NEW PERMIAN CORALS FROM KANSAS, OKLAHOMA, AND TEXAS

By
RAYMOND C. MOORE and
RUSSELL M. JEFFORDS

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both the richness of the coral faunas and the extensive nature of researches on them. In North America, however, less than a dozen kinds of Permian corals have been reported, and descriptions are scattered in about half as many papers.

Previous Studies

Important papers on Permian corals outside of North America include the following: from Australia, by Etheridge (1891) and Hill (1937); from Japan and Korea, by Yabe and Hayasaka (1915, 1916) and Hayasaka (1932); from China, by Grabau (1922, 1928, 1931, 1936), Chi (1935, 1937, 1938), Yu (1934), and Huang (1932, 1932a); from Timor, by Beyrich (1865), Rothpletz (1892), Penecke (1908), Gerth (1921, 1922), Koker (1924), and Heritsch (1937a); from the Salt Range of India, by Waagen and Wentzel (1886), Sen (1931, 1931a, 1931b), and Heritsch (1937a); from Iran, by Heritsch (1933a), and Douglas (1936); from Turkey, by Abich (1878), and Heritsch (1937a); from the U.S.S.R., by Toula (1875), Dobrolyubova (1936), Soschkina (1925, 1928, 1932, 1936), and Yakovlev (1903, 1939); from the Carnic Alps, by Heritsch (1933a, 1936), and Felser (1937, 1937a); from Serbia, by Heritsch (1933, 1934); from Greece, by Heritsch (1937); and from England, by King (1850).

The earliest published record of Permian corals in North America is a description by B. F. Shumard (1858) of specimens from the Guadalupe Mountains in western Texas. These were named *Campophyllum? texanum* and *Polycoelia?* sp. No illustrations are given, and because the descriptions are inadequate and the types are lost, Shumard's species are not recognizable. Girty (1908), in his monograph on the Guadalupian fauna of western Texas, recognized nine species and one variety of corals, distributed in six genera, as follows: *Lindstroemia permicana* Girty, n. sp., *L. permicana* var. Girty, *L. cylindrica* Girty, n. sp., *L.* sp., *Zaphrentis?* sp., *Amplexus* sp., *Campophyllum? texanum* Shumard, *Cladopora spinulata* Girty, n. sp., *C.? tubulata* Girty, n. sp., and *Aulopora* sp. Some of these are not recognizable on the basis of the published descriptions and illustrations but possibly may be made so by study of his types and supplementary specimens. One of us (R. C. Moore) recently has had opportunity to examine Girty's types of Guadalupian corals, but lack of sections prevents diagnosis, at least in the case of the rugose forms. A small horn coral from

STRATIGRAPHIC SIGNIFICANCE OF PERMIAN CORALS

Only locally and exceptionally in North America are Permian corals abundant. Seemingly, the known Permian invertebrate faunas of this continent are much less coralline than those of many other regions. Little attention has been given to search for these fossils, however, and special efforts in field collecting will doubtless result in important additions of study material. Also, it is likely that all together there are many unstudied specimens in collections of various surveys, universities, and museums. Careful investigation of all obtainable fossils should augment considerably the knowledge of the kinds of Permian corals that occur in North America and their stratigraphic distribution.

Heritsch (1936a, 1936c, 1937a, 1937 b) has presented the major outlines of a zonation of rocks belonging to the Permian system that is based on distribution of rugose coral genera. This seems to be very broadly applicable, and classification of late Paleozoic marine deposits in all parts of the world eventually may become well established through verified and amplified information on the nature and occurrence of corals. This group of fossils may then become entitled to rank with ammonoids, fusulinids, and other especially useful guide fossils in these rocks. The corals may be expected to supplement the other biologic groups to an important degree, because noteworthy faunal variations due to ecologic factors are observed. As a whole, corals tend to choose particular features of habitat, but, in addition, Hill (1938a) has called attention to existence of different types of coral assemblages that reflect special environmental conditions. Mud deposits that presumably represent off-shore moderately deep and quiet water are characterized by prevalence of small solitary horn corals. Calcareous shale, commonly interbedded with thin limestone strata, representing moderately shallow, slightly turbid conditions, contains robust horn corals of the *Caninia* type. Warm shallow clear waters, possibly agitated considerably by waves and currents, characterize a limestone-producing environment, in which colonial reef-building corals are abundant. The differentiation of these and other sedimentary facies requires somewhat independent calibration of each type and imposes need for as complete intercorrelation as possible in order to establish a composite paleontologic zonation of wide applicability.

tailed subdivision and tracing of the Permian rocks in this region. Stratigraphic placement of the western Texas specimens rests on the field studies and mapping of the Glass Mountains by P. B. and R. E. King (1930), supplemented in part by personal acquaintance of Skinner with the geologic section of the Glass Mountains.

METHODS OF STUDY.

External features of the Permian rugose corals serve only in small part as basis for classification, and in some types they are almost negligible in taxonomic study. Likewise, the mode of growth, whether solitary or colonial, is believed not to be an important distinction, unless such characters are firmly fixed. Judgments of the taxonomic value of mode of growth and of various structural characters of corals differ widely. Variability of the corals themselves, conjoined with the uncertainty of paleontologists as to significant evolutionary trends and divergences in viewpoints just indicated makes for lack of uniformity in classification and nomenclature of these fossils. In any case, knowledge of internal structures of the Permian corals is absolutely requisite.

After classification of the corals in our collection on the basis of obvious external features, the specimens were cut transversely at selected points. Except in a few cases these sections served to establish the position of the cardinal-counter septal plane and to indicate differentiation of major and minor septa. The sections were photographed at enlarged scale after polishing or immersion in oil in order to bring out structures clearly. By marking the septal grooves of major septa the arrangement and order of introduction of the septa were determined on the exterior of the coral if this was possible. This method usually serves for identification of the alar septa, which may not be independently identifiable from study of the transverse sections. The segments of the transversely cut corals were carefully assembled in proper orientation (by means of index marks and matching septal grooves) and were cemented together. They were then cut longitudinally in a plane approximately at right angles to that of the cardinal and counter septa. The longitudinal section was oiled and photographed, the half of the coral containing the counter septum, if identifiable, being used uniformly.

Illustrations of the structures shown in the transverse and longitudinal sections were prepared by drawing on the photographs with waterproof India ink and then bleaching the photo-

Septa.—The terminology of the classes of septa is in a very confused state. We use the following designation of the septa, as given by Hill (1935, pp. 504-505), because these terms have been used in a consistent manner and have not varied in meaning as is true of the terms primary, secondary, and tertiary. The cardinal, counter, two alar, and two counter-lateral septa are designated as the *protosepta.* A variable number of other septa added in pairs in the cardinal and counter quadrants and closely resembling the protosepta are designated the *metasepta.* The protosepta and the metasepta together are termed the *major septa.* Short septa alternating with the major septa, introduced later than the majors, are termed *minor septa.*

Axial structures.—Both Grabau (1922) and Hill (1935) have proposed detailed classifications of the axial structures of rugose corals. These authors differ widely in terminology, however, and neither has been followed closely by many other workers. Although Grabau states that a true columella is found only in the Hexacoralla, he describes the solid rodlike axial structure of the rugose corals as a columella. The term pseudocolumella is used by him to include all non-solid types of axial structures, most of which are given descriptive names. Hill uses the term columella for a solid rodlike axial structure and restricts the terms pseudocolumella to the Hexacoralla. The general term axial complex includes both the columns formed by the twisting of axial ends of the septa (axial vortex) and those formed by vertical plates in the axial region (axial column).

The terminology used by Grabau and Hill in describing the many types of axial structures is complete and precise, but we do not think it necessary to use these little-known complex technical terms. Because the names now used in describing axial structures are in such a confused state, we designate any columnar structure that is present in the axial region of the corallite as a *column* and describe the features of each in detail. The column may or may not be solid.

Acknowledgments.

We are indebted to Ralph H. King and Charles C. Williams, of the University of Kansas, for aid in collecting specimens, and to Maurice Wallace, of the University of Kansas, for work in sawing

SYSTEMATIC DESCRIPTIONS

General Statement Concerning Taxonomy.

Classification of Paleozoic corals is now in confused, if not almost chaotic state. It is generally recognized by the best-informed students of these fossils that organization of described genera in families has been based very largely on superficial and even artificial lines and that we are yet far from ready to evaluate with reasonable accuracy the significant phylogentic evidence that is given in the structures and geologic distribution of the older corals. Not only do families commonly defined by treatises such as Zittel's (1895) Handbuch der Paläontologie and later works, include some very slightly related forms, but there can be no doubt as to the polyphyletic nature of some genera, especially supposedly long-ranging genera of simple structure, like *"Amplexus."* Schindewolf (1940) has recently described Lower Carboniferous and Permian species of amplexoid adult nature that are shown to be derived from wholly different, unrelated stocks, and on this basis he follows Weissermel (1897) in making new genera out of segments of the stratigraphically almost meaningless assemblage called *Amplexus*. Convergence of characters in adult forms is shown to extend to internal features, such as arrangement and form of the septa, as well as external features, and knowledge of youthful growth stages is necessary in order to recognize the very unlike origins of seemingly identical end forms. A few authors, such as Grabau, recognize finely drawn generic distinctions, of which many may be sound and probably some may be unsound. Many families are proposed. Other authors, such as Hill (1939), are inclined to reduce to synonymy a very large number of the listed Paleozoic coral genera and to group these in a small number of families. Lang, Smith, and Thomas (1940) in their recently published Index, record 566 Paleozoic coral genera, exclusive of objective synonyms, but they make no effort to arrange the genera in families.

The genera and species of Permian rugose corals that are described in this paper are discussed as units, without indication of their inferred family relationships. They are arranged in approximate order of their increasing complexity of internal structure, under each of two main groups, (1) genera that have a well-defined column, and (2) genera that lack a column.

by small wrinkles and growth lines. The calyx is deep, containing a prominent spikelike axial colum in the lower part. The type specimen is 20.2 mm in length and 11.7 mm in maximum diameter, at the calyx.

A section of the type just below the calyx shows 24 short major septa. Alternating minor septa are one-third as long as the major septa. Two other specimens show 20 and 22 major septa, respectively. The cardinal septum is shortened so as to form an open fossula. The counter septum extends to the axis and thickens to form a solid column in the young portion of the corallite, but near the calyx the counter septum is not significantly longer than other major septa. Dissepiments and tabulae are absent. A solid rodlike column in the lower portion of the corallite is formed by the thickened end of the counter septum. It tapers gradually upward and becomes free in the lower part of the calyx.

Transverse sections of the early parts of the corallites show the structural elements much thickened by stereoplasm. The septa are joined at their axial ends to form a large solid column. Successive sections higher in the corallite reveal a progressive decrease in the amount of steroplasm and a shortening of the major septa. The counter septum is the last to draw away from the column. Minor septa are not seen in immature portions of the corallite.

Discussion.—The description and illustrations of the weathered specimens of *Malonophyllum texanum* Okulitch and Albritton (1937) indicate that the septa withdraw only slightly from the axial column in the upper part of the corallite and that they are strongly deflected toward the counter septum.

Malonophyllum kansasense can be distinguished readily from species of *Lophophyllidium* and *Lophamplexus* by the concentration of structural elements and stereoplasm in the lower part of the corallite, and by the absence of dissepiments and tabulae. The form of the corallite of *M. kansasense* is distinctly conical, in contrast to the conical-cylindrical shape of *Lophophyllidium dunbari* and *Lophamplexus eliasi,* and it reaches maximum diameter more rapidly.

Occurrence.—Florena shale member, Beattie limestone, Council Grove group, Wolfcamp series, Lower Permian. Grand Summit, Cowley county, Kansas.

Type.—University of Kansas, no. 23291.

PLATE 1

(All figures 3 times natural size)

the tabulae extend to the inner surface of the wall." Among species assigned to *Koninckophyllum* are some that are definitely of the *Lophophyllum tortuosum* type, and following Carruthers' (1913) restudy of the genotype of *Lophophyllum*, some workers have concluded that *Koninckophyllum* should be suppressed as a synonym of *Lophophyllum*. On the other hand, Smith (1934), Vaughn (1915), Heritsch (1936b), Hill (1939), and other students of these corals regard the two genera as distinct, although closely related. Grabau (1928) and Huang (1932) arbitrarily and incorrectly place corals similar to the genotype of *Lophophyllum L. tortuosum,* in *Koninckophyllum* and use *Lophophyllum* for corals similar to *L. proliferum.*

Edwards and Haime in 1851 (p. 323) described an American column-bearing small horn coral from beds of early Pennsylvanian age (Pottsville) at Flint Ridge, Ohio. This species they called *Cyathaxonia profunda.* McChesney in 1860 (p. 75) described a similar coral from rocks of middle Pennsylvanian age in Illinois, naming it *Cyathaxonia prolifera.* Meek (1872, p. 149) transferred McChesney's species to *Lophophyllum,* and Foerste (1888, p. 136), working on the Flint Ridge fauna, classed *C. profunda* as belonging to *Lophophyllum.* American paleontologists generally have come to regard *L. proliferum* as a synonym of *L. profundum* (Weller, 1898, p. 333), though this may well be an erroneous conclusion. It is very doubtful indeed that *L. proliferum* occurs in Permian rocks of other continents, as reported, for example, by Soschkina (1925, p. 88) in Russia.

Assignment of either *"Cyathaxonia" profunda* or *"Cyathaxonia" prolifera* to *Lophophyllum* is obviously incorrect, because these species lack dissepiments, so far as known, and, more important, they have a nearly solid axial column. On the ground that corals of the *"Cyathaxonia" prolifera* type are generically distinct from *Lophophyllum,* Grabau (1928) proposed for them the new name, *Lophophyllidium,* designating *Cyathaxonia prolifera* McChesney as genotype. Critical studies of the internal structure of authentic examples of *C. prolifera* are needed in order to determine satisfactorily the characters that should be assigned to *Lophophyllidium.* Our studies of Pennsylvanian and Permian corals of this sort, having a solid or comparatively dense axial column, indicate the existence of several types of internal struc-

The axial column of the Lower Permian corals that are here referred to *Lophophyllidium* seems to be formed in part by thickening of the inner margin of the counter septum, but most importantly it consists of the superposed, almost vertically deflected parts of successive tabulae. It is the latter that account for the upward elongation of the column above the floor of the calyx. Deposits of stereoplasm obscure this structure in some specimens, but polished sections of even relatively dense parts of the column reveal its structural elements when studied under the microscope. The superposed laminae of the column seem to be no more numerous than the tabulae, and no basis is seen for designating the steeply inclined plates as tabellae. Transverse sections of some of the specimens show clearly the dilated inner ends of the major septa, forming a stereozone that surrounds but generally does not touch the column. No dissepiments have been seen. The observed structures support identification of the specimens as belonging to *Lophophyllidium,* but there is a measure of uncertainty in determination, owing to lack of detailed information as to the structure of authentic examples of the genotype species, *Lophophyllidium proliferum.* Also important, but taxonomically less vital, is detailed knowledge of the internal structure of *Lophophyllidium profundum,* for if *L. proliferum* is a synonym of this species, the genotype of *Lophophyllidium* should be designated as *L. profundum.*

Occurrence.—Upper Carboniferous and Permian of North America, Europe, and eastern Asia.

LOPHOPHYLLIDIUM DUNBARI, n. sp.

Plate 1, figures 1-5; plate 7, figure 4

Corallites belonging to this species have a conical-cylindrical form that is slightly curved in the plane of the alar septa. The moderately thick theca shows prominent and regular septal grooves and interseptal ridges, the ridges being slightly broader than the grooves. Numerous fine growth lines and somewhat low annulations run transverse to the septal grooves. The type specimen in 25.5 mm in length and has a maximum diameter of 12.0 mm at the calyx.

The laterally compressed column projects as a tall spine into the center of the deep calyx. In early stages the axial column is di-

dalophylloidea Huang (1932) in its smaller axial structure, much shorter minor septa, and fewer tabulae in the longitudinal sections. *Lophophyllidium zaphrentoidea* Huang (1932) seems to lack numerous tabulae, and it has longer and more numerous septa than *L. dunbari*. Also, *L. zaphrentoidea* has a more conspicuous cardinal fossula, and it seems to have no distinct rhopaloid stage. From the Russian form identified by Soschkina (1928) as *Lophophyllidium proliferum*, this species differs in the more prominent development of the rhopaloid septa and tabulae during development, and the more amplexoid septa and smaller column in the mature part of the corallite.

The species is named for Carl O. Dunbar, of Yale University, who was a student of geology at the University of Kansas. A leader in paleontologic and stratigraphic research, Professor Dunbar is especially noted on account of contributions to knowledge of Permian fossils and rock formations. He has aided our study of the Permian corals by loan of many specimens collected in Texas and Mexico.

Occurrence.—Florena shale member, Beattie limestone, Council Grove group, Wolfcamp series, Lower Permian. The type and other specimens were collected by J. W. Mickle and by N. D. Newell near Grand Summit, Cowley county, Kansas.

Type.—University of Kansas, no. 23301.

Genus Leonardophyllum, n. gen.

This genus includes solitary rugose corals of straight or gently curved, conical to cylindrical form, having a well-developed theca that bears transverse growth lines and wrinkles but no clearly defined septal grooves. Except the counter septum, which is joined to the axial column, the septa reach only part way to the column. The major septa are evenly disposed and approximately uniform in length, except the cardinal septum, which is distinguished by its short length and by its position opposite the counter septum. Minor septa occur between the major ones.

The axial column is very prominent, being strongly elevated as a sharp point in the center of the calyx. Generally it shows clearly the component structural elements when studied in longitudinal or transverse section. The most important elements in the axial column are the sharply upturned central portions of tabulae that

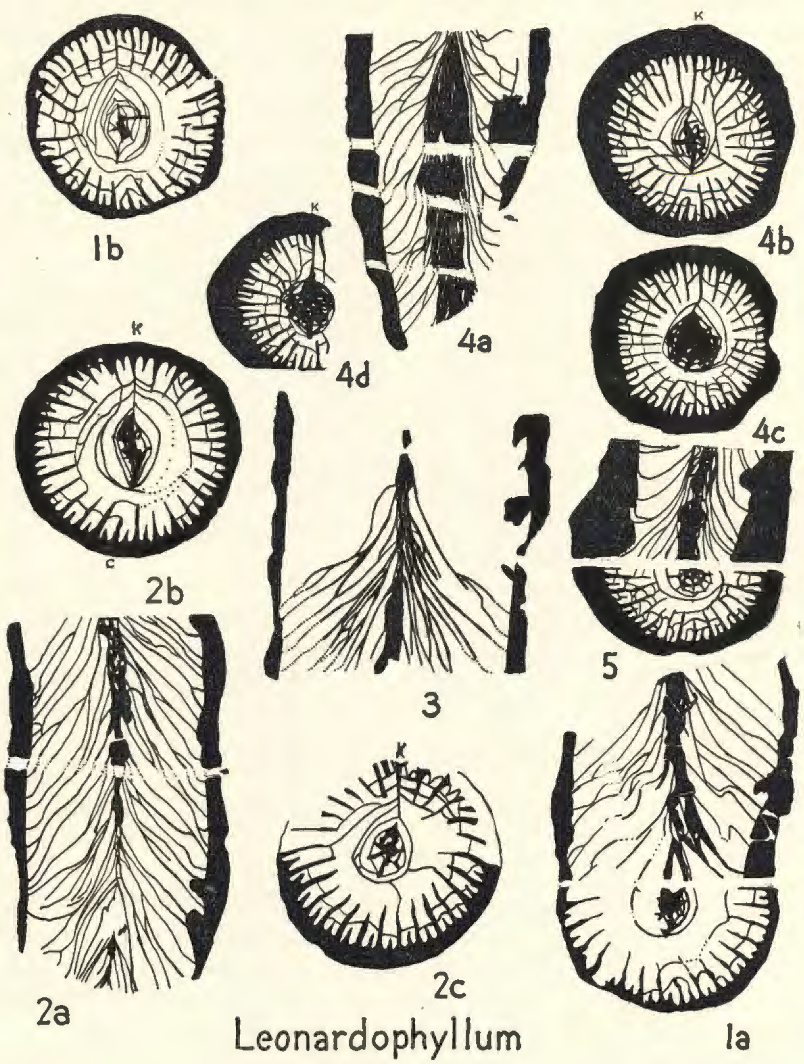


PLATE 2

(All figures 3 times natural size)

column where they become nearly vertical. Dissepiments are absent.

The narrow dibunophyllid column is formed by the intersection of the steeply ascending tabulae, median lamina, and a few strong radiating lamellae. These produce a cob-web appearance of the column in transverse section. The tabulae, however, are not limited to the axial portion, but join the end of the counter septum and more rarely other septa.

Discussion.—The dibunophyllid column and steeply up-arched tabulae clearly separate this species from species of other genera of North American corals. *Leonardophyllum distinctum* differs from *Leonardophyllum acus,* the only other species referred to this genus, in the less numerous and less closely bundled tabulae and in the more nearly cylindrical shape of the corallite.

The thick theca and strong septa of the specimen identified by Dobrolyubova (1936, p. 132) as *Verbeekiella* cf. *rothpletzi* Gerth resemble those of *L. distinctum.* The transverse sections of the Russian specimen, however, show a different septal development and a column formed by a few very thick radiating lamellae without a cob-web appearance.

Occurrence.—Leonard series, Middle Permian, Hess Ranch, saddle north of Leonard Mountain, Glass Mountains, Texas.

Type.—University of Kansas, no. 74161. About a dozen incomplete specimens in our collection are assigned to this species.

LEONARDOPHYLLUM ACUS, n. sp.

Plate 2, figures 4, 5, plate 8, figure 3

The description of this species is based on two well-preserved, although incomplete, conical-cylindrical corallites. The theca is very thick, and shows prominent transverse wrinkles and growth-lines, but no septal grooves. The calyx is not known. The incomplete type specimen is 17.7 mm in length and has a maximum diameter of 11.0 mm at the uppermost part of the fragment.

The strong major septa thicken peripherally. The cardinal septum is only slightly shortened but the counter septum reaches the column and is directly connected to the median lamina. Other major septa reach the column and may be slightly twisted in the early stages, but in maturity withdraw from the column and have

Discussion.—The corals here described are evidently related closely to *Lophophyllidium,* as indicated by correspondence in structures of the juvenile parts of the corallite. They are readily distinguished from *Lophophyllidium* and similar genera by absence of the column in the upper parts of the corallite and by the tendency of the counter septum in the mature region to become even shorter than the adjacent major septa. The cardinal septum is notably shortened in all stages of growth except the earliest. This reduction in length forms a distinct but not prominent open fossula.

The distinctly amplexoid part of the corallite, as observed in specimens assigned to *Lophamplexus,* seems to be less dominant than in such genera as "*Pseudamplexus*" Weissermel (1897, p. 878), *Pleramplexus* Schindewolf (1940, p. 401), and *Pentamplexus* Schindewolf (1940, p. 403). The youthful stages of these genera point to parent stocks that are radically different, one from another, and the amplexoid nature of the mature stages of each of them is a result of the evolutionary modification that Schindewolf calls convergence. *Lophamplexus* is indicated to have been derived from an ancestor belonging to *Lophophyllidium* or a closely related genus.

Occurrence.—Foraker and Beattie limestones, Wolfcamp series, Lower Permian, Kansas and Oklahoma.

Lophamplexus eliasi, n. sp.

Plate 3, figures 2, 3; plate 8, figure 1

The principal structural features of this species are described in the generic description. The conical-cylindrical corallite is slightly curved in the plane of the alar septa. Transverse growth lines and annulations are conspicuous but septal grooves and interseptal ridges are narrow and somewhat shallow. The type specimen has a length of 30.4 mm and a maximum diameter of 12.8 mm, measured at a distance of 20 mm from the apex.

The theca is very thin. There are 27 major septa in the uppermost part of the corallite of the type, which shows no minor septa. Another specimen has very short minor septa alternating with the major septa in a section just below the top of the column-bearing stage. An open cardinal fossula is visible in all but the most mature parts of the corallite. Tabulae are incomplete in youthful

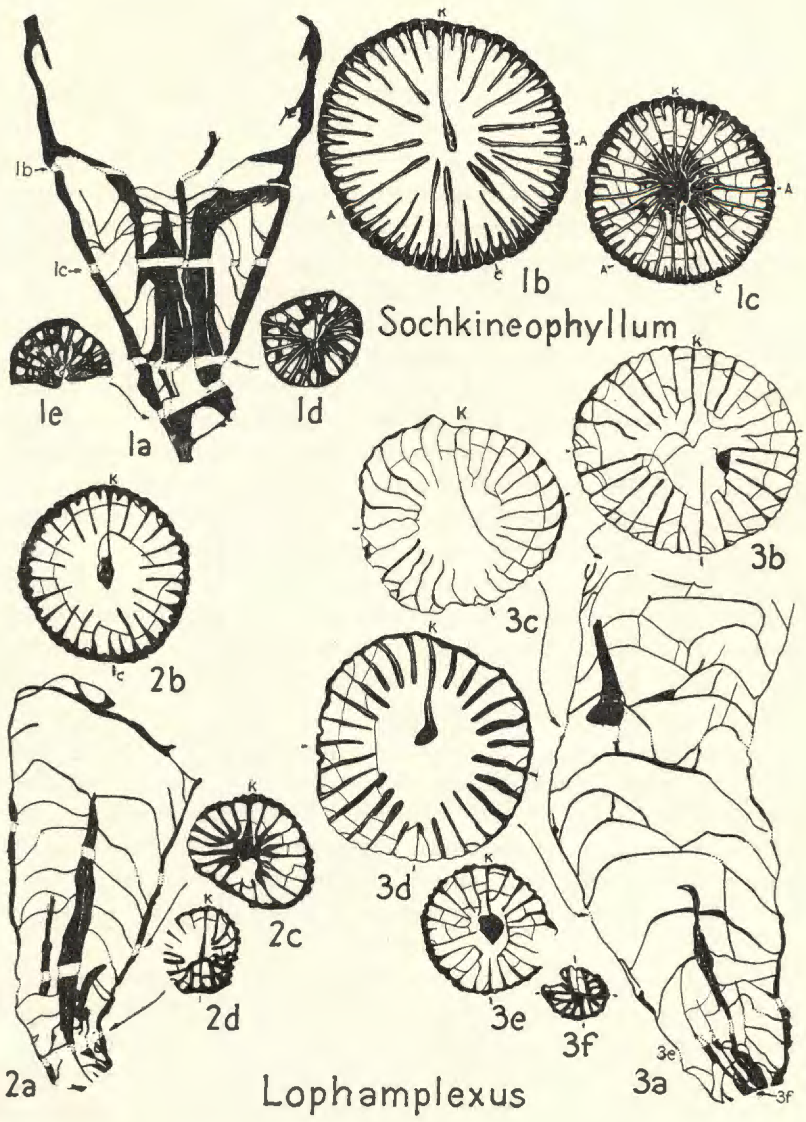


PLATE 3

(All figures 3 times natural size)

to meet the median lamina at different points. These structures are crossed by steeply arched tabellae that slope nearly vertically upward and inward. The septa and the median lamina of the column are fluted along curved lines than run parallel to their distal margins.

Genotype.—*Heritschia girtyi,* n. sp., Florence limestone, Lower Permian, Butler County, Kansas.

Discussion.—Structural features of the corals here described under the new generic name of *Heritschia* are intermediate between those of *Waagenophyllum* Hayasaka and *Iranophyllum* Douglas, on the one hand, and such forms as *Lonsdaleia* McCoy and *Stylidophyllum* Fromentel, on the other. *Waagenophyllum,* as indicated by its genotype species, *Lonsdaleia indica* Waagen and Wentzel, from the middle Productus limestone of the Salt Range, India, comprises compound corals of closely bundled (phaceloid) habit, containing numerous small closely spaced long cylindrical corallites. The septa of these corallites are flexuous and fluted as in *Heritschia;* they are evenly disposed radially, comprise two orders, and they extend inward from the theca to or almost to the axial column. Also, as in *Heritschia,* there is an outer zone of dissepiments sloping outward and upward, an intermediate zone of tabulae similarly inclined except at their inner margins, and in the axial region closely spaced tabellae that slope upward and inward. Unlike *Heritschia,* however, the septa of *Waagenophyllum* are strongest in the peripheral zone, next to the theca, and the tabellae and radial lamellae of the column are much less obscured by stereoplasm than in *Heritschia.* The axial structure of *Waagenophyllum* resembles that of *Dibunophyllum.* Difference in deposits of stereoplasm in the axial region is not deemed to have generic significance, and accordingly the chief distinction between *Waagenophyllum* and *Heritschia,* based on comparison of their genotype species, is found in characters of the peripheral zone, where the externally thickened septa and relatively narrow belt of dissepiments in *Waagenophyllum* contrast with the thin flexuous outer parts of the septa and the strongly developed dissepimental zone of *Heritschia.*

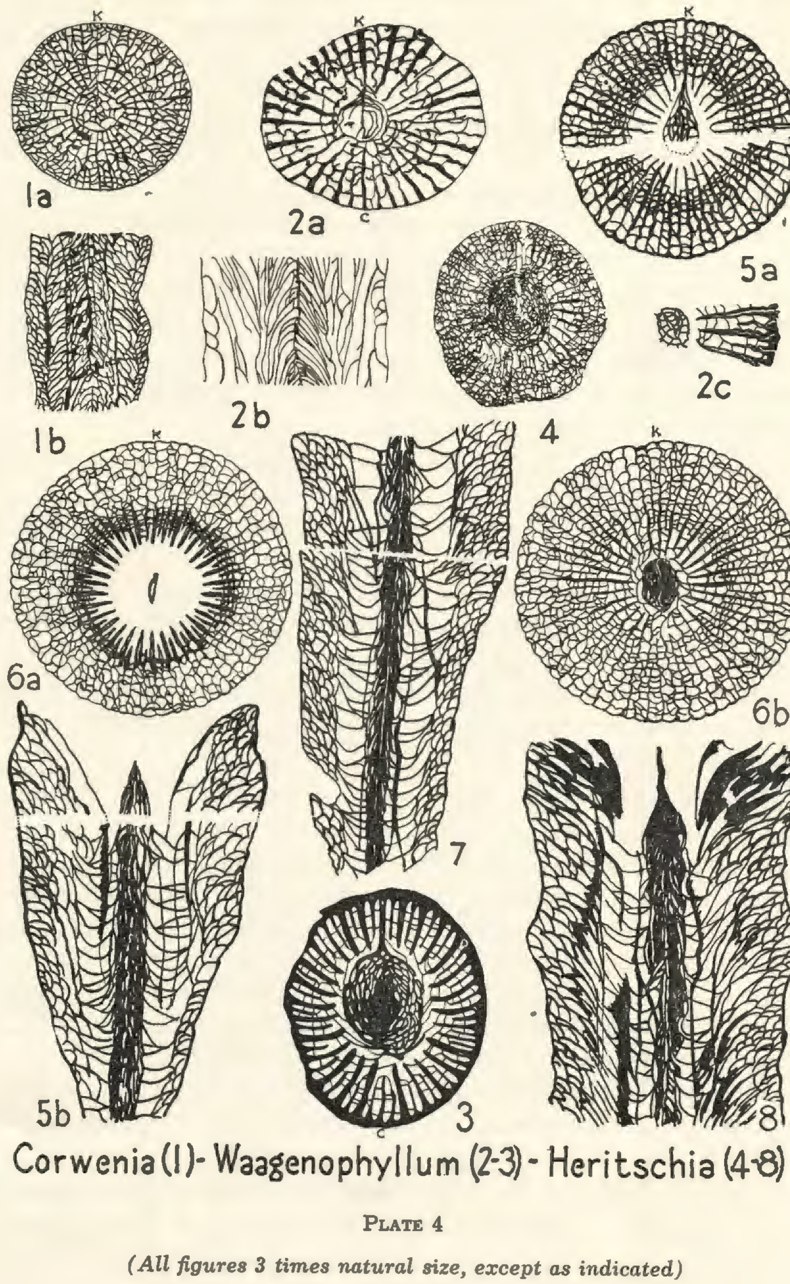
Iranophyllum, which is based on the species *Iranophyllum splendens* Douglas, was established for solitary rugose corals having the internal structure of *Waagenophyllum* and *Wentzelella.* The septa reach the theca, and in general the tabulae are inclined

Waagenophyllum seem to occur only in beds of Middle and Late Permian age.

On the basis of published figures and descriptions, we refer to *Heritschia* the Permian species *Corwenia chutsingensis* Chi (1931, p. 45), *C. chiuyaoshanensis* Huang (1932, p. 43), *C. parachihsianensis* Huang (1932, p. 51), *C. lipoensis* Huang (1932, p. 52), *Waagenophyllum columbicum* Smith (1935, p. 38), and *W. persicum Douglas* (1936, p. 20). Species doubtfully assigned to *Heritschia* include *Corwenia densicolumella* Dobrolyubova (1936, p. 140), *C.* cf. *lipoensis Huang* (Dobrolyubova, 1936, p. 142), *Waagenophyllum chitralicum* Smith (1935, p. 37), *W. muricatum* Douglas (1936, p. 22), and *Lonsdaleia (Waagenella* [sic]*) omiensis* Yabe and Hayasaka (1915 ,p. 104).

Heritsch (1936a, p. 145) differentiated *Waagenophyllum columbicum, W. katoi,* and *W. chitralicum* as a group that is distinct from the typical forms of *Waagenophyllum,* inasmuch as the peripheral parts of the septa are notably reduced in thickness, tending in some cases to disappear. The subhorizontal or somewhat upward and inward sloping attitude of the tabulae of *Heritschia columbica* is more pronounced than in *H. girtyi* and the dibunophyllid column is both broader and less obscured by steroplasm, but essential structural features correspond closely. Although *W. chitralicum* has a prominent stereozone, like that of *Heritschia,* thickening of the peripheral parts of the septa indicate closer relationship with *Waagenophyllum. W. katoi* differs from *Heritschia* in the peripheral thickening of the septa, the type of column, and the form of growth.

As interpreted by Heritsch (1936a, p. 148; 1937b, p. 315-316) from a survey of Permian corals of the world, the zone of *Waagenophyllum* is the upper middle part of the Permian system. *W. indicum* from the Middle Productus limestone of the Salt Range in India certainly represents a horizon far above the base of the Permian. *Waagenophyllum texanum* from the Capitan limestone of West Texas and other species undoubtedly belonging to *Waagenophyllum* are likewise obtained from beds that are much younger than lowermost Permian. *Heritschia girtyi,* on the other hand, comes from beds of late Wolfcamp age. The Florence limestone of Kansas has also yielded *Pseudoschwagerina* (Moore, 1940, p. 314). On the basis of this and much other paleontologic and stratigraphic evidence, the placement of *H. girtyi* in the upper part of the suc-



Corwenia (1) - Waagenophyllum (2-3) - Heritschia (4-8)

PLATE 4

(All figures 3 times natural size, except as indicated)

This species is named in honor of the late George H. Girty, of the U. S. Geological Survey, who for many years enriched the paleontologic literature on Carboniferous and Permian fossils of North America.

Occurrence.—Upper part of the Florence limestone (about 5 feet above top of main chert zone), along road in NE¼ SE¼ sec. 31, T. 27 S., R. 6 E., about 2 miles southwest of Leon, Butler county, Kansas, and in sec. 23, T. 27 S., 6E., about one mile east of Leon; also Florence limestone (?), near Augusta, Kansas.

Type.—University of Kansas, no. 34191.

Corals Not Bearing a Distinct Axial Column

Genus Timorphyllum Gerth, 1921

Small, solitary corals of somewhat irregular elongate cylindrical form are typical of *Timorphyllum.* The theca is not marked by septal grooves but is crossed transversely by growth lines and wrinkles. A short cardinal septum lies in an open fossula; the counter septum is elongate, reaching through the center of the corallite, but its distal part is not distinctly thickened to form a column. Major septa are short, extending inward about one third the diameter of the corallite; they are evenly spaced and not thickened distally. Minor septa are extremely short. Somewhat regularly spaced tabulae arch gently upward and extend to the walls of the corallite. Dissepiments are absent.

Genotype.—*Timorphyllum wanneri* Gerth, Permian of Timor.

Discussion.—The described structural features of this small coral readily distinguish it from other types of Permian corals. Gerth's interpretation of the axial region as consisting of a much flattened columella that is attached to the counter septum is supported by observation that a central structure projects upward in the lower part of the calyx. This feature is not shown in our material, however, and transverse section of the corallite show a barely perceptible thickening of the distal or axial part of the counter septum.

Occurrence.—Lower Middle Permian of Bitauni and Basleo-Weslo, Timor (regarded as equivalent to the Artinsk or Leonard and Word), and Leonard series, Middle Permian, West Texas.

Duplophyllum

PLATE 5

tingent (joined to adjacent major septum outward from the cardinal septum).

The spelling of this generic name calls for brief consideration. The International Rules of Zoological Nomenclature (Article 8h) provide that generic names may be based on patronymics and recommend that the exact form of writing the proper name (using Roman letters) be employed. Thus, such genera as *Müllería*, *Stålia*, *Krøyeria*, and *Ibañezia* are recognized as correctly formulated. Special difficulty is encountered, however, in transliterating some names from Russian, Chinese, and other languages that do not use the Roman alphabet. Lack of uniformity naturally arises from an absence of an agreed procedure in transliteration. We find that Yakovlev, and Jakowlew, as published in various non-Russian literature, all refer to the same person, and that several divergent spellings of the same Chinese name may be given when written in Roman letters. M. K. Elias has pointed out to us that the paleontologist for whom *Sochkineophyllum* was named is a woman and that the surname of Russian women always bears the ending -a, as Soschkina. Published spellings of this name include Sochkine (Soschkina, 1925), Soschkina (1928, 1936), Sochkina (Soschkina, 1932), and Soshkina (Nickles, Siegrist, and Tatge, 1938; Licharew and others, 1939; Lang, Smith, and Thomas, 1940). Grabau adopted the orthography as given in Soschkina's own rendering of her name in 1925, published in French. Study of the Rules indicates that the spelling used by Grabau is not emendable (Moore, Weller and Knight, 1941).

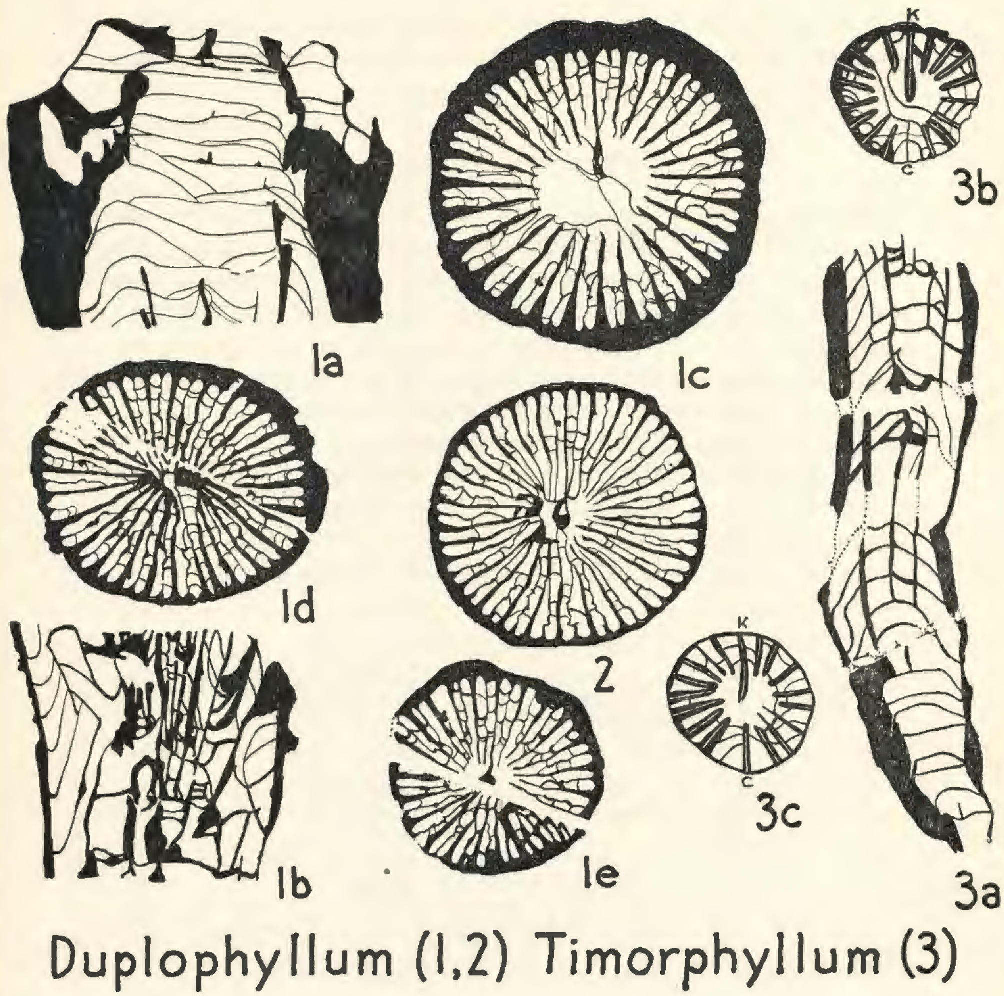
Occurrence.—Upper Carboniferous (Moscovian), China; Lower Permian (Wolfcamp), Kansas; Middle Permian (Artinsk), U.S.S.R.

SOSCHKINEOPHYLLUM MIRABILE, n. sp.

Plate 3, figure 1; plate 7, figure 5

Description of this species is based on a very well preserved, nearly straight conical corallite, which has a length of 22 mm and a maximum diameter (at the calyx) of 17 mm. The theca, which is of medium thickness, is marked by prominent wrinkles and growth lines and by low septal grooves. Calyx 10 mm in depth.

The major septa are of unequal length in the mature part of the corallite. The cardinal septum extends only one-fourth of the dis-



EXPLANATION OF PLATE 6

(All figures 3 times natural size)

Duplophyllum septarugosum, n. sp., upper 400 feet of Leonard series, Middle Permian, at Clay Slide, 2 miles west of Iron Mountains, Texas.

1a-c—Transverse sections of a specimen (Univ. Kansas no. 74141).

2a-c—Transverse sections of a specimen (Univ. Kansas no. 74142).

3a-e—Specimen (Univ. Kansas no. 74143). *a*, Longitudinal section. *b-e*, Transverse sections.

4a-d—Specimen (Univ. Kansas no. 74144). *a*, Longitudinal section. *b-d*, Transverse sections.

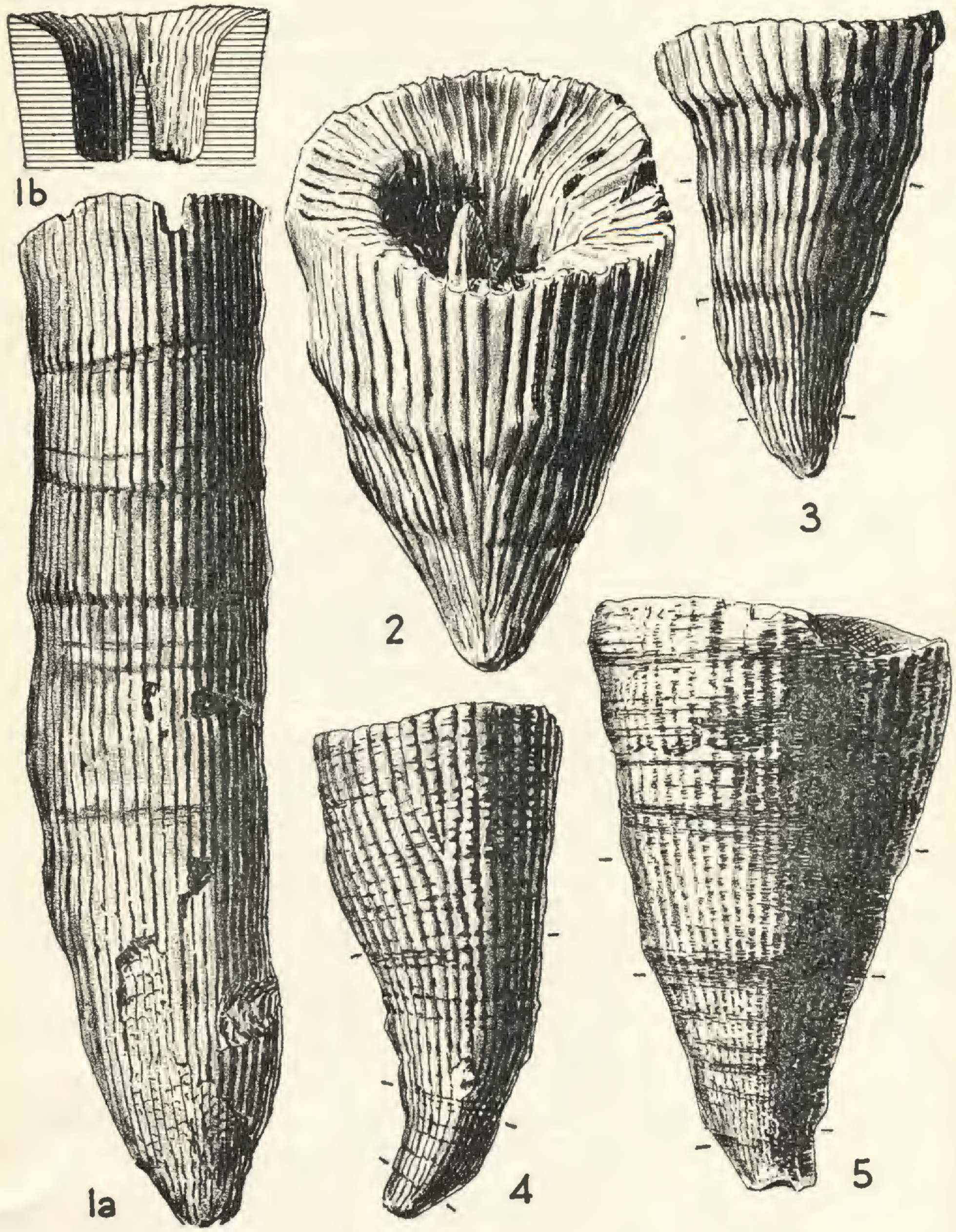


PLATE 7
(All figures 3 times natural size)

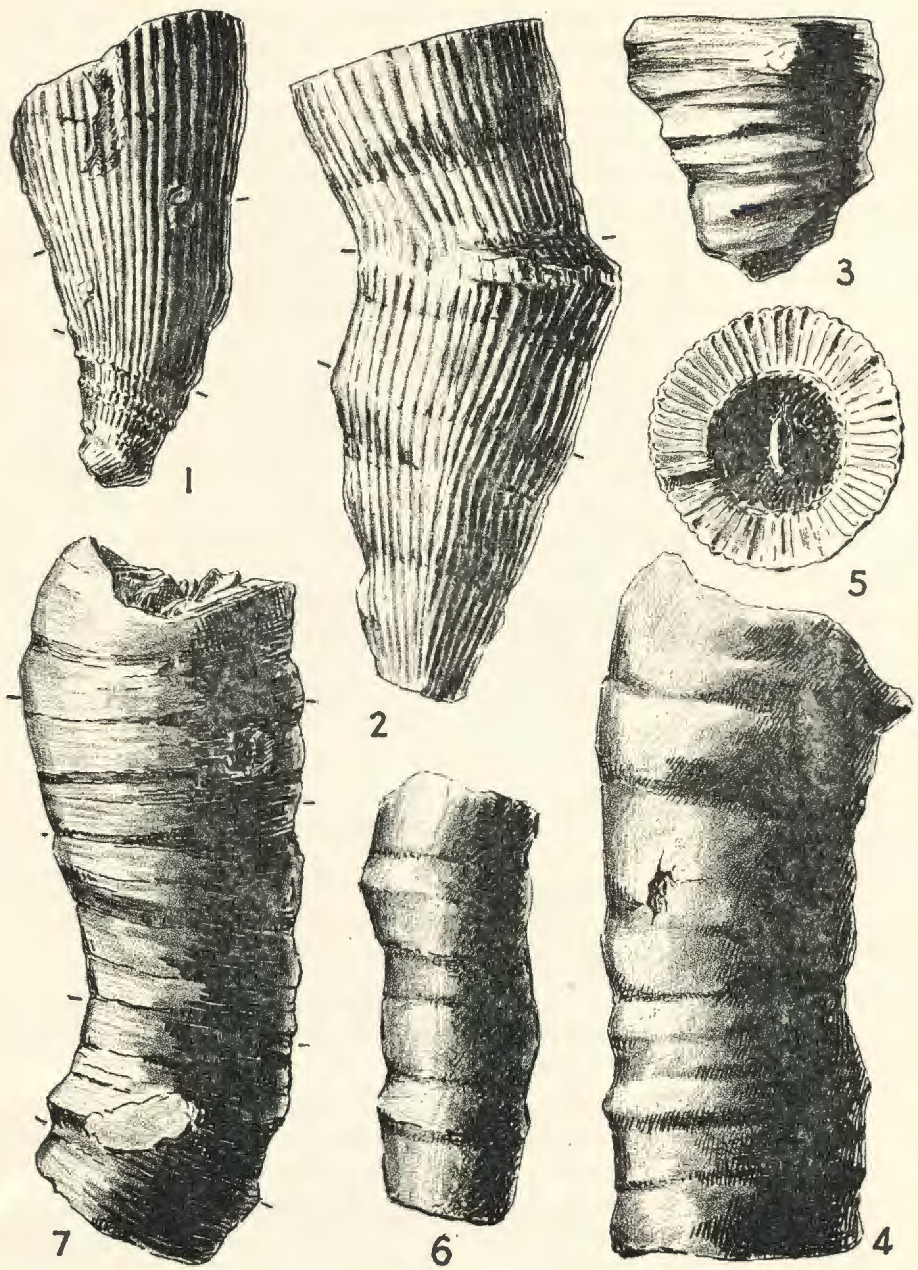


PLATE 8

Fused septa of the type described are reported by Chi (1938, p. 165, pl. 1, figs. 5a-c) in Permian corals from Yunnan, China, called *Duplophyllum compactum.* Similar fused septa are a characteristic structural feature also of some of our corals from the Leonard series of the Glass Mountains. Transverse sections of specimens illustrated by Koker show the notably uneven crooked attitude of some of the septa. This is not seen in Chi's species (*D. compactum*), but is an especially noteworthy feature of the minor septa and a few of the major ones in the West Texas specimens. The septa of these Leonard corals show a tendency to twist slightly in the axial region, suggesting the axial structure of *Clisiophyllum.* No longitudinal sections are given by Etheridge for the genotype species of *Duplophyllum* nor by Koker for the Timor coral that she identified as belonging to this species. Longitudinal sections of the West Texas corals are difficult to interpret, owing to partial disruption of the internal structures. Tabulae are definitely identified, though most of them are broken and somewhat displaced. Undisturbed portions of the tabulae indicate that they arch upward in the central part of the corallite. There are no dissepiments.

Occurrence.—The genotype species of *Duplophyllum* occurs in the Carboniferous? of Australia. The species from Timor that was studied by Koker is reported to have been collected from Wesleo, Timor. Chi's *Duplophyllum compactum* was obtained from the Maping limestone. The American corals that are here placed in *Duplophyllum* are from the Leonard series. If all these references of corals to *Duplophyllum* are correctly made, they indicate that the genus ranges from Carboniferous? to Leonard, and that it occurs in eastern Asia, Australia, the East Indies, and North America.

DUPLOPHYLLUM SEPTARUGOSUM, n. sp.

Plate 5, figures 1, 2; Plate 6, figures 1-4; plate 8, figure 7

This species is represented by straight or irregularly curved, solitary, nearly cylindrical corallites, having growth lines and coarse wrinkles but no longitudinal markings. The theca is thick in all stages of growth. The calyx is unknown. Some of the specimens indicate various stages of rejuvenation, as two definite thecal walls separated by matrix are shown in transverse section.

The type has 28 strong major septa in the upper part of the corallite, alternating with thin crooked minor septa. In this section the

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