium crystalline, tan to grey, weathers grey to blue-grey; bedding medium to thick, regular; partly covered.

Remarks: The upper and lower part of this unit are covered by soil and talus. The rugose corals Koninckophyllum and Pseudozaphrentoides were observed on the weathered surfaces of the beds. Base not exposed.

Petrographic description:

A - 10: Biosparrudite

25.0

Total thickness (Wapanucka Formation only): 44.0

STRATIGRAPHIC SECTION C 12

Description of locality: A low ridge is formed by the Wapanucka Formation where it crosses the SE $\frac{1}{4}$ SE $\frac{1}{4}$ sec. 3, T. 1 S., R 8 E., about one-half mile northwest of Clarita, Coal County, Oklahoma. Strata dip 10° N, and strike N 88 W. The contact of the Wapanucka Formation with the overlying Atoka Formation is not exposed, but the strata of the uppermost unit (unit C) can be traced eastward a short distance to the section road between section 2 and 3 of this Township, where they were observed to be overlain by thin-bedded sandstones and shales of the Atoka Formation. Fusulinella prolifica, a fusulinid of lower Atokan age, was collected by the writer at the type locality of this species, which is about 500 feet north of the Wapanucka-Atoka contact in the section road (about 200 feet stratigraphically above the base of the Atoka Formation) (Thomson, 1935, p. 306).

A measured section in the Wapanucka Formation was described by B. F. Wallis (1915, p. 50). This locality was also recorded by M. H. Kuhleman (1948, loc. 29) who did not, however, describe the section. Section measured for this study by C. Rowett and D. Strong, August 16, 1960.

Unit no.	Description	Thickness (feet)
	Wapanucka Formation:	
C	Limestone, oolitic, fine to medium crystalline, grey to white, weathers grey; bedding thick, regular; sparsely fossiliferous. Remarks: This unit forms the crest of the ridge. Oolites are present throughout, and are well-developed locally. Petrographic description: C - 15: Biosparite	15.9
B	Limestone, cherty, fine to medium crystalline, blue to grey, weathers grey; bedding medium to thick, slightly irregular; interbedded with nodules and stringers of dark blue chert which weather to irregular masses; unfossiliferous. Remarks: These beds are locally oolitic. The contact with the overlying oolitic limestone is not well exposed, but appears to be regular.	51.2
A	Shale, calcareous, brown, locally oxidized to yellow-brown and red; interbedded with thin-bedded ledge-	

forming silty limestone, tan on fresh and weathered surfaces; sparsely fossiliferous.

Remarks: A small collection of fossils was made from this shale, mostly brachiopods. The base of the shale is not exposed.

Petrographic description:

A - 7: Silty biomicrosparrudite

	7.1
Total thickness of exposures:	74.2

STRATIGRAPHIC SECTION C 26

Description of locality: The upper oolitic part of the Wapanucka Formation is exposed at this locality in an abandoned limestone quarry: center SE $\frac{1}{4}$ NW $\frac{1}{4}$ SE $\frac{1}{4}$ sec. 6 T. 1 S., R. 9 E., Coal County, Oklahoma.

Beds strike N 30 W; dip is variable, but averages 10° E. The section is overlain by shales and sandstones of the Atoka Formation. This contact is well-exposed at a second quarry, approximately one-fifth mile to the southeast (see section on depositional history of the Wapanucka, this report), but is poorly exposed at this locality.

Fossils were collected here by M. H. Kuhleman (1948, loc. 35). The upper part of the section was measured and described for this study by C. Rowett, June 9, 1961.

Unit no.	Description	Thickness (feet)
Wapanucka Formation:		
A	Limestone and shale, interbedded: limestone oolitic, grey to white, weathers yellow-white; bedding thick	

to massive, regular; fossiliferous in some zones; interbedded with thin shaly zones near top; shale calcareous, yellow-brown, fossiliferous.

Remarks: A zone in which the crinoid *Paragassizocrinus* is common occurs about 15 feet below the top of the section, at the level of the floor of the quarry in the southeastern part. A shale containing productid and chonetid brachiopods occurs about 5 feet higher in the section. The upper part of the oolite is locally oxidized and contains limonitic stains and concretions. Thickness of oolite calculated. 18.5

Total thickness measured: 18.5

STRATIGRAPHIC SECTION C 9

Description of locality: Approximately 2 miles east of Clarita, Coal County, Oklahoma, the Wapanucka Formation forms a sinuous ridge which trends generally to the north. Dips are typically less than 15° to the east, and the ridge in this area is consequently low. The contacts with the underlying Springer Formation and the overlying Atoka Formation are not exposed. The section was measured from the foot of the ridge eastward, in the southwestern part of the NE ¼ sec. 18, T. 1 S., R. 9 E. Section measured by C. Rowett and D. Strong, August 16, 1960.

Unit no.	Description	Thickness (feet)
Wapanucka Formation:		
D	Limestone, oolitic, grey to white, weathers white; bedding thin to medium in lower part, thick in upper part; regular.	

Remarks: This unit forms the crest and dip slope of the ridge. It is fossiliferous in the lower part, where brachiopods and cephalopods are common, but becomes thick-bedded and less fossiliferous in the upper part. Thickness calculated from average dip of 10°.

20.0

C Shale and limestone: shale calcareous, grey-green, concretionary; interbedded with a few ledge-forming limestones; fossiliferous throughout.

Remarks: Complete crinoid crowns (*Delocrinus*) have been collected from this shale; other fossils include spiriferoid brachiopods and solitary rugose corals. The contact with the overlying oolite is abrupt, but regular. Thickness calculated.

30.0

B Limestone, medium to coarsely crystalline, tan, weathers brown; bedding thin to medium, irregular; sparsely fossiliferous throughout.

Remarks: A broad terrace is formed at this horizon and exposures are poor. Thickness calculated.

10.0

A Shale and limestone, interbedded: shale grey, fissile, unfossiliferous; interbedded with thin (2 to 6 inch) limestone layers which form small ledges; sparsely fossiliferous.

Remarks: Unit A is partially covered by soil and talus; the base of the unit is covered by alluvium. Thickness calculated.

50.0

Total thickness of exposures: 110.0

STRATIGRAPHIC SECTION C 14

Description of locality: The ridge formed by the Wapanucka Formation at this locality stands an estimated 70 to 80 feet above the broad valley to the west. Dips are low, averaging 10° E, and consequently the ridge is almost three-quarters of a mile across. Strata strike N 10° E. The crest of the ridge is formed by a resistant limestone (unit B) which occurs lower in the section exposed at locality C 9, about one-half mile to the northeast. Best access is from the northeast corner of the section. Fossils were collected at this locality by M. H. Kuhleman, (1948, loc. 36) but section was not measured at that time. The section was measured from the foot of the ridge westward across the ridge, parallel to and about 20 yards south of the section-line fence marking the north line of the NW $\frac{1}{4}$ of this section (sec. 19, T. 1 S., R. 9 E., Coal County, Oklahoma). Section measured for the present study by C. Rowett and D. Duggan, November 26, 1961.

Unit no.	Description	Thickness (feet)
Wapanucka Formation:		
D	Limestone, oolitic, fossiliferous, grey to white, weathers white; bedding thin to medium, regular. Remarks: These beds are well-exposed only in the dip slope and as isolated ledges near the crest of the ridge. The upper portion of this oolitic limestone is not fossiliferous, but a few fossils occur in the lower part. The contact with the overlying Atoka Formation is not exposed, but is located at or near the base of the dip slope. Thickness calculated.	20.0
C	Shale, calcareous, grey-green, concretionary, fossiliferous. Remarks: The fauna contained by these shales consists primarily of large well-preserved speriferoid brachiopods. The contact of the shale with the overlying oolite is regular. Limonite	

concretions are common. Thickness calculated. 33.0

B	Limestone, medium to coarsely crystalline, blue-grey, weathers tan to grey; bedding thin, irregular; contains shaly zones which are fossiliferous. Remarks: The crest of the ridge is formed by this limestone. Fossils include several crinoid and brachiopod species. Corals are present, but uncommon. The contact with the overlying shale is abrupt and regular.	9.5
A	Shale and limestone, interbedded: talus and soil covers most of this unit; thickness calculated, and approximate. Unfossiliferous where examined.	50.5
	Total thickness of exposures:	113.5

STRATIGRAPHIC SECTION C 5

Description of locality: The Wapanucka Formation forms a small but prominent ridge in this area, which trends eastward across the N $\frac{1}{2}$ SW $\frac{1}{4}$ sec. 34, T. 1 S., R. 8 E., about 2.5 miles northeast of the town of Bromide in Coal County, Oklahoma. Strata strike N 90° E and dip from 20 to 25° S, toward the axis of the Wapanucka Syncline. The best exposures are along the south bank of Mosley Creek; the section was measured from the bed of this creek southward across the ridge, in the north-central part of the NE $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 34.

M. H. Kuhleman (1948, p. 33) recorded a measured section in the Wapanucka about one-quarter mile east of this locality. Section measured for the present study by C. Rowett and D. Waddell, September 9, 1961.

Unit no.	Description	Thickness (feet)

Base of Atoka Formation:

Limestone conglomerate; clasts of pebble to cobble size; locally oxidized; thin-sections ("D"-1) of this unit indicate that many of the clasts are composed of oolites which were derived from the underlying oolite of the Wapanucka Formation (unit B). 3.5

Wapanucka Formation:

C Limestone, glauconitic, locally oolitic, grey-green, weathers grey to brown; bedding thin, irregular; locally cross-bedded.

Remarks: This unit varies in composition and appearance along strike. One-quarter mile to the east, it contains oolitic intraclasts and is moderately glauconitic; at the present locality, glauconite is abundant, and cross-bedding is well-developed. Thickness varies along strike from 3.0 to 3.5 feet. These beds are unconformably overlain by basal conglomerates of the Atoka Formation. The conglomerate is in turn overlain by thick section of unfossiliferous, concretionary shale of the Atoka Formation. 3.5

B Limestone, oolitic, fine to medium crystalline, light grey, weathers dark grey to brown; bedding thick to massive; extensively veined and jointed; unfossiliferous where examined.

Remarks: The resistance of these thick limestone beds to erosion and the steep dips are responsible for the relief of the Wapanucka ridge in this area. The middle part of the unit is mostly covered by soil, vegetation, and large displaced limestone blocks.

Petrographic description:

B - 1: Oosparite

71.2

A Limestone, fine to medium crystalline, dark blue-grey, weathers pink to brown; bedding medium, regular; sparsely fossiliferous.

Remarks: The lower part of these strata are exposed in the bed of Mosley Creek, where they form ledges. The base of the unit is covered by alluvium in the north bank of the creek, except locally, where it is underlain by unfossiliferous grey-green shales of undetermined age.

Petrographic description:

A - 1: Spicular biosparite

14.9

Total thickness (Wapanucka Formation only): 89.6

STRATIGRAPHIC SECTION C 31

Description of locality: The upper part of the Wapanucka Formation is exposed as a narrow, steep-sided ridge about 1.7 miles northeast of Bromide, Oklahoma: NW $\frac{1}{4}$ SE $\frac{1}{4}$ sec. 33. T. 1 S., R. 8 E., Coal County, Oklahoma.

These strata form part of the north limb of the Wapanucka Syncline, and dip steeply south toward the axis of this structure. The beds strike N 80 W; dip is variable, and ranges from 35-65° S. This section was measured by B. F. Wallis (1915, p. 48). The locality is also listed by M. H. Kuhleman (1948, loc. 41). Section measured for the present study by C. Rowett, June 23, 1961.

Unit no.	Description	Thickness (feet)
Wapanucka Formation:		
B	Limestone, oolitic, medium crystalline, white, weathers grey; bedding thick, regular; cherty in lower part; sparsely fossiliferous throughout. Remarks: These near-vertical limestone beds form a steep-sided narrow ridge about 20 feet high at this locality; they are in fault-contact with incompetent shales of the lower part of the Atoka Formation due to deformation associated with the folding of the Wapanucka Syncline.	52.0
A	Limestone and chert; limestone medium crystalline, blue, weathers tan to brown; interbedded with nodules and stringers of dark blue chert; unfossiliferous. Remarks: The contact between these cherty beds and the overlying oolite is poorly exposed, but field evidence from adjacent localities (e.g., C 5, J 28, J 15) indicates that the contact is unconformable. The base of this unit is in fault-contact with shales of the Springer or Caney Formation.	12.0
	Total thickness of exposures:	64.0

STRATIGRAPHIC SECTION J 28

Description of locality: This section was measured primarily to confirm the unconformable relationship of the upper oolitic beds of the Wapanucka Formation in this area to underlying strata. The section was measured on the west side of the ridge, about one mile southeast of the town of Bromide: NE $\frac{1}{4}$ SE $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 5, T. 2 S., R. 8 E., Johnston County, Oklahoma.

There is a small abandoned quarry at the crest of the ridge at this locality from which a few tons of the oolitic limestone have been removed for local building purposes.

Three lithologic units are recognized in this section. The upper unit, C, is also present at locality J 15, about one mile to the southeast at Delaware Creek. The disappearance of Unit A and B along strike can be explained by tracing the oolite southeastward along the ridge. In this direction the oolite thins rapidly and disappears at the crest of the ridge within a short distance of the quarry. For the next 1500 yards unit B forms the crest and dip slope of the ridge. About 200 yards northwest of the large quarry at Delaware Creek the oolite reappears and thickens rapidly southeastward, to a thickness of over 70 feet at the quarry. Through this interval the oolite progressively truncates the underlying units (A and B). These relationships are shown diagrammatically in figure 2.

Section measured by C. Rowett and R. Hedlund, June 19, 1961.

Unit no.	Description	Thickness (feet)
Wapanucka Formation:		
C	Limestone, oolitic, light grey to white, weathers dark grey; bedding thick to massive; sparsely fossiliferous.	
	Remarks: This oolite forms the dip slope of the ridge, and has the form of a small basin-shaped deposit, replacing the cherty limestone (unit B) at the crest of the ridge for about 150 feet along strike. Maximum thickness is 11 feet in the quarry. The cherty limestone correspondingly thins	

from an exposed 14 feet to less than 3 feet in the quarry. Truncation of individual beds of unit B by the oolite was observed in several places at this locality.

0.0 to 11.0

B Limestone and chert: limestone medium crystalline, locally oolitic, grey to blue, weathers tan; bedding thin, irregular; interbedded with stringers and nodules of dark blue chert.

Remarks: The relationship of this unit to the overlying oolite is described above. A maximum exposed thickness of 14 feet was recorded just south of the quarry; in the quarry, however, only three feet are exposed below the oolite. The base of the unit is not exposed. It is locally fossiliferous.

Petrographic description:

B - 1: Oolitic biosparrudite, locally silicified.

14.0

A Limestone, crinoidal, medium crystalline, tan, weathers brown; bedding thin to medium; mostly covered.

Remarks: Only a few ledges of this unit are exposed; thickness does not exceed 26 feet, but may be considerably less. The contact with the overlying cherty limestone is not exposed, but the two units differ considerably in lithology and in weathering characteristics.

26.0

Total thickness of exposures: 51.0

STRATIGRAPHIC SECTION J 15

Description of locality: Excellent exposures of the upper oolitic portion of the Wapanucka Formation occur in two large abandoned limestone quarries and along a railroad cut: SE $\frac{1}{4}$ SW $\frac{1}{4}$ and SW $\frac{1}{4}$ SE $\frac{1}{4}$ sec. 4, T. 2 S., R. 8 E., Johnston County, Oklahoma. Delaware Creek cuts the ridge formed by the

Wapanucka along the south line of this section and is parallel to the railroad for about one-half mile. (The county map of Johnston County shows this railroad and Delaware Creek to be separated by nearly one-half mile).

Strata forming this ridge are part of the south limb of the Wapanucka Syncline. The beds strike N 40 W and dip 5-15° NE, toward the axis of the syncline. The ridge becomes progressively lower to the northwest and terminates in the NE $\frac{1}{4}$ of sec. 5, at or near the synclinal axis. Less than one-quarter mile northeast from this point strata of the Wapanucka Formation crop out along the north limb of the syncline, where they strike N 60 E and dip 20-30° S.

This section was measured and described by B. F. Wallis (1915, p. 46), who described the unconformable relationship of the oolite. Field work undertaken for this study supports Wallis' conclusions. The section was measured in the quarry and along the railroad cut by C. Rowett and D. Strong, August 18, 1960.

Unit no.	Description	Thickness (feet)
Basal Atoka Formation:		
D	Limestone conglomerate and sandstone; conglomerate grey, tan, and blue-grey on fresh and weathered surfaces; composed of well-rounded to subangular clasts of pebble to cobble size, in part oolitic; interbedded with lenticular zones of sand, medium to coarse grained, strongly current-bedded; numerous crinoid parts also current-bedded; pyrite crystals common throughout matrix.	

Remarks: This conglomerate is exposed about 500 yards east of the main quarry, on the north and south sides of Delaware Creek. The lateral distribution of the conglomerate seems limited. About 50 yards east of the exposures on the north side of the Creek outcrops of thin ferruginous sandstones and concretionary shales typical of the lower part of the Atoka Formation are present. The contact of the conglomerate with the Wapanucka Formation is poorly exposed. Petrographic study (thin-section D-1, D-2) of the conglomerate indicates that many of the clasts are composed of oolites from the underlying Wapanucka Formation.

2.5

Wapanucka Formation:

C Limestone, fine to medium crystalline, tan to dark blue, weathers brown; bedding thin to medium, irregular in upper part; sparsely fossiliferous.

Remarks: The uppermost part of this unit contains medium to coarse quartz sand and fossil debris, which appear to increase upward in average size.

22.0

B Limestone and chert: limestone fine to medium crystalline, tan, weathers tan to yellow-brown; bedding thin, regular; interbedded with thin cherty layers; upper surfaces leached.

Remarks: The contact with the overlying limestone is regular and seems to be conformable; minor cross-faulting causes local reversals of dip in the lower part of the unit. Units B, C, and D are local in their distribution, and correlative beds have not been recognized elsewhere.

5.5

A Limestone, oolitic, white, weathers grey; bedding thick to massive, lenticular, cross-bedded; sparsely fossiliferous.

Remarks: This thick oolitic unit is exposed in a large abandoned quarry at the crest of the ridge and in a smaller quarry about 30 feet east from the main quarry. In the main quarry, the beds are distinctly lenticular, and thicken rapidly to the southeast. The rock is white and deeply leached. In the smaller quarry cross-bedding of the oolites is emphasized by weathering. This small quarry is rectangular and contains a series of narrow tiers; it exposes about 50 feet of the oolite.

Talus and large slump-blocks cover the base of the oolite at this locality, but it is believed to rest unconformably on shales of the Springer Formation. To the northwest the oolitic beds thin rapidly, and at a distance of about 200 yards northwest from the main quarry the oolite disappears entirely at the crest of the ridge. To the southeast, the oolite thins to a minimum of about 3 feet, locally thickening to 10 or 15 feet in small depressions which differ from that at Delaware Creek only in size. A similar deposit of the oolite also occurs at the crest of the ridge about one-half mile to the northwest from Delaware Creek (loc. J 28, this report). The oolite is fossiliferous throughout and contains cephalopods, bryozoans, gastropods and brachiopods. However, deep leaching of the rock has destroyed most fossils.

Petrographic descriptions:

A - 20: Oosparite

A - 70: Oosparite

Thickness of oolite (base not exposed):	71.9
Total thickness (Wapanucka Formation only):	99.4

STRATIGRAPHIC SECTION J 16

Description of locality: Exposures of the Wapanucka Formation occur at this locality in bluffs facing the east side of a small reservoir formed by Sulfur Creek, about 1.4 miles west of the town of Wapanucka, Johnston County, Oklahoma. Strata dip from 25 to 30° NE; the strike is variable, as the ridge shifts from a generally eastward to a northward trend. The section is further complicated by faulting, to the extent that beds exposed in a highway cut (State Highway 7) on the west side of the reservoir can not be identified with certainty on the opposite side.

This section was measured and described by B. F. Wallis (1915, P. 46). The section was measured for the present study from the edge of the spillway eastward to the crest of the ridge in the NE $\frac{1}{4}$ NW $\frac{1}{4}$ sec. 22, T. 2 S., R. 8 E., by C. Rowett and D. Strong, August 20, 1960.

Unit no.	Description	Thickness (feet)
Wapanucka Formation:		
I	Limestone, oolitic, "birds-eye", light grey, weathers white; bedding thick, irregular; fossiliferous. Remarks: These oolitic beds form the dip slope of the ridge, and are undulatory on the upper surfaces due to solution. They rest with apparent unconformity on the underlying limestone unit, and are overlain by the Atoka Formation at the foot of the dip slope. Thickness calculated. Petrographic description: I - 1: fossiliferous oosparite and biosparrudite, zoned.	5.5
H	Limestone, medium crystalline, tan, weather tan to grey; bedding thick, regular; contains nodules and stringers of dark blue chert; unfossiliferous. Remarks: The contact with the overlying oolitic limestone is undulatory, and in places is characterized by thin-bedded argillaceous limestones at the contact. Evidence for an unconformity at this horizon has been secured at nearby locality (J 29). Soil and talus cover most of the middle and lower part of the unit.	30.5

G Limestone, medium to coarsely crystalline, grey, weathers blue-grey; bedding thick, regular; unfossiliferous.

Remarks: Contact with unit H poorly exposed; apparently regular.

4.0

F Limestone and shale, interbedded: limestone medium to coarsely crystalline, tan, weathers tan to grey; bedding thick, regular; interbedded with shales of approximately equal thickness; both shales and limestones unfossiliferous.

Remarks: Mostly covered; thickness computed.

Petrographic description:

F - 1: biomicrosparite

17.0

E Limestone, medium to coarsely crystalline, blue, weathers grey; bedding thin to medium, regular; sparsely fossiliferous.

Remarks: This resistant limestone forms a narrow ledge about 12 feet above the base of the section.

2.5

D Shale and limestone, interbedded: shale calcareous, yellow-brown, abundantly fossiliferous; interbedded with thin discontinuous layers of cherty limestone.

Remarks: Species of Composita are abundant in these shales; other brachiopod species, crinoids, and corals also occur.

8.8

C Limestone, arenaceous, tan, weathers yellow-brown; bedding medium, regular; unfossiliferous.

1.9

B Limestone, fine to medium crystalline, blue-grey, weathers tan; bedding thin, regular; fossiliferous in lower part (mostly crinoid parts).

2.0

A Shale and limestone, interbedded; limestone medium to coarsely crystalline, blue, weathers yellow-brown;

bedding thin, lenticular; interbedded with thin lenticular blue-grey shales; fossiliferous.

Remarks: Complete dorsal cups of Paragassizocrinus, Ethel o crinus, and other crinoid genera have been recovered from these beds. The base of the unit is not exposed.

	5.5
Total thickness of exposures:	77.7

STRATIGRAPHIC SECTION J 29

Description of locality: The Wapanucka Formation in this area forms a prominent ridge which trends eastward about one-half mile south of the town of Wapanucka, Atoka County, Oklahoma: SW $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 23, T. 2 S., R. 8 E. This is considered to be the type area of the Wapanucka Formation (Taff, J. A., 1901). Strata dip gently to the north at about 15°. The edges of the strata are exposed in the steep southwestern slope of the ridge, and the upper surface of the highest unit (unit E) forms the dip slope. The base of the section is covered by talus. The contact with the Atoka Formation is likewise covered, but occurs near the foot of the dip slope. The section was measured from the base of the south side of the ridge, 20 feet west of a cement well slab, to a small abandoned quarry at the crest of the ridge. A water tank is situated on top of the ridge about 200 yards east of this quarry. Section measured by C. Rowett, June 23, 1961.

Unit no.	Description	Thickness (feet)
Wapanucka Formation:		
E	Limestone, locally oolitic, finely crystalline, grey to white, weathers mottled grey; bedding thick and irregular. Remarks: This stone has been quarried at the crest of the ridge. The upper surfaces of the unit form the dip slope of the ridge and are irregular due to solution. This rock is leached in the upper part; unweathered portions are commonly oolitic. "Birds-eye" structures occur in the middle and lower beds. The thickness is variable, due to the irregular upper surface and an equally irregular contact with the underlying unit. This limestone carries a sparse brachiopod fauna. Petrographic description: E - 10: pelletiferous dismicrite	19.0
D	Limestone, oolitic, and chert; limestone locally oolitic, medium crystalline, grey to blue on fresh and weathered surfaces; bedding irregular and variable in thickness; interbedded with lenses and stringers of chert, dark blue to red-brown in color. Remarks: These beds are irregular due to lenses and stringers of chert and lenticular bedding of the limestone. The upper six inches consist of argillaceous, thin-bedded limestone which has weathered back, forming an overhang of several feet; sparsely fossiliferous. Petrographic description: D - 3: fossiliferous oosparrudite	6.0
C	Limestone, limestone conglomerate, and chert: limestone, blue-grey on fresh and weathered surfaces, fine to medium crystalline; bedding thick and regular except in upper two feet, where beds are contorted and lenticular; lenses of red-brown chert and limestone pebbles and cobbles in upper part; base covered.	

Remarks: The upper surface of this unit may represent an intraformational unconformity; it is undulatory, locally channeled, and contains concentrations of fossil debris.

Petrographic description:

C - 17: fossiliferous intrasparrudite and intramicrosparrudite, zoned.

17.5

B Limestone, crinoidal, medium to coarsely crystalline, tan to pink, weathers dark brown; bedding medium to thick, regular; partly covered.

Remarks: This unit may be equivalent to unit F at locality A 24, which is less than one mile to the southeast; concentrations of crinoid parts in the lower three feet of this unit form a distinct bed which is present in both sections. Small stringers of chert occur throughout the beds. The upper part is covered, except for a few projecting ledges in which the pelmatozoan fragments are smaller. The contact with the overlying unit is not exposed.

Petrographic description:

B - 2: biomicrosparrudite and biosparrudite

8.5

A Limestone, crinoidal, fine to medium crystalline, grey to white, weathers grey; bedding thin and regular.

Remarks: This is the lowest unit exposed; below these beds a debris-covered slope appears to be underlain by thin limestone and shales.

Petrographic description:

A - 5: oolitic biosparrudite

6.0

Total thickness of exposures: 57.0

STRATIGRAPHIC SECTION J 24

Description of locality: In this area the Wapanucka Formation forms a steep-sided ridge which trends northwest. Strata dip from 12 to 25^{o} NE, and are exposed near the crest of the ridge. The section was measured from a road cut along State Highway 48 northeastward across the ridge; center of the W line, sec. 24, T. 2 S., R. 8 E. This area is located about one-half mile south of the town of Wapanucka, Johnston County, Oklahoma. Section measured by C. Rowett, August 26, 1961.

Unit no.	Description	Thickness (feet)
Wapanucka Formation:		
G	Limestone, medium crystalline, blue, weathers tan; bedding thick, regular; locally cherty; fossiliferous. Remarks: These beds form the dip slope of the ridge. The contact with the overlying Atoka Formation is covered at the foot of the dip slope.	11.0
F	Limestone, crinoidal, coarsely crystalline, tan, weathers dark grey and brown; bedding medium to thick, regular; fossiliferous. Remarks: The lower 2 feet consist of abundant crinoid parts; this unit is useful for local correlation, and is present at loc. J 29, about one mile to the northwest.	9.0
E	Limestone and shale, interbedded: limestone medium crystalline, tan, weathers tan to grey; bedding thin, regular; interbedded with shales of about equal thickness (2 to 3 feet).	

	Remarks: Beds are mostly covered by soil and vegetation. Thickness computed.	53.5
D	Shale, calcareous, grey; unfossiliferous.	0.8
C	Limestone, coarsely crystalline, light grey, weathers tan to grey; bedding thin, regular; unfossiliferous.	1.1
B	Limestone, fine to medium crystalline, blue, weathers grey; bedding thin, irregular; contains numerous chert nodules and stringers; unfossiliferous.	6.5
	Remarks: Units, A, B, C, and D are recognized only at this locality and are probably local in their distribution.	
A	Shale, calcareous, grey; unfossiliferous. Base covered.	6.0
	Total thickness of exposures:	87.9

STRATIGRAPHIC SECTION A 19

Description of locality: A limestone quarry on the property of the Oklahoma Sub-Prison exposes vertical to slightly overturned strata of the upper part of the Wapanucka Formation. The quarry is located about 9 miles northeast of Atoka, Atoka County, Oklahoma, and lies approximately one-half mile northwest of U. S. Highway 69: South Line, NE $\frac{1}{4}$ sec. 15, T. 1 N., R. 12 E.

The single Wapanucka ridge in this area is steep-sided and sinuous, trending generally in a northeast direction, but is locally deformed into sharp S-shaped curves. The imbricate folding and strike-faulting of the Wapanucka Formation in the Ouachita Mountains is primarily the result of the compressional forces. It is probable that local strike-shortening, such as is observed in this area, was produced by components of the main deformational forces.

Strata exposed here strike N 30 E and are overturned from 5 to 8° to the northwest. Near-vertical bedding planes exposed in the quarry are visible from the highway. This section is correlated with the upper part of the exposures at Limestone Gap (locality A 18) on the basis of a comparable lithologic sequence and a zone of solitary corals.

Section measured by C. Rowett and D. Strong, August 23, 1960.

Unit no.	Description	Thickness (feet)
<u>Wapanucka Formation</u>:		
F	Limestone, finely crystalline, grey, weathers grey; bedding thick, regular; numerous calcite-filled joints. <u>Remarks</u>: Most bedding planes show slickensides; this feature, and numerous thick calcite-filled joints, reflect strong deformation of the unit. Strike faulting has resulted in an incomplete section. Few megafossils observed.	23.8
E	Limestone, fine to medium crystalline, grey to dark blue, weathers grey; bedding thick, regular; extensively jointed; fossiliferous. <u>Remarks</u>: Unit E grades upward into beds which are lithologically similar, but which differ in fossil content and in degree of crystallinity (unit F is a "lithographic" limestone in part). Corals collected from this unit include <u>Pseudozaphrentoides</u> and <u>Koninckophyllum</u>.	25.5

D Limestone and chert: limestone, fine to medium crystalline, dark blue, weathers blue-grey; bedding medium to thick, regular; interbedded with chert "beds", stringers and nodules.

Remarks: Unit D is a "bedded chert" in which replacement of the original limestone has been almost complete; the contact with the non-cherty beds above this unit is abrupt. Unfossiliferous.

45.0

C Limestone, crinoidal, coarsely crystalline, grey to pink, weathers grey; current-bedded.

Remarks: This unit occurs at approximately the same horizon as Unit Q at Limestone Gap (locality A 18). At the present locality, the beds contain numerous thin calcite-filled joints.

1.5

B Limestone and chert: limestone medium crystalline, silty, grey, weathers grey; bedding thin, regular; interbedded with thin stringers and nodules of dark blue chert.

Remarks: The contact with the overlying crinoidal limestone is slightly irregular. No megafossils observed.

5.0

A Limestone and shale: limestone fine to medium crystalline, blue, weathers blue-grey; bedding thin, irregular; interbedded with stringers of dark blue to brown chert and thin shales; unfossiliferous.

Remarks: These beds grade upward into the overlying unit. The base of Unit A is covered by talus on the north side of the ridge.

17.5

119.2

STRATIGRAPHIC SECTION A 20

<u>Description of locality</u>: The upper part of the Wapanucka Formation is exposed in a small abandoned limestone quarry and roadcut where U. S. Highway 69 crosses the Wapanucka ridge, about one-half mile northeast of the settlement of Chockie, Atoka County, Oklahoma: NE $\frac{1}{4}$ SW $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 1, T. N., R 12 E.

The Wapanucka Formation in this area forms a high ridge which is a prominent topographic feature. The ridge has a relief of up to 200 feet over the valleys formed in shales to the north and south. The general trend of the ridge is northeast; strata dip from 45 to 75° S and strike N 50 E.

This section was measured by B. F. Wallis (1915, p. 58) and by B. H. Harlton (1938, p. 912); Harlton correlated these beds with his "Barnett Hill" Formation in Coal County, Oklahoma. The section was measured for this report along the south side of the highway (units A-C), the north side of the highway (unit D), and in a small quarry on the north side of the highway (units E-I). Correlation with the section at Limestone Gap (locality A 18, this report) is based upon a similar lithologic sequence and coral zones.

Section measured by C. Rowett and D. Strong, August 23, 1960.

Unit no.	Description	Thickness (feet)
Wapanucka Formation:		
I	Limestone, finely crystalline, tan to blue-grey, weathers grey; bedding thick to massive, regular; extensively jointed; oolitic in lower part, sparsely fossiliferous. Remarks: The upper bedding planes of this unit form the steep dip slope of the ridge and weather to smooth undulatory surface. The rock is to a large extent "lithographic" (microcrystalline oolite ooze, or micrite) in the upper part. Small pelmatozoan parts are scattered throughout the lower part of the unit, which is cemented by sparry calcite. The lower 2 to 5 feet are oolitic, but this portion of the rock seems to grade upward into the overlying part. Solitary corals occur in the middle part of the section (*Koninckophyllum*, *Pseudozaphrentoides*). Petrographic description: I - 10: Fossiliferous intrasparrudite	69.7
H	Limestone and chert: limestone fine to medium crystalline, tan, weathers tan to grey; bedding medium, slightly irregular; interbedded with dark blue "bedded cherts" of about equal thickness. Remarks: Replacement by chert of the original limestone has occurred along the bedding planes and is locally complete; chert also occurs as irregular stringers and nodules which weather to red and brown. These beds are deeply leached, and concentrations of chert stand out from the bedding planes in irregular masses. No megafossils were observed, but probably were originally present.	45.2
G	Limestone, crinoidal, coarsely crystalline, pink to grey on fresh and weathered surfaces; current-bedded.	

Remarks: An abrupt lithologic change and an undulatory contact separates this unit from the overlying cherty beds. Fossils include only pelmatozoan parts.

3.0

F Limestone, silty, fine to medium crystalline, tan, weathers yellow-brown; bedding medium, regular.

Remarks: The contact with the overlying crinoidal limestone is abrupt and irregular. These beds contain crinoid parts and other fossils.

14.5

E Limestone, crinoidal, coarsely crystalline, grey to pink, weathers tan; current-bedded.

Remarks: Crinoid parts comprise the bulk of this rock; bryozoans, brachiopods, and external molds of cephalopods are common on bedding planes.

Petrographic description:

E - 4: Biosparrudite

4.5

D Limestone, shaley, tan, weathers grey to red; bedding thin, blocky; interbedded with grey to black siliceous to calcareous shale, highly fossiliferous.

Remarks: Bedding planes up to hundred of square feet in area are exposed along the north side of the highway just below the crest of the ridge. These beds are oxidized to red or maroon along joints. Fossils are compressed and distorted but include bryozoans, gastropods, (Bellerophon), brachiopods, crinoids, and cephalopods.

6.9

C Limestone, medium crystalline, tan to blue-grey, weathers tan; bedding thin, lenticular; silty in part.

Remarks: This thin unit may be discontinuous laterally; it is spiculiferous in part, but otherwise is unfossiliferous.

1.9

B Shale, platy, siliceous, grey; sparsely fossiliferous.

Remarks: This shale grades upward into the overlying thin-bedded limestone; it contains abundant sponge spicules and a few small brachiopods.

11.3

A Limestone and shale: limestone medium crystalline, blue-grey, weathers grey; bedding thin to medium, regular; spiculiferous in part; interbedded with thin shaley zones.

Remarks: This unit is moderately fossiliferous and contains about the same fauna as unit D. It is underlain by a thick section of grey to black siliceous and spiculiferous shale.

Correlation of this section with the strata exposed at Limestone Gap (loc. A 18) indicates that units identified as A through D occur at approximately the same horizon as the upper part of unit N at that locality.

17.5

Total thickness of exposures: 174.5

STRATIGRAPHIC SECTION A 18

Description of locality: A thick section of the Wapanucka Formation is exposed at Limestone Gap, about 10 miles northeast of Stringtown, Atoka County, Oklahoma: NE $\frac{1}{4}$ sec. 31, T. 2 N., R. 13 E. The Wapanucka in this area forms a high ridge which trends northeast and has a relief of from 140 to 180 feet. At this locality the ridge is cut by Limestone Creek, which forms a prominent water-gap. The Kansas, Missouri, and Texas Railroad also crosses the ridge obliquely here; because of a thick shale near the middle of the section, there are two railroad cuts which are separated by a railroad trestle over Limestone Creek. The lower part of the section (units A-M) was measured in the cut northeast of the bridge, and the upper part (units O-U) was measured in the larger cut to the southwest of this bridge. Unit V is exposed only in the bed of Limestone Creek. All beds strike N 54 E and dip from 35 to 45° S.

This is a key exposure of the Wapanucka Formation in the frontal belt of the Ouachita Mountains. The section here was measured and described by B. F. Wallis (1915, p. 59); fossils were collected from the lower part of the section by R. V. Hollingsworth (1933, loc. 7), but the section was not measured at that time; B. H. Harlton (1938, p. 904) measured and described the section here in some detail, but ascribed the upper beds (units N-V of this report) to his "Barnett Hill" Formation, which is now generally regarded as a locally developed sandstone facies in the lower Atoka Formation in the Arbuckle Mountains; the section was measured and sampled by the writer (C. Rowett, 1959) as the basis of a petrographic study of the Wapanucka Formation. Measurements made at that time are recorded here.

Unit no.	Description	Thickness (feet)
Wapanucka Formation:		
V	Shale, black, blocky, well-indurated; bedding thin, regular; unfossiliferous. Remarks: This unit is exposed in the bed of Limestone Creek, approximately 100 yards southwest of the small bridge at Gap, Oklahoma. The contact with the underlying massive limestones of unit U is exposed, but is eroded along the bank of the creek at this point. There is no evidence of an unconformity or of a fault-contact between the two units, and there beds are consequently assigned to the Wapanucka Formation. The upper part of the unit is covered by stream alluvium. Thickness recorded is the maximum exposed.	5.2

U Limestone, fine to coarsely crystalline, blue-grey, weathers grey to white; bedding thick to massive; cherty, oolitic, and crinoidal zones; sparsely fossiliferous.

Remarks: These limestone beds are prominent along the crest of the Wapanucka ridge in this area; they are resistent to erosion and are responsible for the relief of the ridges. These strata typically weather to smooth cavernous surfaces, deep hollows, and other unusual forms. Jointing is extensive in most beds; many joints are filled with large calcite crystals. "Birds-eye" structures occur in the upper part of the unit. The solitary rugose corals Stereocorypha, Pseudozaphrentoides, Amplexocarinia, Koninckophyllum occur in the lower part of this unit.

Petrographic description: Thin-sections made from several zones indicate considerable lithologic variation, as follows: U-34, U-53, U-58: Intraclast pelmicrite and dismicrite: the upper 24 feet of this unit are uniform in lithology, and consist of invertebrate fecal pellets in a matrix of microcrystalline calcite, grading in some zones to microsparite. "Birds-eye" structures in the upper part are filled with sparry calcite.

U - 15: Oosparite.

U - 8: Crinoidal biosparrudite

U - 1: Sandy spiculiferous biomicrite

58.6

T Limestone and chert: limestone finely crystalline, tan, weathers tan to grey; bedding medium, irregular; interbedded with dark blue chert.

Remarks: Chert in these beds forms irregular stringers and nodules; megafossils were not observed.

Petrographic description:

T - 3: Cherty, spiculiferous biomicrosparite

3.0

S Limestone, oolitic, medium crystalline, grey, weathers light grey; bedding thick, regular.

Remarks: Oolites in this bed are abundant and well-developed; the bed is remarkably uniform in thickness and character. Fossils and oolites are uniformly small.

Petrographic description:

S - 1, S - 2, S - 3: Fossiliferous oosparite

2.7

R Limestone and chert: limestone tan, weathers tan to brown; bedding thin, irregular; almost completely replaced by chert.

Remarks: This unit approaches a "bedded chert" in appearance. Bedding planes of as much as 600 square feet in area are exposed on the north side of the railroad cut; on these surfaces, the chert is leached, which produces a honeycombed appearance. This surface also contains inclusions (burrows?) composed of oolitic material of the same composition as that of the overlying unit.

Petrographic description:

R - 3, R - 11, R - 24, R - 31, R - 33: Spiculiferous micrite, replaced by chert. Recrystallization and replacement is extensive, but spicules may have comprised as much as 50% of the original rock.

32.2

Q Limestone, crinoidal, coarsely crystalline, pink, weathers tan to grey; current-bedded.

Remarks: An abrupt and irregular contact between this unit and the overlying cherty beds is probably due to the current-bedding. Fossils include only pelmatozoan parts.

Petrographic description:

Q - 1, Q - 2: Crinoidal biosparrudite

1.3

P Sandstone, chert and shale: sandstone cherty, spiculiferous, buff, weathers tan; bedding thin, regular; interbedded with dark grey to black shale, chert stringers and nodules; sparsely fossiliferous.

<u>Remarks</u>: The chert in these beds weathers to irregular masses; shale is platy and siliceous. The unit contains numerous fine quartz-filled joints.

<u>Petrographic description</u>:

P - 1, P - 5: Sandy biomicrite and spiculiferous shale, interbedded. The biomicrite contains hydrous iron oxide, sapropelic material and detrital quartz grains in a cryptocrystalline siliceous matrix. The matrix may originally have been microcrystalline calcite.

4.6

O Limestone, crinoidal, coarsely crystalline, pink, weathers tan to grey; current-bedded.

<u>Remarks</u>: Units O and Q are similar lithologically, and are also recognizable at locality A 20. Megafossils include only pelmatozoan parts.

<u>Petrographic description</u>:

O - 1, O - 2: Crinoidal biosparrudite

1.4

N Shale and spiculiferous limestone: shale siliceous in part, light to dark grey, fissile, concretionary; interbedded with thin spiculiferous limestone; mostly covered; unfossiliferous.

<u>Remarks</u>: Limestone Creek crosses the ridge through a water-gap which is eroded in this shale. The shale is mostly covered by talus and vegetation. Thickness calculated.

149.0

M Limestone, spiculiferous, finely crystalline, light to dark grey, weathers tan to red-brown; bedding thin to medium, regular.

<u>Remarks</u>: Small calcite-filled joints in lower part; increase in sand and silt content upwards; deeply oxidized, unfossiliferous; upper part covered.

<u>Petrographic description</u>:

M - 1, M - 5: Spiculiferous biomicrite (M-1), grading upwards to silty spiculiferous biomicrite (M-5);

siliceous sponge spicules (monaxons) comprise up to 70% of the rock in the lower part; partly replaced by chert.

7.0

L Shale, siliceous, spiculiferous, grey to black, fissile.

<u>Remarks</u>: This shale is gradational with the overlying spiculite; unfossiliferous where observed.

6.3

K Limestone, spiculiferous, finely crystalline, grey, weathers buff to brown; bedding medium to thick, regular.

<u>Remarks</u>: Includes a few shaley zones and chert nodules; the upper part is gradational with the overlying shale; ostracod parts are contained in the lower few inches.

<u>Petrographic description</u>:

K - 1, K - 10: Spiculiferous biomicrosparite, silty in lower part; partly replaced by chert.

10.8

J Shale, siliceous, spiculiferous, calcareous in part, grey to black, platy; sparsely fossiliferous, interbedded with thin spiculites.

<u>Remarks</u>: The contact of this shale with the overlying unit is abrupt; these beds contain abundant ostracod fragments. The unit is characterized by discontinuous zones of spicules which may have resulted from concentration and compaction; spicules are replaced by silica.

<u>Petrographic descriptions</u>:

J - 3, J - 8: Silty spiculiferous biomicrosparite and biomicrite; partly replaced by chert.

10.4

I Limestone, spiculiferous, finely crystalline, grey to blue, weathers tan; bedding medium to thick, regular.

Remarks: The upper part is gradational with unit J; no megafossils observed.

Petrographic description:

I - 1, I - 5, I - 10, I - 11, I - 13, I - 16: Silty biosparite; partly replaced by chert. 15.2

H Shale, siliceous, spiculiferous, calcareous in part, grey to black, platy; sparsely fossiliferous.

Remarks: Upper contact is abrupt; contains ostracod fragments, and pelmatozoan parts. 6.4

G Limestone, spiculiferous, finely crystalline, grey, weathers brown to red-brown; bedding medium, regular.

Remarks: Upper contact abrupt; extensively jointed; no megafossils observed.

Petrographic description:

G - 2, G - 3, G - 5: Silty biomicrite and microsparite; intraclasts of micrite and quartz silt; partly replaced by chert. 4.9

F Shale, siliceous, spiculiferous, grey to black, fissile; unfossiliferous.

Remarks: This shale is gradational with both the overlying and underlying units; sparse ostracod fragments. 8.4

E Limestone, spiculiferous, finely crystalline, grey, weathers tan; bedding medium to thick, regular.

Remarks: This unit is resistant and forms overhanging ledges along its outcrop; it is sparsely fossiliferous. Upper contact gradational.

Petrographic description:

E - 1, E - 8: Silty spiculiferous biomicrosparite and micrite; partly replaced by chert. 8.0

D Shale, siliceous, spiculiferous, calcareous in part, grey to black, platy; unfossiliferous.

Remarks: Upper contact abrupt, regular; ostracod fragments common.

3.7

C Limestone, spiculiferous, finely crystalline, tan, weathers brown to red-brown; bedding medium to thick, regular.

Remarks: These beds exhibit numerous calcite-filled joints; the contact with the overlying shale is abrupt; a shaley zone about 8 inches from the base of the unit contains gastropods (Bellerophon) and fragmental ostracod carapaces.

Petrographic description:

C - 1, C - 4, C - 8, C - 11: Silty spiculiferous biomicrite, grading in places to biomicrosparite. Sponge spicules comprise up to 70% of the rock; partly replaced by chert.

10.2

B Shale, siliceous, spiculiferous, grey to black, platy.

Remarks: Contact with unit C is abrupt and regular; fragments of gastropods (Bellerophon) collected from the surface of this shale were derived from the overlying unit; a few ostracod fragments were observed.

4.3

A Limestone, spiculiferous, finely crystalline, grey to blue, weathers dark brown; bedding medium, regular.

Remarks: Unit A contains numerous calcite-filled joints and minor faults. The contact with the overlying shale is regular. No megafossils were observed.

Petrographic description:

A - 1, A - 3: Silty spiculiferous biomicrite and microsparite.

Unit A is underlain by an undetermined thickness of light to dark grey spiculiferous shale which is sideritic, nodular, and concretionary. There is at present no satisfactory criteria for establishing the base of the Wapanucka Formation in the frontal Ouachita Mountains; the base of the Wapanucka Formation at this locality is therefore arbitrarily placed at the base of unit "A" until further study provides data for a more satisfactory lower boundary in this area.

Thickness of unit A:	2.3
Total thickness of exposures:	355.9

STRATIGRAPHIC SECTION PT 21

Description of locality: The Wapanucka Formation is exposed in a quarry at this locality, which is about 1.2 miles south of Hartshorne, Pittsburg County, Oklahoma. This quarry had not been in operation for over 45 years, but operations were recently resumed. Limestone was originally quarried here for use in a cement plant, and several of the buildings used for this operation are located at the foot of the ridge, on the east side of State Highway 63. A narrow road, now mostly overgrown, leads east from these buildings and up a steep slope to the quarry. The quarry is located in the center of the NW $\frac{1}{4}$ sec. 18, T. 4 N., R. 17 E.

The Wapanucka Formation in this area forms a ridge about 250 feet high. Strata dip 32° S and strike N 50 E. A second and larger quarry lies about one mile east of this locality, from which rock was extracted and crushed (loc. PT 23, this report). Comparison of the lithologic sequence here with that of the latter locality demonstrates abrupt facies changes and possibly local intraformational unconformities within the Wapanucka Formation in this area.

Fossils were collected from the carbonaceous shales near the base and in the middle of this section (here designated units B and D) by R. V. Hollingsworth (1933, locs. 10 and 11). This section was also measured in some detail by B. H. Harlton (1938, p. 906) who considered the section here an equivalent to his "Barnett Hill" Formation.

Section measured in the east and south face of the quarry by C. Rowett and D. Strong, August 25, 1960.

Unit no.	Description	Thickness (feet)
<u>Wapanucka</u> <u>Formation</u>:		
K	Limestone, cherty, finely crystalline, blue to grey, weathers brown to red; bedding medium to thick and regular. <u>Remarks</u>: The replacement of the original limestone in these beds is virtually complete. Silicified fossils attest to an original calcareous composition. Unit K is exposed only in the south face of the quarry, where the upper part is covered by a deep red soil.	18.0
J	Limestone, medium crystalline, grey to blue-grey, weathers grey; bedding massive, regular; fossiliferous. <u>Remarks</u>: The contact of this unit with the overlying "bedded cherts" is abrupt and regular. This unit contains isolated nodules of chert. Solitary rugose corals (<u>Koninckophyllum</u>) were collected from the middle part of the unit, where they appear on weathered surfaces and along shaly zones. A few brachiopods were also collected.	19.0
I	Limestone, crinoidal, medium crystalline, brown, weathers dark brown; bedding massive, regular. <u>Remarks</u>: This bed corresponds to unit H of locality PT 23, about one mile distant. The contact with the overlying unit is abrupt and regular. Aside from small pelmatozoan parts, no megafossils were observed.	8.3

H Limestone, cherty, fine to medium crystalline, light grey on fresh and weathered surfaces; bedding thick, irregular; sparsely fossiliferous.

Remarks: Chert in this unit forms large nodules and concretionary bodies which give the bedding a highly irregular appearance. The contact with the overlying unit is also irregular. Megafossils include crinoid parts and brachiopods. 36.5

G Limestone, coarsely crystalline, tan, weathers red-brown; bedding thick, irregular.

Remarks: This unit contains large concretionary bodies which vary the thickness from 6 to 11 feet. Close examination of the upper and lower surface of the unit has failed to show clear evidence of an unconformity at either horizon, and locally the rock can be seen to grade, within a distance of several feet, into nodular, arenaceous, grey-green strata similar to those of the underlying unit (F). Thickness is variable, and the recorded thickness is the maximum exposed. 11.0

F Limestone, glauconitic, arenaceous, fine to medium crystalline, buff to olive-green on fresh and weathered surfaces; bedding thin to medium, irregular; sparsely fossilerous.

Remarks: Unit F corresponds in part to unit D at locality PT 23; at this locality the beds appear to thin down the dip, but locally the contact is gradational with the overlying unit (G). It is possible that the upper surface of this unit may in part be a surface of subaqueous erosion, but this has not been demonstrated. A few megafossils occur in this unit, including tabulate corals.

Petrographic description:

F - 1: Glauconitic biomicrosparite 1.8

E Limestone and chert: limestone fine to medium crystalline, blue-grey, weathers grey; bedding medium to thick, regular; oolitic in upper part;

interbedded with irregular stringers, lenses and nodules of chert in lower 40 feet; oolitic in upper part.

Remarks: Unit E corresponds closely in lithology and thickness to unit C at loc. PT 23 and is correlated with that unit; at this locality it has a somewhat different appearance which is due to differences in the degree of weathering. The contact with the overlying unit is irregular, but is not accessible for close examination. Megafossils are sparse.

48.4

D Limestone and shale: limestone argillaceous, tan, weathers grey; bedding thin, regular; shaley in upper part; contains finely disseminated carbonaceous plant material and larger segments of carbonized stems and trunks.

Remarks: This unit occurs at the same horizon as a thin carbonaceous shale at locality PT 23 (unit B); the carbonized material at both localities may have been derived from the same source area. Plant material is abundant.

2.5

C Limestone, argillaceous and nodular, medium crystalline, blue, weathers tan; bedding thin, regular; becomes increasingly nodular in upper part; fossiliferous.

Remarks: Nodules in this unit are uniform in size, averaging about one inch in diameter, and may be phospatic. Megafossils include large crinoid columnals, commonly articulated, and several trilobite zones.

21.3

B Shale, black, highly fissile, fossiliferous.

Remarks: Fossils in this shale include pelmatozoan parts, productid brachiopods, and bryozoans. The contact with the overlying unit is abrupt and regular.

9.5

A Limestone, medium crystalline, blue to grey, weathers tan to brown; bedding medium to thick, regular; partly covered.

Remarks: The contact with the overlying black shale is not exposed; the base of the unit is also covered by talus; because the lowest exposed beds are some distance above the foot of the ridge, it is probable that the Wapanucka Formation in this area includes more section than is exposed here. 31.0

Total exposed thickness: 207.3

STRATIGRAPHIC SECTION PT 23

Description of locality: A large quarry exposes part of the Wapanucka Formation, about one mile south and one mile east of the town of Hartshorne, Pittsburg County, Oklahoma: N $\frac{1}{2}$ NW $\frac{1}{4}$ sec. 17, T. 4 N., R. 17 E. In this area the Wapanucka Formation forms a high ridge which trends eastward and rises over 200 feet above the valley to the north. Strata comprising the ridge dip 35-40° south. The quarry is in the north side of the ridge, and consists of an eastern part and a western part; it is not operational at present.

The lower units (A-E) were measured in the western part of the quarry; the upper units (F-I) in the eastern part, and on the back slope of the ridge. Section measured by C. Rowett and R. Hedlund, August 10, 1960.

Unit no.	Description	Thickness (feet)
Wapanucka Formation:		
I	Limestone, fine to medium crystalline, grey to grey-blue, weathers grey; bedding massive; partly covered. Remarks: These strata form the lower part of the dip slope of the ridge; they are poorly exposed and deeply weathered. Solitary rugose corals (*Koninckophyllum*) appear in cross-section on the surfaces of some beds. The lower dip slope is covered and it could not be determined whether higher units in the Wapanucka intervene between these beds and the base of the Atoka Formation.	20.0
H	Limestone, crinoidal, medium crystalline, brown, weathers dark brown; bedding massive. Remarks: This unit forms the crest of the eastern part of the quarry; the brown color of the weathered surfaces are in strong contrast with the lighter greys of overlying and underlying units. The contact with the overlying beds is not well-exposed but seems to be regular. Pelmatozoan parts are uniformly small. Petrographic description: H - 9: Biosparrudite	13.0
G	Limestone, fine to medium crystalline, tan to blue, weathers grey; bedding massive. Remarks: This bed forms the crest of the eastern part of the quarry at its western edge; the rock weathers to smooth undulatory surfaces which are crossed by numerous thin calcite-filled veins. The contact with the overlying unit is inaccessible in the face of the quarry. The change in lithology is marked, however, and the contact seems to be regular. Small pelmatozoan parts are scattered through the rock.	

Petrographic description:

G - 10: Dismicrite

10.3

F Limestone and chert: limestone medium crystalline, grey, weathers light grey; bedding medium to thick; interbedded throughout with chert stringers and nodules.

Remarks: This unit approaches a "bedded chert" in appearance. Chert occurs primarily as beds 6 to 10 inches in thickness. Here the silica appears to have been introduced along bedding planes, partially replacing a thick-bedded limestone. The upper contact of this unit is not accessible in the quarry, but seems to be regular and abrupt. Fossils are uncommon.

Petrographic description:

F - 8: Biosparite

21.8

E Limestone, crinoidal, fine to medium crystalline, blue-grey, weathers light grey; bedding thick to massive.

Remarks: Unit E forms the crest of the western part of the quarry and extends to the quarry floor in the eastern part. The contact with the overlying "bedded chert" is well exposed in the western part of the quarry, where it is abrupt and regular. Beds weather to smooth undulatory surfaces which are cut by numerous thin calcite veins. Small pelmatozoan parts are scattered throughout the rock, but there are no collectable megafossils. The lower one foot is locally conglomeratic, and contains clasts up to pebble-size. The contact with the underlying unit is sharp, and at first gives the impression of being an unconformable contact. Evidence from other localities, however, indicates that the transition may be due to a rather abrupt facies change.

15.7

D Sandstone, limestone, and chert: sandstone fine-grained, glauconitic, buff to olive green; interbedded with limestone, finely-crystalline, tan to blue-grey, nodular, concretionary, weathers tan to brown; contains thin bands of blue chert; bedding thin to medium and irregular throughout.

Remarks: Unit D is visibly discontinuous laterally and may replace portions of adjacent units through a lateral change in sedimentation. In the western part of this quarry this unit appears to thicken at the expense of unit C, and attains a maximum exposed thickness of about 24 feet and extends to the quarry floor. However, truncation of the underlying units has not been demonstrated, and a chert bed about 1.5 feet in thickness near the base of the unit seems to be continuous. These beds disappear in the eastern part of the quarry, where the relationships to adjacent units are also uncertain. The upper 1.5 to 2 feet of the unit consist of thin-bedded arenaceous limestones interbedded with layers of black carbonaceous material. These beds contain one or more zones of trilobites which were observed on slump blocks but which were not found in place.

Petrographic description:

D - 10, D - 11: Silty, spicular, pelmicrite and intrapelmicrite, interbedded; locally silicified.

23.9

C Limestone and chert: limestone fine to medium crystalline, blue-grey, weathers grey; medium to thick-bedded, oolitic in upper part, sparsely fossiliferous; interbedded in lower 40 feet with regular beds of dark blue chert.

Remarks: These beds are best exposed in a near-vertical cliff which separates the quarry into an eastern part and a western part; chert occurs as irregular beds 4 to 10 inches in thickness which are relatively resistent to weathering. The entire unit is extensively jointed; open joints are due to blasting, while others are filled with calcite and are due to post-depositional deformation. The calcite-filled joints are up to 5 inches in thickness and are slickensided. Joints cut across both the limestone and the cherty beds, suggesting that silicification of the beds preceded deformation. The upper 6.5 feet of this unit is almost entirely free of chert and consists of grey oolitic limestone. The upper (oolitic) part of unit C is replaced to the west by glauconitic beds, which may indicate a rapid facies change at this horizon. Megafossils other than palmatozoan parts are uncommon.

Petrographic description:

C - 43: Intraclast oosparite; intraclasts are composed of oolites.

46.7

B Shale, carbonaceous, grey to black, weathers grey to white; fossiliferous.

Remarks: This shale has weathered back several feet, producing a strong overhanging ledge formed by the overlying unit. The contact with unit C is abrupt and regular. The shale is highly carbonaceous and contains abundant fossil debris including crinoid parts, bryozoans, fragments of pelecypod shells, solitary corals, and brachiopods. Preservation is poor.

2.6

A Limestone and shale: limestone fossiliferous, oolitic in part, medium to coarsely crystalline, tan, weathers brown; bedding thin and irregular; shale partings concretionary, fossiliferous.

Remarks: These beds underlie the carbonaceous shale with an abrupt and regular contact. The base of the unit is not exposed.

1.7

Total thickness of exposures (excluding unit D): 131.8

APPENDIX II

REGISTER OF LOCALITIES

Descriptions of measured sections are indicated by page numbers following locations.

PO 1. NE $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 6, T. 1 N., R. 7 E., Pontotoc County, Oklahoma. (p. 206).

PO 2. 600 feet south and 90 feet east of NW cor. sec. 8, T. 1 N., R. 7 E., Pontotoc County, Oklahoma (p. 207).

PO 3. NE $\frac{1}{4}$ NW $\frac{1}{4}$ SE $\frac{1}{4}$ sec. 8, T. 1 N., R. 7 E., Pontotoc County, Oklahoma (p. 208).

PO 4. NE $\frac{1}{4}$ SE $\frac{1}{4}$ SE $\frac{1}{4}$ sec. 8, T. 1 N., R. 7 E., Pontotoc County, Oklahoma (p. 212).

C 5. NE $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 34 T. 1 S., R. 8 E., Coal County, Oklahoma (p. 230).

PO 6. SE $\frac{1}{4}$ SE $\frac{1}{4}$ sec. 15, T. 1 N., R. 7 E., Pontotoc County, Oklahoma (p. 214).

PO 7. NE $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 33, T. 3 N., R. 7 E., Pontotoc County, Oklahoma (p. 216).

PO 8. NE $\frac{1}{4}$ SE $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 34, T. 3 N., R. 7 E., Pontotoc County, Oklahoma (p. 218).

C 9. SW $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 18, T. 1 S., R. 9 E., Coal County, Oklahoma (p. 227).

C 10. Center NW $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 7, T. 1 S., R. 9 E., Coal County, Oklahoma (no section measured).

C 11. Center SL, SW $\frac{1}{4}$ sec. 4, T. 1 S., R. 8 E., Coal County, Oklahoma (no section measured).

C 12. SE $\frac{1}{4}$ SE $\frac{1}{4}$ sec. 3, T. 1 S., R. 8 E., Coal County, Oklahoma (p. 224).

C 13. SW $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 2, T. 1 S., R. 8 E., Coal County, Oklahoma (no section measured).

C 14. Along NL, NW $\frac{1}{4}$ sec. 19, T. 1 S., R. 9 E., Coal County, Oklahoma (p. 228).

J 15. Along SL, SE $\frac{1}{4}$ and SL, SW $\frac{1}{4}$ sec. 4, T. 2 S., R. 8 E., Johnston County, Oklahoma (p. 235).

J 16. NE $\frac{1}{4}$ NW $\frac{1}{4}$ sec. 22, T. 2 S., R. 8 E., Johnston County, Oklahoma (p. 238).

C 17. NE $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 30, T. 1 N., R. 8 E., Coal County, Oklahoma (p. 223).

A 18. NE $\frac{1}{4}$ sec. 31, T. 2 N., R. 13 E., Atoka County, Oklahoma (p. 251).

A 19. Center SL, NE $\frac{1}{4}$ sec. 15, T. 1 N., R. 12 E., Atoka County, Oklahoma, (p. 245).

A 20. NE $\frac{1}{4}$ SW $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 1, T. 1 N., R. 12 E., Atoka County, Oklahoma (p. 248).

PT 21. NW $\frac{1}{4}$ sec. 18, T. 4 N., R. 17 E., Pittsburg County, Oklahoma (p. 259).

PT 22. Center WL, SW $\frac{1}{4}$ SE $\frac{1}{4}$ sec. 10, T. 4 N., R. 17 E., Pittsburg County, Oklahoma (no section measured).

PT 23. N $\frac{1}{2}$ NW $\frac{1}{4}$ sec. 17, T. 4 N., R. 17 E., Pittsburg County, Oklahoma (p. 263).

J 24. Center WL, sec. 24, T. 2 S., R. 8 E., Johnston County, Oklahoma (p. 244).

C 25. SW $\frac{1}{4}$ SW $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 19, T. 1 N., R. 8 E., Coal County, Oklahoma (p. 219).

C 26. Center SE $\frac{1}{4}$ NW $\frac{1}{4}$ SE $\frac{1}{4}$ sec. 6, T. 1 S., R. 9 E., Coal County, Oklahoma (p. 226).

C 27. NE $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 30, T. 1 N., R. 8 E., Coal County, Oklahoma (p. 220).

J 28. Center NE $\frac{1}{4}$ SE $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 5, T. 2 S., R. 8 E., Johnston County, Oklahoma (p. 233).

J 29. SW $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 23, T. 2 S., R. 8 E., Johnston County, Oklahoma (p. 241).

J 30. NW $\frac{1}{4}$ NW $\frac{1}{4}$ sec. 22, T. 2 S., R. 8 E., Johnston County, Oklahoma (no section measured).

C 31. NW $\frac{1}{4}$ SE $\frac{1}{4}$ sec. 33, T. 1 S., R. 8 E., Coal County, Oklahoma (p. 232).

C 32. Center NL, SE $\frac{1}{4}$ sec. 30, T. 1 N., R. 8 E., Coal County, Oklahoma (no section measured).

C 33. NE $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 6, T. 1 S., R. 8 E., Coal County, Oklahoma (no section measured).

APPENDIX III

PETROGRAPHIC THIN-SECTION DATA

Explanatory note: The terminology used in this appendix is that proposed by Folk (1959a) for the petrographic description of limestones. Thin-sections are listed by localities (see Appendix II). Letters refer to the lithologic unit sampled (see Appendix I) and numbers refer to the distances (in foot-intervals) from the base of the unit at which the sample was collected. Percentages of allochems, orthochems, and terrigenous admixtures are based upon visual estimates from charts; diameters recorded represent the average for 25 randomly selected particles.

Petrographic thin-sections prepared for this study will be deposited with Dr. Charles J. Mankin at the University of Oklahoma.

LOCALITY, THIN-SECTION, PETROGRAPHIC DESCRIPTION	ALLOCHEMICAL CONSTITUENTS (%)	(mm.)	ORTHOCHEMICAL CONSTITUENTS (%)	(mm.)	TERRIGENOUS ADMIXTURES (%)	(mm.)
Locality PO 1						
A-7 Silty brachiopod biomicrudite: allochems, chonetid brachiopod valves; terrigenous admixtures, angular quartz silt (19%), pyrite (1%).	25	1.0	55	0.01	19	0.05
Locality PO 2						
A-1 Fossiliferous oosparrudite: allochems, tests of Millerella, Paramillerella.	40	1.0	59	1.0	-	
Locality PO 3						
D-4 Fossiliferous oosparrudite: allochems, fossil fragments, rare tests of Millerella; traces of glauconite, quartz silt, collophane(?), finely-divided hematite.	50	1.0	49	0.1	1	0.1
F-10 Oolitic biosparrudite: allochems, rimmed fossils (50%); orthochems (spar) replaced by hematite in part.	50	1.5	49	0.25	1	0.10
Locality PO 4						
B-1 Millerella biomicrosparrudite: fusulinids Millerella and Paramillerella abundant(10%)	30	1.4	70	0.05	-	
B-2 Biomicrosparrudite: allochems, oolites (30%), rimmed fossil fragments (10%), pellets (1%), finely-divided organic material.	50	1.5	50	0.001	trace	
Locality C 5						
A-1 Spiculiferous biosparite: monaxon spicules, mostly recrystallized; rare fusulinids (Millerella).	10	0.05	90	0.02	-	
B-1 Oosparite	50	0.70	50	0.05	-	

LOCALITY, THIN-SECTION, PETROGRAPHIC DESCRIPTION	ALLOCHEMICAL CONSTITUENTS (%)	(mm.)	ORTHOCHEMICAL CONSTITUENTS (%)	(mm.)	TERRIGENOUS ADMIXTURES (%)	(mm.)
Locality C 5 (cont'd)						
"D"-1 Limestone conglomerate: (base of Atoka Formation); clasts include limestone (Arbuckle?), oolite pebbles, fossils; orthochems, spar and replacement hematite; quartz silt.	87	10.0	10	0.01	3	0.25
Locality PO 7						
A-1 Fossiliferous oosparite: oolite rims with high organic content; orthochems (spar) partly replaced by hematite; cephalopod fragments; magnetite (1%).	40	0.40	59	3.0	1	0.01
Locality C 12						
A-7 Silty biomicrosparrudite: quartz grains angular.	85	1.0	14	0.01	1	0.15
C-15 Biosparite	55	0.5	45	0.4	-	
Locality J 15						
A-20 Oosparite: rock shows preferential leaching of oolites, rather than matrix (sparry calcite);20% rimmed fossils.	45	0.7	55	0.1	-	
A-70 Oosparite	45	0.8	55	0.05	-	
"D"-2 Limestone conglomerate: (base of Atoka Formation); clasts include limestone (Arbuckle?), oolite pebbles, some typical of Wapanucka oolite, others not; fossils; spar is replaced in part by authigenic hematite; terrigenous constituents, pyrite, glauconite, quartz silt.	75	(maximum size, cobbles)	22	0.50	3	
"E"-2 Silicified oolitic pelmicrite(?); (basal Atoka Formation) apparently replaced pelmicrite; some relic oolites(?); almost complete silicification of orthochems.	40	0.2	58	-	2	0.1
Locality J 16						
F-1 Fossiliferous biomicrosparrudite: allochems, pellets, fragments of *Millerella*; trace glauconite, quartz silt.	40	1.5	59	0.1	1	0.1

LOCALITY, THIN-SECTION, PETROGRAPHIC DESCRIPTION	ALLOCHEMICAL CONSTITUENTS (%)	(mm.)	ORTHOCHEMICAL CONSTITUENTS (%)	(mm.)	TERRIGENOUS ADMIXTURES (%)	(mm.)
Locality J 16 (cont'd)						
I-1 Fossiliferous oosparite and biosparrudite, zoned: allochems oolites and superficial oolites, intraclasts; minor pyrite; percentages for oolitic zones.	50	0.5	50	0.1	1	-
Locality C 17						
A-10 Biosparrudite	40	1.2	60	0.1		-
B-2 Oosparite: oolites and a few superficial oolites.	40	0.6	60	0.06		-
Locality A 18						
A-1 Spiculiferous, silty, biomicrite and biomicrosparite, zoned: all sponge spicules in this and other thin-sections from this locality (units A-N) appear to be monaxons; terrigenous admixtures include quartz silt, pyrite, magnetite, chlorite; hydrous iron oxide is present in many zones; recrystallization from microspar to spar common; percentages given here include micrite, microspar and spar; diameters recorded are maximums for orthochems and average for allochems, which are sponge spicules.	52	0.05	12	0.01	35	
C-4 Spiculiferous biomicrite-biomicrosparite	70	0.05	19	0.01	11	-
E-1 Spiculiferous, silty biomicrite-biomicrosparite	50	0.05	29	0.01	21	-
G-3 Silty biomicrite	45	0.05	24	0.008	31	-
I-11 Silty biosparite	45	0.05	29	0.12	26	-
J-3 Silty biomicrite-biomicrosparite	20	0.05	65	0.01	15	-
K-1 Silty biomicrosparite	30	0.05	39	0.01	31	-
M-1 Silty biomicrosparite; allochems include spiculiferous intraclasts.	32	0.75	57	0.01	11	-
O-1 Crinoidal biosparrudite: intraclasts form 5% of slide; orthochems are spar; terrigens, quartz, mica.	55	2.0	42	1.0	3	-

LOCALITY, THIN-SECTION, PETROGRAPHIC DESCRIPTION		ALLOCHEMICAL CONSTITUENTS (%)	(mm.)	ORTHOCHEMICAL CONSTITUENTS (%)	(mm.)	TERRIGENOUS ADMIXTURES (%)	(mm.)
Locality A 18 (cont'd)							
P-1	Sandy biomicrite: partly silicified; allochems, fossils; orthochems, micrite; terrigens, quartz grains.	15	0.05	55	0.004	30	0.07
Q-1	Crinoidal biosparrudite: terrigens, quartz (5%), mica.	55	1.5	39	0.5	6	0.2
R-24	Fossiliferous micrite: partly silicified; allochems, fossils, terrigens, quartz.	55	0.05	38	0.004	7	0.02
S-1	Fossiliferous oosparite: allochems, oolites, rimmed fossils; orthochems, spar; terrigens, quartz (3%), mica.	75	0.4	21	0.02	4	0.1
T-8	Biomicrosparite: partly silicified; allochems, fossils, terrigens, quartz (7%)	25	0.06	67	0.01	8	0.03
U-1	Silty biomicrite: partly silicified; allochems, fossils; terrigens, quarts (25%), mica (3%), hydrous iron oxide.	35	0.05	37	0.004	28	0.05
U-5	Biomicrite: contains sponge colonies (in place?)	-	-	-	-	-	-
U-8	Crinoidal biosparrudite: allochems, fossils (70%), intraclasts (5%); terrigens, quartz (8%), pyrite (2%), mica, hydrous iron oxide.	75	1.2	15	0.1	10	0.1
U-15	Oosparite: allochems, 70% oolites; terrigens, quartz.	74	0.3	25	0.5	1	0.05
U-34 U-53 U-58	Intraclast pelmicrite: allochems, intraclasts of micrite (5%), fossils (1%), pellets (50%); orthochems, spar (10%), microspar (4%), micrite (30%); terrigens, trace.	56	0.3-1.0	44	0.004-1.0	-	
Locality A 20							
E-4	Fossiliferous biosparrudite: terrigens include quartz silt, glauconite, pyrite.	80	0.8	19	0.05	1	0.05
I-10	Fossiliferous intramicrosparrudite: allochems, fossils (10%), intraclasts (25%), pellets (trace).	35	5.0	65	0.005	-	
Locality PT 21							
F-1	Spiculiferous intramicrosparite: intraclasts up to pebble-size, spiculiferous; few echinoid spines.	85	2.5	15	0.005	-	

LOCALITY, THIN-SECTION, PETROGRAPHIC DESCRIPTION	ALLOCHEMICAL CONSTITUENTS (%)	(mm.)	ORTHOCHEMICAL CONSTITUENTS (%)	(mm.)	TERRIGENOUS ADMIXTURES (%)	(mm.)
Locality PT 23						
C-43 Intraclast oosparrudite: allochems, oolites (27%), rimmed fossil fragments (10%), intraclasts (15%).	52	9.5	48	0.25	-	
D-10 Silty, spiculiferous pelmicrite: allochems, sponge spicules (10%), fossils (5%), pellets (35%); terrigens, quartz silt.	50	0.75	48	0.003	2	0.05
D-20 D-23 Spiculiferous intrapelmicrite: allochems, intraclasts (44%), sponge spicules; terrigens, quartz silt, finely-divided hydrous iron oxide; locally silicified.	44	12.0	54	0.003	2	0.05
F-1 Glauconitic biomicrosparite: allochems, fossil fragments; terrigens, glauconite, chlorite(?), quartz.	84	0.6	10	0.005	6	0.15
F-8 Biosparite: allochems, fossil fragments, pellets.	40	0.5	60	0.05	-	
Locality PT 23						
G-10 Dismicrite: rare tests of Millerella; spar in cavities.	1	0.1	99	0.001	-	
H-19 Biosparrudite: rare tests of Millerella; glauconite.	30	1.2	67	0.1	3	0.05
Locality C 27						
"E"-1 Limestone conglomerate: (base of Atoka Formation) clasts include limestone, oolite pebbles, fossil fragments.	60	9.0	39	-	1	0.05
Locality J 28						
B-1 Oolitic biosparrudite: partly silicified; allochems, oolites (8%), intraclasts (20%), rimmed fossils (20%), pellets (7%); terrigens, hematite, mica.	55	2.0	43	0.4	2	-
Locality J 29						
A-5 Oolitic biosparrudite: allochems, fossils (25%), oolites.	35	0.9	64	0.25	1	
B-2 Biomicrosparrudite: allochems, fossil fragments.	75	1.5	24	0.01	1	
C-17 Fossiliferous intrasparrudite: intraclasts (45%), fossils.	65	(max) 35.0	35	0.25	-	
D-3 Fossiliferous oosparrudite: all fossils rimmed.	40	1.2	60	0.3	-	
E-10 Pelletiferous dismicrite: allochems, pellets (7%), fossils	10	0.75	90	0.001	-	

APPENDIX IV

STATISTICAL PARAMETERS - RUGOSA

Explanatory note: The statistical parameters of the coral populations from the Wapanucka Formation are recorded (in millimeters); the following abbreviations are used.

Diameter (d) : measured in transverse thin-sections or in transverse cuts, in a direction normal to the cardinal-counter plane.

Tabularium diameter (d^t): measured along the same line and in the same section as (d).

Dissepimentarium diameter (d^d): equals $\frac{1}{2}$ ($d-d^t$); measured along the same line and in the same section as (d) and (d^t).

Height from apex (h): indicates the distance from the apex at which measurement was made; not recorded for corallites in which the apex is missing. As used here, (h) equals the vertical distance between the plane of the section and a parallel plane at the base of the apex; (h) therefore approximates length (along curvature) only in straight corallites. The observed ranges of total height for a given species is recorded in the systematic descriptions.

Number of major septa (n): direct count from transverse sections or from cut surfaces; does not include minor septa.

Septal ratio (n/d): equals number of major septa per 1 millimeter diameter; computed from (d) and (n).

Additional parameters, such as the arithmetic mean, tabularium ratio, standard deviation, standard error, and coefficient of variation can be computed from the recorded data.

Statistical Parameters - Rugosa

Empodesma aff. imulum Moore and Jeffords

No.	(d)	(n)	(h)	(n/d)
OU 4801	15.0	32	35.0	2.3
	10.0	31	15.0	3.1
	6.0	24	3.7	4.0

Stereocorypha cf. annectans Moore and Jeffords

No.	(d)	(n)	(h)	(n/d)
OU 4802	15.2	39	18.0	2.5
	14.2	38	13.0	2.6
	12.5	37	7.0	2.8
	11.0	36	4.0	3.2
54-u	12.0	34	-	2.8

Amplexocarinia corrugata (Mather)

No.	(d)	(n)	(h)	(n/d)
OU 4803	4.5	16	11.2	3.5
	4.0	16	10.2	4.0
	3.7	16	9.2	4.3
	3.4	16	8.5	4.7
OU 4804	5.0	22	28.0	4.4
	4.7	21	27.5	4.4
	4.5	-	26.5	-

Lophophyllidium idonium Moore and Jeffords

No.	(d)	(n)	(h)	(n/d)
OU 4807	11.5	27	12.6	2.3
OU 4808	12.0	28	13.0	2.3
OU 4809	11.8	28	12.3	2.3
OU 4810	9.5	26	15.5	2.7
38	7.5	24	11.0	3.2
49	8.0	26	11.5	3.2
59-a	8.0	25	10.3	3.1
88-b	6.7	24	12.0	3.5
72	6.1	20	9.7	3.2

Lophophyllidium minutum Jeffords

NO.	(d)	(n)	(h)	(n/d)
OU 4811	6.0	22	8.7	3.6
OU 4812	5.0	19	6.9	3.8
OU 4813	5.5	23	8.3	4.1
21-c	5.0	21	7.2	4.0
21-b	6.0	22	7.4	3.6
21-1	5.2	22	8.3	4.3
35-r-y	6.1	21	8.9	3.4
	6.0	21	9.7	3.5
	6.2	24	8.2	3.8
	6.1	20	9.1	3.2
	6.7	21	9.4	3.1
	5.1	21	8.8	4.1
	5.0	19	8.7	3.8
	4.8	20	7.3	4.1

Lophophyllidium ignotum Moore and Jeffords

No.	(d)	(n)	(h)	(n/d)
OU 4814	10.0	23	15.0	2.3
	8.5	22	10.0	2.5
OU 4815	9.5	23	11.7	2.4
	6.5	23	9.2	3.5

Lophophyllidium extumidum Moore and Jeffords

No.	(d)	(n)	(h)	(n/d)
OU 4816	10.0	24	14.1	2.4
	9.7	24	12.5	2.4
59-f	7.0	23	9.5	3.2
	7.8	23	14.5	2.9
	9.0	23	18.5	2.3

Lophophyllidium cf. mundulum Jeffords

No.	(d)	(n)	(h)	(n/d)
OU 4817	7.8	26	13.0	3.3
	7.5	26	11.5	3.4
	6.0	24	7.5	4.0
OU 4818	6.0	20	7.0	3.3
	6.5	24	9.5	3.6
	7.5	25	13.0	3.3
OU 4819	10.0	30	10.0	3.0

Lophophyllidium cf. angustifolium Moore and Jeffords

No.	(d)	(n)	(h)	(n/d)
OU 4820	9.5	24	15.5	2.5
OU 4821	9.0	26	14.8	2.8
OU 4822	6.7	24	13.5	3.5
OU 4823	8.5	25	14.7	2.9
21-g	7.2	26	13.2	3.7
30	9.2	28	20.3	3.0

Lophophyllidium new species A

No.	(d)	(n)	(h)	(n/d)
OU 4824	7.0	24	12.5	3.4
OU 4825	7.1	23	12.6	3.2
OU 4826	6.1	24	13.0	3.9
OU 4881	7.0	23	10.6	3.2
OU 4871	6.3	21	11.0	3.3
OU 4872	6.0	21	9.5	3.5
OU 4873	6.0	21	11.8	3.5
OU 4874	5.1	20	11.0	3.9
OU 4875	6.8	23	11.0	3.3
OU 4876	6.2	21	10.3	3.3
OU 4877	5.3	21	9.2	3.9
OU 4878	5.3	21	9.4	3.9
OU 4879	7.0	21	11.3	3.0
OU 4880	6.0	21	9.5	3.5

Lophophyllidium new species B

No.	(d)	(n)	(h)	(n/d)
OU 4827	12.0	29	23.5	2.4
	11.1	29	20.5	2.6
	8.5	26	13.0	3.0
OU 4828	9.5	26	13.8	2.7
	9.2	22	11.8	2.3
OU 4829	8.8	24	14.5	2.7
	8.0	24	10.0	3.0
	5.0	16	3.0	3.2
OU 4830	9.0	25	-	2.7
OU 4882	8.5	25	16.8	2.9
	7.6	24	11.8	3.2
	7.0	23	7.6	3.2

Lophophyllidium sp. "X"

No.	(d)	(n)	(h)	(n/d)
OU 4831	16.5	30	21.6	1.8
	13.5	30	14.1	2.2
OU 4832	11.5	30	20.0	2.6
	6.0	22	8.3	3.6
OU 4883	14.0	31	24.0	2.2
	12.8	29	18.0	2.2
	11.3	29	14.5	2.5

Lophomplexus new species C

No.	(d)	(n)		(h)	(n/d)
OU 4833	10.5	25		24.6	2.3
	8.0	25		-?-	3.1
OU 4834	9.5	23		22.0	2.4
	4.5	20		4.7	4.4
OU 4835	7.0	26	?	35.5	3.7
	6.5	22	?	11.5	3.3
OU 4836	9.0	23	?	26.0	2.5
	6.0	20	?	9.4	3.3

New genus M new species D

No.	(d)	(n)		(h)	(n/d)
OU 4844	9.5	24		30.3	2.5
	8.5	24		21.3	2.8
OU 4839	9.2	23		29.1	2.4
	6.0	22		5.5	3.6
OU 4840	10.0	26		-	2.6
	6.0	23		-	3.8
OU 4838	9.8	24		-	2.4
	7.0	24		-	3.4
OU 4842	9.2	24		20.5	2.5
	5.5	20		7.0	3.6
OU 4841	-	22		37.5	-
	8.0	22		25	2.7
OU 4843	13.5	23		27.9	1.7
	14.0	23		16.3	1.6
	4.7	22		3.5	4.6
OU 4884	8.5	26		-	3.0
	5.6	24		-	4.2
OU 4885	10.5	24	?	26.0	2.2
	5.8	21	?	8.0	3.6
OU 4886	8.0	25	?	30.2	3.1
	5.5	21	?	8.6	3.8

New Genus M new species E

No.	(d)	(n)	(h)	(n/d)
OU4846	12.0	26	47.3	2.1
	10.0	25	34.2	2.5
	8.5	24	21.8	2.8
	4.6	19	5.4	4.1
OU 4845	9.6	24	19.9	2.5
	6.0	24	5.1	4.0
OU 4885	9.8	26	-	2.6

Amplexizaphrentis tumidum (Moore and Jeffords)

No.	(d)	(n)	(h)	(n/d)
OU 4847	11.0	30	13.5	2.7
OU 4848	8.7	24	13.0	2.7
OU 4849	11.9	28	14.5	2.3

Amplexizaphrentis cf. crassiseptatum (Moore and Jeffords)

No.	(d)	(n)	(h)	(n/d)
OU 4850	7.5	30	11.4	4.0
	5.5	26	7.1	4.7

Amplexizaphrentis sp.

No.	(d)	(n)	(h)	(n/d)
OU 4851	4.5	22	13.0	4.8

Barytichisma crassum Moore and Jeffords

No.	(d)	(n)	(h)	(n/d)
OU 4852	16.0	35	20.0	2.1
	9.5	29	14.0	3.0
	8.5	29	6.0	3.4
OU 4853	15.0	31	25.4	2.0
	11.5	31	15.5	2.6
	6.5	26	11.0	4.0
OU 4854	13.0	34	19.3	2.6
OU 4855	20.0	37	23.0	1.8
	9.5	34	12.5	3.5
69-a	18.5	39	22.5	2.1
4	15.8	36	22.5	2.2
	12.5	35	17.5	2.8
	12.2	35	10.0	2.8

Barytichisma callosum Moore and Jeffords

No.	(d)	(n)	(h)	(n/d)
OU 4858	27.0	44	58.8	1.6
	23.6	44	53.5	1.4
	18.4	43	38.8	2.3
	11.0	?35	17.8	3.1
OU 4886	23.5	50	36.0	2.1

Barytichisma repletum Moore and Jeffords

No.	(d)	(n)	(h)	(n/d)
OU 4856	11.0	36	14.4	3.2
OU 4857	15.5	39	18.7	2.5
	8.0	25	7.5	3.1

Koninckophyllum simplex (Moore and Jeffords)

No.	(d)	(d^t)	(d^d)	(n)	(h)	(n/d)
OU 4859	21.5	15.0	3.2	41	44.4	1.4
	18.5	13.5	2.5	38	28.7	2.0
	10.5	7.5	1.5	31	11.7	2.9
OU 4860	20.5	11.0	4.2	47	44.0	2.2
	24.5	16.0	4.3	47	30.9	1.9
	20.0	13.5	3.2	44	18.5	2.2
91-a	16.0	9.0	3.5	36	?19.0	2.2
91-c	16.5	12.0	2.2	39	13.5	2.3
91-b	19.0	11.0	4.0	38	23.3	2.0
91-d	26.0	15.0	5.5	44	28.5	1.6

(K. simplex, continued)

No.	(d)	(d^t)	(d^d)	(n)	(h)	(n/d)
54-c	15.0	-	-	40	21.4	2.6
54-b	22.0	14.0	4.0	43	-	1.9
54-a	23.0	16.0	3.5	42	49.0	1.8
54-d	15.4	11.0	2.2	37	-	2.4
54-i	19.0	12.0	3.5	36	-	1.8
54-k	19.5	12.5	3.5	36	-	1.8
54-n	20.0	12.0	4.0	37	-	1.8
54-j	17.5	12.5	2.5	37	29.0	1.5
54-r	24.0	14.0	5.0	39	39.0	1.6
81	19.0	11.0	4.0	37	?43.0	1.9

Koninckophyllum new species F

No.	(d)	(d^t)	(d^d)	(n)	(h)	(n/d)
OU 4861	29.0	15.0	7.0	45	42.0	1.5
	13.0	10.0	1.5	33	12.2	2.5
	4.0	4.0	0	?16	4.2	4.0
OU 4862	22.4	11.0	5.7	36	48.0	1.6
OU 4863	19.0	13.0	3.0	41	25.3	2.1
	11.5	9.5	1.0	31	8.3	2.6
OU 4887	25.0	16.0	4.5	45	?32.0	1.6
OU 4888	27.0	13.0	7.0	44	?55.0	1.6
OU 4889	25.0	18.0	3.5	45	?27.0	1.8

Koninckophyllum gracile (Moore and Jeffords)

No.	(d)	(d^t)	(d^d)	(n)	(h)	(n/d)
OU 4864	15.0	13.0	1.0	34	-	2.2
OU 4865	14.5	12.5	1.0	30	?17.0	2.0
OU 4866	15.6	11.0	2.3	-	17.5	-

Pseudozaphrentoides nitellus Moore and Jeffords

No.	(d)	(d^t)	(d^d)	(n)	(h)	(n/d)
OU 4867	9.6	6.0	1.8	28	37.0	2.9
	12.0	7.6	2.2	28	23.2	2.3
OU 4868	20.0	13.2	3.4	34	-	1.7
40	9.0	6.0	1.5	26	15.0	2.8
37	10.0	7.0	1.5	23	12.3	2.3
69-e	14.0	8.0	3.0	23	12.7	1.6
45-c	11.0	7.0	2.0	-	27.0	-

Dibunophyllum sp.

No.	(d)	(d^t)	(d^d)	(n)	(h)	(n/d)
OU 4870	17.0	12.0	2.5	30	-	1.7
	16.0	12.0	2.0	30	-	1.8
	14.4	11.0	1.7	30	-	2.0
	13.0	10.0	1.5	28	-	2.1

APPENDIX V

TERMINOLOGY USED IN CORAL DESCRIPTIONS

acceleration of septal insertion: increase in the rate of septal insertion; typically occurs in counter quadrants.

amplexoid septa: (brevisepta of authors): septa whose greatest length is along the distal (upper) surface of tabulae, as in *Amplexus*, *Barytichisma*.

apical: refers to the lowermost (proximal, immature) portion of a corallite.

aulophylloid trend: a phylogenetic increase in the complexity of the axial structure of some coral genera.

axial region: refers to the central area of a corallite; adjacent to the coral axis.

axis: the mid-line of a corallite; may be used to designate the position of structures (e.g., axial tabellae, axial column).

brephic: (nepionic of authors): earliest recognized stage of growth, during which the six protosepta are inserted.

calyx: (calice of authors): the uppermost (distal, oral) surface of the corallite, typically bowl-shaped, to which the coral polyp was attached.

closed fossula: cardinal fossula restricted by joined axial ends of adjacent metasepta of cardinal quadrant.

column: (columella, pseudocolumella, axial structure, etc.): a general term used in this study to designate any type of axial structure.

contratingent: refers to minor septa which lean on adjacent major septa on their counter sides.

<u>cyathophylloid trend</u>: tendency of corallites to change progressively from bilateral to radial symmetry.

<u>dibunophylloid column</u>: web-like axial structure characteristic of the genus <u>Dibunophyllum</u>, with medial plate, radiating septal lamellae, and axial tabellae.

<u>dissepiments</u>: small, cyst-like or vesicular domed plates which occur typically in a peripheral zone around tabularium.

<u>dissepimentarium</u>: (dissepimental zone): peripheral area within a corallite occupied by dissepiments.

<u>ephebic</u>: growth-stage in which adult (mature, specific) characters are fully developed.

<u>epitheca</u>: (theca of authors): outer skeletal wall surrounding corallite.

<u>fossula</u>: depression in floor of calyx formed by the suppression of the cardinal septum, or rarely the counter septum; the cardinal fossula, when present, can be recognized in thin-sections through most growth-stages.

<u>holotheca</u>: outer wall of skeletal material surrounding the basal portion of a corallum, i.e., coral colony.

<u>incomplete tabulae</u>: tabulae which do not extend uninterrupted across the tabularium, or from the peripheral edge of the tabularium to the column; composed of smaller, inosculating, plate-like elements.

<u>inner wall</u>: secondary thickening of dissepiments bordering on tabularium, which forms a more or less distinct wall at this point, as in <u>Koninckophyllum</u>.

<u>interseptal ridges</u>: longitudinal elevations on the exterior of the epitheca which correspond in position to interseptal areas within the corallite.

<u>major septa</u>: protosepta and metasepta.

<u>medial lamella</u>: a lamellar structure which lies in the cardinal-counter plane and comprises part of the axial structure; if well-developed, may be termed a <u>medial plate</u>.

<u>metasepta</u>: septa which are inserted pinately at four points, subsequent to the insertion of the protosepta; insertion is on either side of the counter septum and on the cardinal side of the alar septa; does not include protosepta or minor septa.

minor septa: comparatively short septa which may be inserted between major septa.

monocanthine trabeculae: trabeculae in which fibrous skeletal elements are related to single centers of growth which shift progressively upward and axially along the septa.

mural pores: subcircular openings through the walls of adjacent corallites in some tabulate corals, as in Favosites, Michelinia.

neanic: (immature, adolescent): the juvenile stages of growth of a corallite; growth-stages between brephic and ephebic stages.

open fossula: cardinal fossula not restricted by axial ends of adjacent metasepta of counter quadrants.

protosepta: the six first-formed septa in rugose corals; includes the cardinal septum (C), the counter septum (K), which is opposite in position, and two intervening alar septa (A).

quadrant: one of four areas within a corallite, bounded by the cardinal septum and an alar septum, or the counter septum and an alar septum.

rhabdacanthine trabecuale: trabeculae in which skeletal fibers are related to numerous separate, irregularly disposed centers which are in turn grouped around a main center.

rhopaloid septa ("club-shaped" septa of authors) septa which are thickened axially.

rootlets: (radiciform processes of authors): outgrowths of epitheca at or near apex of corallite for attachment.

septal formula: an abbreviated notation which designates the position, sequence, and number of major septa; tabulated clockwise (when corallite is viewed from above; thus, the formula K4A3C3A4K indicates: counter septum (K), four metasepta, alar septum (A), three metasepta, cardinal septum (C), three metasepta, alar septum (A), four metasepta, and the counter septum (K) once more. Notation does not include minor septa.

septal grooves: longitudinal depressions on the exterior of the epitheca which correspond in position to the septa within the corallite.

septal lamellae: radially disposed elements comprising part of the axial structure of some corals which may be aligned with, but typically are not continuous with, the septa.

<u>septa</u>: radially disposed vertical skeletal elements within a corallite; may be comprised of trabeculae.

<u>solitary corals</u>: (simple corals, "horn" corals): individual corallites which do not form part of a coral colony (corallum).

<u>stereoplasm</u>: (Lamellar sclerenchyme and stereone of authors): calcareous skeletal deposits, often at the periphery or in the axial region of corallites; assumed due to secondary deposition by most authors.

<u>tabellae</u>: small subhorizontal or domed plates which may replace complete tabulae in axial region; if tabellae contribute to the structure of the axial column, they may be called axial tabellae.

<u>tabularium</u>: space within a corallite occupied by tabulae (or tabellae).

<u>trabeculae</u>: pillars of more or less organized groups of radiating skeletal fibers, which form the septa of some rugose corals.

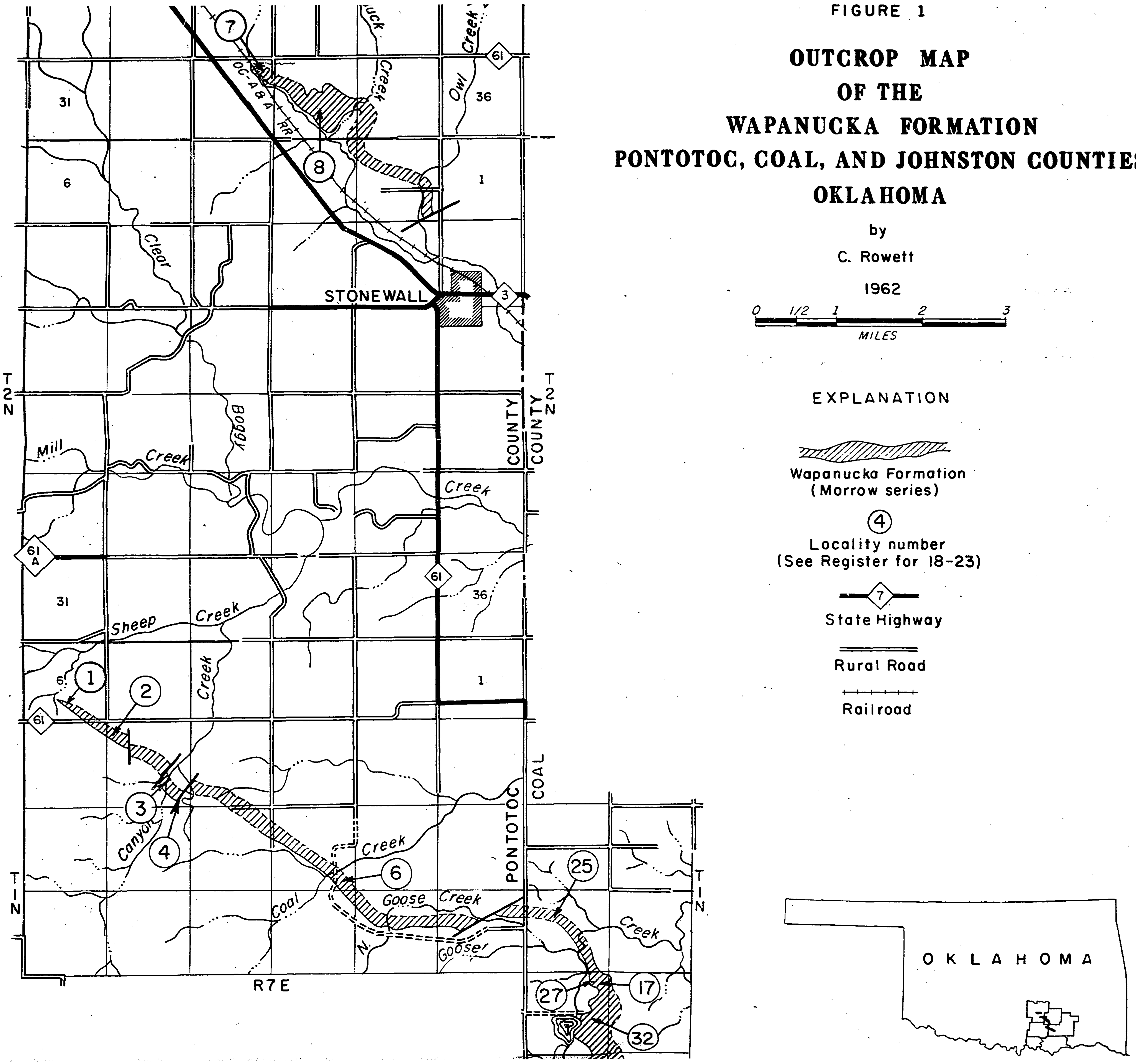
FIGURE 1

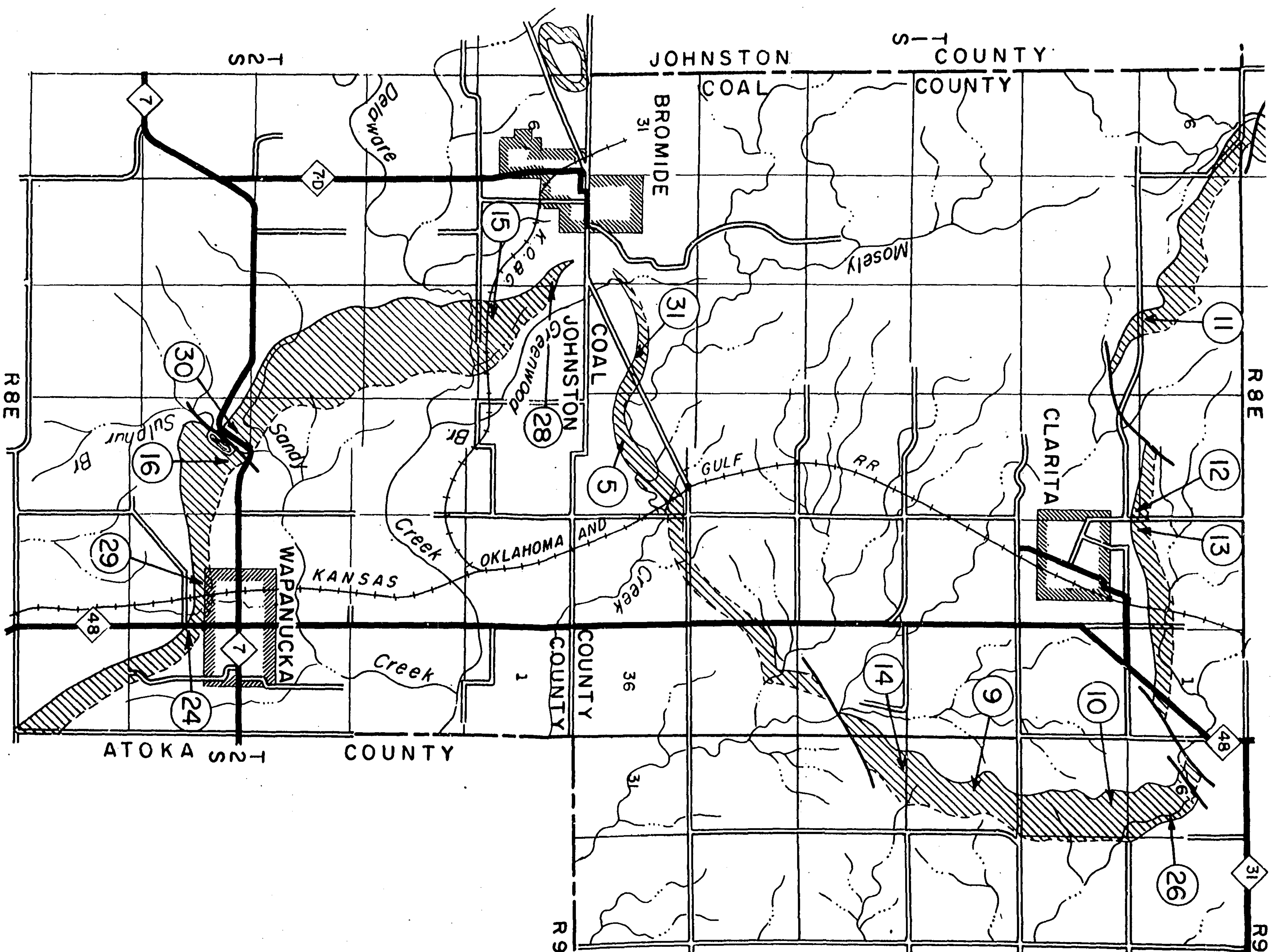
OUTCROP MAP OF THE WAPANUCKA FORMATION PONTOTOC, COAL, AND JOHNSTON COUNTIES OKLAHOMA

by

C. Rowett

1962



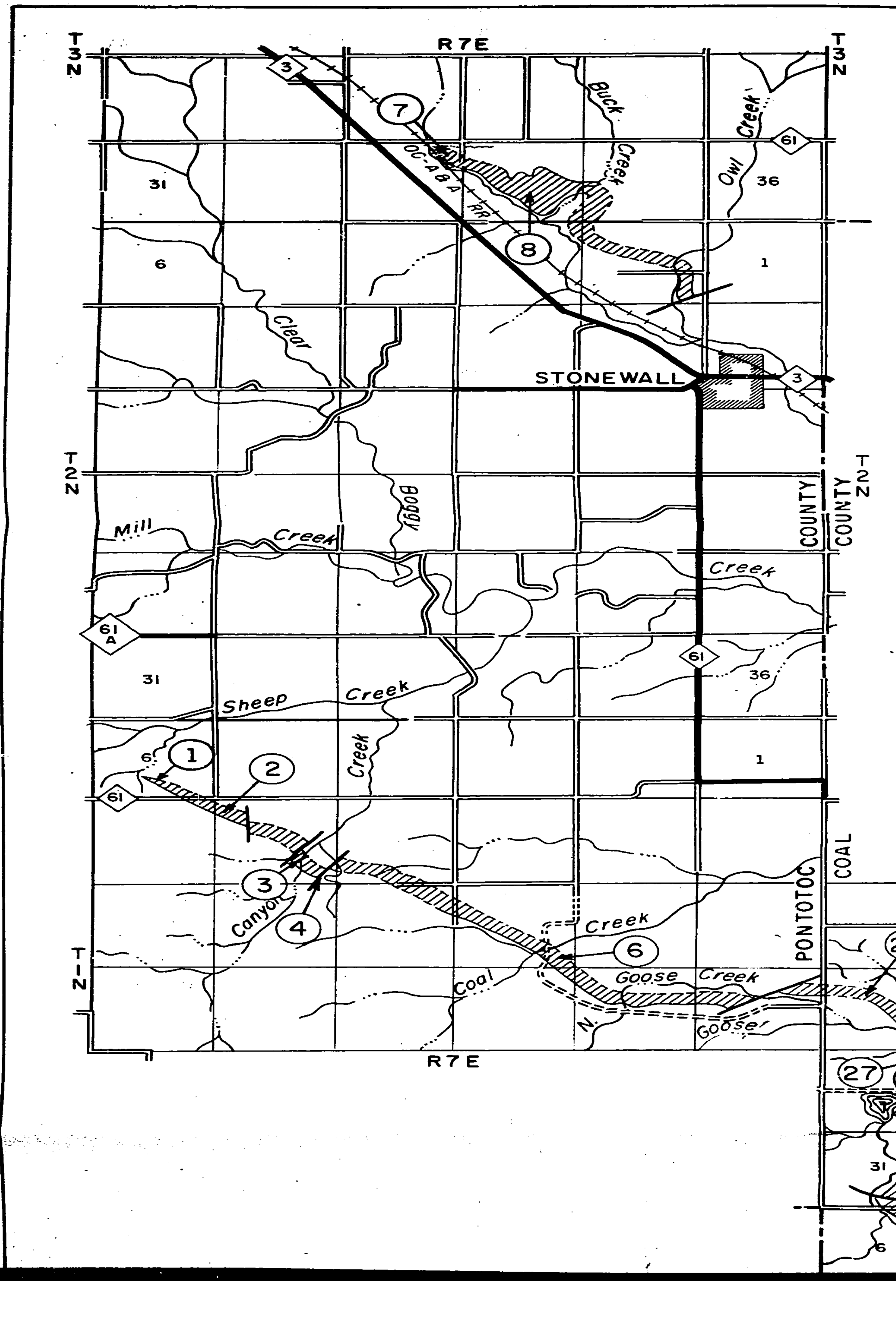


JOHNSTON COUNTY
COAL COUNTY
BROMIDE
CLARITA
WAPANUCKA
JOHNSTON COUNTY
COAL COUNTY
ATOKA COUNTY
KANSAS OKLAHOMA AND GULF RR
K.O.& G.
Delaware
Mosely
Greenwood Br.
Sulphur Br
Sandy
Creek
Creek
Creek
R8E
R8E
R9E
R9E
T-2-S
T-2-S
T-2-S
T-2-S
7
7D
7
48
48
31
1
5
9
10
11
12
13
14
15
16
24
26
28
29
30
31

	PO 3	PO 4	PO 6	PO 7	PO 8	C 9	C 12	C 13	C 14	J 15	J 16	C 17	A 18	A 19	A 20	PT 21	PT 23	J 24	C 25	C
imilum																		F		
f. annectans													U							
corrugata													U							
ignotum																	B			
minutum		A																		
idonium	D	A									D							F		A
extumidum																	B	F		
cf. angustifolium		A																		
cf. mundulum											D									
new species A		A																		
new species B																H	B			
species X		A																		
species D	A	A																		
species E	A	A																		
is tumidum		A											C	E						
is cf. crassiseptatum											D									
is sp.																	B			
llosum	D	A																F		
ssum	D	A										A								
letum	D	A																		
r species C	A	A																		
.													U							
simplex	F												U	E	I	J				
gracile													U	E	I					
new species F			A									A								
des nitellus	D			A		B			A			A		E						
losa	ADF	A		AB	B	B						A								A
ata				A							D		U					F	F	A
cula	A	A		A								A								A
rosa		A		A														F		
ta					B															
giosa																				
lindrica		A																		
ilis		A																		
sensis	F																			
	C			AB																
				A																
sis	AF			A							AD							F		
	D															C				
rrowensis						B				A										
tus				A																
osus				A																
branneri				AB		B														
sasensis	F																			
aneyanum								A	D	A										
noxense	AF	A		B					D					B	A	C				
	F								D											
carinatus													C		AE					
nus													C							
ayvillense	A	A				B		A		A										
	A	A																		
narius															E					
rbonaria	F																F			
iscoides				A																
nemites) cf. pernodosus				A																
niscapha) subrugosus	DF											A								
pecies	A																			
s	A	A		A							A	A								
obsoletus						B														
.						B														
	DF																			
riata	F							A									B			
arica	AD	A																		
				A																
	A	A				B		A												
morrowensis	A																			
species	D																			
cies	DF	A																		
p.	A																			
	A					B	A		D		F					B				
leri	D					B	C													
missouriensis	AF	A	B				C		D		D	B				C		F		
muricatina	A	A									A									
kensis																				
	AD																			
rowensis	D	A			B				CD	A	D					H	B	F		
	F																			
	A	A		A	B		C				AD	A				B				
.									C											
es			B																	
new species	F																			
ahomensis	ADF	A				B	A		D		A	B					B			
resupinoides				A		C			D						B					
ana	D								D											
.	DF	A																		
oconvexa			B								D									
num				A							D									
spatulatum				B					B											
gentea	F					C					D									A
ita	F		B			C				A	D	A								
	F		B			C			D	A	D	A								A
.	F		B			C			D	A	D	A						F		
a	D		B			C	A		D		D									
ata											D									
	ADF	A	B	A			C		D		D								A	
	D			AB							D									
											D									
odensis	ADF	A	B	A	B	C	C		D		D	A							A	A
lcosta	AF		B			C	C		D		D				B					
fer	D	A																		
ensis		A							C		AD							F		
inus		A																		
	D	A									D									
nus	AF	A		A					C		AD	B								
	ADF	A		AB		B	A		D	A	D	A	U		A	C		F		
anus							C		D			A								
	F	A	B		B	B	AC		CD		D									
dentalis	A			AB					D	A	A				B					A
ntuckiensis	ADF			AB								A						F		
mpestris	ADF	A	B	AB		C	C		D		D							F		
cus	F																			
tus	ADF	A		A	B							AB								A
homensis	ADF	A				BC	A		B	A	A	B						F		A
eri	F								B		D									
dum	AF	A																		
fosteri	DF	A							B				P			H		F		
species	A					C														A
morrowensis	A	A																		
						C										H				
i	ADF											B								
panucka	F																			
formosus	A																			
deltoideus	D	A		A							D	B								
atoka											D									A
asymmetricus	DF	A																		A
turris	F																			A
cf. springeri																				A
disculus	D			A																A
new species						B					A							F		A

Figure 7
DISTRIBUTION OF SPECIES IN THE WAPANUCKA FORMATION
Note: Letters A-U refer to lithologic units at the indicated localities
(See Appendix I)

C. Rowett – 1962



T 3 N
R7E
T 2 N
T 1 N
STONEWALL
PONTOTOC
COUNTY
COAL
COUNTY
Buck Creek
Owl Creek
OC-A & A RR
Clear
Boggy
Mill
Creek
Sheep
Creek
Canyon
Creek
Coal
Goose
Creek
N. Goose
61
61 A
3
1
2
3
4
6
7
8
27
31
36

FIGURE 1

OUTCROP MAP OF THE WAPANUCKA FORMATION PONTOTOC, COAL, AND JOHNSTON COUNTIES OKLAHOMA

by

C. Rowett

1962

EXPLANATION

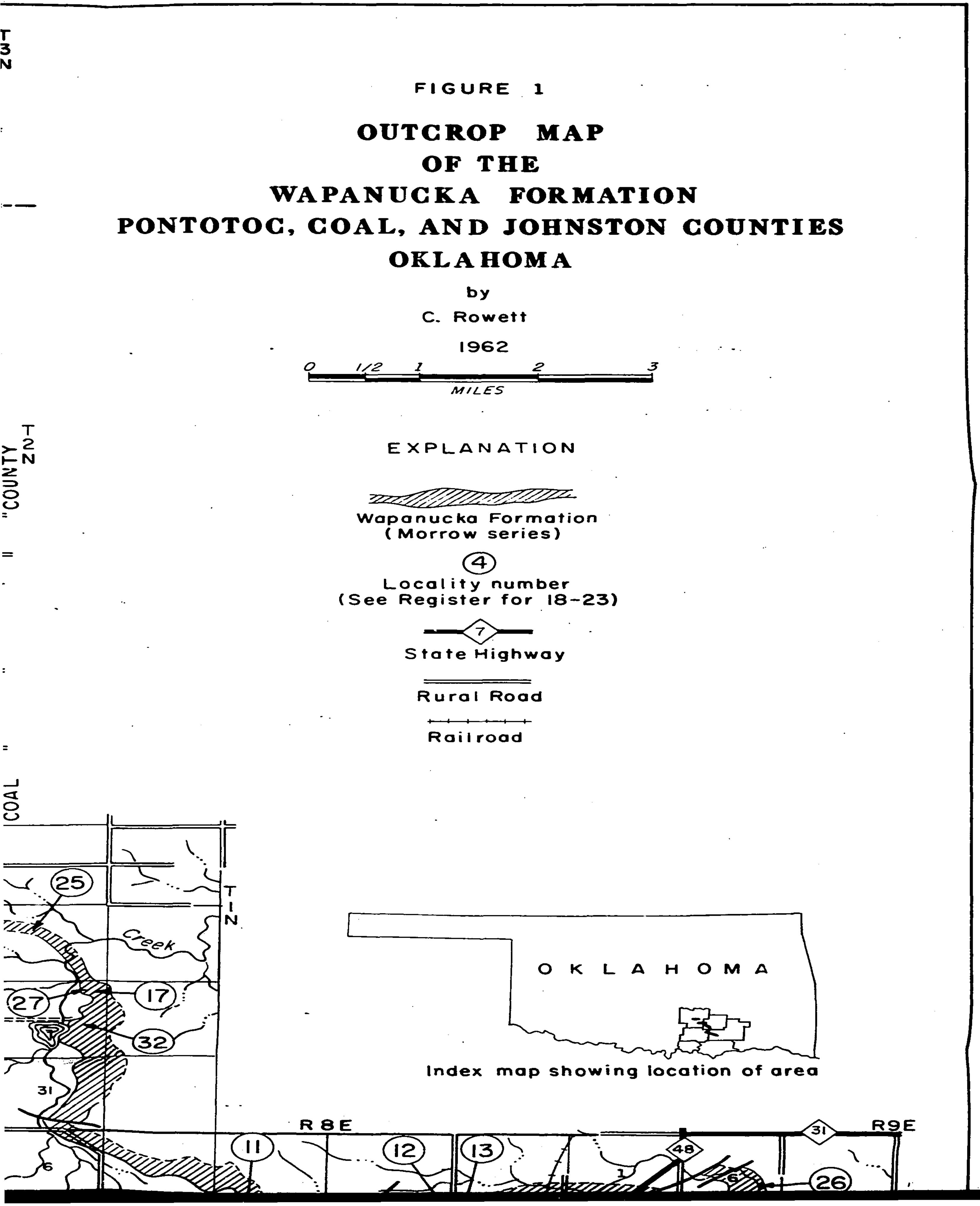
Wapanucka Formation
(Morrow series)

Locality number
(See Register for 18-23)

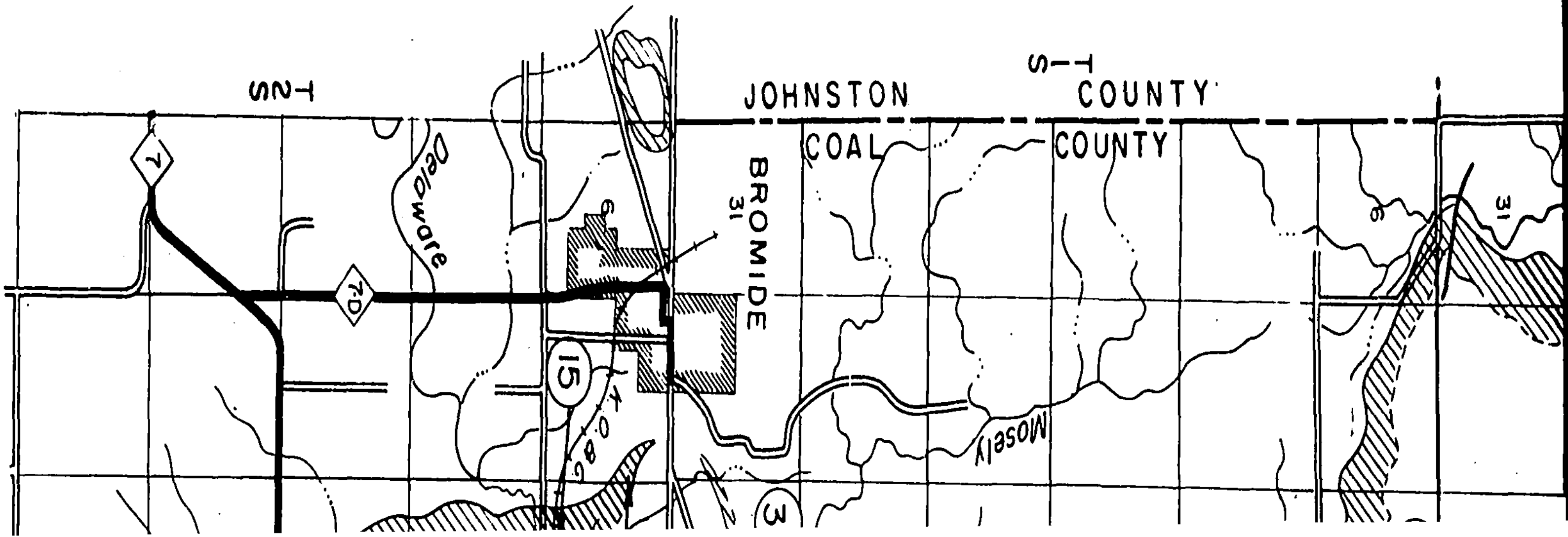
State Highway

Rural Road

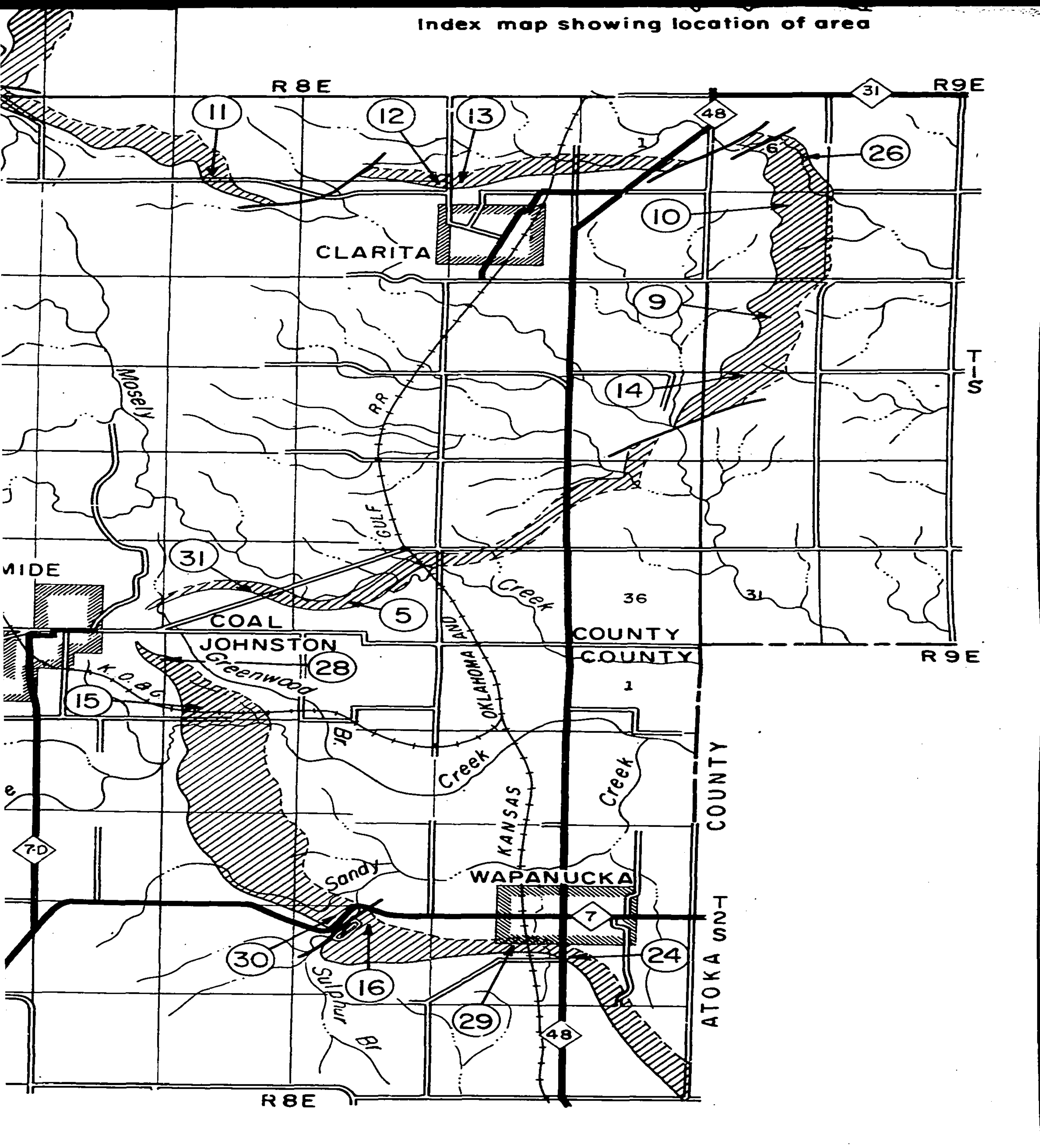
Railroad



Index map showing location of area



JOHNSTON COUNTY
COAL COUNTY
BROMIDE
31
Delaware
Mosely
15



Index map showing location of area
R 8 E
R 9 E
11
12
13
26
10
9
14
CLARITA
T 1 S
Mosely
RR
GULF
31
5
MIDE
COAL
JOHNSTON
COAL COUNTY
JOHNSTON COUNTY
Greenwood
28
15
K.O.& G.
Creek
36
OKLAHOMA AND KANSAS
Br.
Creek
Creek
ATOKA COUNTY
7-D
Sandy
WAPANUCKA
7
48
31
T 2 S
30
24
16
Sulphur Br.
29
R 8 E
R 9 E

	PO 3	PO 4	PO 6	PO 7	PO 8	C 9	C 12	C 13	C 14	J 15	J 16	C 17	A 18	A 19	A 20	PT 21	PT 23	J 24	C 25	C 26	C 27	J 28	J 30
RUGOSA																							
Empodesma aff. imulum																		F					
Stereocorypha cf. annectans													U										
Amplexocarinia corrugata													U										
Lophophyllidium ignotum																	B						
Lophophyllidium minutum		A																					
Lophophyllidium idonium	D	A									D							F		A			
Lophophyllidium extumidum																	B	F					
Lophophyllidium cf. angustifolium		A																					
Lophophyllidium cf. mundulum											D												
Lophophyllidium new species A		A																					
Lophophyllidium new species B																H	B						
Lophophyllidium species X		A																					
New genus M new species D	A	A																					
New genus M new species E	A	A																					
Amplexizaphrentis tumidum		A											C	E									
Amplexizaphrentis cf. crassiseptatum											D												
Amplexizaphrentis sp.																	B						
Barytichisma callosum	D	A																F			A	A	
Barytichisma crassum	D	A										A									C		
Barytichisma repletum	D	A																					
Lophamplexus new species C	A	A																					
Dibunophyllum sp.													U										
Koninckophyllum simplex	F												U	E	I	J					C		
Koninckophyllum gracile													U	E	I								
Koninckophyllum new species F			A									A									C		
Pseudozaphrentoides nitellus	D			A		B			A			A		E							C		
TABULATA																							
Michelinia scopulosa	ADF	A		AB	B	B						A								A			
Michelinia spissata				A							D		U					F	F	A			
Michelinia tenuicula	A	A		A								A								A			
Michelinia latebrosa		A		A														F					
Michelinia referta					B																		
Striatopora religiosa																					B		
Acaciapora subcylindrica		A																					
Cladochonus fragilis		A																					
Cladochonus texasensis	F																						
SCYPHOZOA																							
Conistichus sp.	C			AB																	A		
Conularia sp.				A																			
ARTHROPODA																							
Paladin morrowensis	AF			A							AD							F					
Griffithides sp.	D															C							
AMMONOIDEA																							
Cravenoceras? morrowensis						B				A													
Eoasianites oblatus				A																			
Eoasianites globosus				A																			
Gastrioceras cf. branneri				AB		B																	
Pronorites arkansasensis	F																						
Owenoceras cf. caneyanum								A	D	A													
NAUTILOIDEA																							
Pseudorthoceras knoxense	AF	A		B					D					B	A	C							
Liroceras sp.	F								D														
GASTROPODA																							
Pharkidonotus percarinatus													C		AE								
Bellerophon crassus													C										
Glabrocingulum grayvillense	A	A				B		A		A													
Worthenia sp.	A	A																					
Euphemites carbonarius															E								
Shansiella cf. carbonaria	F																F						
Trepospira cf. discoides				A																			

Gastrioceras cf. branneri				AB		B																	
Pronorites arkansasensis	F																						
Owenoceras cf. caneyanum								A	D	A													
NAUTILOIDEA																							
Pseudorthoceras knoxense	AF	A		B					D					B	A	C							
Lirooceras sp.	F								D														
GASTROPODA																							
Pharkidonotus percarinatus													C		AE								
Bellerophon crassus													C										
Glabrocingulum grayvillense	A	A				B		A		A													
Worthenia sp.	A	A																					
Euphemites carbonarius															E								
Shansiella cf. carbonaria	F																F						
Trepospira cf. discoides				A																			
Straparolus (Euphemites) cf. pernodosus				A																			
Straparolus (Amphiscapha) subrugosus	DF											A											
PELECYPODA																							
Schizodus? new species	A																						
Platyceras parvum	A	A		A							A	A											
Parallelodon cf. obsoletus						B																	
Aviculopecten sp.						B																	
Myalina sp.	DF																						
Nuculana bellistriata	F							A									B						
Astartella cf. varica	AD	A																					
Allorisma? sp.				A																			
Nucula parva	A	A				B		A															
BRACHIOPODA																							
Orbiculoidea cf. morrowensis	A																						
Heteralosia new species	D																						
Krotovia new species	DF	A																					
?Echinoconchus sp.	A																						
Buxtonia sp.	A					B	A		D		F					B							
?Protoniella welleri	D					B	C																
Desmoinesia cf. missouriensis	AF	A	B				C		D		D	B				C		F					
Desmoinesia cf. muricatina	A	A									A												
Juresania nebraskensis																							
Juresania sp.	AD															H	B						
Antiquatonia morrowensis	D	A			B				CD	A	D							F					
Antiquatonia sp.	F																						
?Ovatia nodosus	A	A		A	B		C				AD	A				B							
Linoproductus sp.									C														
Derbya new species			B																				
Streptorhynchus new species	F																						
Schizophoria oklahomensis	ADF	A				B	A		D		A	B					B						
Schizophoria cf. resupinoides				A		C			D						B								
Schizophoria texana	D								D														
Schuchertella sp.	DF	A																					
Crurithyris planoconvexa			B								D												
Dielasma arkansanum				A							D												
Dielasma cf. subspatulatum				B					B														
Composita cf. argentea	F					C					D									A			
Composita subtilita	F		B			C				A	D	A											
Composita ovata	F		B			C			D	A	D	A								A			
Composita gibbosa	F		B			C			D	A	D	A						F			D		
Composita elongata	D		B			C	A		D		D												
Composita trilobata											D												
Composita sp.	ADF	A	B	A			C		D		D								A				
Hustedia mormoni	D			AB							D										D		
Hustedia miseri											D												
Hustedia brentwoodensis	ADF	A	B	A	B	C	C		D		D	A							A	A			
Rhynchopora magnicosta	AF		B			C	C		D		D				B						AD		
Chonetes granulifer	D	A																					
Chonetes chateauensis		A							C		AD							F					
Chonetes cf. dominus		A																					

Streptorhynchus new species	F																						
Schizophoria oklahomensis	ADF	A				B	A		D		A	B					B						
Schizophoria cf. resupinoides				A		C			D						B								
Schizophoria texana	D								D														
Schuchertella sp.	DF	A																					
Crurithyris planoconvexa			B								D												
Dielasma arkansanum				A							D												
Dielasma cf. subspatulatum				B					B														
Composita cf. argentea	F					C					D									A			
Composita subtilita	F		B			C				A	D	A											
Composita ovata	F		B			C			D	A	D	A								A			
Composita gibbosa	F		B			C			D	A	D	A						F			D		
Composita elongata	D		B			C	A		D		D												
Composita trilobata											D												
Composita sp.	ADF	A	B	A			C		D		D								A				
Hustedia mormoni	D			AB							D										D		
Hustedia miseri											D												
Hustedia brentwoodensis	ADF	A	B	A	B	C	C		D		D	A							A	A			
Rhynchopora magnicosta	AF		B			C	C		D		D				B						AD		
Chonetes granulifer	D	A																					
Chonetes chateauensis		A							C		AD							F			A		
Chonetes cf. dominus		A																					
Chonetes laevis	D	A									D												
Chonetes arkansanus	AF	A		A					C		AD	B									A		
Spirifer goreii	ADF	A		AB		B	A		D	A	D	A	U		A	C		F			A	A	A
Spirifer rockmontanus							C		D			A											
Spirifer opimus	F	A	B		B	B	AC		CD		D										AD		
Spirifer cf. occidentalis	A			AB					D	A	A				B					A	A		C
Punctospirifer kentuckiensis	ADF			AB								A						F					
Reticulariina? campestris	ADF	A	B	AB		C	C		D		D							F					
BLASTOIDEA																							
Pentremites rusticus	F																						
Pentremites angustus	ADF	A		A	B							AB								A			
CRINOIDEA																							
Ethelocrinus oklahomensis	ADF	A				BC	A		B	A	A	B						F		A			
Ethelocrinus sphaeri	F								B		D												
Cibolocrinus tumidus	AF	A																					
Morrowcrinus aff. fosteri	DF	A							B				P			H		F		A			
Diphuicrinus new species	A					C																	
Allocatillocrinus morrowensis	A	A																					
?Cromyocrinus sp.						C										H							
Delocrinus matheri	ADF											B											
Paradelocrinus wapanucka	F																						
Synerocrinus aff. formosus	A																						
Paragassizocrinus deltoideus	D	A		A							D	B								A			
Paragassizocrinus atoka											D									A	D		
Paragassizocrinus asymmetricus	DF	A																		A	A		
Paragassizocrinus turris	F																			A			
Paragassizocrinus cf. springeri																				A			
Paragassizocrinus disculus	D			A														F					
Paragassizocrinus new species						B					A									A			

Figure 7

DISTRIBUTION OF SPECIES IN THE WAPANUCKA FORMATION

Note: Letters A-U refer to lithologic units at the indicated localities

(See Appendix I)

C. Rowett - 1962