Silurian Rugose Corals of the Central and Southwest Great Basin

GEOLOGICAL SURVEY PROFESSIONAL PAPER 777

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By CHARLES W. MERRIAM

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A stratigraphic-paleontologic investigation of rugose corals as aids in age determination and correlation of Silurian rocks of the Great Basin with those of other regions

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By CHARLES W. MERRIAM

ABSTRACT

Corals representing 13 families of Silurian Rugosa from limestones and dolomites of the central and southwest Great Basin are described, classified, and figured. Coral-bearing Silurian beds of this province occur in two contrasting carbonate rock facies: the eastern dolomite belt and the intermediate limestone belt. A third major Silurian rock suite characterizes the western, or Pacific Border, belt, which extends from the western Great Basin to northern California and southeastern Alaska.

On the basis of rugose corals and associated fossils, the Great Basin Silurian is subdivided as five coral zones, lettered A through E in ascending order. These provisional zones are a result of detailed stratigraphic studies and geologic mapping of reference sections in areas extending from the Inyo Mountains northeastward to the Roberts Mountains and northern Simpson Park Mountains.

Of importance environmentally, as well as with the identification and correlation of Great Basin Silurian, are the large dasycladacean algae associated with Rugosa. As the genus *Verticillopora,* these algae appear to have peaked in coral zone D.

Rugose corals of special importance in correlation with distant Silurian rocks are *Palaeocyclus, Dalmanophyllum, Kodonophyllum, Mucophyllum, Arachnophyllum, Toquimaphyllum,* and the lykophyllids. The closest foreign correlations are with the Gotland section, a Silurian carbonate standard for western Europe. Fairly close similarities are recognized with Silurian of Czechoslovakia and Eastern Australia.

INTRODUCTION

Monographic treatment of Silurian Rugosa emerges as a late byproduct of Great Basin Silurian and Devonian stratigraphy. Beginning in 1933, geologic mapping of middle Paleozoic exposures in the central and southwest Great Basin stimulated search for dependable means of identifying and subdividing monotonous Silurian carbonate rocks. Above all, there existed need for definitive criteria whereby Ordovician and Devonian dolomites might be separated from seemingly identical carbonate strata of the Silurian in areas of complex geologic structure. Rugose corals seemingly filled this need.

Progress was slow during initial stages of the investigation because of discouraging internal preservation of silicified coral material from dolomite. Later discoveries of limestone faunas better suited to thin section study have largely removed these obstacles.

Mapping in recent years over large areas of the Great Basin by several U.S. Geological Survey field parties has brought to light numerous coral-bearing Silurian exposures. Resultant correlation and integration of data from the many isolated occurrences has made possible a composite Silurian sequence based largely on coral faunas. This succession parallels, in some respects, that of the western European Gotland standard.

Partly empirical, partly inferential, and assuredly provisional, the proposed Great Basin coral succession requires the field and laboratory testing which will follow in the course of continued mapping and stratigraphic study of these yet little known rocks. In its present state the composite scheme is nonetheless a workable, albeit loose-knit, framework for evolutionary and taxonomic research upon Cordilleran Silurian Rugosa, the primary objects of this study.

Research upon Great Basin Silurian Rugosa has proceeded concurrently with investigation of Pacific Border province Silurian corals of the Klamath Mountains and Alaska, and with monographic study of the Early and early Middle Devonian Rugosa of the central Great Basin. Collectively, these studies provide opportunity for comparison of coral biotas of different facies and a means of evaluating expected paleontologic changes near the Silurian-Devonian boundary.

PURPOSE AND SCOPE OF INVESTIGATION

This report describes and illustrates representative Silurian Rugosa and discusses their application to stratigraphic zoning and correlation of Great Basin Silurian rocks. Among ancillary objectives are classification of Silurian regose corals, determination of their environmental significance in connection with depositional facies, and application of coralline biofacies data to problems of geologic correlation. Finally, the Rugosa are considered in the light of their value to interpretation of Silurian historical geology in the Great Basin province and the Cordilleran belt generally.

HISTORY OF INVESTIGATION

Presence of halysitid chain corals was ample justification for Silurian age assignment by pioneer geologists attached to early Great Basin surveys, up to and including the Eureka district work by Hague and Walcott (Hague, 1892; Walcott, 1884). Some halysitid-bearing rocks initially called Silurian are doubtless Late Ordovician

(Richmondian) of today; the Silurian System was more inclusive prior to adoption of the Ordovician as an independent system by the U.S. Geological Survey. So far as known, the Rugosa did not figure in determining the Silurian age of the Lone Mountain Dolomite (restricted) until current studies. Coral faunas of the Laketown Dolomite at Gold Hill, Utah, were known to include Rugosa when reported upon by Kirk (in Nolan, 1935, p. 18). With the examination of Silurian limestones in the Roberts Mountains, Nev. (fig. 1), during the 1930's (Merriam, 1940, p. 12), rugose corals of these somewhat more hospitable facies became available for study. Duncan (1956) documented all known occurrences of Great Basin Silurian Rugosa up to the 1950's.

Geologic mapping of the Cerro Gordo mining district beginning in 1946 (Merriam, 1963a) provided opportunity for stratigraphic and paleontologic study of coral-bearing Silurian rocks of the Inyo Mountains and the adjacent Panamint Range (fig. 1). At that time the Mazourka Canyon reference section was measured, and rugose coral collections from the Vaughn Gulch Limestone were made.

Geologic mapping and stratigraphic investigation of Paleozoic strata in the northern Panamint Range by J. F. McAllister beginning in 1937 (McAllister, 1952) provided much of the best Silurian rugose coral material from the Hidden Valley Dolomite. Current mapping in the Funeral Mountains by McAllister for the U.S. Geological Survey has resulted in additional collecting of coral material from these rocks.

Renewal of geologic mapping in Paleozoic rocks of central Nevada came with initiation of the Kobeh Valley study by T. B. Nolan and Merriam in 1958, giving opportunity for stratigraphic work and fossil collecting in the Lone Mountain Dolomite of areas within and adjacent to the Eureka mining district (Merriam, 1963b). During this period, comparative studies dealt also with Silurian coral-rich limestone facies of the Roberts Mountains, the Toquima Range, and the Simpson Park Mountains.

In 1968 the U.S. Geological Survey initiated a stratigraphic study by T. E. Mullens of the Roberts Mountains Formation in north-central Nevada. Under a comprehensive program bearing upon problems of ore occurrence and genesis, this investigation was undertaken to support detailed geologic mapping of the structurally complex terrane encompassing the Cortez and Carlin gold mines. Participation by Merriam has entailed identification of rugose corals and other fossils in Silurian and Early Devonian strata. In these economically important areas, the Late Silurian faunas of coral zone E are represented and the overlying Helderbergian (Early Devonian) Rabbit Hill Limestone has been recognized.

Research upon Silurian Rugosa of the Klamath Mountains, northern California, and of the islands of southeastern Alaska was in progress during this investigation. Comparison with these Pacific Border Silurian rugose corals has had an important bearing upon the coral taxonomy and upon correlation and facies analysis of the Great Basin Silurian rocks.

Silurian Rugosa in dolomite facies of the Sandpile Group of northwest Canada have been investigated by Norford (1962), providing for the first time a basis for comparison of Great Basin Silurian with Silurian of the northern Cordilleran region.

Oliver's (1964) contribution on the slipper coral *Rhizophyllum* brings together what is known of this diagnostic rugose coral genus in the central Great Basin, the Inyo Mountains, the Klamath Mountains, and Alaska.

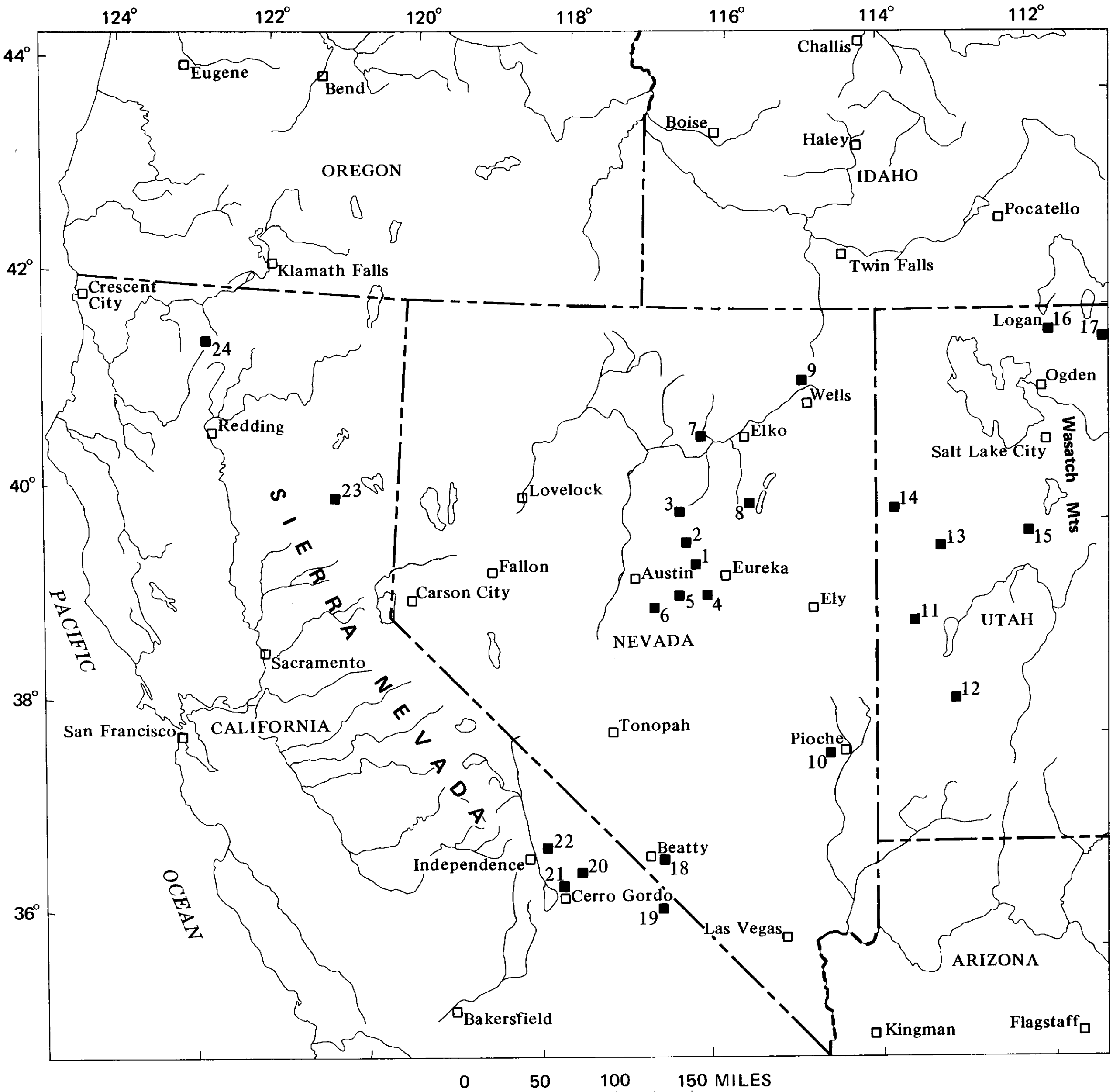
METHODS OF STUDY

Stratigraphic investigation conducted jointly with geologic mapping is the background of these Silurian coral studies. The framework of vertical succession and coral evolution is of necessity theoretical, but detailed mapping procedures help minimize the amount of inference which attends stacking of composite sections in a region of complex geologic structure and rapid facies change. Section measuring and fossil collecting without mapping control are far less dependable; experience demonstrates that the better and more complete sections for measurement are likely to be disclosed during later phases of a mapping program.

Reference stratigraphic sections employed in zoning the Great Basin Silurian corals are in geologically mapped areas or in areas where mapping is in progress. Some of the fossil collections were made close to Brunton compass and tape traverses within mapped areas. Other collections are weathered surface material from outcrop bands 200 or more feet wide and may include float from a greater interval. Attempts were made to find the same species in situ.

Stratigraphic and taxonomic studies of Silurian Rugosa depend upon comparison with species from classic European sections, among which are those of Gotland, Sweden, and of Czechoslovakia. The Gotland section (fig. 8) is a world Silurian yardstick for the coral-bearing carbonate facies. Since Wedekind's 1927 treatise on Rugosa of northern Gotland there have been no comprehensive paleontologic studies of entire Gotland rugose coral faunas in relation to field stratigraphy. Most Gotland Rugosa still require photographic illustration of thin sections, and much additional detail is needed on field occurrence, stratigraphic ranges of species, and faunal association. The same applies to the Czechoslovakian Rugosa, known mainly from exterior figures (Počta, 1902) and requiring thin-section study and establishment of species ranges.

Study of fine structure of the Rugosa depends on preservation of material, which ranges from retention of minute



EXPLANATION

1. Kobeh Valley at Lone Mountain
2. Roberts Creek Mountain in the Roberts Mountains
3. Simpson Park Mountains, north end at Coal Canyon
4. Fish Creek Range, south end
5. Antelope Valley
6. Toquima Range at Ikes Canyon
7. Carlin gold mine area
8. Ruby Mountains, southern part
9. Antelope Peak, Elko County
10. Ely Springs Range
11. Confusion Range
12. San Francisco district
13. Thomas Range
14. Deep Creek Range at Gold Hill
15. East Tintic Mountains
16. Logan area
17. Randolph area
18. Bare Mountain area
19. Funeral Mountains
20. Panamint Range, northern part
21. Inyo Mountains at Cerro Gordo mine
22. Inyo Mountains at Mazourka Canyon
23. Taylorsville area
24. Northeast Klamath Mts; Gazelle area

FIGURE 1.—Index map showing principal areas of Silurian coral-bearing rocks referred to in text.

thin-section detail of wall features in unsilicified limestone material to complete loss of fine structure in silicified corals from dolomite. Many of the dolomite corals were obtained by block etching; these specimens usually make poor thin sections. Sections of unetched dolomite corals may reveal patches of fine structure where silica replacement is incomplete. To avoid loss of detail in the silicified corals, thicker slices are usually more satisfactory.

Silicified material well enough preserved for study of the internal characters is uncommon; therefore, characterization is based to a considerable extent on gross external features, and quantitative morphologic studies must await more extensive collecting.

Description and classification of Silurian rugose corals here dealt with are based on gross features of exterior and interior. In some families, such as the Tryplasmatidae and Kodonophyllidae, fine structure of wall and septa will eventually be useful taxonomically (Wang, 1950; Kato, 1963). With regard to photographic illustration, enlargement of critical details to X 8 or greater is of value for identification and future taxonomic investigation.

ACKNOWLEDGMENTS

Acknowledgment is made to those U.S. Geological Survey field geologists engaged in mapping of Great Basin Silurian rocks whose fossil collections added materially to this report. Among these contributors and the areas of their mapping efforts are J. F. McAllister, the northern Panamint Range and the Funeral Mountains, Calif.; D. C. Ross, the northern Inyo Mountains, Calif.; H. R. Cornwall and F. J. Kleinhampl, Bare Mountain, Nev.; R. K. Hose, the Confusion Range, Utah; and Ronald Willden and R. W. Kistler, the Ruby Mountains, Nev. Corals from the Simpson Park Mountains and the Toquima Range, Nev., were contributed by A. J. Boucot and J. G. Johnson.

The writer thanks Helen Duncan and Jean M. Berdan of the U.S. Geological Survey for assistance in connection with *Entelophylloides* and for material representing this genus collected by them from the Cobleskill and Keyser Limestones.

The writer also thanks Prof. S. W. Muller and Stanford University for use of the McAllister thesis fossil collections from the northern Panamint Range.

All fossil photographs are the work of Kenji Sakamoto of the U.S. Geological Survey.

Thin sections used during the last 2 years of this study were prepared by Robert G. Shely.

IDENTIFICATION OF THE SILURIAN SYSTEM IN THE GREAT BASIN

The Silurian System in the central and eastern Great Basin is part of a fairly continuous saccharoidal dolomite section that includes Late Ordovician and Devonian strata as well. These somewhat monotonous and not infrequently barren dolomites occupy a stratigraphic interval between the Pogonip Group or the Eureka Quartzite and various horizons of the Middle Devonian. The lowest dolomites of this three-system sequence are readily distinguishable as Late Ordovician by a widespread Richmondian brachiopod-coral fauna containing abundant streptelasmid and halysitid corals. The top of the Silurian within the upper third of the sequence is less readily distinguishable, for above the uppermost fossil zone of unequivocal Silurian age no diagnostic faunas of Early and early Middle Devonian age have thus far been recognized in the dolomite facies. Most of the well-documented Early Devonian fossils have come from limestone or dolomitic limestone facies of the west-central and southwest Great Basin.

Halysitid corals and large pentameroid brachiopods of the *Conchidium* and *Virgiana* types are the commonly accepted criteria of Silurian age in the three-system dolomite succession. Halysitids have been considered more indicative of the lower beds, and the large pentameroids more characteristic of the higher Silurian. In view, however, of the great abundance of halysitids in the Richmondian or Late Ordovician beds, these tabulates are not definitive unless identified generically and specifically.

Silurian faunas of the Cordilleran belt have received little attention by the paleontologist and stratigrapher. Until recently, scarcity and poor preservation of fossils in dolomite discouraged serious paleontologic study. Routine fossil idenfifications for stratigraphic purposes were always provisional and uncertain—the species assigned with a query to a described fossil of a distant province, and the genera long-ranging and in most instances of doubtful value for system discrimination. Except possibly for graptolites in appropriate facies, there has been almost no paleontologic basis for zoning or stratigraphic subdivision of the Great Basin Silurian; in fact, paleontologic identification of the system itself has in some areas remained in doubt. Thus far, evidence from graptolites is lacking in the prevailingly dolomitic facies of the central and eastern Great Basin.

Whereas most of the identified Silurian of the Great Basin is marine dolomite, mapping in the west-central and southwestern parts of this province discloses areas of Silurian and Early Devonian limestone rich in fossils, of which many of the more distinctive are rugose corals. Northwest of the Great Basin, from the north end of the Sierra Nevada to the Klamath Mountains, there exists a third Silurian stratified rock suite in which siliceous clastic rocks of the graywacke type prevail, and where all carbonate rocks are nondolomitic. In limestone lenses of this graywacke province, the rugose corals are again among the distinctive Silurian indicators.

AREAL DISTRIBUTION OF GREAT BASIN SILURIAN CORAL-BEARING ROCKS

Silurian marine rocks of the southwest Cordillera, including the Great Basin, are distributed in three belts, contrasted with respect to lithology and faunas. These belts are the (1) eastern dolomite belt, (2) intermediate limestone belt, and (3) western, or Pacific Border, graywacke belt. Paleogeographically, the boundary trends of these belts are poorly defined, but they appear to have extended across the Great Basin province in north to northeasterly directions (fig. 2), not necessarily in alinement with existing orographic features. A border zone between the intermediate limestone belt and the eastern dolomite belt may be fairly accurately delineated in the vicinity of the Inyo Mountains and the Panamint Range, and in the Roberts Mountains and east of the Monitor Range. The boundary relationship of the intermediate limestone belt and the western graywacke belt is inferential, mainly because of cover by younger rocks. Coral faunas in the three Silurian belts differ because of facies and by reason of the vagaries of faunal dispersal and paleogeography.

Eastern dolomite belt.—This belt includes Silurian strata of the southern and eastern Great Basin and much of the central part that have been described as Hidden Valley Dolomite, Lone Mountain Dolomite, and Laketown Dolomite. In general terms, these rocks will be referred to hereafter as the Lone Mountain–Laketown facies. Only in the east-central and southwest Great Basin have the coral faunas of the eastern dolomite belt been studied intensively. However, in several mining districts of the eastern Great Basin, Silurian corals are fairly abundant, and provisional generic identifications have been made.

Intermediate limestone belt.—In such areas as the northern Inyo Mountains, Toquima Range, Monitor Range, Simpson Park Mountains, and the Roberts Mountains, the Silurian is represented by limestones. These limestone beds have yielded the greater part of the well-preserved rugose coral material herein described. Plotted distribution of limestone occurrences relative to occurrences of the eastern dolomite belt suggests that depositional change from dolomite to limestone took place in a westerly to northwesterly direction. Only in the Roberts Mountains is there evidence of intertonguing of Silurian dolomite and limestone facies, and there the structural conditions related to major thrusting are unfavorable for stratigraphic deductions. Recent discoveries of Silurian coral-bearing beds in the north-central Great Basin are mostly within the intermediate limestone belt, although those in the Ruby Mountains lie on the eastern dolomite side.

Western, or Pacific Border, graywacke belt.—In the western Great Basin occurrence of the Pacific Border graywacke belt beneath younger rocks is mainly inferential; the nearest exposures of such beds are at the north end of the Sierra Nevada near Taylorsville, Calif. Ordovician black shales and arenaceous deposits are known in the western Great Basin, and clastic deposition may have persisted into Silurian time in that part of the province. From the Taylorsville area northwest through the Klamath Mountains of northernmost California, the Silurian rocks of the Pacific Border province comprise argillite, graywacke, conglomerate, bedded chert, and fairly pure limestone. There is no dolomite. Much of the graywacke was probably derived from more or less contemporaneous volcanic rocks. Silurian strata of the Pacific Border graywacke suite are best exposed in southeastern Alaska, where they resemble those of the northern California region. In southeastern Alaska, mafic volcanic rocks with pillow structure are interbedded with the Silurian graywacke. All carbonate rocks are, again, nondolomitic. Silurian rugose coral faunas of the Pacific Border province differ to a considerable degree from those of the adjoining intermediate limestone belt on the east and probably to a greater extent from those of the eastern dolomite belt. The Rugosa of the Klamath Mountains Sililurian are described in a separate report (Merriam, 1972.)

DEPOSITIONAL AND FAUNAL FACIES OF GREAT BASIN SILURIAN CORAL-BEARING ROCKS

Two contrasting marine depositional and faunal facies are recognized in many parts of the world where the Ordovician and Silurian Systems are well represented. Faunally speaking, these are referred to in England as the graptolitic facies and the shelly facies (Jones, 1933, p. 474). The graptolitic facies in both geologic systems is commonly black, organic clay shale; the shelly facies—characterized by predominance of heavier shelled organisms, such as Mollusca, brachiopods, and the corals—is typified by carbonate rock and marlstone. Facies contrasts of this kind are especially impressive in the Great Basin Ordovician, where black shales, siltstones, cherts, and minor limestones of graptolitic sequences, such as the Vinini Formation, occupy separate outcrop belts and form thrust sheets of exceedingly complex structure. Carbonate shelly facies, being more competent structurally, have been less intensely deformed. In places the two Ordovician facies come together in thrust fault contact. Wholly graptolitic facies of the Silurian, although poorly understood, appear to be less extensive than other facies in the Great Basin. Limestone and dolomite, which include shelly facies only, make up the greater part of the known Silurian. Graptolitic facies of this system are mainly calcareous shale and thinly bedded calcareous siltstone that are lithologically unlike the very extensive noncalcareous clay shale, argillite, and chert of the Ordovician graptolitic sequences. In the western part of the Great

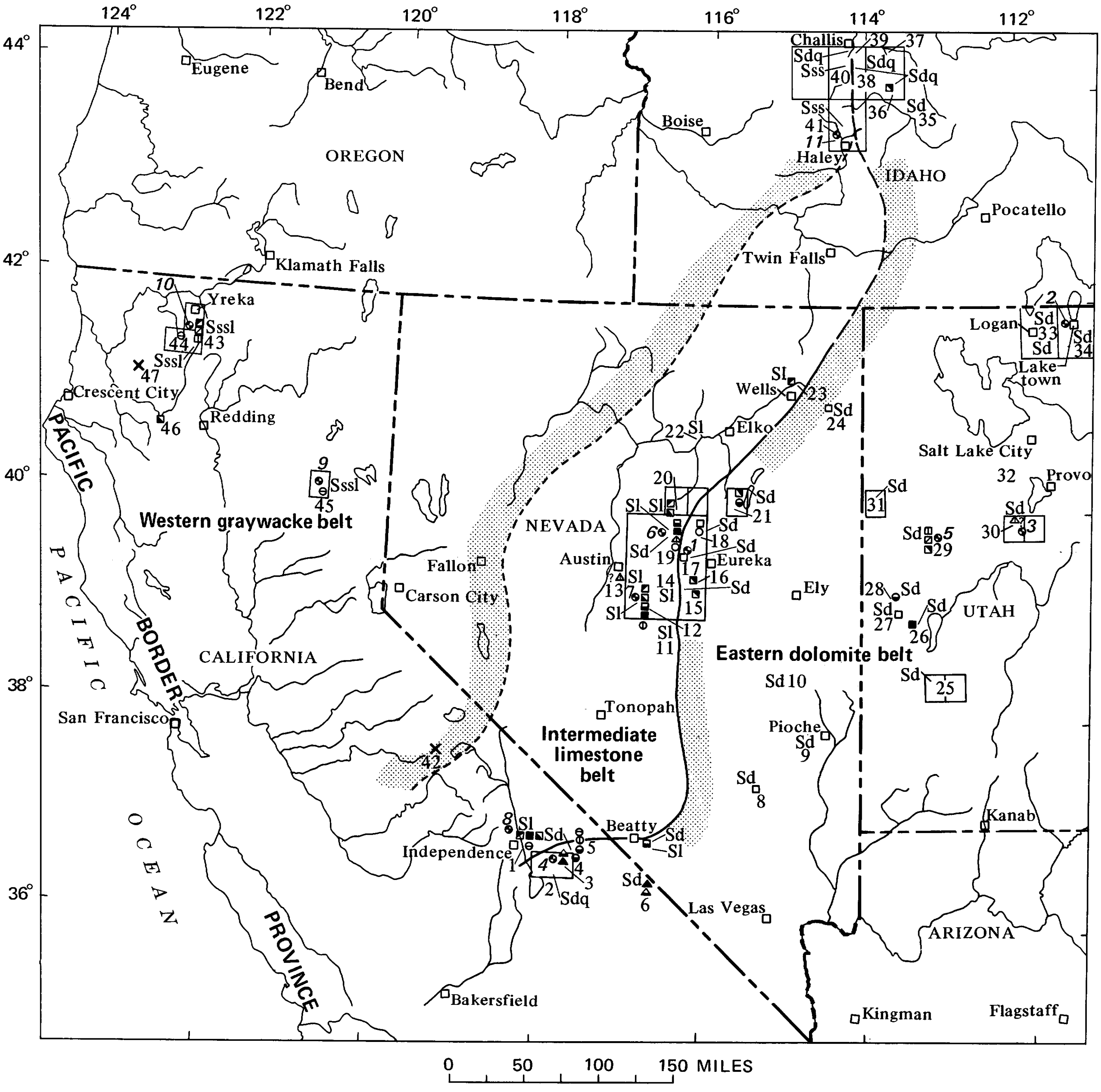


FIGURE 2.—Major lithologic belts, distribution of Silurian reference sections, and coral localities in the Great Basin.

Basin, some of the localized outcrops of Silurian limy shale and platy siltstone yield only graptolites. Other Silurian graptolite deposits are more sporadic, occurring as occasional calcareous shale tongues or interbeds in limestone units wherein the shelly facies predominate. In some areas of almost exclusively graptolitic facies, such as the Ordovician Vinini, it is not improbable that graptolite-bearing clay shale and chert deposition persisted on into Silurian time.

Eastern dolomite belt.—Silurian dolomites of this belt (Staatz and Osterwald, 1959) range in thickness from 2,500 feet at Lone Mountain, Nev., to 1,200 feet in western Utah. Thick-bedded blocky gray dolomite of saccharoidal texture is characteristic; most of these dolomites have a rather uniform and monotonous appearance and lack easily recognizable and persistent lithologic changes by which they might conveniently be subdivided into map units. Argillaceous beds are uncommon within the eastern

EXPLANATION

Type areas of Silurian marine rock units

1. Lone Mountain Dolomite
2. Laketown Dolomite
3. Bluebell Dolomite (Silurian part)
4. Hidden Valley Dolomite (Silurian part)
5. Laketown Dolomite: four described members in Thomas Range, Utah
6. Roberts Mountains Formation
7. Masket Shale of Kay and Crawford (1964)
8. Vaughn Gulch Limestone
9. Montgomery Limestone
10. Gazelle Formation
11. Trail Creek Formation

Silurian rugose coral genera

Late Silurian

- *Toquimaphyllum* and related corals
- *Rhizophyllum*
- *Entelophyllum*
- *Stylopleura*
- Lykophyllids
- *Zelophyllum*

Middle Silurian

- Lykophyllids
- *Zelophyllum*

Lower Silurian

- *Palaeocyclus*
- *Arachnophyllum*
- *Dalmanophyllum*

Silurian dasycladacean algae

Late Silurian

- *Verticillopora*

Middle Silurian

- *Verticillopora*

Prevailing lithology

Sssl, shale, sandstone, and limestone
Sss, shale and sandstone
Sl, limestone
Sd, dolomite
Sdq, dolomite and quartzite

Silurian localities

1. Mazourka Canyon, northern Inyo Mts
2. Cerro Gordo area, southern Inyo Mts
3. Ubehebe Peak area, northern Panamint Range
4. Andy Hills, northern Panamint Range
5. Whitetop Mtn., northern Panamint Range
6. Funeral Mts
7. Bare Mtn. area
8. Pahranagat Range
9. Ely Springs Range
10. Sunnyside
11. Dobbin Summit
12. Ikes Canyon
13. Austin area
14. Copenhagen Canyon
15. Southern Fish Creeks Range
16. Southern Mahogany Hills
17. Lone Mountain, Eureka County
18. Southern Sulphur Spring Range
19. Roberts Creek Mountain
20. Coal Canyon, northern Simpson Park Mts
21. Ruby Mts
22. Maggie Creek, Eureka County
23. Antelope Peak, Elko County
24. Pequop Mts
25. San Francisco district
26. Ibex Hills
27. Kings Canyon, Confusion Range
28. Confusion Range, southern part
29. Thomas Range
30. East Tintic Mts
31. Gold Hill district
32. Stockton and Fairfield areas
33. Logan area
34. Randolph area
35. Elbow Canyon
36. Rock Creek, Lost River Range
37. Grouse Creek, Lost River Range
38. Bayhorse quadrangle, east-central part
39. Bayhorse quadrangle, north-central part
40. Bayhorse quadrangle, central part
41. Trail Creek
42. Mount Morrison area
43. Northeast Klamath Mts, Willow Creek area
44. Northeast Klamath Mts, Horseshoe Gulch area
45. Taylorsville area
46. Weaverville quadrangle, Douglas City area
47. Knownothing Creek, Cecilville area, Klamath Mts

dolomite belt; toward the west occur sporadic lenses of clean lime-cemented quartz sandstone or quartzite. Continuous diagenetic dolomite accumulation without significant stratigraphic discontinuity during most of the Silurian suggests a stable marine environment, little disturbed by crustal deformation, under conditions commonly ascribed to the "stable shelf."

Fossils are scarce or absent throughout most of the eastern dolomite. Silicified fossil material is locally abundant, especially in scattered bodies of dark-gray carbonaceous dolomite surrounded by the normal, lighter gray rock. Within these highly organic lenses and pockets, corals and brachiopods became silicified early and mysteriously survived destruction during the magnesian recrystallization. Fossil assemblages of these carbonaceous dolomite lenses differ in character from those in approximately correlative limestone facies of the intermediate limestone belt. Among rugose corals, *Entelophyllum* is the best known in the eastern dolomite belt; in terms of biofacies the eastern dolomites are referred to as the *Entelophyllum* facies, as this coral genus is not a common element of the intermediate limestone belt to the west.

Intermediate limestone belt.—Medium- to dark-gray and bluish-gray limestones of this Silurian belt have been traced from the northern Inyo Mountains, Calif., to the Tuscarora Mountains of northern Nevada. Ranging in thickness from 1,200 feet in the Inyos to more than 2,000 feet in the Simpson Park Mountains and the Roberts Mountains, the limestones of this belt are here and there rich in well-preserved rugose corals and other fossils. In these facies are to be found the more continuous marine reference sections. Platy and flaggy to thick-bedded limestones are characteristic, with relatively few massive members. Bioclastic facies are common; the contributing organisms are crinoids, stromatoporoids, corals, brachiopods, calcareous algae, and Mollusca, in approximate order of decreasing abundance. Bedded dark-gray chert is widespread at the base of these limestone successions.

Calcareous shaly interbeds and partings are most numerous in the lower parts of stratigraphic sequences in the intermediate limestone belt. There is little wholly noncalcareous clay shale in these strata. Graptolites are most obvious to the collector in these lower, shaly intercalations. The higher and more thickly bedded parts of Great Basin Silurian limestone sequences have thus far yielded relatively few graptolites.

Limestones of the intermediate limestone belt contain dolomite tongues in the type section of the Roberts Mountains Limestone (Winterer and Murphy, 1960). It is possible that we have here a boundary relationship with the eastern dolomite belt. A lateral interfingering relationship between the coral-rich Vaughn Gulch Limestone of the intermediate limestone belt and graptolitic facies can be observed in Mazourka Canyon, northern Inyo Mountains. There, the Sunday Canyon Formation (Ross, 1966, p. 32), a calcareous but partly shaly graptolitic unit, reveals probable northward tongues of the Vaughn Gulch Limestone, which has yielded no graptolites.

No exposures which bridge the gap between facies of the intermediate limestone belt and the Pacific Border graywacke belt are known in the western Great Basin. Rocks of the Pacific Border graywacke belt have thus far disclosed no diagenetic dolomite; coral-bearing limestones of this belt are quite subordinate to the siliceous clastics of which the source material is in considerable part volcanic.

GREAT BASIN SILURIAN REFERENCE SECTIONS

Because of structural complexity and lack of continuous exposure, Silurian rock sequences with depositional contact at bottom and top are a rarity in the central and southwest Great Basin. Faults are the common system boundaries. Hence, vertical and evolutionary order of faunas is partly dependent upon composite sequences, the reliability of which is within the limits of accuracy imposed by physical or fossil correlation between separate, but theoretically overlapping, partial sections.

Of the many Silurian outcrop areas mapped or examined during the course of these studies, few are sufficiently inclusive to serve as reference sections for the system. Those so designated within the intermediate limestone belt are as follows: The Mazourka Canyon section, northern Inyo Mountains; the Ikes Canyon section, Toquima Range; the Roberts Creek Mountain section; and the section in Coal Canyon, northern Simpson Park Mountains. Reference sections for the eastern dolomite belt are those of the northern Panamint Range near Ubehebe Peak and Whitetop Mountain, the Funeral Mountains section, California, and the Lone Mountain section, Eureka County, Nev. The section at Bare Mountain near Beatty, Nev., may eventually be suitable for reference purposes; like the Roberts Creek Mountain section, it also lies near the border between the eastern dolomite and intermediate limestone belts.

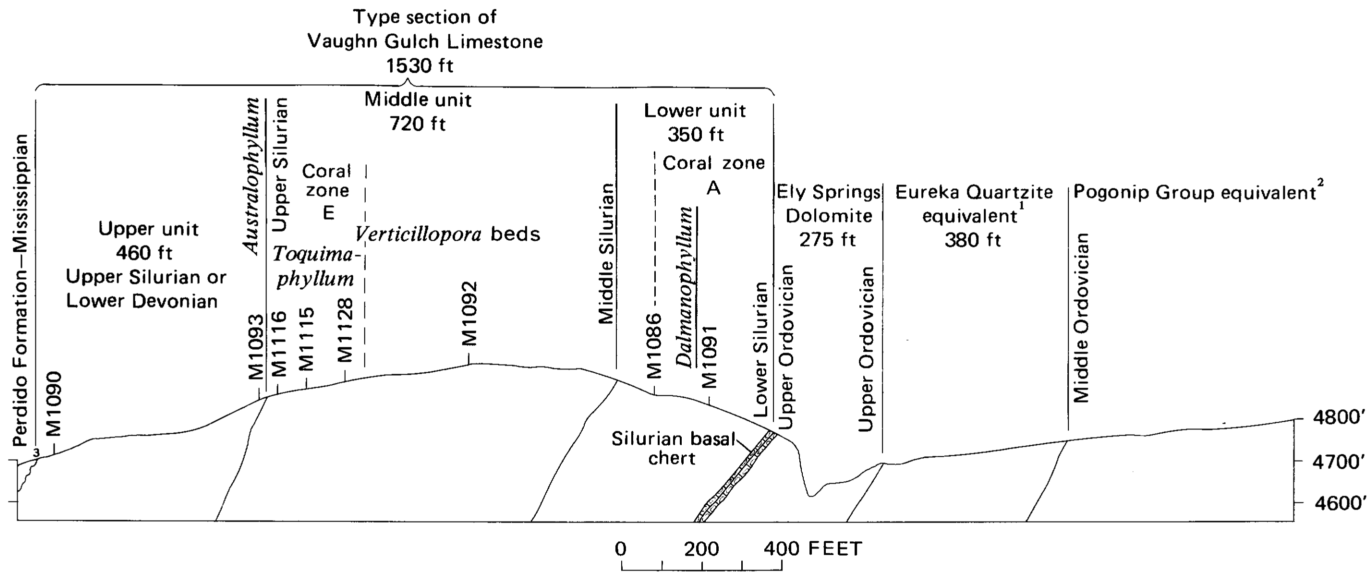
MAZOURKA CANYON REFERENCE SECTION

At Mazourka Canyon a continuous limestone sequence about 1,500 feet thick rests conformably upon the Late Ordovician Ely Springs Dolomite and is overlain disconformably by Mississippian conglomerate and quartzites (fig. 3). Named the Vaughn Gulch Limestone by Ross (1963, p. B81), this formation has been a subject of paleontological investigation since 1912, at which time these strata were considered to be Devonian (Kirk, 1918; Stauffer, 1930). Mapping of the Cerro Gordo mining district in 1946 brought renewed interest in these beds, when it became fairly evident that the Silurian and Lower Devonian Hidden Valley Dolomite (McAllister, 1952) of the southern Inyo Mountains near Cerro Gordo changes northward into limestone (Merriam, 1963a). Rugose coral studies of Vaughn Gulch material from what is now called coral zone E indicated correlation with coral faunas in central Great Basin Silurian limestones.

The Vaughn Gulch Limestone appears to be an unbroken sequence of well-bedded medium- to dark-gray, partly bluish-gray, impure carbonaceous limestone, argillaceous limestone, and calcareous siltstone, including many fossil-rich beds. Some of the more argillaceous and silty interbeds weather in subdued fashion to a light gray, stained pink or orange in places. Black chert zones are stratigraphically significant, occurring at the base and top of the formation; elsewhere, minor chert is present as scattered nodules or thin lenses. Platy and flaggy exposures predominate, with limestone beds ranging in thickness from 1 to 6 inches separated by calcareous shaly or siltstone partings. Thicker limestone beds, some more than 3 feet thick, are fairly common, and many of them are bioclastic. These weather out prominently and are the most numerous in the upper middle part of the formation.

Readily mappable lithologic divisions (Ross, 1965, 1966) have not been recognized within the Vaughn Gulch Limestone. For faunal distribution, however, the column can be divided into a lower part 350 feet thick, a middle part 720 feet thick, and an upper part 460 feet thick.

More uniformly bedded and having fewer bioclastic and fossil beds than higher parts of this formation, the lower 350 feet consists largely of platy to flaggy, partly laminated dark-gray or bluish-gray argillaceous limestone that



[1] Barrel Spring and Johnson Spring are local names (Ross, 1966) applied to units of the Eureka Quartzite interval; normal Eureka Quartzite occupies this interval along the west Inyo Mountains front 15 miles to the south (Merriam 1963a). Ranges from Middle to possibly Late (Richmond) Ordovician age.

[2] Local names have been given to these strata (Ross, 1963, 1966).

[3] Disconformity at top of Vaughn Gulch Limestone (Merriam, 1963a, p. 15).

FIGURE 3.—Mazourka Canyon reference section, showing type section of the Vaughn Gulch Limestone. Section extends northeasterward along divide between Vaughn Gulch and Willow Springs Canyon, Indepencence quadrangle, California. Based on unpublished geologic mapping by Merriam.

weathers light gray in places. A persistent dark-gray chert member at the bottom, some 15 feet thick, corresponds to that forming the base of the Silurian System elsewhere in the Great Basin. Weak partial dolomitization and nodular chert decrease upward to the lowest fossil bed of coral zone A, which lies 130 feet above the thick basal chert. The few fossil beds in this division contain abundant *Heliolites* and favositids; more distinctive zone indicators, such as *Dalmanophyllum,* are uncommon.

The 720 feet of limestone constituting the middle part of the Vaughn Gulch includes the prominent medium- to dark-gray richly fossiliferous coralline and bioclastic beds in its upper half, of which the uppermost 200 feet falls within Great Basin Silurian coral zone E. The thicker, darker gray beds, ranging in thickness form 10 inches to more than 3 feet, are generally the biogenic beds; these are commonly sculptured into prominent ribs separated by subdued intervals of silty or argillaceous limestone that weather lighter gray. Crinoidal debris is much of the bioclastic material of these thicker fossil ribs. Some of the fossils which weather in relief are complete but are partially silicified and limonite impregnated. Below the middle of this 720-foot division, most of the limestones are thinner bedded and show fewer bioclastic members. No fossil accumulations with true biohermal relief were found. Chert is a minor constituent. About 300 feet of beds in the middle of this 720-foot division contain an abundance of the large dasycladacean alga *Verticillopora.* Though long-ranging, these calcareous algae appear to be most numerous in Great Basin Silurian coral zone D.

A 460-foot upper interval of the Vaughn Gulch includes those beds between the top of Silurian coral zone E and the Mississippian disconformity. Bioclastic beds within the topmost 75 feet contain abundant poorly preserved fossils. Contorted layers of dark-gray chert in the upper 30 feet are associated with massive dark-bluish-gray crinoidal limestone which contains silicified, partly macerated, limonite-stained brachiopods, favositids, and large rugose corals, both solitary and colonial. Below the upper beds, the limestone is partly laminated and platy down to the lower strata adjoining coral zone E, where thicker bioclastic and coralline beds become more numerous. As noted elsewhere under correlation, there is inconclusive paleontologic evidence of Early Devonian age for the 460-foot upper interval.

IKES CANYON REFERENCE SECTION

Silurian limestone, calcareous shale, and siltstone some 500 feet thick at Ikes Canyon, northern Toquima Range, Nev., are rich in well-preserved coral material at several stratigraphic horizons. Mapping by Kay and Crawford (1964) shows this area to be structurally very complex; measurable stratigraphic sections are uncommon because of the many thrust and normal faults. Fairly abrupt facies changes from graptolite-bearing calcareous shale to shelly facies and coralline limestone further complicate stratigraphic and structural interpretation. The strata in question were assigned by Kay and Crawford (1964, p. 437–441) to the Masket Shale and Diana Limestone of Silurian age, and the McMonnigal Limestone was assigned to the Devonian.

Fossil collections upon which Merriam's appraisal is based came from the west side of Copper Mountain, north of Ikes Canyon, where coral-bearing medium- to dark-bluish-gray limestones crop out at successive horizons across strata mapped by Kay and Crawford as Masket, overlain by McMonnigal. The lower coral collections representing Great Basin Silurian coral zones A and D came from sites within the Masket; the upper collections, those of coral zone E, appear to fall within the McMonnigal.

Appraisal of Silurian and Ordovician stratigraphy at Ikes Canyon suggests that the upper chert member of Kay and Crawford's (1964, p. 437) prevailingly dolomitic Gatecliff Formation beneath the Masket is actually the widespread Great Basin basal Silurian chert, whereas the underlying dolomitic members of the Gatecliff correspond to the Ely Springs Dolomite of Late Ordovician (Richmondian) age.

ROBERTS CREEK MOUNTAIN REFERENCE SECTION

The Roberts Creek Mountain reference section is 1½ miles west-northwest of the summit of Roberts Creek Mountain on the spur between the north and middle forks of Pete Hanson Creek. The type sections of the Late Ordovician (Richmondian) Hanson Creek Formation and the conformably overlying Roberts Mountains Formation of Silurian age are included.

About 2,200 feet thick, the Roberts Mountains Formation is approximately 80 percent limestone with a prominent cherty member at the base and dolomitic limestone and dolomite beds in the upper 450 feet (fig. 4). Stratigraphic relationships are clearly shown in the lower 1,500 feet of this column; the higher part, being closer to the Roberts Mountains thrust, is more deformed, and the beds in this direction become increasingly more dolomitic.

The Roberts Creek Mountain reference section was measured in 1934 (Merriam, 1940) and has more recently been mapped by Winterer and Murphy (1960, p. 120) in connection with study of intertonguing dolomite and limestone. In the immediate type area, lithology and paleontology make feasible a three-unit division as unit 1 (180 ft), unit 2 (1,100ft), and unit 3 (900 ft), in ascending stratigraphic order.

Unit 1, a cherty division, comprises a basal chert overlain by fine-textured thin-bedded or laminated dark-gray limestone that weathers platy and flaggy with shaly partings. The limestones weather light gray. The distinctive basal chert is bluish black; its lowermost 10 feet is 75 percent chert containing subordinate limestone lenses. The chert decreases upward, occurring in ½ to 2-inch layers separated by laminated limestone. The chert largely disappears toward the top of unit 1. The basal chert, conformable with underlying Hanson Creek Formation, is the widely recognized basal chert of the Great Basin Silurian. Fossils are scarce in the laminated limestone, but shaly partings yield poorly preserved graptolites. In other areas correlative basal cherts contain pentameroid brachiopods.

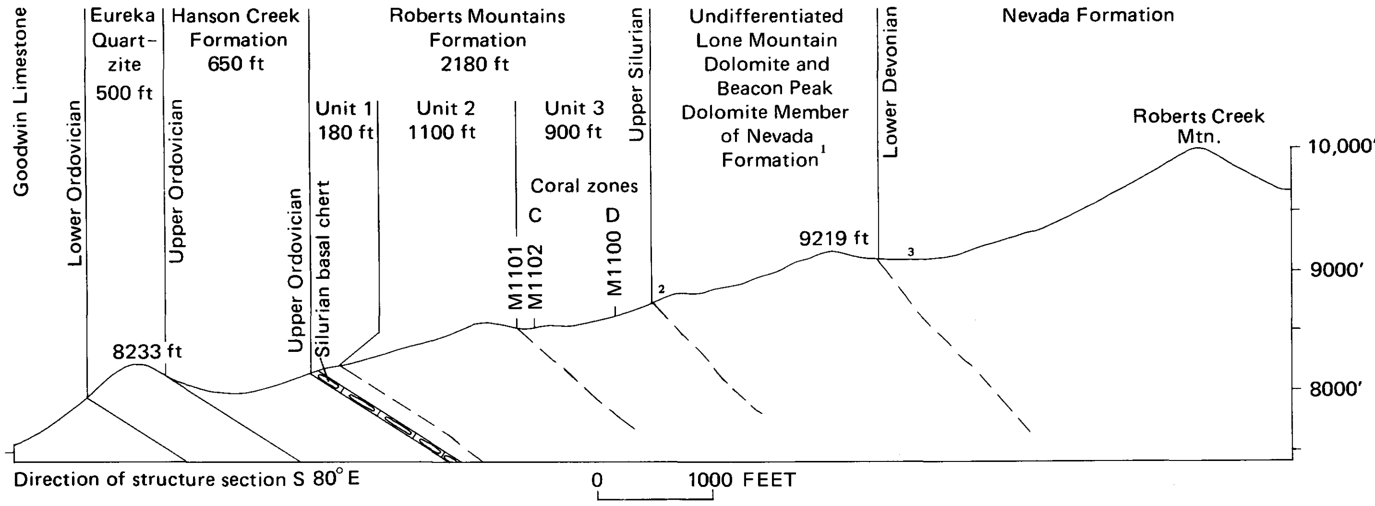
Unit 2 comprises platy to flaggy dark, sometimes bluish-gray, limestones and heavier limestone interbeds up to 2 feet thick. Calcareous shaly partings separate the limestone layers, many of which are coarse textured and highly fossiliferous, much of the debris being crinoidal. The absence of chert and the introduction of the thicker, coarsely bioclastic and crinoidal beds distinguish unit 2 from unit 1. Scattered black chert lenses are, however, present above the middle of unit 2. In the upper part are a few light-gray recrystallized carbonate layers that appear to be somewhat dolomitic. Tabulate corals and pentameroids and other brachiopods are abundant in the many bioclastic beds, but rugose corals are in the minority.

Unit 3 is gradational with unit 2 through an interval in which the coarser textured crinoidal layers containing abundant *Conchidium*-like brachiopods pass upward into a thicker bedded sequence of light- and dark-gray blocky weathering limestones which include coralline beds. These coral beds contain large colonial Rugosa and represent Great Basin Silurian coral zone C. Some 250 feet above the base, this unit becomes prevailingly lighter gray and less well bedded as it passes into the magnesian limestone and dolomite of the upper half. Light-gray weathering magnesian limestones in the middle part of this unit contain abundant silicified corals of Great Basin Silurian coral zone D. Bedding is poorly defined and blocky through the upper 400 feet, where fossils become fewer and the rock passes into dolomite of the overlying unit.

Some 1,600 feet of blocky dolomite between unit 3 and the richly fossiliferous beds of the Devonian Nevada Formation were initially correlated with the Lone Mountain Dolomite (Merriam, 1940, p. 32). No identifiable fossils were obtained from this interval. It probably includes not only a partial equivalent of the Lone Mountain but also higher dolomitic limestones and dolomites which elsewhere represent the lowermost Nevada containing the Helderbergian Rabbit Hill fauna and faunas of Oriskany age.

COAL CANYON REFERENCE SECTION

The Coal Canyon reference section, at the north edge of the northernmost Simpson Park Mountains, includes 5,000 feet of east-dipping strata ranging in age from Late Ordovician to Middle Devonian. Along the east slopes of Coal Canyon near its mouth are the best known exposures



[1] Upper 500 feet of this undifferentiated dolomite may include the Beacon Peak Dolomite Member of the Nevada Formation, which 10 miles east in the Sulphur Spring Range contains the Rabbit Hill fauna of Helderberg Early Devonian age.

[2] Expected position of Great Basin Silurian coral zone E; corals of this zone absent possibly because of dolomite facies.

[3] *Acrospirifer kobehana* and *Eurekaspirifer pinyonensis* faunas in Nevada Formation of lower plate below Roberts Mountains thrust.

FIGURE 4.—Roberts Creek Mountain reference section, showing type section of the Roberts Mountains Formation and type section of the underlying Hanson Creek Formation. Section extends S. 80° E. between south and middle forks of Pete Hanson Creek, Roberts Creek Mountain quadrangle, Nevada.

of uppermost Roberts Mountains Formation in normal stratigraphic contact with overlying Rabbit Hill Limestone of Early Devonian age. The strata of this section probably occupy the lower plate of an overthrust. One-half mile southeast of the mouth of Coal Canyon, a flat-lying discordant outcrop of brecciated Ordovician Vinini chert and shale probably represents the upper plate of the thrust. All strata of this area are cut by later north-trending high-angle faults which exert topographic control and hamper measurement of continuous stratigraphic sections. A north-trending shear zone along the west side of Coal Canyon is several hundred feet wide and separates the less disturbed upper beds of the Roberts Mountains Formation along the east wall of the canyon from the dislocated limestone and calcareous shale of probable Silurian age to the west. On the east of the canyon, the uppermost 250 feet of the Roberts Mountains Formation below the Rabbit Hill boundary comprises flaggy to thick-bedded dark-bluish-gray limestone containing lenses and interbeds of coarse depositional limestone breccia (Winterer and Murphy, 1960). Clasts and matrix of these breccia bodies contain well-preserved corals and brachiopods representing Silurian coral zone E of this report.

The Roberts Mountains–Rabbit Hill contact is drawn where the thicker coralline beds and lenses of Silurian coral zone E pass upward into thinner bedded and platy, somewhat darker gray limestone and calcareous shale of the Rabbit Hill. This boundary appears to be gradational and is without recognized features of disconformity, such as might be expected along a tradational system boundary.

The Helderbergian Rabbit Hill of this eastern structural block has a minimum thickness of 900 feet. Allowing for probable duplication of Rabbit Hill strata by faulting, the total width of outcrop, which exceeds half a mile, suggests that this formation may be more than 1,000 feet thick in this area.

The easternmost and stratigraphically uppermost exposures in the Coal Canyon section are the argillaceous limestones of Merriam's Nevada Formation unit 2 (Merriam, 1973c). Alluvial cover prevents determination of true stratigraphic relationship of the Rabbit Hill Limestone to the contiguous Nevada. No strata of the Early Devonian (Siegenian) unit 1 of Merriam (1973c) of the Nevada Formation were recognized.

The Roberts Creek Mountain stratigraphic section appears fairly continuous in the structural block west of the Coal Canyon shear zone. Johnson and Murphy (1969) used the name "Windmill Limestone" for upper beds of this block and have included in this unit not only the Coal Canyon shear zone but also the uppermost Roberts Mountains Formation below the Rabbit Hill contact in the contiguous eastern structural block. Johnson and Murphy (1969, fig. 2) regarded their Windmill Limestone as Early Devonian on the basis of somewhat controversial evidence from graptolites, conodonts, and brachiopods.

This rugose coral investigation, together with concurrent detailed geologic mapping of the Coal Canyon area by Merriam, fails to support the conclusions of Johnson and Murphy (1969) with respect to Devonian age assignment of the uppermost Roberts Mountains Formation in this reference column. Clearly, the

"Quadrithyris zone' of Johnson and Murphy is Merriam's Silurian coral zone E, which contains here, as elsewhere in the Great Basin, a large and distinctive rugose coral assemblage of Gotlandian character. Rationalization of this question should await the completion of detailed geologic mapping in this area. Other structural and paleontologic problems engendered by the Johnson-Murphy stratigraphy call for review of fossil identifications and fossil ranges. As presently interpreted by these workers, the lower part of their Windmill Limestone, dated as Early Devonian by species of *Monograptus (M. hercynicus* and *M. praehercynicus)* with support from conodont and brachiopod evidence, underlies their *"Quadrithyris* zone," which brackets Merriam's Silurian coral zone E.

The Coal Canyon reference section supplements the type section of the Roberts Mountains Formation 12 miles to the southeast (Merriam, 1940, p. 11). Both occupy structural belts of thrusting and subsequent high-angle faulting. In detail the two sections present both similarities and differences. Dolomite, present as tongues and interbeds in the type section, has not been found at Coal Canyon, whereas the coral-rich depositional limestone breccias of Coal Canyon are unrecognized in the type section of the Roberts Mountains Formation. Graptolitic facies are better shown and probably more extensive in the Coal Canyon Silurian. Most noteworthy is the failure to recognize the Helderbergian Rabbit Hill beds where they are to be expected above the type Roberts Mountains Formation on Pete Hanson Creek. However, in this section these Helderbergian strata may well be represented in the thick dolomites occupying the interval between the Silurian Roberts Mountains beds and the Devonian Nevada Formation at Roberts Creek Mountain.

NORTHERN PANAMINT RANGE REFERENCE SECTION

The Silurian strata of the northern Panamint Range reference section are a part of the Hidden Valley Dolomite in its type locality 2½ miles north of Ubehebe Peak (McAllister, 1952, p. 15). There, the Hidden Valley is 1,365 feet thick and rests conformably upon Late Ordovician (Richmondian) Ely Springs Dolomite. In neighboring areas to the east, higher beds of this dolomite formation contain Early Devonian (Oriskany) fossils. Only Silurian fossils are known in the type area, and a system boundary cannot be indicated within the unbroken sequence.

McAllister (1952, p. 15, 16) defined three lithologic units. Only in the lower unit, or unit 1, having a thickness of 435 feet, are Silurian fossils abundant. The thick-bedded saccharoidal dolomites of this division weather blocky and medium to light gray and are cherty. Coral-rich beds of Great Basin Silurian coral zone B occur in the upper part of unit 1, about 300 feet above its base. Few fossils have been found in the 730 feet of dolomite in overlying unit 2.

A faulted Hidden Valley Dolomite sequence at Whitetop Mountain, 10 miles northeast of the type section, shows the lowermost beds of unit 1, which contain the fauna of Great Basin Silurian coral zone A. A similar zone A assemblage was collected by McAllister in the Andy Hills 6½ miles east of the type locality. Thus far, the Early Silurian zone A fauna has not been found below coral zone B, where it would be expected, in the lowermost dolomites of the Hidden Valley in its type locality.

LONE MOUNTAIN REFERENCE SECTION

The Lone Mountain Reference section is on the southwest side of Lone Mountain, Eureka County, Nev., where the entire carbonate sequence from the top of the Eureka Quartzite to the base of the Nevada Formation of Devonian age is diagenetic dolomite. Detailed geologic mapping of Lone Mountain, which is within the type area of the Lone Mountain Dolomite, was carried out under the Kobeh Valley project of Nolan and Merriam; this mapping called for stratigraphic revision, in accordance with which the name Lone Mountain Dolomite is applied to the entire 2,500 feet of section from the bottom of the Silurian basal chert directly overlying the Hanson Creek Formation to the base of the Nevada Formation. Merriam's (1940, p. 13, 21) earlier redefinition of Hague's (1892, p. 57) Lone Mountain Limestone had used the term Roberts Mountains Formation for the lower 750 feet of darker weathering dolomite now designated as Lone Mountain unit 1. Thus revised and reapportioned (fig. 5), Hague's original Lone Mountain Limestone comprises, at the bottom, a Late Ordovician dolomitic facies of the Hanson Creek Formation, overlain by unit 1 and unit 2 of the Silurian Lone Mountain Dolomite. Stratigraphy and paleontology of the Lone Mountain Dolomite are treated in a separate paper (Merriam, 1973a).

Approximately 80 feet thick in places, the lower chert member of Lone Mountain unit 1 is much thicker than usual for the basal Silurian chert in limestone facies; together, the basal chert and the overlying darker gray saccharoidal dolomite total about 750 feet thick. Although barren of identifiable fossils, Lone Mountain unit 1 probably correlates with the basal chert and limestone of Roberts Mountains Formation unit 1 and part of unit 2 in the richly fossiliferous Silurian limestone facies of the Roberts Mountains area to the north.

Lone Mountain Dolomite unit 2, having a thickness of about 1,750 feet, is lighter gray, more massive, and blockier weathering than unit 1. Although coarse saccharoidal texture is characteristic of unit 2, the finer textured dolomite members occur toward the top. In the type section, Lone Mountain Dolomite unit 2 appears to be gradational with the overlying, richly fossiliferous dolomitic Lower Devonian sandy limestone of Nevada Formation unit 1. No trace of the Helderbergian Rabbit Hill fauna has been found where it would be expected near this boundary.

Hague (1892)	Merriam (1940)	Merriam (this report)	
Nevada Limestone	Nevada Formation	Nevada Formation unit 1	Early Devonian (early Emsian)
Lone Mountain Limestone	Lone Mountain Formation (restricted)	Lone Mountain Dolomite unit 2	Silurian ↕
	Roberts Mountains Formation (dolomite facies)	Lone Mountain Dolomite unit 1	
	*	*	
	Hanson Creek Formation (dolomite facies)	Hanson Creek Formation (dolomite facies)	Ordovician
Eureka Quartzite	Eureka Quartzite	Eureka Quartzite	

↕ All known fossils of the Lone Mountain Dolomite type area are Silurian.
* Silurian basal chert marker.

FIGURE 5.—Comparative diagram illustrating present usage of the stratigraphic name Lone Mountain Dolomite in its type area.

Fossils are scarce and very poorly preserved because of magnesian recrystallization through the Lone Mountain Dolomite type section. In the upper 500 feet of unit 2, scattered very dark gray carbonaceous dolomite lenses contain fairly abundant but fragmentary and partly macerated colonial rugose corals probably of the Silurian genus *Entelophyllum*, a common and well-preserved silicified fossil in neighboring Lone Mountain Dolomite exposures.

Supplementary Lone Mountain exposures yielding *Entelophyllum* and well-preserved Silurian brachiopods have recently been mapped in the Mahogany Hills, 16 miles southeast of Lone Mountain, and in the Fish Creek Range, 25 miles southeast of Lone Mountain. Other outcrops of Lone Mountain Dolomite have been mapped in the southern Sulphur Spring Range, 20 miles northeast of Lone Mountain. There, the large dolomite fault block of East Ridge, near Romano Ranch, contains Silurian coral faunas probably representing lower horizons of the Lone Mountain Dolomite. As discussed below under correlation of Great Basin Silurian coral zones, the higher Lone Mountain in the Mahogany Hills and the Fish Creek Range pertains to the Late Silurian upper Lone Mountain–Laketown Dolomite faunal facies.

In the Sulphur Spring Range, the large East Ridge dolomite fault block near Romano Ranch includes about 1,200 feet of blocky Lone Mountain with two coral horizons—one about 250 feet above the base, and the other near the top. Abundant *Halysites* and Silurian *Pycnostylus* (pl. 15, fig. 11) and *Stylopleura*? (pl. 16, figs. 3, 4) occur in these horizons. These dolomites may be partly correlative with Lone Mountain unit 1. In a separate fault block west of the East Ridge block occur dolomitic limestones with a Helderbergian Rabbit Hill fauna. These beds lie above the Lone Mountain Dolomite at the base of Nevada Formation unit 1 (Merriam, 1973a). Mapping of these dolomitic Helderberg beds in the Sulphur Spring Range has led to the conclusion that they are correlative with the Beacon Peak Dolomite Member, the lowest member of the Nevada Formation in the Eureka mining district (Nolan and others, 1956, p. 38). Southeast of Eureka in its type section, the fine-textured Beacon Peak is separated from coarse-textured subjacent Lone Mountain Dolomite by a sharply incised undulant erosion surface unrecognized in the type section of the Lone Mountain Dolomite.

RUGOSE CORAL ZONATION OF THE GREAT BASIN SILURIAN

Study of the stratigraphic distribution of Silurian Rugosa in correlative and overlapping reference sections makes possible a hypothetical fivefold paleontologic zonation based on ranges of species and genera. Provisional zones are designated by capital letters A through E, in ascending stratigraphic order. Gaps in the coral record within a single reference section may be filled in the correlative sections to complete the overlapping composite zonal scheme. At present, no more than three coral zones have been recognized within any one reference column; additional collecting is expected to eliminate some of these local gaps.

Ranging in age from late Early to Late Silurian, the five coral zones are as follows:

Age	Great Basin Silurian coral zone	British Series
Late Silurian	E D	Ludlovian
Middle Silurian	C B.	Wenlockian
Late Early Silurian	A	Late Llandoverian

As noted elsewhere, there is inconclusive evidence of biofacies or ecologic difference between the rugose corals in diagenetic dolomite and those in approximately correlative limestone deposits. Rugosa of the upper part of the Lone Mountain Dolomite and of the Laketown Dolomite are, in a biofacies sense, unlike those of the more or less equivalent limestones and cannot, therefore, be included at present in the fivefold zonal arrangement.

Silurian coral zone A is based on rugose coral genera present in both dolomite and limestone facies, as well as on forms collected only in the dolomites (fig. 6). Coral zone B assemblages have been collected only in the dolomites. Coral zones C and E are established on the basis of limestone faunas, whereas coral zone D indicators have been found in both carbonate facies.

ZONE A

Early Silurian faunas of coral zone A occupy lower beds of the Hidden Valley Dolomite in the reference section of the northern Panamint Range. These are the lowest known Silurian shelly faunas of the Great Basin, occurring in the lower 100 feet of Hidden Valley unit 1 and above the Ely Springs Dolomite with a Richmondian fauna. Rugose corals in basal Silurian beds of Whitetop Mountain, northern Panamint Range, are as follows:

- *Rhegmaphyllum* sp. h
- *Dalmanophyllum* sp. A
- *Palaeocyclus porpita* subsp. *mcallisteri*
- *Rhabdocyclus* sp. d
- *Arachnophyllum kayi*

Other diagnostic Rugosa present in limestone facies coral zone A of the Toquima Range are *Cyathophylloides fergusoni* and *Neomphyma crawfordi*, there in association with *Arachnophyllum kayi*. *Palaeocyclus*, a small button coral, is the distinctive fossil of this zone. However, it seemingly has facies-restricted distribution, having been collected only in dolomites of the Panamint Range, the Ruby Mountains of north-central Nevada, and the Confusion Range of western Utah.

Characteristic Rugosa of the Great Basin Silurian coral zones

Age	Characteristic rugose corals of Great Basin Siluriar	Great Basin Silurian coral zone
Late Silurian	*Stylopleura berthiaumi*, n. gen., n. sp. *Stylopleura nevadensis*, n. gen., n. sp. *Mucophyllum oliveri*, n. sp. *Kodonophyllum mulleri*, n. sp. *Rhizophyllum* cf. *R. enorme* *Rhizophyllum* sp. D *Chonophyllum simpsoni*, n. sp. *Australophyllum (Toquimaphyllum) johnsoni*, n. subgen., n. sp. *Kyphophyllum nevadensis*, n. sp. *Salairophyllum*?* sp.	E
	Stylopleura berthiaumi, n. gen., n. sp. *Tryplasma duncanae*, n. sp. *Tonkinaria simpsoni*, n. gen., n. sp.	D
Middle Silurian	*Denayphyllum denayensis*, n. gen., n. sp. *Tryplasma newfarmeri*, n. sp. *Entelophylloides (Prohexagonaria) occidentalis*, n. subgen., n. sp.	C
	Small streptelasmid corals *Brachyelasma* sp. B *Ryderophyllum ubehebensis*, n. sp. *Pycnactis* sp. k *Petrozium mcallisteri*, n. sp.	B
Early Silurian	*Rhegmaphyllum* sp. h *Dalmanophyllum* sp. A *Cyathophylloides fergusoni*, n. sp. *Palaeocyclus porpita* subsp. *mcallisteri*, n. subsp. *Rhabdocyclus* sp. d *Arachnophyllum kayi*, n. sp. *Neomphyma crawfordi*, n. sp.	A

* *Salairophyllum*? material from uncertain stratigraphic horizon at Coal Canyon, Simpson Park Mountains, Nev., probably from beds in coral zone E.

Tabulate corals, thus far unstudied, are the common corals of Silurian coral zone A. These include massive favositids, *Cladopora*, *Heliolites*, and *Halysites*. Silicified brachiopods associated with this assemblage are assigned to *Dicaelosia*, *Dalmanella*, *Camarotoechia*, and *Atrypa*.

Of the Rugosa in coral zone A, only *Arachnophyllum* and *Neomphyma* are known in strata above the Lower Silurian, but in regions other than the Great Basin. *Cyathophylloides* is more commonly a Late Ordovician genus.

ZONE B

Of early Middle Silurian age, coral zone B includes the following Rugosa;

- Small streptelasmid corals
- *Brachyelasma* sp. B
- *Ryderophyllum ubehebensis*
- *Pycnactis* sp. k
- *Petrozium mcallisteri*

Corals of zone B are known in dolomites of the Great Basin Silurian reference sections north of Ubehebe Peak, Panamint Range, and in the Funeral Mountains. At the

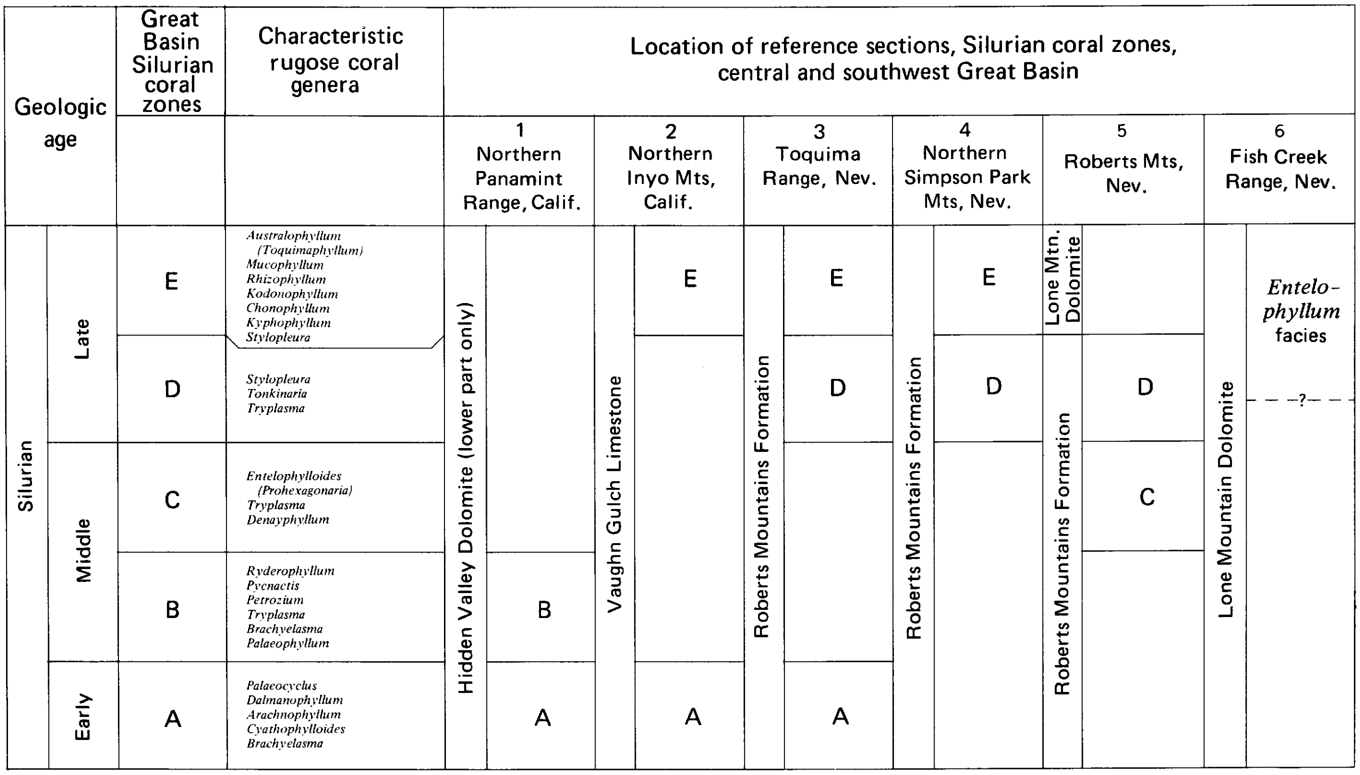


FIGURE 6.—Great Basin Silurian coral zones and common rugose coral genera and subgenera.

former locality in the type area of the Hidden Valley Dolomite, the zone B fauna occurs in McAllister's (1952, p. 15) unit 1, about 325 feet above the base of the formation. Tabulates are the abundant fossils, as in coral zone A. These include *Halysites, Heliolites,* and *Syringopora.* The halysitids are diverse, ranging from the large *Halysites* (*Cystihalysites*) of the *magnitubus* type to species with medium and small corallites. Brachiopods are relatively scarce; only the genus *Atrypa* has been recognized.

Dasycladacean algae first make their appearance in coral zone B, where they are represented in some abundance by a species of *Verticillopora* with narrow shaft; these do not attain the large size of the *Verticillopora* in coral zone D.

ZONE C

Coral zone C of late Middle Silurian age is characterized by the following Rugosa:

Denayphyllum denayensis
Tryplasma newfarmeri
Entelophylloides (*Prohexagonaria*) *occidentalis*

Coral zone C is proposed for the richly coralline beds near the base of unit 3 of the Roberts Mountains Formation (fig. 4) in the type section of that formation on Pete Hanson Creek. No associated brachiopods or other fossils were found in these beds.

ZONE D

Great Basin Silurian coral zone D of Late Silurian age includes the following rugose corals:

Stylopleura berthiaumi
Tryplasma duncanae
Tonkinaria simpsoni

The reference section for this zone is also the type section for the Roberts Mountains Formation on Pete Hanson Creek (fig. 4), where these corals and associated tabulates and brachiopods occupy dolomitic limestones in the upper 250 feet of unit 3. Beds of coral zone D lie about 500 feet above coral zone C in the same section. Between the two intervals this section is penetrated by mafic dikes, but it appears to be otherwise unbroken; toward zone D the limestones become progressively more dolomitic, passing upward into a thick blocky dolomite unit. All fossils obtained in coral zone D are silicified. Predominant in the coral beds are massive and digitate favositids, followed in order of abundance by Rugosa, brachiopods, and calcareous algae. Among the silicified brachiopods prepared by acid etching are *Dicaelosia, Homoeospira, Kozlowskiellina,* and *Atrypa.*

One of the more distinctive elements of the coral zone D assemblage in this section is the dasycladacean alga *Verticillopora.*

ZONE E

Uppermost of the five zones is coral zone E of Late Silurian age, which is characterized by the following Rugosa:

Stylopleura berthiaumi
Stylopleura nevadensis

Mucophyllum oliveri
Kodonophyllum mulleri
Rhizophyllum cf. *R. enorme*
Chonophyllum simpsoni
Australophyllum (*Toquimaphyllum*) *johnsoni*
Ryderophyllum? sp.
Cyathactis? sp.

Coral zone E is proposed for the diverse assemblage occurring in the uppermost beds of the Coal Canyon reference section, northernmost Simpson Park Mountains. The zone fossils come from a limestone interval which includes bodies of breccia-conglomerate; some were extracted from clasts of the depositional breccia.

Other than Rugosa, the common fossils of coral zone E at Coal Canyon are stromatoporoids, massive *Favosites* with medium and small corallites, chaetetids, *Alveolites*, and *Cladopora*. Much of this limestone is bioclastic, is dark, slightly bluish-gray, and contains abundant crinoidal debris and large columnal segments. Well-preserved silicified brachiopods prepared by acid etching are as follows:

Orthostrophia sp.
Schellwienella? sp.
Barrandella? sp.
Sicorhyncha? sp.
Rhynchospirina sp.
Plectatrypa? sp.
Atrypa? sp.
Kozlowskiellina sp.
Meristella sp.

The large dasycladacean alga *Verticillopora* is present but very uncommon in coral zone E at Coal Canyon.

Other than fossils removed from breccia clasts or the limestone in place, most collections made on this outcrop band are surface weathered material and float, some of which may be derived from upslope overlying exposures of the Early Devonian Rabbit Hill Limestone. Surface rubble of this kind, which cannot with full assurance be ascribed to coral zone E, yielded the following fossils:

Orthostrophia? sp.
Cymostrophia sp.
Rafinesquina sp.
Howellella? sp.
Atrypa? sp.
Leonaspis sp.
Harpid trilobite
Proetid trilobite
Phacopid trilobite
Orthoceras-like cephalopod
Conocardium sp.
Leperditia sp. (large)
Large crinoid columnals and abundant crinoid debris

A complex solitary rugose coral (pl. 12, figs. 6–8) placed provisionally in the Russian genus *Salairophyllum* was collected at Coal Canyon locality M1117 and was probably derived from uppermost beds of the Roberts Mountains Formation, Silurian coral zone E. This coral resembles an undescribed species from Kuiu Island, southeastern Alaska, where it occurs at locality M1186 with the Late Silurian *Conchidium alaskense*.

The subgenus *Toquimaphyllum* is the most diagnostic fossil of coral zone E, occurring at all sites where this zone has been recognized. At Ikes Canyon in the Toquima Range, *Toquimaphyllum* is associated with large phaceloid *Kyphophyllum*, found also in coral zone E of the Mazourka Canyon reference section. Coral zone E is known only in the intermediate limestone belt of the Great Basin.

STRATIGRAPHY AND RUGOSE CORALS OF THE LONE MOUNTAIN AND LAKETOWN DOLOMITE

The Lone Mountain Dolomite of the central Great Basin and the Laketown Dolomite of the eastern Great Basin are comparable lithologic units in which silicified fossils occur sporadically, most exposures being devoid of identifiable material. Stratigraphy and fossils of the Lone Mountain are dealt with in a separate contribution (Merriam, 1973a).

In the eastern Great Basin where Silurian limestone facies are as yet unknown, the term Laketown Dolomite has been applied locally to most of the rocks believed to be of Silurian age. Possible time-stratigraphic equivalence of the entire Laketown to the entire Lone Mountain in its type area as redefined herein remains unsupported by paleontologic evidence. Like faunas of the Lone Mountain those of the Laketown Dolomite seemingly represent biofacies differing from those of Great Basin Silurian limestones in which the fivefold rugose coral zonation here proposed is best shown. Fossils and stratigraphy of both Silurian dolomite formations are at present insufficiently known for coral zoning.

Equivalence of the upper part of unit 2 of the Lone Mountain Dolomite to upper beds of the Laketown is convincingly supported by occurrence in both of the *Howellella pauciplicata* brachiopod fauna, the precise stratigraphic position of which is established in unit 48 (fig. 7, col. 10) of the Confusion Range, Utah, stratigraphic column (R. K. Hose, written communs., 1954–64). These correlative Silurian dolomites are referred to faunally as upper Lone Mountain–Laketown biofacies. Fossils of this biofacies have not been recognized in Silurian limestones.

Adjacent to the Lone Mountain Dolomite type area, strata in the upper 500 feet of this formation contain faunas of the upper Lone Mountain–Laketown biofacies with the Silurian rugose coral *Entelophyllum*. At Lone Mountain itself, macerated corals of this kind are too poorly preserved for positive identification. As unit 2 of the Lone Mountain Dolomite is traced southeastward from the Lone Mountain area through the Mahogany Hills to the Fish Creek Range, scattered bodies of dark-gray to black carbonaceous dolomite become increasingly numerous within the lighter, barren blocky phase. Well-preserved silicified fossils in these dark dolomites represent the upper Lone Mountain–Laketown biofacies. Coral beds largely made up of favositids with associated *Entelophyllum engelmanni* and *E. eurekaensis* are extensive. Associated brachiopods are *Howellella pauciplicata* Waite, *H. smithi* Waite, *Camarotoechia pahranagatensis* Waite, and *Protathyris hesperalis* Waite, together with undescribed species of ?*Hyattidina, Hindella, Salopina,* and *Atrypa*. The Confusion Range (Ibex Hills) unit 48 (fig. 7, col. 10) *Howellella pauciplicata* brachiopod assemblage described in part by Waite (1956) has more recently been elucidated in the Pahranagat Range of southeastern Nevada by Johnson and Reso (1964).

Coral faunas in the lower part of the Lone Mountain Dolomite or Lone Mountain unit 1 are little known, as are those in the lower part of the Laketown. *Halysites* and pycnostylid genera of the East Ridge dolomite block near Romano Ranch, Sulphur Spring Range, are believed to occur in lower beds of this formation. Beds containing an Early Silurian coral zone A assemblage with *Palaeocyclus* in the Confusion Range, Utah (loc. M1129), occupy an isolated fault block whose position in the Laketown section remains uncertain.

RUGOSE CORALS AND GEOLOGIC CORRELATION OF SILURIAN ROCKS WITHIN THE GREAT BASIN

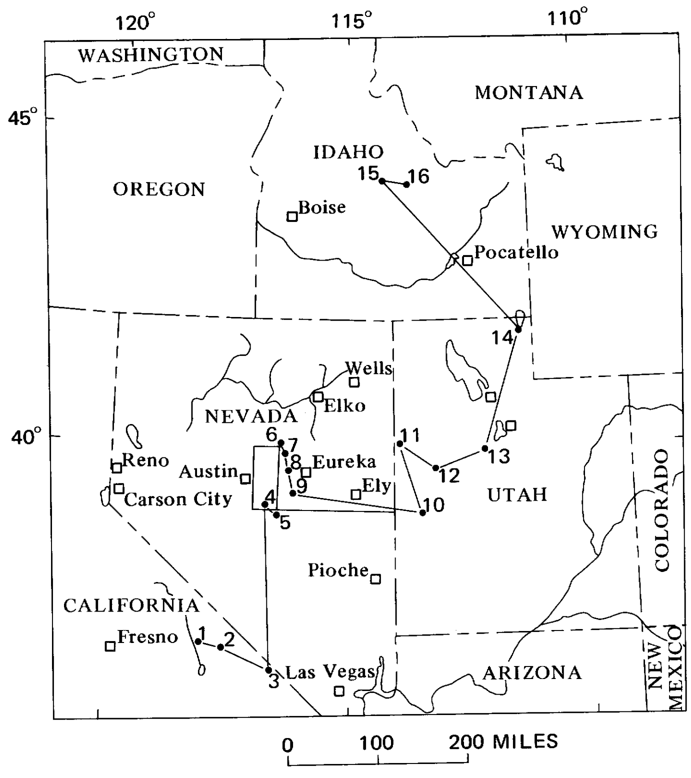
Interpretation of overall vertical and evolutionary order among Great Basin Silurian corals depends upon reliability of interarea geologic correlation within the province, as well as upon paleontologic ties with distant reference columns, such as those of eastern North America, Gotland (Sweden), England, and eastern Europe. Within the province, lithologic criteria exclusive of fossils also have value in this connection (fig. 7). Among pertinent factors are lateral continuity of bedded cherts at the system base and wide areal persistence of other distinctive sedimentary rock types, such as continuity in particular directions of diagenetic dolomite or the contrasting limestone lithofacies.

Contrasting facies belts distinguished by predominance of either graptolitic or shelly biofacies have long been recognized in Ordovician and Silurian Systems of the Great Basin. Facies differences of this order greatly complicate or obviate direct paleontologic correlation from basin to basin and justify the multiplication of separate local stratigraphic columns. No better example of such facies variance may be cited than the Ordovician Vinini graptolitic sequences as compared with those of the Pogonip Group, thus far recognized together in fault relationship only. Facies isolation is but slightly less of a deterrent to correlation in the Silurian System of this province.

Because of wide acceptance and growing dependability of the remarkable British graptolite sequence, worldwide Silurian stratigraphy and correlation lean heavily upon these fossils. Some belts of Great Basin Silurian exposure have thus far yielded only graptolite evidence, such as the calcareous shales of the Monitor Range stratigraphically below the Helderbergian type Rabbit Hill Limestone. Conversely, much of the Silurian in this province has thus far disclosed no graptolites, as throughout the eastern dolomite belt. By comparison, the intermediate limestone belt with its calcareous shales and platy limestone is graptolite bearing in some places. Graptolites are most abundant in lower horizons, where the shales and laminated limestones readily disclose their graptolitic nature to the collector. Higher in some of the same stratigraphic sections, where limestone bedding is generally thicker and more massive, graptolites are either less evident to the collector or seemingly absent. It is in upper beds of limestone reference sections, as in Coal Canyon, Simpson Park Mountains, in the type Roberts Mountains Limestone area, and in the Mazourka Canyon area, Inyo Mountains, Calif., that the greatest possibilities exist for future discovery of intercalated graptolitic and shelly biofacies. In the northwestern part of the Great Basin, approaching the Pacific Border graywacke belt (Pacific Border province), graptolitic shales may theoretically be expected to become even more widespread.

Geologic correlation by means of a single biologic group may be misleading; use of corals alone in this respect would doubtless lead to error. Correlation of seemingly equivalent or identical coral assemblages from place to place is the equating of ecologically comparable coralline biofacies. In the present state of knowledge of these assemblages, it cannot be said with confidence that they do not have greater value as environmental indicators than of time equivalence. Little is yet known of the vertical ranges of Silurian coral genera and species. Data from research upon associated fossils are essential in support of rugose coral evidence. Among these, brachiopods are usually common and closely associated in the coral biota. Their supplementary use facilitates greater resolution of correlation problems. Studies of other associated fossil groups are needed; among these are trilobites, ostracodes, conodonts, and calcareous algae. A test of the correlation value of any one of these groups individually is the degree of adjustment required to bring data and the specialist's conclusions based upon these data into reasonable accord with evidence from independent study of the other stratigraphically associated groups.

At best, a standard Silurian paleontologic sequence for the Great Basin will always be composite. Thus, for the



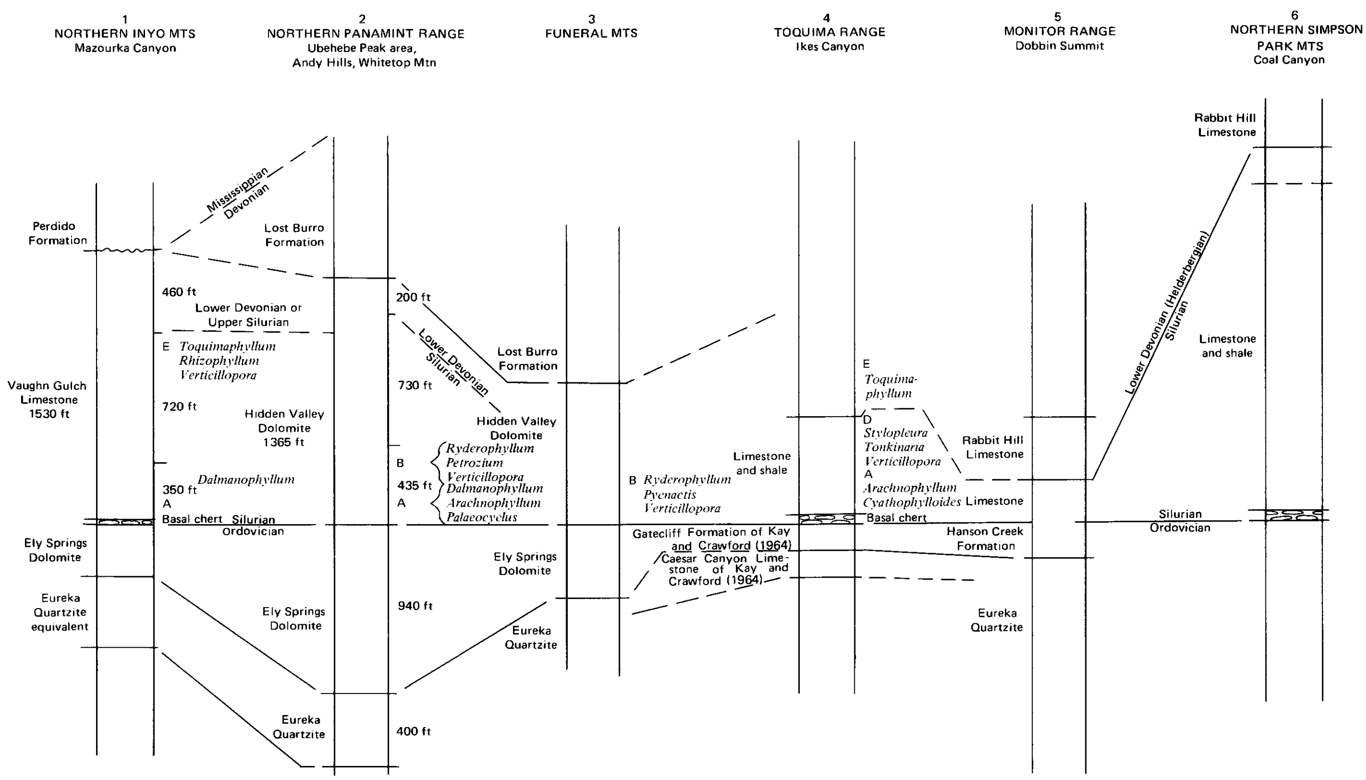
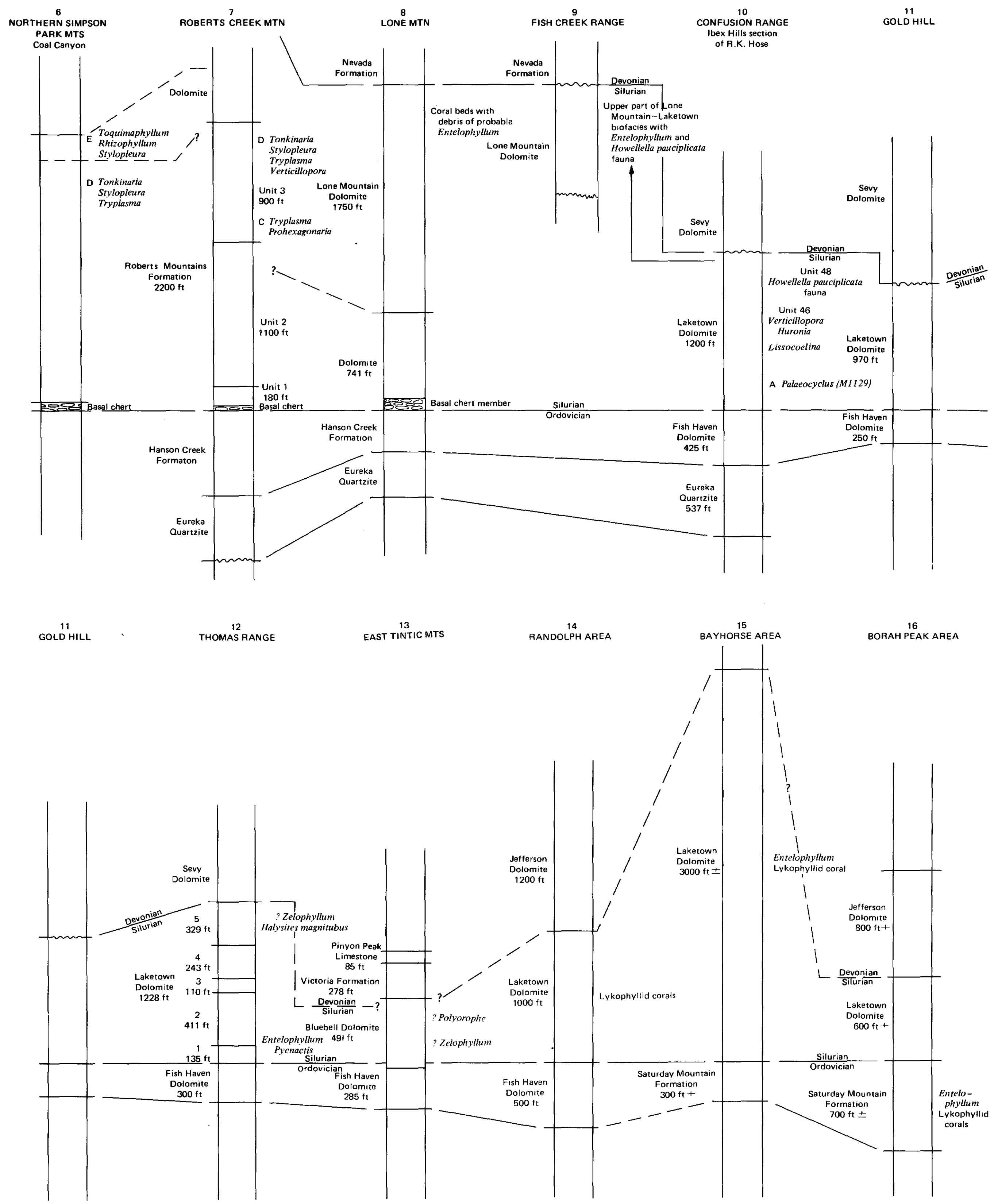


FIGURE 7.—Correlation chart of Great Basin



Silurian formations, showing lettered coral zones.

proposed coral zonation, no single measureable reference section has been found to include all five of the zones in succession. Piecing together of zonal units in partial, overlapping sections passing from one mountain area to another of structurally deformed beds calls for integration of physical-stratigraphic and paleontologic data, not only from coral and graptolite research but also from investigation of all associated organic groups, toward a converging pattern of geologic dating evidence.

ZONE A

Mazourka Canyon reference section, California.—Comparative thicknesses suggest that the Vaughn Gulch Limestone occupies about the same stratigraphic interval as the Hidden Valley Dolomite to the southeast. The lowest Vaughn Gulch beds contain the zone A solitary rugose coral *Dalmanophyllum* sp. A, together with a small tryplasmid, a pycnostylid, favositids, *Heliolites,* and the brachiopod *Camarotoechia.* The primary zone A indicator *Palaeocyclus* of the basal Hidden Valley Dolomite was not found in the Vaughn Gulch Limestone.

Detailed geologic mapping of the Independence quadrangle by Ross (1966) demonstrates that northward in Mazourka Canyon the stratigraphic interval normally occupied by the Vaughn Gulch Limestone is in considerable part occupied by calcareous shale, siltstone, and argillaceous limestone in which *Monograptus* is a common fossil. Named separately as the Sunday Canyon Formation by Ross (1963), these graptolitic beds may be compared to wholly graptolitic facies equivalents of the Roberts Mountains Formation of the central Great Basin. The Sunday Canyon graptolite beds probably represent horizons above coral zone A. Corals in the uppermost beds of this unit are discussed below under correlatives of Great Basin Silurian coral zone E.

Tuscarora Mountains, Nev.—Graptolite beds perhaps slightly younger than coral zone A are known in the Tuscarora Mountains, 75 miles north of Roberts Creek Mountain (Berry and Roen, 1963). The graptolites a few feet above the basal chert corresponding to the basal chert of unit 1 in the type Roberts Mountains Formation were considered to be early Wenlockian by Berry and Roen, representing the British zone of *Monograptus riccartonensis.* No associated coral or other shelly faunas were reported.

Carlin mining district, Nevada.—Strongly deformed Silurian rocks assigned to the Roberts Mountains Formation underlie large areas in the Carlin mine vicinity of the southernmost Tuscarora Mountains. Coral and brachiopod faunas from localities along Maggie Creek for the most part probably represent horizons in the upper part of the formation. A Silurian fossil assemblage of unknown horizon contains *Cyathophylloides* similar to *C. fergusoni* of coral zone A. Associated brachiopods are small *Coelospira, Fardenia, Ptychopleurella,* and small coarse-ribbed *Conchidium*-like pentamerids. The brachiopods suggest that this assemblage may be younger than coral zone A.

Ruby Mountains, Nev.—Crinoidal dolomitic limestone containing the button coral *Palaeocyclus* occurs at locality M1336, on the north side of the north fork of Mitchell Creek, 3 miles northeast of Mitchell Ranch. Associated are *Halysites,* favositids, *Atrypa,* and *Camarotoechia*-like brachiopods in a fauna probably representing coral zone A.

Confusion Range, Utah.—Isolated exposures of Silurian dolomite in this area (loc. M1129) contain a large zone A fauna. Beds in question (R. K. Hose, written commun., 1964) do not form part of a continuous Laketown Dolomite section but crop out in a minor fault block. Rugose corals of this assemblage are *Palaeocyclus* cf. *P. porpita, Brachyelasma* sp., and *Tryplasma* cf. *T. hedströmi.* Tabulate corals include favositids, *Alveolites, Heliolites,* and *Halysites.* Other fossils are *Encrinurus, Hesperorthis, Atrypa,* and *Atrypina.*

Ikes Canyon reference section, Nevada.—Platy limestone and calcareous shale in the lower part of the Masket Shale of Kay and Crawford (1964, p. 439) are correlative with coral zone A and share with it the colonial rugose coral *Arachnophyllum kayi.* Other rugose corals in these lower beds are *Cyathophylloides fergusoni* and *Neomphyma crawfordi.* The primitive cerioid genus *Cyathophylloides* is more commonly Late Ordovician. Similar *Arachnophyllum* was reported in the lowermost Gotland Silurian by Lindström (1884, p. 7). This genus ranges upward as high as the Brownsport Formation of eastern North America, but in Gotland and the Great Basin it is known only in Early Silurian beds.

Roberts Creek Mountain reference section, Nevada.—The 300-foot interval of unit 1 and the lowermost part of unit 2 in the type Roberts Mountains Formation probably includes the time-stratigraphic equivalent of coral zone A, but it has yielded no *Palaeocyclus, Dalmanophyllum,* or *Arachnophyllum.* Other than poorly preserved *Monograptus,* these beds contain pycnostylids, *Orthophyllum,* favositids, *Cladopora, Heliolites,* and *Halysites.* Among the brachiopods are small *Conchidium*-like pentamerids, *Dicaelosia, Eatonia?, Atrypa,* and *Merista?*.

ZONE B

Funeral Mountains section, California.—Coral zone B faunas have been collected by J. F. McAllister 3 miles south-southwest of Schwaub Peak (Ryan quadrangle), 110 feet above the base of the Hidden Valley Dolomite. Rugose corals are *Ryderophyllum, Pycnactis,* and *Brachyelasma,* together with favositids, *Heliolites, Hesperorthis,* and the cephalopods *Huronia* and *Huroniella.* Also present is the large dasycladacean alga *Verticillopora.* About 300 feet above the base in the same section occurs another fauna characterized by *Tryplasma, Halysites, Alveolites, Romingerella,* and *Cladopora.* Associated brachiopods include *Leptaena, Fardenia, Rhipidium, Atrypa, Atrypina,* and *Eospirifer* (*Striispirifer*). Lykophyllids, generally to be expected in coral zone B, were not found in this upper horizon.

Roberts Creek Mountain reference section, Nevada.—Fossils of coral zone B are to be expected in the middle and upper beds of unit 2 of the type Roberts Mountains Formation. Possibly because of limestone facies, the zone B indicators *Ryderophyllum, Pycnactis,* and *Petrozium* of the Hidden Valley Dolomite have not been found in this section. Rugose corals occurring here are *Tryplasma, Palaeophyllum, Diplophyllum,* and *Microplasma,* together with the tabulates *Halysites, Heliolites, Cladopora,* and *Aulopora.*

Brachiopods abundant in the higher part of unit 2, possibly within the range of coral zone B, are *Coelospira, Pytchopleurella,* and finely ribbed *Conchidium*-like pentamerids. Of the last one species superficially resembles the Norwegian *Conchidium münsteri* Kiaer, as described and figured by St. Joseph (1938, p. 301); this species has been reported in southern Norway Silurian zone 5b and is considered Early Silurian (Llandoverian).

ZONE C

The distinctive rugose coral fauna of zone C in the Roberts Creek Mountain reference section has not been recognized elsewhere in the Great Basin. In California, that part of the Hidden Valley Dolomite above McAllister's (1952, p. 15) unit 1 and above coral zone B of the type area Hidden Valley has yielded no significant fossil material. Likewise the Vaughn Gulch Limestone in Mazourka Canyon is sparingly fossiliferous within the interval where zone C indicators would be expected. In other areas studied, lithologic equivalents of the Roberts Mountains Formation, possibly correlative with zone C, belong to the platy graptolitic facies and, therefore, have yielded no Rugosa.

ZONE D

Mazourka Canyon reference section, California.—Abundant fossils below coral zone E in the middle of the Vaughn Gulch Limestone are the large dasycladacean algae *Verticillopora.* These are similar to *Verticillopora* associated with the zone D coral biota in the Roberts Creek Mountain and Ikes Canyon reference sections.

Ikes Canyon reference section, Nevada.—*Stylopleura, Tonkinaria,* and large *Verticillopora* occupy an interval considerably above the horizon of coral zone A in the Masket Shale of Kay and Crawford (1964, p. 439) at Copper Mountain. Intermediate strata have not yielded the indicators of coral zones B and C, but coral zone E is present in higher strata, which Kay and Crawford included in their McMonnigal Limestone.

Confusion Range, Utah.—Abundance of the dasycladacean alga *Verticillopora* in the upper part of the Laketown Dolomite of the Confusion Range, Utah (fig. 7, col. 10), suggests that the time-stratigraphic interval of coral zone D may be represented. *Verticillopora* is especially common elsewhere in limestone facies of coral zone D, during which time the genus appears to have peaked. The horizon of prolific *Verticillopora* lies in unit 46, 330 feet below the top of the Laketown in a stratigraphic section measured by R. K. Hose, of the U.S. Geological Survey, in the Ibex Hills, Confusion Range, Utah (written commun., 1954). In this section the Laketown Dolomite is 1,203 feet thick and lies between the Fish Haven Dolomite of Late Ordovician age below and the Sevy Dolomite of Early Devonian age above. The distinctive *Howellella pauciplicata* fauna is present in beds 87 feet below the top of the Laketown in unit 48 of the Hose measured section. This fauna also characterizes the higher beds of Lone Mountain Dolomite unit 2 in Nevada and occupies the upper Lone Mountain–Laketown biofacies. Perhaps because of facies differences, the Rugosa of coral zone D do not occur in the *Verticillopora* beds of the Laketown or the Lone Mountain.

ZONE E

Roberts Creek Mountain reference section, Nevada.—Strata above coral zone D in the upper part of unit 3 in the type Roberts Mountains Formation are sparsely fossiliferous dolomite, passing upward into barren dolomite beneath the Nevada Formation. Within this undifferentiated and barren dolomite, coral zone E may well be represented, together with an Early Devonian Rabbit Hill equivalent. Certain zone D corals, such as *Stylopleura berthiaumi,* are very similar to zone E species, suggesting that zones D and E may overlap; however, as presently known they represent somewhat different biofacies.

Ikes Canyon reference section, Nevada.—*Australophyllum (Toquimaphyllum) johnsoni,* a limestone facies occupant and the most distinctive zone E indicator, is associated with *Kyphophyllum* on the northwest side of Copper Mountain. The beds appear to lie within the McMonnigal Limestone of Kay and Crawford (1964). Lower horizons in the same section on the southwest contain corals of zones D and A. Exposures east of Copper Mountain contain *Rhizophyllum* and probably also fall in coral zone E.

Carlin mine area, Nevada.—Mapping and stratigraphic investigation in progress by the U.S. Geological Survey in this part of northern Eureka County and adjoining Elko County, Nev., has disclosed strongly deformed rugose-coral-bearing strata of Late Silurian and Early Devonian ages. These coralline beds are provisionally assigned to the Roberts Mountains Formation and to the Rabbit Hill Limestone. At the Bootstrap mine, north of the open-pit Carlin mine, upper beds of the

Roberts Mountains Formation contain large heads of *Australophyllum* (*Toquimaphyllum*), n. sp., having smaller and more slender corallites than *A.* (*Toquimaphyllum*) *johnsoni*, n. sp., of Silurian coral zone E. Other exposures in the Carlin mine area yield another type of *Australophyllum* and fragmentary corals classified as *Entelophyllum, Palaeophyllum,* and *Chonophyllum.* The Bootstrap mine *Toquimaphyllum* is very similar to *Australophyllum* (*Toquimaphyllum*) *originalis* (Zhmaev) from the Ural Mountains, Russia (Shurygina, 1968, pl. 59, figs. 3a, b). The Ural species *originalis* is reported to occur with Gotlandian type Silurian corals, this association being interpreted by Russian paleontologists as Early Devonian.

Antelope Peak, Elko County, Nev.—Rugose corals from this area north of Wells, collected by B. L. Peterson, include *Toquimaphyllum* similar to *johnsoni* of coral zone E and pycnostylids resembling *Stylopleura.*

Mazourka Canyon reference section, California.—Great Basin Silurian coral zone E occupies a 200-foot interval at the top of the middle unit of the Vaughn Gulch Limestone (fig. 3). The interval contains a large and diverse but rather poorly preserved coral biota. The common coral is *Toquimaphyllum,* which closely resembles *Australophyllum (Toquimaphyllum) johnsoni*; occurring with this are *Australophyllum* sp., *Kyphophyllum, Chonophyllum*-like forms, and *Crassilasma*? sp. Float material of *Rhizophyllum* sp. D doubtless came from these beds. *Plectatrypa* is the only associated brachiopod identified. Strata just below coral zone E carry abundant large *Verticillopora* (pl. 16); this dasycladacean alga ranges up into zone E, appearing also in the lowest beds of the upper unit of the Vaughn Gulch Limestone at locality M1093. The upper unit is considered to be Upper Silurian or Lower Devonian. The *Verticillopora*-rich beds beneath coral zone E may represent Silurian coral zone D, as these large dasycladaceans appear to have peaked at about that time-stratigraphic interval. Rugose coral indicators of coral zone D were not found in this section.

The lowest beds of the Vaughn Gulch upper unit at locality M1093 contain, in addition to *Verticillopora,* the rugose corals *Australophyllum* sp. (pl. 12, fig. 5), *Kyphophyllum* similar to *K. nevadensis* (pl. 14), *Ryderophyllum* sp. (pl. 6, fig. 8), *Crassilasma* sp. (pl. 6, fig. 9), and *Chonophyllum* sp. (pl. 8, fig. 8).

The Sunday Canyon Formation (Ross, 1966) exposed north of the Vaughn Gulch area in Mazourka Canyon is largely a graptolitic facies. However, a cerioid rugose coral collected in 1969 by C. H. Stevens in the upper 40 feet of the Sunday Canyon is provisionally assigned to *Australophyllum*; this coral resembles *Australophyllum* sp. from locality M1093 in the upper Vaughn Gulch unit just above Silurian coral zone E. In both places these higher strata are provisionally classified as Upper Silurian or Lower Devonian (fig. 3).

GREAT BASIN RUGOSA AND CORRELATION WITH DISTANT SILURIAN ROCKS

Most Great Basin Silurian rugose corals are congeneric with forms known in Europe, Australia, and eastern North America. Several special researches and monographs upon Silurian Rugosa of Great Britain, Gotland, Czechoslovakia, and Russia facilitate fossil comparison and correlation with reference sections in these distant regions.

The Gotland column is an incomparable yardstick for the coral-bearing carbonate Silurian of western Europe and for the rest of the world; it is with Rugosa of this large island that many of the closest paleontologic comparisons are made (fig. 8). Correlation with the standard British Silurian sequence is indirect and places a premium upon graptolite evidence. Neither in the Great Basin nor in Gotland does the known Silurian graptolite succession approach completeness. Hede's (1942) evaluation of the Gotland column in terms of British graptolites provides a circuitous avenue of geologic comparison between the Great Basin and British sequences, through the medium of associated Gotland rugose corals. Noteworthy comparisons of Great Basin Rugosa with American and Old World Silurian species are dealt with below in accordance with the proposed fivefold zonal scheme.

ZONE A

Northwest Canada and Alaska.—*Palaeocyclus,* reported by Norford (1962, p. 12) from the dolomitic Sandpile Group of northern British Columbia, suggests the presence of an Early Silurian horizon. However, the rather extensive coral assemblages dealt with by Norford appear on the whole to be somewhat younger and are perhaps representative of coral zone B. *Palaeocyclus kirbyi* Meek from Porcupine River, Alaska, was reported by Bassler (1937, p. 190, pl. 30, figs. 7–9) as Devonian; this occurrence has not been confirmed, and an Early Silurian age seems plausible.

New York State.—The diagnostic button coral *Palaeocyclus* of coral zone A suggests correlation with the Clinton Group of New York State and eastern Canada, where species of this coral are fairly common (Bassler, 1937, p. 190). A species of *Palaeocyclus* from the Michigan Silurian is reported to be somewhat younger.

Gotland, Sweden.—Early Silurian (Llandoverian) deposits include the Lower Visby Marl, Upper Visby Marl (fig. 8), and reddish marl stratigraphically beneath the Lower Visby. Oldest of the Gotland rugose corals is a species of *Arachnophyllum* similar to *A. typus* (McCoy) which occurs at Visby below the low-water line in the reddish marl underlying the Lower Visby (Lindström, 1884, p. 7; Hill, 1958, p. 153). The genus *Arachnophyllum* is not reported above the reddish marl horizon in Gotland. In North America it continues upward to younger beds of the Niagara Group and the Brownsport Formation

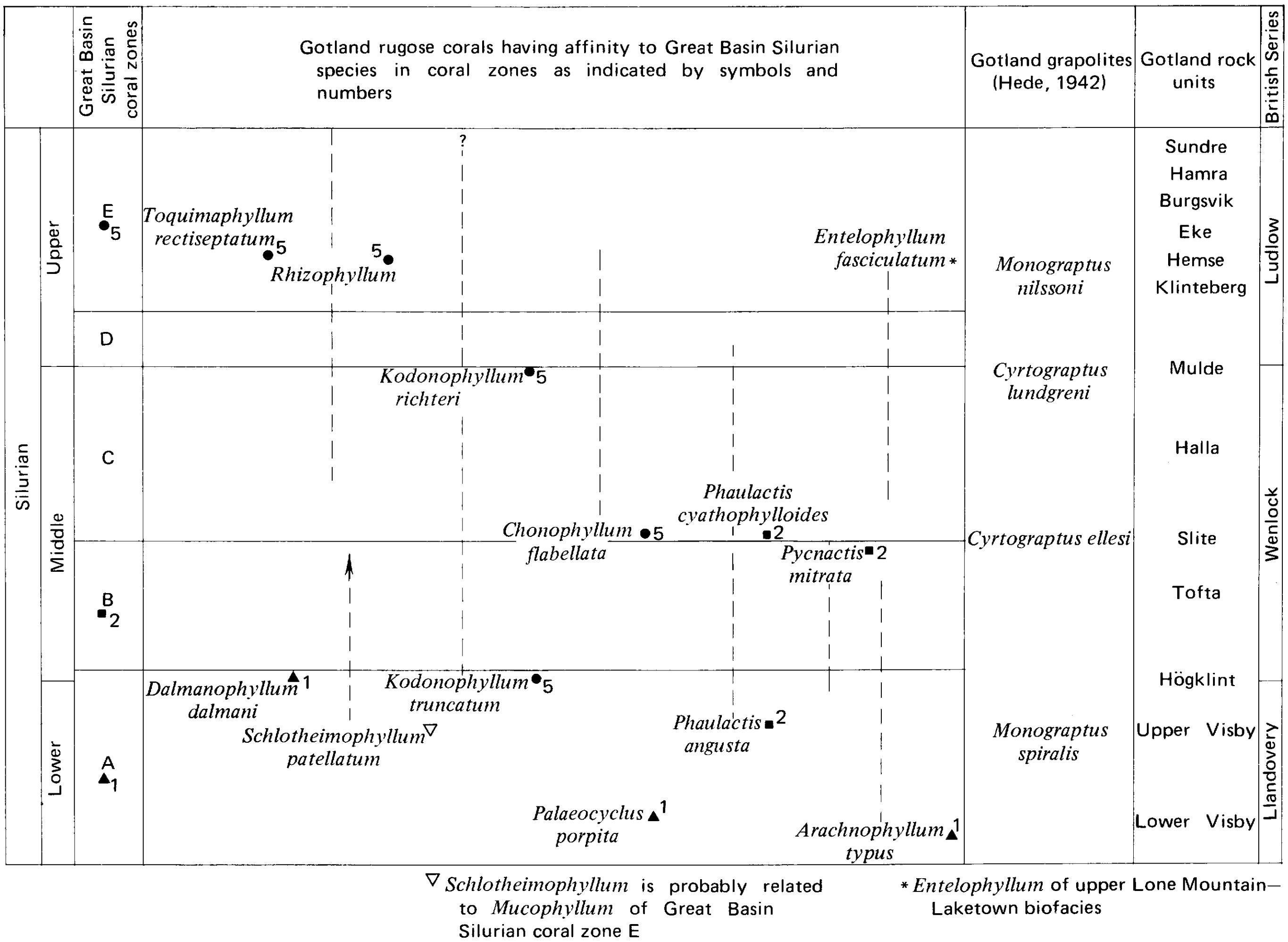


FIGURE 8.—Gotland stratigraphic units and rugose corals related to Great Basin forms.

(Amsden, 1949, p. 104; Stumm, 1964, p. 30) *Arachnophyllum kayi* of Great Basin Silurian coral zone A is similar to *A. typus.*

Palaeocyclus porpita subsp. *mcallisteri* of coral zone A rather closely resembles the Lower Visby *P. porpita,* and *Dalmanophyllum* sp. A is close to *D. dalmani* of the Högklint Group (fig. 8), which is earliest Wenlockian (Hede, in Regnéll and Hede, 1960, p. 55).

The Llandoverian Upper Visby Marl contains lykophyllid corals (*Phaulactis*) and kodonophyllids (*Schlotheimophyllum*) not present in great Basin coral zone A, the lykophyllids appearing in coral zone B and the kodonophyllids in coral zone E.

In terms of the classic Gotland sequence (fig. 8), Great Basin Silurian coral zone A fits in the interval bracketing the Llandoverian reddish marl below the Lower Visby Marl and the early Wenlockian Högklint Group.

ZONE B

Klamath Mountains, Calif.—Lykophyllid Rugosa assigned to *Cyathactis* and the kyphophyllid genus *Petrozium* are present in upper beds of the Gazelle Formation, which is considered to be Ludlovian on the basis of brachiopod evidence, supported by similarity of its endophyllid corals to Great Basin zone E *Toquimaphyllum.*

Northwest Canada.—Solitary lykophyllids suggesting zone B *Ryderophyllum* occur in the Sandpile Group of northern British Columbia (Norford, 1962, pl. XIV, figs. 5–8). *Palaeocyclus* reported here presumably comes from lower strata representing coral zone A.

Gotland, Sweden.—Lykophyllid corals characterizing zone B are common in the Lower and lower Middle Silurian beds of Gotland, where they are represented by the genera *Phaulactis* and *Pycnactis.* Zone B lykophyllids are assigned to *Ryderophyllum,* which, in mature growth stages, closely resembles *Phaulactis.* In Gotland the lykophyllids appear to have peaked in Wenlockian time.

Russia.—A lykophyllid from Podolia assigned by Bulvanker (1952, pl. 2) to *Phaulactis cyathophylloides* Ryder resembles zone B *Ryderophyllum.* The Podolian species comes from beds reported to range in age from middle Wenlockian to Ludlovian.

Shropshire, England.—Petrozium mccallisteri of zone B resembles *P. dewari*, the type species, described from the Shropshire, England, Early Silurian (Smith, 1930, p. 307). This colonial genus ranges through the Silurian, to judge from the Gazelle occurrence (Klamath Mountains, Calif.), here considered to be Ludlovian.

ZONE C

New York State.—Entelophylloides (*Prohexagonaria*) *occidentalis* is not closely related to Rukhin's type species of *Entelophylloides,* which is the American Cobleskill Late Silurian *Columnaria inequalis* (Hall). It appears doubtful that Great Basin coral zone C is as young as the New York Cobleskill.

Gotland, Sweden.—An undescribed *Entelophylloides* (*Prohexagonaria*) from the Visby vicinity, figured only in transverse section by Smith and Tremberth (1939, pl. VIII, fig. 1), rather closely resembles zone C *occidentalis.* The Gotland species, to judge from its recorded geographic occurrence, came from beds somewhere in the interval of the Lower Visby Marl to the Högklint Group and is, therefore, high Llandoverian to early Wenlockian.

Ural Mountains and Siberia.—Cerioid Rugosa resembling *Entelophylloides* (*Prohexagonaria*) *occidentalis* are known from middle and Upper Silurian beds of the Ural Mountains and Siberia (Sytova, 1952, p. 140, pl. IV; Soshkina, 1955, p. 126, pl. XIII, figs. 2a, 25; Ivanovsky, 1963, p. 86–90, pl. XXII, figs. 1a, 1b, and pl. XXIV, figs. 2a, 2b). These were initially assigned to *Entelophyllum* Wedekind, *Evenkiella* Soshkina, and *Tenuiphyllum* Soshkina. Species classified as *Entelophyllum* and *Evenkiella* are closest to the Great Basin *occidentalis. Evenkiella* has more of a tendency to develop lonsdaleioid dissepiments, a character not usual with *Entelophyllum* or *Entelophylloides. Entelophyllum* is normally phaceloid, not cerioid; thus, some of the Russian and Siberian species in question may belong in Rukhin's *Entelophylloides.*

Eastern Australia.—Tryplasma newfarmeri of coral zone C, a smooth, cylindrical, phaceloid tryplasma, is rather close morphologically to *Tryplasma lonsdalei* Etheridge, as figured by Hill (1940, p. 406, pl. XII, figs. 13a–c) from the Yass-Bowning district. The host rocks are reported to be Wenlockian, possibly including early Ludlovian (Hill, 1940, p. 388–390), and therefore younger than coral zone C. Several Yass-Bowning Rugosa are, in fact, very similar to species in Great Basin coral zone E, here considered to be Ludlovian.

ZONE D

Kentucky and Tennessee.—Externally rugate *Tryplasma* as represented by *T. duncanae* of coral zone D occurs in the Louisville Limestone of Kentucky and the Brownsport formation of Tennessee. The Louisville species is *T. prava* (Hall) as figured by Stumm (1964, pl. 6, fig. 8); *T. brownsportensis* Amsden is the Brownsport representative (Amsden, 1949, pl. XXVII, figs. 7–13). It is probable that both species are older than Great Basin Silurian coral zone D.

Gotland, Sweden.—Tryplasma hedströmi Wedekind (1927, pl. 29, figs. 1, 2) is externally suggestive of *T. duncanae.* The Gotland species comes from the Visby area, probably from strata ranging in age from late Llandoverian to early Wenlockian (fig. 8) and therefore considerably older than coral zone D.

ZONE E

Klamath Mountains, Calif.—Rugose corals related to species of Great Basin coral zone E occur in the higher beds of the Gazelle Formation of the northeast Klamath region; other Rugosa in these strata are closer to zone B species. Similar species of the brachiopod *Plectatrypa* are present in coral zone E and the upper Gazelle beds.

Of the Rugosa, Gazelle species of *Kodonophyllum, Kyphophyllum,* and undescribed endophyllids are allied to zone E species. The Gazelle endophyllids are the analogue of the new subgenus *Toquimaphyllum.* Gazelle lykophyllids assigned to *Cyathactis* resemble zone B *Ryderophyllum* and Gotland *Phaulactis.* Gazelle *Petrozium* differs specifically from *P. mcallisteri* of coral zone B. Brachiopod ties between the Gazelle Formation and the Alaskan Silurian favor Ludlovian age and bring these beds more in line with Great Basin Silurian coral zone E.

Southeastern Alaska.—A complex solitary coral collected in Coal Canyon, Simpson Park Mountains, and assigned provisionally to the Russian genus *Salairophyllum* Besprozvannikh, 1968 (pl. 12, figs 6–8) is similar to undescribed *Salairophyllum* in Late Silurian beds of northern Heceta Island and Kuiu Island, Alaska. Collections from locality M1186, Kuiu Island, also include this form in direct association with Late Silurian *Conchidium alaskense.*

Gotland, Sweden.—Three zone E rugose genera are represented in Gotland (fig. 8) by similar species. *Chonophyllum simpsoni* resembles *C. flabellata* (Wedekind) of the Slite Group (Wenlockian), *Kodonophyllum mulleri* resembles *K. richteri* Wedekind from Lilla Karlsö Island off Gotland, and *Rhizophyllum* cf. *R. enorme* Etheridge may be compared to *Rhizophyllum* of the Hemse Group (Ludlovian). Patellate corals of coral zone E assigned to *Mucophyllum oliveri* have certain features of Gotland *Schlotheimophyllum patellatum* (Schlotheim) from the Visby Marl, as figured by Smith (1945, p. 18, pl. 32), but are generically different.

Spongophyllum rectiseptatum Dybowski (1873a, p. 479, pl. IV, figs. 3, 3a) is probably *Toquimaphyllum.* The locality of Dybowski's material suggests a horizon near the Eke Marl of Gotland (fig. 8), and therefore a Ludlovian age.

Gotland Rugosa comparable to species of coral zone E occur within the age range of late Llandoverian for *Schlotheimophyllum* to early Ludlovian or *Monograptus nilssoni* zone for the Hemse Group *Rhizophyllum* (Hede, 1942, p. 22). *Kodonophyllum* from Lilla Karlsö Island is high Wenlockian or low Ludlovian in age.

Czechoslovakia.—Australophyllum (Toquimaphyllum) fritschi (Novak, in Počta, 1902, pl. 102, figs. 6–8) resembles the undescribed Gazelle Formation endophyllids but is probably more closely allied to *Australophyllum (Toquimaphyllum) johnsoni* of Great Basin coral zone E. The Czechoslovakian analogue is considered to be Ludlovian, occurring in strata at Kozel ("Bande e2"). Prantl (1940, p. 9) termed these beds the "eβ" zone.

Ural Mountains.—Newly described rugose corals from the Ural Mountains (Shurygina, 1968) resemble species known in the Gotland Silurian, in Silurian rocks of the Cordilleran belt of North America, in southeastern Alaska, in Eastern Australia, and in eastern Europe. Among these Russian corals are species of *Toquimaphyllum,* several forms of *Tryplasma, Neomphyma, Rhizophyllum, Spongophylloides, Holmophyllum,* pycnostylids, and lykophyllids. Others among these Ural corals are possible *Kodonophyllum* and *Kyphophyllum* as well as an undescribed cerioid genus occurring in the Silurian Gazelle Formation of the Klamath Mountains, Calif. Strata containing these Russian Silurian-Devonian boundary coral assemblages are in part classified by Shurygina as Early Devonian; in general, all have a decidedly Gotlandian aspect in terms of Rugosa. *Australophyllum (Toquimaphyllum) giganteum* (Shurygina) resembles *Toquimaphyllum johnsoni* of Great Basin Silurian coral zone E. *Australophyllum (Toquimaphyllum) originalis* (Zhmaev) is strikingly similar to the undescribed *Toquimaphyllum* earlier mentioned from the higher beds of the Bootstrap mine Silurian section, Carlin mine area.

Eastern Australia.—Several rugose corals in Silurian beds of the Yass-Bowning district, as figured by Hill (1940), reveal fairly close morphologic similarities to species of coral zone E. Among these is *Australophyllum (Toquimaphyllum) spongophylloides* (Foerste), which shows features of Great Basin *johnsoni.* Also comparable to corals of Great Basin zone E are Yass-Bowning species of *Mucophyllum* and *Rhizophyllum. Tryplasma lonsdalei* of these Australian beds resembles a Great Basin Silurian coral zone C *Tryplasma.* The Yass-Bowning beds were considered by Hill to range in age from high Wenlockian to Ludlovian.

CORRELATION OF LONE MOUNTAIN AND LAKETOWN DOLOMITE

Silurian dolomite in the Ruby Mountains, Nev. (Ronald Willden and R.W. Kistler, written commun., 1967), is lithologically comparable to Lone Mountain Dolomite. The distinctive button coral *Palaeocyclus* collected by Willden and Kistler suggests that lower dolomites of this sequence are correlative with Hidden Valley Dolomite coral zone A and may accordingly be equivalent by inference to lower beds of the Roberts Mountains Formation in the intermediate limestone belt. Other and probably higher dolomite of the Ruby Mountains contains *Entelophyllum* like that of the upper Lone Mountain–Laketown biofacies in the eastern dolomite belt.

As noted elsewhere, isolated dolomite exposures of the Confusion Range, Utah, doubtless pertaining to lowermost Laketown, contain a large coral zone A assemblage. Few of the rugose corals from other Laketown exposures in the eastern Great Basin have been sufficiently studied for generic identification. However, the published lists suggest that some are lykophyllids; others are probably *Entelophyllum* and the pycnostylids. None suggest the prolific colonial Rugosa of the intermediate limestone belt to the west.

Rugose corals provide but meager evidence for correlation of the Lone Mountain and Laketown Dolomites with the Silurian of eastern North America. *Palaeocyclus* of the Confusion Range Laketown and the Ruby Mountains suggests a Silurian Clinton equivalence for lowermost Laketown. *Entelophyllum* of the upper Lone Mountain–Laketown biofacies reveals no intimate or specific relationship to described *Entelophyllum* of the eastern Louisville Limestone and the Brownsport (Smith, 1933; Amsden, 1949; Stumm, 1964), all of which are geologically older.

Gotland *Entelophyllum* ranges upward from Visby Marl (Wedekind, 1927) to the Eke Marl and Hemse Group. Upper Lone Mountain–Laketown *Entelophyllum* is closer to Gotland species from the higher Wenlockian and to those of the Eke and Hemse (Ludlovian). Among these, *Entelophyllum articulatum* (Wahlenberg) resembles the Lone Mountain *E. eurekaensis,* and *E. fasciculatum* Wedekind is similar to *E. engelmanni* of the Lone Mountain Dolomite.

Ludlovian age of the upper Lone Mountain–Laketown biofacies containing *Entelophyllum,* as concluded on the basis of the *Howellella pauciplicata* fauna, suggests that this higher Silurian zone may fall within the interval of combined coral zones D and E. In possible support of this conclusion, the dasycladacean alga *Verticillopora* seems to have peaked in about the interval of coral zone D and occurs abundantly in unit 46 beneath the *Howellella pauciplicata* beds of Confusion Range unit 48. (See fig. 7, col 10.)

AGE CONCLUSIONS BASED ON SILURIAN RUGOSA

Provisional age determinations are based largely upon rugose coral comparison with European and Australian faunas, especially those in formations of the Gotland section. Of supplementary value are coral and brachiopod comparisons with Klamath Mountains and Alaskan Silurian, as well as with Silurian of eastern North America.

Base and top of the Great Basin Silurian are fixed paleontologically with some assurance by coral faunas of zones A and E, of which zone A is the firmer in terms of European correlation (fig. 9). Zone A is late Llandoverian; zone E is considered to be late Ludlovian. Intermediate zones B and C are Wenlockian; zone D is provisionally regarded as early Ludlovian. Supporting evidence is needed from detailed study of associated brachiopods, as well as from graptolites collected in established sections where graptolitic and shelly facies are both represented.

Stratigraphic ranges of Silurian rugose coral genera are little known. A few, such as *Palaeocyclus* and *Dalmanophyllum,* seem restricted to the lower part of the system, but most carry through the middle Silurian Wenlockian to the Late Silurian. Peaks or regional bursts within certain generic lineages and confined to given stages may have age significance, as among the lykophyllids. In Gotland the Lykophyllidae peak, or attained an evolutionary acme, within early and middle Wenlockian time. Gotland *Rhizophyllum* reveals but a single burst—that of the Ludlovian Eke and Hemse (fig. 8).

The subgenus *Toquimaphyllum* and related endophyllids have thus far been recognized only in Ludlovian and Early Devonian (Helderbergian) rocks. Mycophyllidae range upward from the late Llandoverian (Upper Visby) to Great Basin coral zone E (Ludlovian). The Upper Visby *Schlotheimophyllum* is generically distinct from the higher Wenlockian and Ludlovian *Mucophyllum* of Australia, the Klamath Mountains, and the Great Basin.

Long-ranging as a big genus, *Entelophyllum* will eventually lend itself to taxonomic subdivision. In Gotland (fig. 8), *Entelophyllum* is common and diverse in the Eke Marl (Ludlovian), as it is in the Great Basin upper Lone Mountain–Laketown biofacies, also considered to be Ludlovian. Eastern representatives of this group in the Louisville and Brownsport are older.

Great Basin Silurian coral zone A.—Late Llandoverian age of coral zone A harmonizes with the Gotland occurrence of *Palaeocyclus porpita* and pre-Lower Visby *Arachnophyllum* (fig. 9). Great Basin *Dalmanophyllum* sp. A is related to Högklint *Dalmanophyllum dalmani,* an early Wenlockian coral in Gotland.

Great Basin Silurian coral zone B.—Wenlockian age of coral zone B is supported by fairly conclusive superposition above the interval of coral zone A and by the presence of the lykophyllids *Ryderophyllum* and *Pycnactis.* In Gotland this family peaks in the Wenlockian. *Petrozium* of coral zone B resembles the high Llandoverian *P. dewari* of Shropshire, England, but is also similar to *Petrozium* of the Ludlovian beds in the upper part of the Gazelle Formation in the Klamath Mountains.

Great Basin Silurian coral zone C.—Probable Wenlockian age of coral zone C is neither strongly supported nor controverted by two rugose corals, *Tryplasma newfarmeri* and *Entelophylloides (Prohexagonaria) occidentalis,* or by its stratigraphic position in the Roberts Creek Mountain reference section (fig. 4) below coral zone D. *Tryplasma newfarmeri* is similar to *T. lonsdalei* of the late Wenlockian and Ludlovian Yass-Bowning beds of Australia. The *Entelophylloides* resembles a species from Visby, Gotland, which is probably no younger than Wenlockian.

Study of the abundant brachiopod fauna of Roberts Mountains unit 2 just beneath coral zone C is expected to shed light on the age of these beds. *Conchidium*-like pentamerids seemingly differ from all known Late Silurian *Conchidium* of the Pacific Border province in the Klamath Mountains and in southeastern Alaska.

Great Basin Silurian coral zone D.—This coral zone is provisionally regarded as early Ludlovian, pending elucidation of the stratigraphic relationship of coral zone D to Ludlovian coral zone E within the Roberts Creek Mountain reference section. The two zones share the distinctive pycnostylid genus *Stylopleura* and may overlap in the time-stratigraphic sense. Occurrence of *Verticillopora* in type coral zone D suggests that it may predate zone E; this dasycladacean is especially abundant immediately below coral zone E of the Mazourka Canyon reference section (fig. 3). The rugate *Tryplasma duncanae* of coral zone D suggests a somewhat greater age, as it resembles probable Wenlockian *T. prava* of the Louisville Limestone (Stumm, 1964, pl. 6, fig. 8) and the Gotland *T. hedströmi* from strata that are probably also Wenlockian (Wedekind, 1927, pl. 29, figs. 1, 2).

Great Basin Silurian coral zone E.—Coral zone E of late Ludlovian age includes the uppermost Silurian beds of the Great Basin within the intermediate limestone belt. Overlying beds in the Coal Canyon reference section carry the Helderbergian (Early Devonian) Rabbit Hill fauna. Endophyllid corals of the subgenus *Toquimaphyllum* are characteristic and related to an undescribed member of this family in Ludlovian upper members of the Klamath Mountains Gazelle Formation. *Australophyllum (Toquimaphyllum) johnsoni* of zone E is comparable to *Spongophyllum rectiseptatum* Dybowski of the Gotland Ludlovian Eke Marl, as well as to species of *Toquimaphyllum* in the Late Silurian of Czechoslovakia. Australian species in the Yass-Bowning beds are reported to be of late Wenlockian and Ludlovian age.

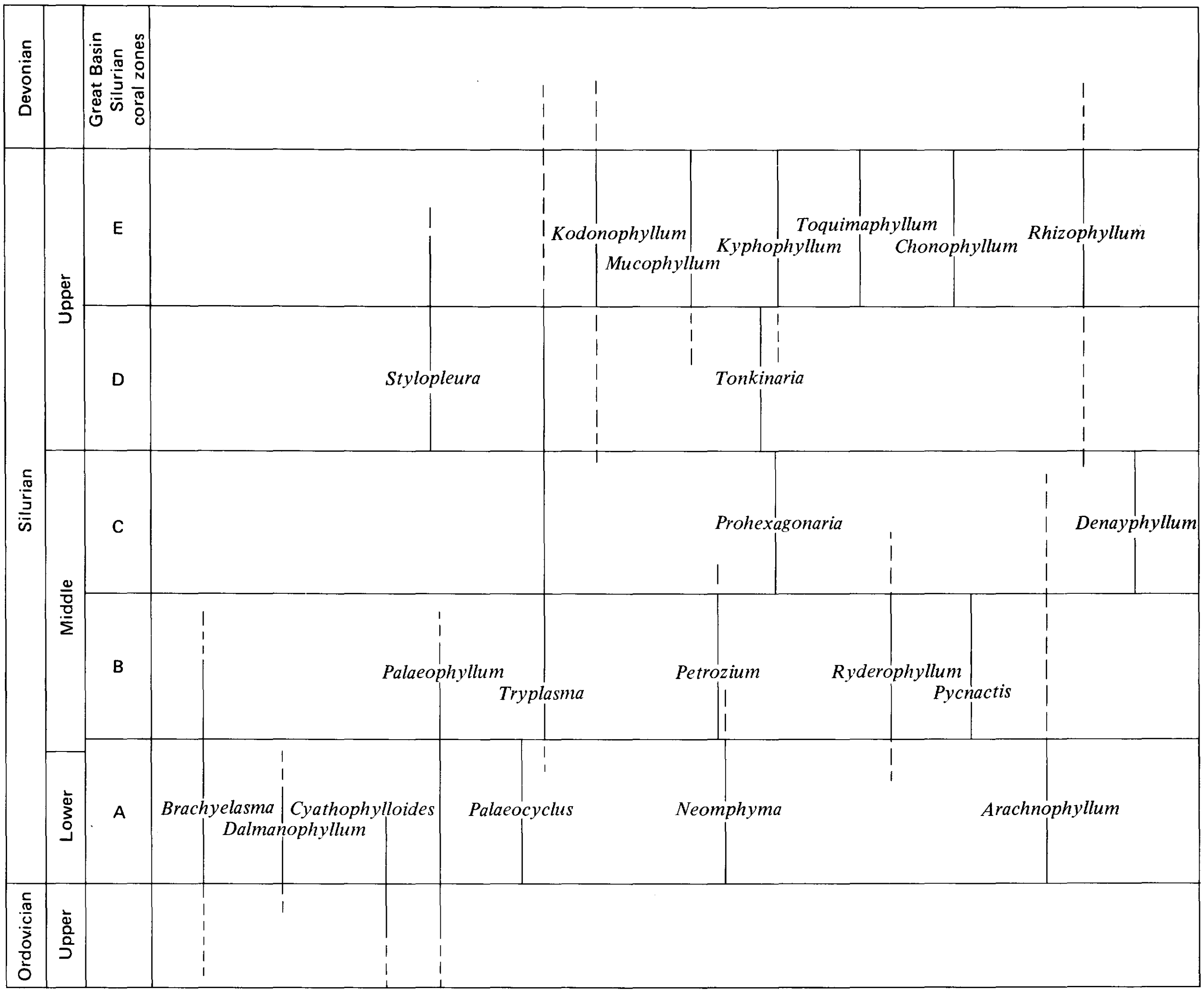


FIGURE 9.—Stratigraphic occurrence of characteristic Great Basin Silurian rugose coral genera.

The Ludlovian burst of *Rhizophyllum* in the Hemse and Eke horizons of Gotland (fig. 8) is more or less paralleled by *Rhizophyllum* of Silurian coral zone E. However, the stratigraphic range of this genus extends at least from the Brownsport of eastern North America to the Early Devonian Konieprus of eastern Europe. In Australia and in Alaska, also, this coral is reported to have survived into the Devonian Period.

COMPARISON OF SILURIAN CORALLINE ROCKS IN THE GREAT BASIN WITH THOSE OF OTHER REGIONS

Morphologic and taxonomic comparisons of Great Basin Silurian corals with corals of the classic Silurian regions provide a basis for geologic correlation; at the same time, these studies invite comparative treatment of depositional and environmental conditions under which the coral-bearing strata accumulated. In this connection, two types of marine environment, broadly speaking, are considered: the environment of tectonically active geosynclinal belts, represented by the graywacke belt of the Pacific Border province, and the shelf environment, represented by the Niagara Series of the Great Lakes and the Gotland Silurian.

In the Pacific Border graywacke belt, great volumes of siliceous conglomerate, graywacke, bedded chert, and submarine volcanics manifest recurrent crustal movement and vulcanism. Depositional environments such as this might be expected to inhibit limestone accumulation and therefore to provide few benthonic sites favorable for extensive coral growth. Coralline rocks of the Klamath Mountains, Calif., and of southeastern Alaska fall within this province. Limestones of these regions are mostly lenses within the "dirty" siliceous clastics. Surprisingly enough, however, many of these circumscribed carbonate bodies are fairly pure, and many are coral bearing. Diagenetic dolomitization processes were not in operation here. Rugose corals of colonial growth habit are more abundant in the Klamath Mountains than in southeastern Alaska, where Silurian coralline life in general appears to have been somewhat less diverse and prolific. So far as known, the unstable tectonic-volcanic conditions of this belt did not foster environments required for widespread patch reef or biohermal growth like those of shelf seas. Silurian corals of the Pacific Border graywacke belt and the rocks in which they occur are treated in a separate report (Merriam, 1972).

Coral faunas of the Great Basin Silurian appear to be less closely related to those of the Middle Silurian Niagara shelf seas than to those of either the Pacific Border province or the Gotland Silurian. However, the lack of well-preserved Niagara coral comparative material makes possible only the vaguest of generalizations in this regard. Taxonomically and environmentally, the western faunas appear to differ appreciably. Unlike the Great Basin Silurian seas, shallow Niagara carbonate seas of the Great Lakes area were optimal for proliferation of bioherm-patch-reef complexes characterized by unstratified, altered core rock, inclined flank beds, and partial dolomitization, especially of the core rock (Lowenstam, 1948, 1950).

For purposes of this investigation, the coral faunas of Gotland, Sweden, have provided a most valuable standard of morphologic and taxonomic comparison. In terms of deposition and environment, the Gotland column is, likewise, the best yardstick for the world Silurian marine carbonate rocks.

In Gotland, the Silurian System is about 1,600 feet thick (Regnéll and Hede, 1960, p. 46), a thickness comparing favorably with the Great Basin Silurian average thickness. Both sequences have the carbonate depositional characteristics of shelf seas, and both have a comparatively small thickness for the Silurian System in a world sense. For example, the geosynclinal Silurian of southeastern Alaska is about 20,000 feet thick, or 12 times the thickness of the system in carbonate stable-shelf columns. Conceivably, the greater part of Silurian time is recorded by sediments and faunas of the Gotland reference column, which comprises 13 primary map units that are defined on the basis of physical rock differences and supported by paleontological evidence. Whereas the Gotland strata and those of the Great Basin Silurian are predominantly carbonate, much argillaceous matter was pervasively admixed during the course of sedimentation in Gotland. The argillaceous debris, evidently of terrigenous derivation, occurs throughout the section as argillaceous limestone, marlstone, claystone, and shale. Associated with these sediments in Gotland are biohermal limestone, sandstone, oolitic limestone, and minor bentonitic deposits. Unlike Great Basin Silurian and unlike the Great Lakes Niagaran, the Gotland Silurian includes very little dolomite. Major lime contributors in Gotland were the crinoids, stromatoporoids, calcareous algae, and corals.

Especially distinctive of the Gotland Silurian are innumerable bioherms in which the corals are associated with other lime contributors. These depositional features are found in some 10 of the 13 Gotland units. Typically, the Gotland bioherms have unstratified limestone cores of inverted cone shape which intertongue laterally with reef detritus (Hadding, 1941, 1950; Jux, 1957; Regnéll and Hede, 1960). Unlike the Niagara bioherms, those of Gotland do not ordinarily have core-rock dolomitization. Greenish-gray or red argillaceous limestones occur with some Gotland bioherms.

Although the Gotland Silurian is mainly of shelf-sea character, these lithologically diverse strata were repeatedly influenced during accumulation by landward crustal disturbances. Hinterland deformation acting upon the terrigenous debris source areas is manifested in the complex record of Gotland marine-sediment discontinuities, both vertical and lateral. Bioherm growth on the shallow sea floor was markedly influenced by frequent marine current changes, together with landward or seaward shift of the shore zone as a result of deformation.

DEPOSITIONAL FEATURES OF GREAT BASIN SILURIAN CORALLINE ROCKS IN RELATION TO THE REEF PROBLEM

Field studies of Great Basin Silurian coral-bearing strata have thus far failed to disclose complex bedding structures like the classic bioherms or patch reefs of the Niagara and Gotland sequences. Coral-rich limestones of the intermediate limestone belt are usually medium-coarse-grained jumbled bioclastics in which bedding is fairly even and crinoidal debris predominates. All fossils in such facies are obviously transported, the corals commonly showing little evidence of wear and having scattered, random distribution. Such deposits appear to have formed as banklike accumulations to which the fossils had been carried only short distances from their growth sites. Generally lacking in these limestones are in situ organic-growth depositional structures which possessed initial bottom relief. Unstratified core rock and inclined flank beds like those of the Niagara and Gotland patch reefs have not thus far been recognized in the Great Basin Silurian strata.

In the Great Basin Silurian, few exposures have been observed which reveal corals entombed in their original growth positions, but among these exposures are certain *Entelophyllum* beds in Lone Mountain Dolomite of the Mahogany Hills and the Fish Creek Range. There, large, laterally extended colonies of a rather open colonial form occupy fairly even beds and seemingly existed in thin, dispersed coral fields. None of these in situ growths were observed to have the wave-resistant mound, or dome configuration, which might have developed as a result of continued upward accretion of corals, algae, and other organisms, aided by sediment-binding agents.

Theoretically, the Silurian shelf seas of the Great Basin in both limestone and dolomite belts would be expected to favor bioherm or patch-reef complexes in ecologically suitable places. The coral-rich bioclastics earlier discussed are perhaps interreef facies; the *Entelophyllum* fields may be reef-marginal or lagoonal. Another suggestion of reef proximity is the lenticular occurrence of contemporaneous depositional limestone breccias containing abundant corals. These have been described in the topmost Roberts Mountains limestone of the Simpson Park Range, Nev. (Winterer and Murphy, 1960, p. 126). At Coal Canyon the limestone clasts and matrix of these depositional breccias have yielded much of the Silurian coral study material from that vicinity. In theory, coarse depositional breccias of this kind might form as a product of wave action along a reef front. Other reefal features, such as inclined flank beds and unstratified core rock, were not observed in association. Similar coarse coral-rich limestone breccia-conglomerates are known also in the Klamath Mountains Silurian within the tectonically active Pacific Border graywacke belt; here again there is no further supporting evidence of reef origin (Merriam, 1972).

In comparison with the great stratigraphic and facies complexities of the shelf sea Gotland Silurian with its numerous patch reefs, the Great Basin Silurian of the eastern dolomite belt is on the whole far more uniform, as it has fewer abrupt lithofacies discontinuities. Tectonically, the marine environmental conditions appear to have been more stable in the Great Basin dolomite belt than in the Gotland nondolomitic, commonly very muddy seas. From these environmental assumptions, one can perhaps speculate that the more uniform, dolomitic deposition in the eastern dolomite belt served in some manner to arrest the development of reefal structures.

Fairly stable tectonic conditions, again without proven marine reefal manifestations, prevailed also to the west within the Great Basin intermediate limestone belt. Decreasingly stable tectonic conditions probably prevailed in the westernmost part of the limestone belt as the hypothetical transition to the Pacific Border graywacke belt of active Silurian tectonism is approached. Hence, marine environments more like those of Gotland may conceivably have existed in buried and unexplored terrane in the northwestern part of the Great Basin province.

DASYCLADACEAN ALGAE IN GREAT BASIN SILURIAN CORALLINE DEPOSITS

Plate 16, figures 5–17

Calcareous algae of the family Dasycladaceae were among the major limestone builders and played a significant role in the economy of Great Basin Silurian seas. Dasycladaceae are represented here by *Verticillopora* Rezak, the conical to cylindrical thalli of which were long confused with sponges or with large crinoid stalks, either of which they may closely resemble. In 1954, P. E. Cloud called the writer's attention to plant affiliation of these fossils, following which the collections were intensively studied by Rezak (1959). Intimate ecologic association of Great Basin Silurian Rugosa with dasycladaceans calls for a brief reference to these plants.

As in the Gotland Silurian (Rothpletz, 1908, 1913), calcareous algae are known to have contributed much lime in the Great Basin and the Pacific Border seaways. Johnson and Konishi (1959) and Rezak (1959) showed that Dasycladaceae, Solenoporaceae, and other algal families were active in the Klamath Mountains Silurian; however, the large *Verticillopora* was not recognized in that region.

The Great Basin *Verticillopora* ranges upward from coral zone B through coral zone E. It is, however, in about the interval of coral zone D that this fossil is most abundant. *Verticillopora annulata* develops to large size and in a variety of cylindrical, conical, and irregular turbinate shapes. In some beds of the Vaughn Gulch Limestone below coral zone E, this alga outnumbers the rugose corals. Similar large thalli occur with Rugosa in zone D of the Ikes Canyon reference section. In the Roberts Creek Mountain reference section, *Verticillopora* of coral zone D is smaller and more like that of unit 46 in the Laketown of the Confusion Range. (See fig. 7, col. 10.) *Verticillopora* of coral zone B is narrowly cylindrical, strongly suggestive of a crinoid stalk, and may represent a distinct species.

CLASSIFICATION OF GREAT BASIN SILURIAN RUGOSA

Great Basin Silurian rugose corals here described are classified in 13 families. The usage and content of several families depart from Hill's 1956 classification, the most comprehensive and authoritative published thus far. Departures from Hill's scheme include the elevation of certain subfamilies to independent family status, the restoration of the family Pycnostylidae, and the shift of certain genera from one family to another believed to be more appropriate. Of three new genera proposed, *Denayphyllum* is not assigned to a family.

Family Streptelasmatidae Nicholson,[1] 1889 (as Streptelasmidae).
- Genus *Rhegmaphyllum* Wedekind, 1927
  - *Rhegmaphyllum* sp. h
- Genus *Brachyelasma* Lang, Smith, and Thomas, 1940
  - *Brachyelasma* sp. B
- Genus *Dalmanophyllum* Lang and Smith, 1939
  - *Dalmanophyllum* sp. A

Family Stauriidae Edwards and Haime, 1850
- Genus *Cyathophylloides* Dybowski, 1873
  - *Cyathophylloides fergusoni*, n. sp.

[1] In Nicholson and Lydekker (1889).

Family Stauriidae Edwards and Haime, 1850—Con.
 Genus *Palaeophyllum* Billings, 1858
  Palaeophyllum sp. b
  Palaeophyllum? sp. c
Family Pycnostylidae Stumm, 1953
 Genus *Stylopleura*, n. gen.
  Stylopleura berthiaumi, n. sp.
  Stylopleura nevadensis, n. sp.
Family Tryplasmatidae Etheridge, 1907
 Genus *Tryplasma* Lonsdale, 1845
  Group 1: Solitary-rugate *Tryplasma*
  Tryplasma duncanae, n. sp.
  Group 2: Fasciculate-cylindrical *Tryplasma*
  Tryplasma newfarmeri, n. sp.
  Tryplasma sp. R
 Genus *Rhabdocyclus* Lang and Smith, 1939
  Rhabdocyclus sp. B
  Rhabdocyclus sp. d
  Rhabdocyclus sp. K
 Genus *Palaeocyclus* Edwards and Haime, 1849
  Palaeocyclus porpita subsp. *mcallisteri*, n. subsp.
 Genus *Zelophyllum* Wedekind, 1927
Family Kodonophyllidae Wedekind, 1927
 Subfamily Kodonophyllinae, new subfamily
 Genus *Kodonophyllum* Wedekind, 1927
  Kodonophyllum mulleri, n. sp.
 Subfamily Mycophyllinae, new subfamily
 Genus *Mucophyllum* Etheridge, 1894
  Mucophyllum oliveri, n. sp.
Family Arachnophyllidae Dybowski, 1873
 Genus *Arachnophyllum* Dana, 1846
  Arachnophyllum kayi, n. sp.
Family Lykophyllidae Wedekind, 1927
 Genus *Pycnactis* Ryder, 1926
  Pycnactis sp. k
 Genus *Cyathactis* Soshkina, 1955
  Cyathactis? sp.
 Genus *Ryderophyllum* Tcherepnina, 1965
  Ryderophyllum ubehebensis, n. sp.
Family Cystiphyllidae Edwards and Haime, 1850
 Genus *Microplasma* Dybowski, 1873a
  Microplasma? sp. R
Family Goniophyllidae Dybowski, 1873a
 Genus *Rhizophyllum* Lindström, 1866
  Rhizophyllum sp. D, Oliver
Family Kyphophyllidae Wedekind, 1927
 Genus *Kyphophyllum* Wedekind, 1927
  Kyphophyllum nevadensis, n. sp.
 Genus *Petrozium* Smith, 1930
  Petrozium mcallisteri, n. sp.
 Genus *Entelophyllum* Wedekind, 1927
  Entelophyllum eurekaensis, n. sp.
  Entelophyllum engelmanni, n. sp.
 Genus *Entelophylloides* Rukhin, 1938 (as subgenus)
 Subgenus *Prohexagonaria*, n. subgen.
  Entelophylloides (Prohexagonaria) occidentalis, n. sp.
 Genus *Neomphyma* Soshkina, 1937
  Neomphyma crawfordi, n. sp.
 Genus *Tonkinaria*, n. gen.
  Tonkinaria simpsoni, n. sp.
Family Chonophyllidae Holmes, 1887
 Genus *Chonophyllum* Edwards and Haime, 1850
  Chonophyllum simpsoni, n. sp.
Family Endophyllidae Torley, 1933
 Genus *Australophyllum* Stumm, 1949
 Subgenus *Toquimaphyllum*, n. subgen.
  Australophyllum (Toquimaphyllum) johnsoni, n. subgen., n. sp.
Family Acervulariidae Lecompte, 1952
 Genus *Diplophyllum* Hall 1852
  Diplophyllum? sp. m
No family assignment
 Genus *Salairophyllum* Bresprozvannikh, 1968
  Salairophyllum? sp.
 Genus *Denayphyllum*, n. gen.
  Denayphyllum denayensis, n. gen., n. sp.

SYSTEMATIC AND DESCRIPTIVE PALEONTOLOGY

All 35 rugose coral species treated in this report were previously undescribed. Five are classified in the new genera *Stylopleura, Tonkinaria,* and *Denayphyllum*; two are assigned to the new subgenera *Entelophylloides (Prohexagonaria)* and *Australophyllum (Toquimaphyllum)*. Twenty of the new species are given formal names, being represented in our collections by well-preserved material considered appropriate for complete diagnosis. Fifteen species, mostly solitary Rugosa, are designated provisionally and informally by letter; whereas these lettered taxa have prime stratigraphic value, they are represented by rather poorly preserved, mostly incomplete specimens judged too few and inadequate to warrant formal species naming at present. In general, the stratigraphically more important unnamed species are assigned capital letters. Regretfully, with all of the studied species, the number of sectioned coralla is insufficient for quantitative variation techniques, which by modern standards is a part of any species characterization.

The Great Basin Silurian coral zone is indicated under occurrence of most species. Locality numbers, such as M1097, are recorded in the U.S. Geological Survey Menlo Park Paleozoic fossil locality catalogue; also, a register of these locality numbers accompanies this report.

Descriptive terminology used in this report is largely that proposed by Hill in 1935 and 1956.

Family STREPTELASMATIDAE Nicholson, 1889 [2] (as STREPTELASMIDAE)

Reference genus and species.—*Streptelasma corniculum* Hall. Ordovician, New York.

Mostly solitary rugose corals lacking dissepiments, and with a septal stereozone; tabulae and tabellae usually but not always arched, and involved with septal ends as an axial structure in some species. In genera with a wide stereozone, tabulae may be obscure.

This diverse and long-ranging family is probably ancestral to a large number of the post-Ordovician rugose

[2] In Nicholson and Lydekker (1889).

corals and will probably eventually lend itself to subfamily taxonomic subdivision. *Rhegmaphyllum, Brachyelasma,* and *Dalmanophyllum* are the Great Basin Silurian Rugosa here classified.

Genus RHEGMAPHYLLUM Wedekind, 1927

1831. *Turbinolia turbinata* Hisinger (in part), p. 128.
1868. *Zaphrentis conulus* Lindström, p. 428; pl. 6, fig. 8.
1927. *Rhegmaphyllum* Wedekind, p. 14, pl. 24, figs. 6–8.
1940. *Rhegmatophyllum* Lang, Smith, and Thomas, p. 114.
1956. *Rhegmaphyllum* Wedekind. Hill, p. F269, fig. 182,9b, 9c.

Type species.—Rhegmaphyllum turbinatum (Hisinger); by subsequent designation (Soshkina, 1937, p. 85; see also Lang, Smith, and Thomas, 1940, p. 114). Silurian, Wenlockian, Slite group, Gotland, Sweden.

Diagnosis.—Small, solitary ceratoid-trochoid rugose corals with long, smooth major septa, some of which extend to axis; minor septa less than half the length of major septa. Septal stereozone narrow. Tabulae arched, some complete; may be weakly developed. Exterior nearly smooth; septal grooves weak or absent.

Remarks.—These small and rather simple solitary streptelasmid corals are smaller than *Streptelasma* and have a narrower stereozone and a more discrete fossula. *Orthophyllum* of Počta (1902, pl. 112, figs. 5–7) has few or no minor septa and lacks a well-defined fossula. (See also Smith, 1930, p. 304, fig. 4.)

In the Great Basin province, corals of this kind occur in the lower part of the Silurian.

Rhegmaphyllum sp. h

Plate 1, figures 7, 8

Small silicified corals assigned to *Rhegmaphyllum* sp h occur in the lower part of the Hidden Valley Dolomite of southwest Great Basin. Only the exterior is known because the material is inadequate for thin-section preparation.

Figured corallum with 26 smooth major septa in a deep conical calice, at the bottom of which most major septa meet the axis. Cardinal septum abbreviated in its fossula. Outer surface is almost smooth, with faint traces of longitudinal grooves.

Occurrence.—In lower beds of the Hidden Valley Dolomite, Early Silurian, coral zone A northern Panamint Range, where it is associated with *Dalmanophyllum, Tryplasma,* and *Palaeocyclus.* Whitetop Mountain, northern Panamint Range, locality M1096. Study material consists of three silicified coralla.

Genus BRACHYELASMA Lang, Sn. 1940

1927. *Dybowskia* Wedekind, p. 18, pl. 1, figs. 10, 11 [not Dall, 1876].
1940. *Brachyelasma* Lang, Smith, and Thomas, p. 28.
1956. *Brachyelasma.* Hill, p. F268, fig. 182,5a, 5b.

Type species.—Dybowskia prima Wedekind; by original designation (Lang, Smith, and Thomas, 1940, p. 28). Stavnestangen, Tyrifjord, Norway; in strata of either Late Ordovician or Early Silurian age.

Diagnosis.—Trochoid-ceratoid solitary rugose corals lacking dissepiments and having subhorizontal, straight, or slightly arched tabulae, some of which are complete. Tabulae bent downward as they approach the wall. Major septa not meeting the axis, though commonly extending more than half that distance. Minor septa short. Septal stereozone narrow. A fossula recognizable in some species.

Remarks.—Brachyelasma shares some of the characteristics of Devonian siphonophrentids, especially the subgenus *Breviphrentis* which differs in possessing an elongate subcylindrical corallum and has amplexoid septa together with a wider stereozone (Merriam, 1973c). *Siphonophrentis (Breviphrentis)* commonly undergoes repeated rejuvenescence to give the corallum a narrow segmented appearance.

Brachyelasma occurs in rocks of Late Ordovician, Early Silurian, and early Middle Silurian age. The type species, *B. prima,* is reported by Lang, Smith, and Thomas (1940, p. 28) to be Llandoverian, although Hill (1956, p. F268) implied a Late Ordovician age. In the Toquima Range of the Great Basin this genus has been found in the lower part of the Gatecliff Formation of Kay and Crawford (1964, p. 437), which may be pre-Richmondian; *Brachyelasma* is found also in the Ely Springs Dolomite of Richmondian age, and in Silurian coral zones A and B.

Brachyelasma sp. B

Plate 1, figures 9–11; plate 16, figures 1, 2

Silicified corals upon which this description is based were collected from the lower part of the Hidden Valley Dolomite in the northern Panamint Range and in the Funeral Mountains, Calif.

About 32 major septa, thickened peripherally, tapering axially, and withdrawn from the axis; minor septa short. Septal stereozone very narrow. Tabulae complete, close spaced, and straight except for peripheral downward bend. No suggestion of a fossula in transverse thin sections. One weathered specimen (pl. 16, fig. 2) shows a discrete fossular down-bend of the calice tabula in the position of a primary septum.

Occurrence.—Early Middle Silurian, coral zone B; lower part of the Hidden Valley Dolomite. Northern Panamint Range: Ubehebe Peak area, locality M1094; Andy Hills, locality M1095. Funeral Mountains, Pyramid Peak area, localities M1097, M1127. A somewhat different *Brachyelasma* occurs at locality M1098 in the Schwaub Peak area, Funeral Mountains (pl. 1, figs. 5, 6). Study material consists of two coralla (M1094), one corallum (M1095), one corallum (M1097), and one corallum (M1127).

In the Confusion Range, Utah (loc. M1129), *Brachyelasma* of this same general type is associated with *Palaeocyclus* and a large fauna indicative of Silurian coral zone A. *Brachyelasma* like the sp. B occurs elsewhere in beds of probable Late Ordovician age, such as the Gatecliff Formation of Kay and Crawford (1964) in the Toquima Range and beds in the Tuscarora Mountains of northern Eureka County, Nev., where this coral genus is associated with *Catenipora, Palaeofavosites,* and *Hesperorthis.*

Genus DALMANOPHYLLUM Lang and Smith, 1939

1933. *Tyria* Scheffen, p. 33, pl. V, figs. 2, 3.
1939. *Dalmanophyllum* Lang and Smith, p. 153.
1940. *Dalmanophyllum.* Lang, Smith, and Thomas, p. 49.
1956. *Dalmanophyllum.* Hill, p. F269, fig. 182.6a–6c.
1961. *Dalmanophyllum* Lang and Smith. Minato, p. 81–86, text figs. 20–23; pl. XI, pl. XIX, figs. 2–5.

Type species.—Cyathaxonia dalmani Edwards and Haime, 1851; by original designation (Lang and Smith, 1939, p. 153). Silurian, Högklint Group, early Wenlockian, Gotland, Sweden.

Diagnosis.—Small solitary rugose corals of trochoid shape with solid bladelike axial structure projecting upward in bell-shaped calice; transverse outline of calice rim broadly ovoidal and nonangulate. Fossula in line with median plane of axial structure. Major septa project axially to columella in early adult and younger growth stages. Minor septa short; major septa dilated. Septal stereozone narrow. Tabulae largely suppressed by septal thickening. Dissepiments absent.

Remarks.—Dinophyllum differs from *Dalmanophyllum* in having a loose and open axial structure rather than a solid columella; its major septa are usually less dilated and are twisted toward the axis. *Dinophyllum* commonly does not develop well-defined short minor septa and is more often ceratoid than trochoid.

The Late Ordovician *Bighornia* (Duncan, 1957) resembles *Dalmanophyllum,* but it normally is flattened apically, and the mature transverse section is commonly angulate. *Bighornia* may show even more dilated major septa than *Dalmanophyllum,* and minor septa are more weakly developed.

Dalmanophyllum sp. A

Plate 1, figures 1–3

Dalmanophyllum sp. A is known only from exteriors; available material is insufficient for sectioning. Externally, this species closely resembles *D. dalmani* (Edwards and Haime), as figured by them (1851, pl. 1, fig. 6); a copy of one holotype figure of *dalmani* is here reproduced for comparison (pl. 1, fig. 4).

Epitheca with faint longitudinal striations, but no pronounced septal grooves; moderate rugae developed. Major septa in mature calice about 36; septa straight and smooth peripherally, becoming periaxially wavy where they join the laterally compressed columella. Solid columella projecting upward 3 millimeters in calice and elongate-ovoid in cross section, with long axis in cardinal-counter plane. Short septum in fossula probably the cardinal septum; fossula situated on convex side of corallum.

Occurrence.—Early Silurian, coral zone A. Basal beds of Hidden Valley Dolomite, Whitetop Mountain, northern Panamint Range; locality M1096. Basal part of Vaughn Gulch Limestone, Mazourka Canyon, northern Inyo Mountains, locality M1091. Study material consists of the two complete silicified figured specimens and fragments of coralla from Whitetop Mountain (loc. M1096).

Comparable columellate solitary corals assignable either to *Dalmanophyllum* or to *Dinophyllum* occur in the lower part of the Silurian section, Gazelle area, northeastern Klamath Mountains, Calif., and in the Montgomery Limestone near Taylorsville, Calif.

Family STAURIIDAE Edwards and Haime, 1850

Reference genus and species.—Stauria astreiformis Edwards and Haime. Silurian, Gotland, Sweden.

Fasciculate and cerioid rugose corals having slender corallites mostly without dissepiments; tabulae straight or arched, and long lamellar major septa commonly extend to the axis. In some lineages of this family, dissepiments in a single column or sporadically in a broken column.

Two of the species here described are placed in genera classified as Stauriidae; these are *Cyathophylloides* and *Palaeophyllum.*

Genus CYATHOPHYLLOIDES Dybowski, 1873

1851. *Columnaria gothlandica* Edwards and Haime, p. 309, pl. 14, figs. 2, 2a.
1873. *Cyathophylloides* Dybowski, p. 334, 379.
1940. *Cyathophylloides* Dybowski. Lang, Smith, and Thomas, p. 43.
1950. *Cyathophylloides* Dybowski, Bassler, p. 274 (in part).
1956. *Cyathophylloides.* Duncan, pl. 24, figs. 6a, 6b.
1956. *Cyathophylloides* Dybowski, Hill, p. F296, fig. 202,3a,3b?
1961. *Cyathophylloides* Dybowski, Flower, p. 83, pl. 43, figs. 1–10; pl. 44, figs. 1–5.

Type species.—Cyathophylloides kassariensis Dybowski, 1873; by subsequent designation (Sherzer, 1891, p. 278). Island of Kassar, Estonia, from beds believed to be Upper Ordovician (Bassler, 1950, p. 274).

Diagnosis.—Massive cerioid rugose corals having 12–14 smooth, simple lamellar major septa which meet axially, where they may be twisted but do not form a discrete axial structure or columella. Tabulae complete, highly variable from straight to arched distally with median sag or sagging slightly overall; widely spaced to closely set. Minor septa short to rather long. No dissepiments.

Remarks.—Cyathophylloides is closely related to "*Favistella*" or *Favistina* Flower, a new generic term (Flower, 1961, p. 77) which, in adjustment of a nomenclatural problem, may appropriately cover species previously assigned to "*Favistella.*" Characters such as arching of tabulae and axial meeting of septa are, however, not overly constant in *Cyathophylloides*, which also, as here interpreted, may have some straight or nearly horizontal tabulae and whose major septa may in places be shorter, as in normal *Favistina*. Nonetheless, there is evidently a recognizable group of these Rugosa with the septal arrangement of *Cyathophylloides* which ranges from Late Ordovician into the Silurian and is represented by the lower Masket *Cyathophylloides fergusoni*, n. sp. *Cyathophylloides gothlandicus* (Edwards and Haime) (1851, p. 309, pl. 14, figs. 2, 2a), one of the few described Silurian species, is insufficiently known internally. Bassler's (1950, pl. 18, figs. 10, 11) figures of *gothlandicus* do not show long, axially meeting septa. The stratigraphic horizon of *gothlandicus* is not known, but presumably the type material may have come from the vicinity of Visby, Gotland, in the lower part of the Silurian column.

In a comprehensive study of Late Ordovician colonial Rugosa from the Montoya Dolomite of New Mexico, Flower (1961, p. 77-87) emphasized a close genetic relationship of *Cyathophylloides* to *Favistina*, pointing up the survival of *Cyathophylloides* into the Silurian, where its species differ more widely from those of the shorter ranging *Favistina*.

Cyathophylloides similar to *fergusoni* occurs in rocks of probable Silurian age in northern Eureka County, Nev. Float specimens which may represent either the Late Ordovician Hanson Creek Formation or the lower part of the Silurian Roberts Mountains Formation were collected by the writer at Section Ridge, Roberts Mountains (Duncan, 1956, explanation of pl. 24). Another float specimen from the same locality represents a seemingly undescribed genus with some features of *Cyathophylloides* but having an aulos and a single column of large peripheral dissepiments.

Cyathophylloides fergusoni, new species

Plate 5, figures 9, 10

Type material.—Holotype USNM 159393; Early Silurian, Toquima Range, Nev.

Diagnosis.—Massive cerioid *Cyathophylloides* forming large colonies. Wall thick for the genus, major septa meeting axially, minor septa very short; tabulae widely spaced, horizontal to arched.

External features.—Coralla developed as large lenticular masses more than 1 foot in diameter; weathered distal surfaces showing the thick-walled character and fairly uniform size of corallites.

Transverse sections.—Major septa 12-14, fairly straight to axial part, smooth and of nearly uniform width without taper; some septa wavy toward the axis. In some individuals, two or more septa merge laterally, others terminate against the side of a contiguous longer septum. In a few individuals, median dark line of a septum continues across the axis into that of an opposite septum. No axially twisted intertwining of septal terminations as in some columellate Rugosa.

Longitudinal sections.—Wall much thicker than tabulae and septa. Septa continuous lamellae, smooth and fairly even periaxially. Tabulae in part domed distally, in part nearly horizontal. No crenulation or pronounced downward bend of the periphery as in the genus *Crenulites*. Tabulae for the greater part widely spaced.

Microstructure.—Major septa show well-defined medial dark line. Trabecular wall structure indistinct in longitudinal section.

Comparison with related forms.—Bassler's figures (1950, pl. 17, figs. 10, 11) of the type species, *C. kassariensis*, show more closely set tabulae with decided peripheral depression of tabulae not shown by *fergusoni*. Major septa of *kassariensis* are more numerous and taper toward the axis. *Cyathophylloides gothlandicus* (Edwards and Haime) as figured by Bassler (1950, pl. 18, figs. 10, 11) shows close-set tabulae and major septa which are thinner and do not reach the axis as, by definition, they would be expected to do in this genus. *C. burksae* Flower (1961, p. 83, pl. 43, figs. 1-10, pl. 44, figs. 1-5) of the Middle and Late Ordovician Montoya Group appears to be the closest to *fergusoni*, differing in its somewhat longer minor septa and in its distinctly arched, more closely spaced tabulae.

Occurrence.—Lower Silurian, coral zone A, Masket Shale of Kay and Crawford (1964). Ikes Canyon, Toquima Range, Nev., locality M1088. Study material consists of one very large, nearly complete corallum, two partial coralla, and fragments of coralla.

Genus PALAEOPHYLLUM Billings, 1858

1858. *Palaeophyllum* Billings, p. 168.
1956. *Palaeophyllum*. Duncan, pl. 25, figs. 1a, 1b.
1959. *Palaeophyllum* Billings. Hill, p. 4.
1961. *Palaeophyllum* Billings, Flower, p. 88.
1963. *Palaeophyllum* Billings. Oliver, p. G4.

Type species.—*Palaeophyllum rugosum* Billings. Ordovician, Black River or Trenton, Quebec, Canada.

Diagnosis.—Phaceloid Stauriidae with narrow peripheral stereozone and no dissepiments. Major septa long and simple, minor septa short; tabulae complete, commonly arched with axial depression. Forms very large colonies by lateral increase.

Remarks.—All aspects of the morphology, taxonomy, and genetic relationships of *Palaeophyllum* have in recent years been dealt with by Flower, Hill, and Oliver. This phaceloid genus is probably closely related to the cerioid *Favistina* or *Favistella* and to *Cyathophylloides*. These nondissepimented colonial Rugosa are especially important in the higher Ordovician. In the Silurian, forms which appear to fit best in *Palaeophyllum* and *Cyathophylloides* are common in the Cordilleran belt;

these occur with other nondissepimented species having complete tabulae and similar growth habit, but having partly acanthine septa and therefore probably unrelated.

Palaeophyllum sp. b

Plate 3, figures 4, 5

A large silicified colony of this coral was collected by H. R. Cornwall and F. J. Kleinhampl from the lower part of the Silurian section at Bare Mountain near Beatty, Nev., in beds above the Ely Springs Dolomite.

Palaeophyllum sp. b has 20 major septa, most of which extend more than half the distance to the axis; minor septa are short. The tabulae are straight to slightly arched and lack axial sag.

Palaeophyllum sp. b lacks the well-arched tabulae with axial sag of *thomi* (Hall), *multicaule* (Hall), and *margaretae* Flower; it has more major septa than the Silurian *multicaule* (Oliver, 1963, pl. 4, figs. 1, 2).

Occurrence.—Lower part of the Silurian carbonate section on the east side of Bare Mountain, Nev., between Tarantula Canyon and Chuckwalla Canyon, locality M1085. The Great Basin Silurian coral zone of this occurrence has not been established; it probably represents coral zone A.

Palaeophyllum? sp. c

Plate 2, figures 5, 6

Coral collections from the lower part of the Vaughn Gulch Limestone of the Owens Valley region, California, include a phaceloid species provisionally assigned to *Palaeophyllum*. Major septa number about 22; minor septa commonly exceed half the length of major septa. Major septa of most corallites are amplexoid and extend less than half the distance to the axis. Tabulae are straight or slightly arched.

Occurrence.—Lower 300 feet of Vaughn Gulch Limestone, 125 feet stratigraphically above beds with *Dalmanophyllum* sp. A. Associated with *Heliolites* and small indeterminate horn corals either near top of Silurian coral zone A or base of coral zone B. Northern Inyo Mountains, east of Kearsarge, at mouth of Mazourka Canyon, locality M1086.

Family PYCNOSTYLIDAE Stumm, 1953

Reference genus and species.—*Pycnostylus guelphensis* Whiteaves, 1884. Silurian, Guelph Dolomite; Ontario, Canada.

Fasciculate rugose corals with subcylindrical mature corallites; septa low, continuous longitudinal ridges arising from narrow stereozone without acanthine spines. Tabulae complete, straight, unarched; no dissepiments. Reproduction by multiple wall (peripheral) offsets from calice interior. Trumpet-shaped flaring calices are characteristic.

Long lamellar septa and arched tabulae of the Stauriidae and acanthine septa of the Tryplasmatidae are absent in this family, which otherwise presents homeomorphic features. The slender fasciculate tryplasmids are externally similar and may, as with *Tryplasma fascicularia* Oliver, 1960, have fivefold axial increase (W. A. Oliver, written commun., 1969). Multiple calice offsets are probably less characteristic of the tryplasmids. The *Zelophyllum* group with sporadic acanthine spines are also homeomorphic; they are not known with multiple calice offsets as in the pycnostylids and seemingly do not produce the markedly flaring calices.

The problematic *Fletcheria* is poorly understood. This Silurian pycnostylid has some cystose tabulae, and a rather thick wall with structure suggesting that of *Syringopora* (Duncan, 1956, pl. 25, figs. 6a, 6b). According to Duncan, *Fletcheria* lacks septa and does not have the inward-projecting free trabecular spines of tryplasmids. On the basis of Duncan's evaluation and the original figure of Edwards and Haime (1851, pl. 14, fig. 5), it appears somewhat doubtful that the type species of *Fletcheria* is congeneric with *Pycnostylus*, as implied by Lang, Smith, and Thomas (1940, p. 112).

Genera assigned to the Pycnostylidae are as follows:

Pycnostylus Whiteaves, 1884
Fletcheria Edwards and Haime, 1851
Stylopleura, new genus
(?)*Cyathopaedium* Schlüter, 1889
(?)*Fletcherina* Lang, Smith, and Thomas, 1955
(?)*Maikottia* Lavrusevich, 1967

Genus STYLOPLEURA, new genus

Type species.—*Stylopleura berthiaumi*, n. sp., here designated. Silurian, Roberts Mountains Formation; Roberts Creek Mountain, Nev.

Diagnosis.—Facsiculate rugose corals with subcylindrical mature corallites joined by long, in some instances hollow, connecting processes. Septa low, longitudinal ridges, not differentiated into major and minor. Tabulae complete, straight, horizontal, and generally rather widely spaced. Septal stereozone narrow. No dissepiments. Multiple reproductive offsets, as many as 11, developed peripherally from the calice wall. Mature calice flaring.

Remarks.—*Stylopleura* differs from *Tryplasma* and *Zelophyllum* in its lack of acanthine septa and in possessing the connecting pillars. *Fletcheria* is believed to lack septal ridges and connecting processes.

Among well-characterized pycnostylid genera, *Pycnostylus* is closest to *Stylopleura*; but insofar as known, it does not have the connecting pillars and is, by definition, reported to produce only four calicinal offsets; this quadripartite offset pattern may not be a valid generic character. It is not unlikely the number of offsets is subject to considerable variation, as in *Stylopleura* and probably also in *Fletcheria*.

Probably a pycnostylid related to *Stylopleura* is the

Asiatic genus *Maikottia* Lavrusevich, 1967, with type species *M. turkestanica* Lavrusevich from Upper Silurian rocks of the Turkestan Range. As figured by Lavrusevich (1967, pl. 3, figs. 4-6), *Maikottia* has a compact cerioid growth habit, whereas *Stylopleura* reveals both phaceloid and cerioid features, with partly open phaceloid characteristics predominant in some species. *Maikottia* is not known to possess lateral connecting pillars like those of *Stylopleura*.

Maikottia resembling Asiatic *M. turkestanica* Lavrusevich (pl. 2, figs. 13, 14) has been collected by Michael Churkin, Jr., of the U.S. Geological Survey from Upper Silurian or Lower Devonian beds on the Porcupine River, half a mile upstream from the mouth of the Salmontrout River, Alaska.

Stylopleura berthiaumi, new species

Plate 3, figures 6-20

Type material.—Holotype USNM 159382; paratypes 159381, 159383, 159384; figured specimen USNM 159385.

Diagnosis.—*Stylopleura* forming loose phaceloid colonies with some mature cylindrical corallites of large size. Exterior with rugae and long, partly tubular connecting processes which are fairly straight and join corallites at all angles. Peripheral calice offsets variable, numbering as many as 11.

External features.—Some immature corallites ceratoid in lower part of colony, becoming cylindrical upward. Longitudinal grooves well defined; where wall is thin, these are true septal grooves. Within the loose colonies, generation of multiple calicinal offsets oblique becoming more nearly erect upward. Interspaces and corallite surfaces occupied in places by attached *Cladopora* and *Aulopora*. External rugae, rather obtuse folds, reflected internally as circular grooves. Large nonreproductive corallites flaring outward in a trumpetlike calice without offsets.

Transverse sections.—Septal ridges within corallites from 44 to about 60 in mature corallites, some ridges with very minute surficial spines. Narrow stereozone showing no internal trabeculae in the silicified material available. No differentiation of septal ridges as major and minor. Septal ridges broadly rounded on the reflected calice platform.

Longitudinal sections.—Tabulae complete, rather widely spaced. No trabeculae or spines visible in narrow stereozone of silicified specimens. Some tubular connecting processes communicating with interiors of attached corallites through open pores.

Reproductive offsets.—Offsets growing inward and upward from the calice wall, numbering from five to 11. Offsets stand erect or axially inclined if the calice is flared; where vertical, offsets occupying most of the calice. Size of offsets fairly uniform within the calice.

Comparison with related forms.—No other described pycnostylid corals having long tubular connecting processes are known. The closest morphologically is *Pycnostylus guelphensis* Whiteaves of the Middle Silurian Niagara Series, reported to have quadripartite arrangement of interior calice offsets, not multiple as in *Stylopleura*; it is not known to have the connecting stolonal processes of *Stylopleura*.

Occurrence.—Upper part of unit 3 of type section of the Roberts Mountains Formation (fig. 4), Silurian coral zone D; locality M1100 on upper Pete Hanson Creek, west side of Roberts Creek Mountain. Simpson Park Mountains near mouth of Coal Canyon, Silurian coral zone E; locality M1106, in upper coral-bearing limestone breccia. Toquima Range, at Ikes Canyon, Masket Shale of Kay and Crawford (1964); locality M1103 in Silurian coral zone D associated with large *Verticillopora*.

Similar *Stylopleura* occurs in Silurian limestone at Bare Mountain near Beatty, Nev. In Chuckwalla Canyon (loc. M1099), dark-gray limestones containing *Stylopleura* lie in the lower part of the Silurian sequence (Cornwall and Kleinhampl, 1960) and are probably correlative with some part of the Roberts Mountains Formation. The Bare Mountain *Stylopleura* shows numerous lateral connecting pillars, but available specimens do not reveal the multiple calice offsets of *berthiaumi*.

Study material of *Stylopleura berthiaumi* consists of about 175 corallites from several coralla (loc. M1100), three corallites (loc. M1103), and one corallite (loc. M1106).

Stylopleura nevadensis, new species

Plate 2, figures 11, 12, 15, 16; plate 15, figures 1-4

Type material.—Holotype USNM 159431; paratypes USNM 159379, 159440, 159440a.

Diagnosis.—Wide, subcylindrical, somewhat meandering corallites loosely to tightly appressed in large fasciculate coralla with few connecting pillars. Tabulae not distantly spaces.

External features.—Holotype a large unsilicified lenticular head 10 inches in greatest diameter, having nonuniform corallites which vary considerably in size at distal surface. Corallum with cerioid tendency where closely appressed. Flaring calices not observed.

Transverse sections.—At maturity, about 56 short undifferentiated septa, forming longitudinally continuous bladelike internal ridges. Septal stereozone medium to narrow, vaguely lamellar; epitheca discrete.

Longitudinal sections.—Most tabulae straight to slightly wavy, terminating at inner stereozone margin. Trabeculae vague, nearly horizontal.

The single observed lateral connecting pillar (pl. 15, fig. 4) is stereoplasm filled. Longitudinal sections prepared thus far show corallites in parts of the corallum, where they are tightly appressed and would not, therefore, be expected to reveal connecting processes.

Reproductive offsets.—Three to five offsets, possibly more, filling most of calice.

Comparison with related forms.—*Stylopleura berthiaumi* has narrower corallites, some of which have more widely spaced tabulae and more numerous offsets than *nevadensis*. *Stylopleura nevadensis* reveals fewer lateral connecting pillars, having more closely appressed corallites. Markedly flaring calice margins like those of some corallites of the type species have not been observed in *nevadensis*.

Remarks.—The types of *S. berthiaumi* are silicified and were prepared by etching, such that connecting pillars are evident. The holotype of *nevadensis* is unsilicified and was studied internally by thin sections which show few of these lateral processes. It is possible that *nevadensis* is no more than a subspecies of *berthiaumi*.

Occurrence.—Late Silurian, coral zone E in upper limestone beds of the Roberts Mountains Formation. Coal Canyon, northern Simpson Park Mountains, Nev., localities M1107, M1105, M1317. Late Silurian coral zone D, Ikes Canyon, Toquima Range, Nev., in association with large *Verticillopora* and *Tonkinaria*, locality M1103. Study material consists of the large complete corallum which is the holotype (USNM 159431, loc. M1107), two large coralla (locs. M1105, M1317), and one large corallum (loc. M1103).

Stylopleura? sp. T.

Plate 2, figures 7–10

This loosely appressed phaceloid-cerioid coral with unusually large corallites is provisionally assigned to *Stylopleura*. The wall is much thickened stereoplasmically, and its tabulae straight, mostly complete, and very closely spaced, in places being essentially in contact one upon another. Wall trabeculae are nearly horizontal; none extend internally as acanthine spines.

Stylopleura? sp. T is not known to have the lateral connecting pillars of *Stylopleura berthiaumi*, n. sp., or *S. nevadensis*, n. sp. Its wall is thicker and its tabulae more even, much more closely spaced, and more nearly complete than in the Asiatic and Alaskan *Maikottia*, which also differs in having big arched tabellae and a uniformly cerioid growth habit.

Occurrence.—Silurian or Lower Devonian limestone; Toquima Range, Nevada, Ikes Canyon vicinity, locality M1104. Collected by Kay and Crawford (1964).

Family TRYPLASMATIDAE Etheridge, 1907

Reference genus and species.—*Tryplasma aequabile* Lonsdale, 1845. Silurian, Ural Mountains, Russia.

Solitary and colonial rugose corals with acanthine septa composed of vertical columns of trabecular spines protruding from a peripheral stereozone. Tabulae complete or partial; no dissepiments.

In some species of Tryplasmatidae the trabecular septal spines are mostly buried in peripheral stereoplasm with only tips exposed; in others, they project obliquely inward and upward as long free spines where the stereozone is narrowed. Trabecular spines may develop also in radial rows on upper tabular surfaces to produce longer acanthine septa (Hill, 1936).

Genera of the Tryplasmatidae recognized in the Great Basin Silurian are as follows:

Tryplasma Lonsdale, 1845
Rhabdocyclus Lang and Smith, 1939
Palaeocyclus Edwards and Haime, 1849
Zelophyllum Wedekind, 1927

The true Cystiphyllidae of the Silurian commonly have trabecular septal spines and, on this basis, have from time to time been considered as genetically related to this family. However, the pervasively dissepimented character of the Cystiphyllidae does not add support to this conclusion.

Genus TRYPLASMA Lonsdale, 1845

1845. *Tryplasma* Lonsdale, p. 613.
1871. *Pholidophyllum* Lindström, p. 125.
1894. *Spiniferina* Penecke, p. 592.
1907. *Tryplasma* Lonsdale. Etheridge, p. 76–77.
1927. *Tryplasma* Lonsdale. Lang and Smith, p. 461.
1927. *Pholidophyllum* Lindström. Wedekind, p. 25.
1927. *Stortophyllum* Wedekind, p. 30.
1936. *Tryplasma* Lonsdale. Hill, p. 204.
1940. *Tryplasma* Lonsdale. Lang, Smith, and Thomas, p. 135.
1940. *Pholadophyllum* Lang, Smith, and Thomas, p. 99.
1940. *Tryplasma* Lonsdale. Hill, p. 405.
1950. *Tryplasma* Lonsdale. Schouppé, p. 80–84.
1952. *Tryplasma* Lonsdale. Stumm, p. 841–843.
1956. *Tryplasma* Lonsdale. Hill, p. F312.
1960. *Tryplasma* Lonsdale. Oliver, p. 96.
1962a. *Tryplasma* Lonsdale. Oliver, p. 13.

Type species.—*Tryplasma aequabile* Lonsdale, 1845; by subsequent designation (Etheridge, 1907, p. 42). Silurian, near Bogoslovsk, east of northern Ural Mountains, Russia.

Diagnosis.—Solitary and fasciculate rugose corals with acanthine septa which are vertical columns of trabecular spines. Corallites elongate or subcylindrical. Septal stereozone medium wide to narrow. No dissepiments. Tabulae mostly complete, commonly straight and widely spaced.

Remarks.—*Tryplasma* and related corals with acanthine septa have been the subject of special studies by Hill (1936), Schouppé (1950), Stumm (1952), and Oliver (1960). Species of this genus are characteristic of Silurian deposits in Europe, Australia, and North America, and, as noted by Duncan (1956, p. 226–227; pl. 23, figs. 3a, 3b), they are among the common fossils in the Silurian of western North America. Oliver (1960, p. 96) noted that the range of *Tryplasma* extends into the Lower Devonian of Europe, Australia, and eastern North America.

The genus *Tryplasma*, as understood at present, includes species with considerably different growth habits, ranging from solitary forms with elongate coralla showing repeated rejuvenescence rims to bushy phaceloid colonies of slender, relatively smooth branches.

The genus *Tryplasma* may be further subdivided taxonomically, on the basis of external form and growth habit, into units which may eventually be considered subgenera. Two such form groups are recognized in the Great Basin Silurian:

1. Solitary-rugate *Tryplasma* with numerous rejuvenescence rims like those of the Gotland *T. hedströmi* (Wedekind) and the Great Basin *T. duncanae,* n. sp.
2. Fasciculate cylindrical *Tryplasma* with loosely arranged slender subcylindrical, nearly smooth corallites like those of the Australian *T. lonsdalei* Etheridge and the Great Basin *T. newfarmeri,* n. sp.

Rugate *Tryplasma* of group 1 conceivably began with a form like the nontabulate *Rhabdocyclus.* Fasciculate members of group 2 may include species transitional to the colonial *Zelophyllum,* with less obviously acanthine septa. A third tryplasmid group has the growth habit of *Polyorophe* Lindström, 1882 (1882a), of the Gotland Silurian, which shows excessive lateral outgrowths of attachment. Certain rugose corals of the Lone Mountain Dolomite have the external appearance of *Polyorophe,* but internally reveal the nonacanthine structure of *Entelophyllum.* (See pl. 10, fig. 10.)

Tryplasma of group 1 (solitary-rugate)

Tryplasma duncanae, new species

Plate 1, figures 26–28

1956. (?)*Tryplasma* Duncan, pl. 23, fig. 3a.

Type material.—Holotype USNM 159374; paratypes USNM 159375, 159376. Silurian, Roberts Mountains Formation, Nevada.

Diagnosis.—Small solitary *Tryplasma* with elongate subcylindrical mature corallum having repeated rejuvenescence rims and prominent septal grooves. Calice deep and flat-bottomed with near vertical sides and septa which are vertical rows of short trabecular spines. Lateral attachment processes developed in nepionic and neanic growth stages.

External features.—Attachment processes and talons present on the ceratoid early growth stages, after which the corallum becomes more nearly cylindrical with irregularly spaced and very prominent rejuvenescence rims and local changes in growth direction at rejuvenescence.

Transverse section.—Outer wall a moderately thick stereozone in which the trabecular spines are largely buried. About 22 short acanthine septa.

Longitudinal section.—Some widely spaced tabulae straight and complete; others slightly bowed, incomplete, and inclined at 45° or less.

Comparison with related forms.—*Tryplasma duncanae* has much more numerous and prominent rejuvenescence rims, stronger septal grooves, and shorter septal spines than *Tryplasma nordica* Stumm from the Silurian of Maine and Quebec. *T. duncanae* resembles externally both *T. prava* (Hall) Stumm of the Louisville Limestone, Ky., and *T. hedströmi* (Wedekind) of the Gotland Silurian, which have numerous rejuvenescence rims. The similarity to *hedströmi* seems particularly close, but the septal spines of *duncanae* are shorter, and the tabulae are more widely spaced.

Occurrence.—Upper beds of unit 3, Roberts Mountains Formation; Late Silurian, coral zone D. Northwest side of Roberts Creek Mountain, Nev., upper Hanson Creek drainage basin, locality M1100. Study material consists of 14 corallites.

Tryplasma of group 2 (fasciculate-cylindrical)

Tryplasma newfarmeri, new species

Plate 2, figures 1–4

Type material.—Holotype USNM 159377; Silurian, Roberts Mountains Formation.

Diagnosis.—Compound *Tryplasma* with slender small, very elongate, loosely phaceloid cylindrical corallites reproducing by calicinal offsets at the periphery. Wall moderately thick with no prominent rejuvenescence rims, lateral connections, or attachments. Tabulae mostly complete and widely spaced.

External features.—Fairly straight cylindrical corallites; abundant annular incremental striations, but no conspicuous rejuvenescence rims, and no septal grooves. No calice features on available specimens.

Transverse sections.—About 40 acanthine septa; septal spines short, set in a moderately wide stereozone.

Longitudinal sections.—Short septal spines projecting axially and distally within and beyond stereozone. Most tabulae widely spaced and complete or nearly complete; many nearly straight, others slightly bowed. Well-defined columns of spine bases within the stereozone seen in tangential sections.

Reproductive offsets.—Calicinal offsets observed in longitudinal section arise at stages where the calice is of greater than average width; several offsets developed concurrently within some individual calices.

Comparison with related forms.—*Tryplasma newfarmeri,* n. sp., is a more slender form than *T. nordica* Stumm, which is solitary (Oliver, 1962a, p. 13). *T. lonsdalei* Etheridge is an Australian Silurian colonial species (Hill, 1940, p. 406) similar to *newfarmeri,* but *T. lonsdalei* appears to differ by having more closely spaced tabulae, and according to Hill, its corallites may be connected by processes.

Occurrence.—Lower beds of unit 3, Roberts Mountains Formation; Middle Silurian, coral zone C. Northwest side of Roberts Creek Mountain, Nev., upper Hanson Creek drainage basin, locality M1102. Study material consists of one very large corallum and fragments of other coralla.

Tryplasma sp. R

Plate 1, figures 29, 30

This subcylindrical species, known only as isolated corallites, has especially long and robust trabecular spines; rows of more slender spines occur on upper surfaces of slightly undulant tabulae. In transverse thin section the septal spines lack uniformity of length and weight.

Occurrence.—Unit 3 of Roberts Mountains Formation. Roberts Creek Mountain, Nev., locality M1101.

Genus RHABDOCYCLUS Lang and Smith, 1939

1850–54. *Palaeocyclus fletcheri* Edwards and Haime, p. 248; pl. LVII, figs. 3–3f.
1851. *Palaeocyclus fletcheri* Edwards and Haime, p. 205.
1873a. *Acanthocyclus* Dybowski, p. 333, 359; pl. 1, figs. 10, 10a, 10b [not Lucas, [3] 1843–44].
1927. *Acanthocyclus fletcheri* (Edwards and Haime). Lang and Smith, p. 450, figs. 1, 2.
1927. *Acanthocyclus porpitoides* Lang and Smith, p. 486, fig. 16.
1936. *Acanthocyclus porpitoides* Lang and Smith. Hill, p. 196; figs. 9, 12, 15, 19; pl. 29, fig. 37.
1936. *Acanthocyclus fletcheri.* Hill, p. 199, fig. 21.
1939. *Rhabdocyclus* Lang and Smith, p. 152.
1940. Rhabdocyclus. Lang, Smith, and Thomas, p. 113.
1956. *Rhabdocyclus* Lang and Smith. Hill, p. F311, fig. 213. 1a, 1b.

Type species.—*Palaeocyclus fletcheri* Edwards and Haime, by author's designation (Lang and Smith, 1927, p. 450; Lang, Smith, and Thomas, 1940, p. 113). Silurian, Wenlock Limestone, Dudley, England.

Diagnosis.—Turbinate or curved trochoid solitary rugose corals with acanthine septa and lacking tabulae and dissepiments. Deep calice extending to nepionic tip.

Remarks.—*Rhabdocyclus* is morphologically intermediate between *Palaeocyclus* and *Tryplasma.* There is, however, no evidence of evolutionary lineage. In *Rhabdocyclus* the initial cone is usually excentric, whereas in *Palaeocyclus* it is commonly near the center. Some individuals of typical *porpita* do show an excentric initial cone and patellate convexity of the basal disk. *Tryplasma* is distinguished from *Rhabdocyclus* by development of complete tabulae and could be derived from the latter.

The type species of *Rhabdocyclus* is reported to come from the Wenlock Limestone of Dudley, England. The Hidden Valley specimens here dealt with occur in the lower part of that formation in coral zone A and are believed to be Lower Silurian (Llandoverian).

[3]In Edwards and Lucas, 1843-44.

Rhabdocyclus sp. B

Plate 1, figures 24, 25

Large silicified trochoid individuals of this form collected at Bare Mountain, Nev., have about 74 acanthine septa in which the trabecular spines are especially coarse. There is an incipient differentiation into major and minor septa. The exterior is longitudinally grooved and has well-developed rugae.

This species resembles *R.* sp. d but is much larger, and its trabecular spines are coarser.

Occurrence.—In dark-gray Silurian limestone about 150 feet stratigraphically below contact with light-gray dolomite. Study material of sp. B consists of four silicified coralla. Bare Mountain quadrangle, Nevada, near mouth of Chuckwalla Canyon, locality M1099.

Rhabdocyclus sp. d

Plate 1, figures 22, 23

Small silicified specimens assigned to this genus were collected by J. F. McAllister from the lower unit of the Hidden Valley Dolomite at Whitetop Mountain, northern Panamint Range.

Rhabdocyclus sp. d is curved trochoid and has about 26 major septa with coarse trabecular spines; minor septa are short and comprise rather widely spaced columns of spines. The septal stereozone is medium wide to narrow. Lateral projections are present on the exterior.

Edwards and Haime's figures of *R. fletcheri* show more numerous primary septa and a reflected calice rim not present in sp. d.

Large individuals of *Rhabdocyclus* sp. B from the Silurian of Chuckwalla Canyon, Bare Mountain, Nev., reveal more numerous acanthine septa and a trochoid corallum.

Occurrence.—Lower part of the Hidden Valley Dolomite; Early Silurian, coral zone A. Whitetop Mountain, northern Panamint Range, locality M1096.

Study material of sp. d consists of two silicified coralla and fragmentary coralla.

Rhabdocyclus sp. K

Plate 15, figures 5–9

A curved-turbinate to near-patellate *Rhabdocyclus* representative of this Silurian tryplasmid genus was collected from the Laketown Dolomite of the Confusion Range, Utah, by A. J. Boucot. Its acanthine septa are differentiated as major and minor, with 26 major septa. Columns of trabecular nodes form minor septa. This species possesses un excentric apex, the apical cone flaring abruptly in the neanic growth stage, followed by abrupt curvature in some individuals. Weak obtuse longitudinal ribs are crossed by fine incremental lines and rugae on the exterior.

Rhabdocyclus sp. K resembles the British type species *fletcheri* more closely than either of the other two Great

Basin forms. *Rhabdocyclus* sp. K differs from *fletcheri* in having fewer septa but is very similar in its septal character and exterior ornamentation.

Occurrence.—Laketown Dolomite. Confusion Range, Utah; Kings Canyon, Conger Mountain quadrangle, locality M1137. Study material consists of six silicified coralla.

Genus PALAEOCYCLUS Edwards and Haime, 1849

1767. *Madrepora porpita* Linnaeus, p. 1272 (in part).
1849. *Palaeocyclus* Edwards and Haime, p. 71.
1850–54. *Palaeocyclus* Edwards and Haime, p. xlvi, p. 246–248.
1851. *Palaeocyclus* Edwards and Haime, p. 203–206.
1927. *Palaeocyclus porpita.* Lang and Smith, p. 485.
1936. *Palaeocyclus* Edwards and Haime. Hill, p. 193.
1936. Not *Porpites* Schlotheim (in part). Wells, p. 127.
1937. *Paleocyclus* Edwards and Haime. Bassler, p. 190, pl. 30, figs. 1–4.
1940. *Palaeocyclus* Edwards and Haime. Lang, Smith, and Thomas, p. 94.
1940. *Porpites* Schlotheim. Lang, Smith, and Thomas, p. 103.
1956. *Porpites* Schlotheim. Hill, p. F312.

Type species.—*Madrepora porpita* Linnaeus, 1767 (by monotypy). Silurian, Gotland. Uncertainty has long existed regarded validity of the name *Palaeocyclus* as opposed to *Porpites* Schlotheim, involving the status of Schlotheim's syntypes (Wells, 1936, p. 127; Lang, Smith, and Thomas, 1940, p. 103–104). W. A. Oliver, Jr. (written commun., 1969), has pointed out that unless there was an earlier selection of a genolectotype for *Porpites,* Wells fixed the genus by selecting *P. globulatus* in 1936. Accordingly, the selecting of another species by Lang, Smith, and Thomas in 1940 is invalid. *Porpites globulatus* is a scleractinian, and, thus, *Porpites* is not available as a name for a Paleozoic coral.

Diagnosis.—Small discoid tryplasmid rugose corals with flat to slightly patellate epithecal base having a small central cone and concentric incremental rings. Thick beaded septa with free, broadly convex peripheral edges; distal margins of major septa gradually sloping toward bottom of deep calicular pit. Minor septa commonly more than one-half the length of major septa. No fossula, tabulae, or dissepiments. Septal pattern distinctly radial.

Remarks.—The septal beads or nodes are distal ends of large trabeculae. As seen on lateral surfaces of major septa, these trabeculae rise obliquely from the base as external ridges and slope toward the axis with increasing steepness. (See Hill, 1936, figs. 14–17.) The nodes may be very prominent or even spinose, and toward the periphery they become transverse, like yardarm carinae of other Rugosa.

In some species the basal disk extends laterally as a flange beyond the exposed septa. Generally, most of the central cone has been removed by abrasion.

Palaeocyclus porpita, the type species, occurs in the Lower Visby Marl of Gotland, regarded as late Llandoverian Lower Silurian. At Gotland *Palaeocyclus* is not known to range higher. In England this genus is reported in the Wenlockian (Hill, 1936, p. 193). Reported occurrences of the genus in North America (Bassler, 1937, p. 190) range from the Silurian Clinton Group and Manistique Dolomite to the Devonian of the Porcupine River, Alaska. Except for the Great Basin forms here dealt with these American forms differ considerably from *porpita,* Devonian assignment of the Alaskan form is certainly in need of review.

Palaeocyclus porpita subsp. mcallisteri, n. subsp.

Plate 1, figures 12–15, 17

1952. *Porpites porpita.* McAllister, p. 16.

Type material.—Holotype USNM 159365; paratypes USNM 159364, 159366, 159367. Early Silurian, coral zone A; Ubehebe district, California.

Diagnosis.—Septa thick, with coarse noding for the species *porpita;* septal thickness slightly exceeding length of radial interspaces between nodes.

Transverse features.—Thick major septa, numbering 20–22, tapering gradually toward axis, where some of the attenuated projections meet. (This feature may be observed through the transparent basal disk of worn individuals of Gotland *porpita.*) Minor septa ½–⅔ the length of major septa. Trabecular nodes on upper edges of the major septa number 10 to 12. Central pit reaching basal plate.

Longitudinal features.—Coralla broken in two radially, with a radial profile of septa with curve inflection of distally convex major septa usually closer to periphery than to axis. Individuals with evenly rounded septal profile and steep-sided axial calice pit predominate. Sides of major septa show 10–12 slightly curved, thick trabecular spines standing almost vertical near axis, but toward the corallite periphery rising in a gentle arc inclined axially 30°–40°.

Fine structure.—Available silicified material lacks fine structure. Hill's classic studies of well-preserved Gotland *porpita* material (1936, p. 193–196) deal with minute details of trabeculae and are basic to understanding of acanthine septal structures among Rugosa.

Comparison with other species.—As noted above, the Hidden Valley form is regarded as conspecific with the Gotland *porpita* but is sufficiently different morphologically to warrant its classification as a geographic subspecies. Of described American species (Bassler, 1937, p. 190, pl. 30 figs. 5 –12), all are too poorly known for meaningful comparison. *P. Michiganensis* Bassler of the Manistique Dolomite appears to have more slender, wider spaced septa, *P. rotuloides* (Hall) of the Clinton Group has fewer septa, and *P. kirbyi* Meek of supposedly Devonian strata at the Porcupine River, Alaska, is a larger form with more numerous and more closely spaced, seemingly unbeaded septa. The last may represent a different genus and requires restudy.

The undescribed Confusion Range, Utah *Palaeocyclus* resembles typical *porpita* but is, on the whole, smaller. Several of the individuals are slightly patellate, like variants of the Gotland *porpita*. Some have a peripheral flange on the basal disk.

Occurrence.—Lower Silurian, Great Basin coral zone A. Basal beds of unit 1 in the lower part of Hidden Valley Dolomite. Whitetop Mountain, Northern Panamint Range, locality M1096. Southern Andy Hills, northern Panamint Range.

Similar *Palaeocyclus* occurs in the Confusion Range, Utah, locality M1129, and in the Ruby Mountains, Nev. (pl. 15, fig. 10), 3 miles northeast of Mitchell Ranch, Sherman Mountain quadrangle, locality M1336.

Study material is as follows: Whitetop Mountain (M1096), 25 coralla; Andy Hills, two coralla; Confusion Range (M1129), six coralla; Ruby Mountains (M1336), two coralla.

Genus ZELOPHYLLUM Wedekind, 1927

1927. *Zelophyllum* Wedekind, p. 34–35, pl. 5, figs. 1–5; pl. 6, figs. 11–13.
1956. *Zelophyllum* Wedekind. Hill, p. F312, fig. 213.7.

Type species.—Zelophyllum intermedium Wedekind, by author designation. Silurian, Högklint, Gotland, Sweden.

Diagnosis.—Solitary and colonial nondissepimented rugose corals with cylindrical corallites of large and medium size. Wall moderately thick, tabulae straight to undulant and unarched. Septa short or stubby, usually tapering abruptly from wall; in places, walls thinned and studded with acanthine trabecular spines. Outer surface fairly even, with longitudinal grooves and no pronounced rugae.

Remarks.—Silurian species from Alaska show especially well the acanthine septal spines and possible tryplasmid relationships of this coral. In some individuals the large trabeculae are buried in the wall stereome and do not project inward as free spines. Differentiation of septa as major and minor may be unrecognizable in those forms with stout abruptly tapering very short uniform septa. Other cylindrical Silurian genera with which *Zelophyllum* may be confused are *Palaeophyllum* and *Stylopleura*. *Palaeophyllum* is more slender, has lamellar septa of greater length, and usually possesses well-arched tabulae, whereas tabulae of *Zelophyllum* are normally straight. *Stylopleura* has a trumpetlike calice, has lateral connections between corallites, and is not known to have acanthine septal spines.

Zelophyllum is common in the Silurian of the Pacific Border province, as in southeastern Alaska and the Klamath Mountains of northern California. In the Great Basin most of the larger nondissepimented rugose corals of this general construction are assigned to the new genus *Stylopleura*.

Occurrence.—Nondissepimented corals possibly representing *Zelophyllum* occur in the Great Basin, but the wall structure is generally not well enough known to confirm this generic assignment. Corals with abundant acanthine septa and cylindrical corallites are placed in *Tryplasma*. Possible *Zelophyllum* occurs at Dry Canyon, Toyabe Range, 8 miles south of Austin, Nev., in the Thomas Range, Utah, and in the east Tintic Mountains of Utah.

Family KODONOPHYLLIDAE Wedekind, 1927

Representative genus and species.—Kodonophyllum milne-edwardsi (Dybowski). Silurian; Gotland, Sweden.

Solitary and colonial rugose corals with long septa, a very wide stereozone, no dissepiments, and a tabularium of flat tabulae or arched tabellae which may combine with septal ends to produce an axial structure.

Two subfamilies are recognized: Kodonophyllinae and Mycophyllinae.

Subfamily KODONOPHYLLINAE Wedekind

Fasciculate colonial and platelike solitary rugose corals with the family characteristics and arched tabulae and tabellae which combine to form an axial structure.

Genera included in this subfamily are *Kodonophyllum* Wedekind and *Schlotheimophyllum* Smith.

Genus KODONOPHYLLUM Wedekind, 1927

1758. *Madrepora truncata* Linnaeus (in part), p. 795.
1873b. *Streptelasma milne-edwardsi* Dybowski, p. 409–410, pl. xiii, figs. 5–12.
1927. *Kodonophyllum* Wedekind, p. 9–10, 35–36, pl. 5, figs. 5–11.
1927. *Patrophontes* Lang and Smith, p. 456–457, figs. 8–9.
1929. *Kodonophyllum* Wedekind; Smith and Tremberth, p. 367–370, pl. viii, figs. 5–7.
1937. *Kodonophyllum* Wedekind; Soshkina, p. 52–55 (in part), pl. ix, figs. 4, 5; pl. x, figs. 3–6; pl. xxi, figs. 1, 2.
1940. *Codonophyllum* Lang, Smith, and Thomas, p. 39.
1956. *Kodonophyllum* Wedekind; Hill, p. F271, fig. 184,1a, 1b.
1962b. *Kodonophyllum* Wedekind; Oliver, p. 23–26, pls. 9–13.
1964. *Kodonophyllum* Wedekind; Stumm, p. 26, pl. 25, figs. 9–14.

Type species.—Streptelasma milne-edwardsi Dybowski, 1873; Silurian, Gotland.

Diagnosis.—Solitary and compound rugose corals with trochoid to ceratoid and turbinate corallites. Septa thickened peripherally to form a wide sterozone. Major septa extending to axis, where they are involved with tabulae to form an axial structure thickened by stereoplasm. Tabulae sloping downward from axis. No dissepiments.

Remarks.—According to Smith and Tremberth (1929, p. 368, 369), Dybowski's *Streptelasma milne-edwardsi* is a synonym of *Madrepora truncata* Linnaeus, 1758, which occurs at Hall, Lilla Karlsö, Gotland, and other localities, in beds of Wenlockian and Ludlovian age, principally the last. In England this species is reported by Smith and Tremberth from the Wenlock only.

The relationship of *Kodonophyllum* to *Schlotheimo-*

phyllum requires clarification; they appear to be distinct genera with quite different growth habits, and they occur in different parts of the Gotland section.

The Great Basin *Kodonophyllum mulleri* has a large columellar boss projecting up in the calice and is more nearly ceratoid than trochoid.

Kodonophyllum mulleri, n. sp.

Plate 4, figures 3–7

Type material.—Holotype USNM 159386, 159386a–b; paratype USNM 159389.

Diagnosis.—Medium to large solitary *Kodonophyllum* with trochoid to ceratoid corallum and deep calice with columellar boss.

Transverse sections.—Major septa numbering about 48, smooth and fairly straight except as they approach the axis; septa thickened somewhat throughout but excessively in the wide septal stereozone and within the axial structure. Minor septa less than half the length of major; in some individuals projecting axially beyond stereozone. No fossula. Transverse interseptal traces are downward-inclined tabulae, not dissepiments.

Longitudinal sections.—Tabularium more than half the corallite diameter. Stereozone width about one-fifth the corallite diameter. Tabulae close-spaced, discontinuous, arched steeply to axial structure, where they are obscured by intersection with stereoplasm and septal ends. Marginal tabellae flat or axially inclined. Trabeculae in septal stereozone inclined peripherally. Large calice boss with axial depression.

Comparison with related forms.—*Kodonophyllum truncatum* of the Gotland Silurian is a colonial species and has a narrower tabularium with a less robust axial structure and wider septal stereozone. *K. richteri* Wedekind, also of the Gotland Silurian, has fewer major septa and more widely spaced, more nearly complete, arched tabulae. An undescribed species from the uppermost Gazelle Formation of the Klamath Mountains, Calif., differs in having somewhat nodose or spiny septa.

Occurrence.—In limestone breccia near the top of the Silurian section; coral zone E. Coal Canyon, northern Simpson Park Mountains, Nev., locality M1107. Study material consists of three partial coralla.

Subfamily MYCOPHYLLINAE Hill, 1940

Large solitary platelike and subcylindrical rugose corals with the family characteristics and having straight, usually unarched, and complete tabulae with no axial structure.

Genera included in this subfamily are as follows:

Mucophyllum Etheridge, 1894
Chlamydophyllum Počta, 1902
Pseudamplexus Weissermel, 1897
(?)*Briantia* Barrois, 1889

Other Rugosa, having similar growth habit but differing in details of internal structure, have been considered in connection with the Kodonophyllidae. Among these are *Naos* (Lang, 1926) and *Craterophyllum* (Foerste, 1909), which are dissepimented. The name *Chonophyllum* has been applied erroneously to corals now classified as *Schlotheimophyllum* (Smith, 1945, p. 18).

Genus MUCOPHYLLUM Etheridge, 1894

1894. *Mucophyllum* Etheridge, p. 11–18, pls. iii, iv.
1926. *Mucophyllum*. Lang, p. 431, 433; pl. xxx, figs. 7, 8.
1940. *Mycophyllum*. Lang, Smith, and Thomas, p. 87.
1940. *Mucophyllum crateroides* Etheridge. Hill, p. 400; pl. 12, figs. 1, 2.
1940. Not *Mycophyllum liliiforme* (Etheridge). Hill, p. 401, pl. 12, figs. 3–6.
1945. *Mucophyllum crateroides* Etheridge. Smith, p. 19.
1949. *Mycophyllum* Etheridge. Stumm, p. 49, pl. 23, figs. 9, 10.
1956. *Mucophyllum* Etheridge. Hill, p. F277, fig. 189.3a.

Type species.—*Mucophyllum crateroides* Etheridge, 1894, by monotypy. Silurian, Hatton's Corner, Yass River, New South Wales, Australia.

Diagnosis.—Large discoid or patellate to turbinate, usually solitary, rugose corals with broad calice platform, reflexed margin, and flat-bottomed central pit. Numerous thick septa in contact laterally to form a wide stereozone, some longer septa reaching the axis. Tabulae medium wide or narrow, complete, and straight to undulant. No dissepiments. Longitudinal section showing fine, near-horizontal incremental layering of thick stereozone transected by near-vertical trabecular pillars. Radial grooves of calice platform overlying sutures between thickened septa.

Remarks.—The layered and usually thick stereoplasmic peripheral disk of *Mucophyllum* is the most distinctive feature of this genus. *Schlotheimophyllum,* with similar growth habit, has a comparable, though possibly less dense, stereozone and differs in possessing a more complex axial structure like that of *Kodonophyllum. Naos* Lang, 1926 (possibly a synonym of *Craterophyllum* Foerste, 1909), differs in having well-defined dissepiments and zigzag septa which break up peripherally in naotic fashion. *Chonophyllum* Edwards and Haime, 1850, has been confused with all of these genera; as here interpreted, this coral has separate generic status. Other forms which might be confused externally with *Mucophyllum* or *Chonophyllum* having a trumpet-shaped calice are longer stemmed corals, some of which are referrable to the new genus *Stylopleura.*

The longest septa of *Mucophyllum* extend in part beyond the stereozone and become involved with tabulae in an incipient axial structure, as in *M. oliveri*, n. sp.; this structure does not become complex like that of *Schlotheimophyllum.*

Occurrence.—The type species from Yass River, Australia, occurs in beds of high Wenlockian or Ludlovian age (Hill, 1940, p. 388). The Klamath Mountains representatives are of equivalent age; those from the Great Basin are believed to be Ludlovian.

Mucophyllum oliveri, n. sp.

Plate 5, figures 1-6

Type material.—Holotype USNM 159390; paratype USNM 159391.

Diagnosis.—*Mucophyllum* with multiple, fine horizontal layering of massive stereozone and close-spaced fine trabecular pillars normal to layers. Tabulae narrow, nearly horizontal, and undulant; thickened where involved with long septa.

Traverse, sections.—About 76 septa, most of which extend to the tabularium; a few attenuated and very irregular twisted extensions reaching or curving around the axis. Septa straight and even within the wide stereozone; prominent dark radial bands are sutures between thickened septa. Enlargement of transverse section reveals a closely spaced pattern of trabecular rods in septa disposed normal to the section. Ends of these trabecular rods number about 30 per square millimeter. Ends of rods commonly revealing clear calcite interior and shadowy dark peripheral zone, suggesting initially tubular construction.

Longitudinal sections.—Horizontal laminae of massive stereozone reflecting curvature of calice platform, bending as they approach the tabularium to a steep axial inclination. Laminae alternating light and dark, varying considerably in thickness, and averaging about six per millimeter. Trabecular rods normal to laminae, becoming inclined peripherally near the tabularium. Tabulae numbering about 16 per centimeter, wavy and only in part complete, some terminating against other complete tabulae. Some tabulae thickened throughout, with excessive swelling close to the axis, where septa intersect.

Comparison with related forms.—*Mucophyllum oliveri* resembles an undescribed species in the Gazelle Formation of the Klamath Mountains, Calif. The Gazelle form possesses a similar calice platform, but layering of the massive stereozone is more widely spaced. The Gazelle species has thickened horizontal tabulae but lacks the tabular undulation and thickened septal intersections, being in this regard more typical of *Mucophyllum*. *Mucophyllum crateroides*, the type species, has a wider tabularium and straight tabulae with seemingly less closely spaced horizontal stereozone laminae.

Certain features of the tabularium and axis of *M. oliveri* are in a sense more suggestive of the genus *Schlotheimophyllum* than of typical *Mucophyllum* because of the development of an incipient axial structure. Compared in detail with a longitudinal section of *S. patellatum*, the type species figured by Lang (1926, pl. xxx, fig. 5), there is little close similarity. In *Schlotheimophyllum* the marginal parts of the tabulae are peripherally inclined, and these tabulae are strongly arched. A fairly complex wide axial structure is formed in *Schlotheimophyllum* by the meeting of the numerous major septa and their twisted involvement with arched tabulae. In *S. patellatum* the stereozone trabecular rods show steep axial inclination over a large part of the peripheral disk; this is not a feature of *Mucophyllum*.

Occurrence.—Limestone breccia zone near the top of the Silurian section coral zone E. Coal Canyon, northern Simpson Park Mountains; locality M1108. Study material consists of two nearly complete coralla and three partial coralla.

Family ARACHNOPHYLLIDAE Dybowski, 1873a

Reference genus.—*Arachnophyllum* Dana, 1846.

These Early and Middle Silurian astraeoid and thamnostraeoid rugose corals resemble in growth habit certain Devonian Disphyllidae and Phillipsastraeidae, among which are *Billingsastraea* and *Pachyphyllum*. The superficial similarity is one of gross morphologic convergence and is not indicative of genetic relationship. Dybowski (1873a, p. 339), in naming the family, erroneously included Devonian homeomorphs and strangely enough, assigned his *Darwinia*, a homonym and synonym of *Arachnophyllum*, to the Ptychophyllidae.

It appears doubtful that among described corals there are other genera sufficiently close morphologically to warrant their inclusion in the Arachnophyllidae. However, the single genus as it stands is highly diverse (Stumm, 1964) and may lend itself, on detailed study, to at least subgeneric division.

Genus ARACHNOPHYLLUM Dana, 1846

1839.	*Acervularia baltica* Schweigger (in part). Lonsdale,[4] pl. XVI, figs. 8b–e.
1846.	*Arachnophyllum* Dana, p. 186, text fig. 1.
1848.	*Arachnophyllum* Dana, p. 360.
1850–54.	*Strombodes typus* (McCoy). Edwards and Haime, p. 293, pl. 71, figs. 1, 1a, 1b, 2a.
1873a.	*Darwinia* Dybowski, p. 404, pl. II, figs. 8, 8a.
1927.	*Arachnophyllum typus* (McCoy). Lang and Smith, p. 452, figs. 5, 6, 7.
1937.	*Darwinia* Dybowski. Soshkina, p. 57, pl. XVI, fig. 5.
1940.	*Arachniophyllum*; Lang, Smith, and Thomas, p. 19.
1949.	*Arachnophyllum pentagonum* (Goldfuss). Amsden, p. 104, pl. XXVI, figs. 1–6.
1956.	*Arachnophyllum* Hill, p. F274, fig. 187.3a, 3b.
1964.	*Arachnophyllum* Dana. Stumm, p. 30, pls. 20, 21.

Type species.—*Acervularia baltica* Schweigger (in part), Lonsdale,[5] 1839, pl. XVI, figs. 8b–e, according to Lang, Smith, and Thomas (1940). Lang and Smith (1927, p. 452) and Lang, Smith, and Thomas (1940, p. 19) gave localities for the type species at Wenlock and Dudley, England, Silurian Wenlock limestone.

Diagnosis.—Astraeoid or thamnastraeoid rugose corals building horizontally layered colonies in which individual corallites lack a discrete wall but on the distal surface are defined by elevated rim and axial pit, with or with-

[4]In Murchison (1839).
[5]In Murchison (1839).

out crateriform margin. Septa thin, commonly with abundant angulation carinae; longer major septa reaching the axis. Dissepiments very numerous, largely with near-horizontal bases in a wide dissepimentarium. with tabellae arched distally or rather flat. Longitudinal sections showing groups of vertical trabecular thickenings commonly defining septal traces.

Remarks.—These corals with shallow platform calice and axial pit have frequently been classified as "*Strombodes*," the presently accepted type of which is a phaceloid species (*Strombodes stellaris* Linnaeus) differing in many other structural details. Described *Arachnophyllum* species show a considerable diversity with respect to size range of the flat dissepiments, continuity and carination of septa, prominence of calice rims, and arching of tabellae. In some species the tabularium is weakly defined and the arching much less distinct than that shown in Dybowski's (1873a, pl. 2, fig. 8) drawing of *speciosa*. Peripheral discontinuity of septa and development of outer zones of irregular lonsdaleioid dissepiments is a characteristic of some species.

As at present understood, *Arachnophyllum* is mainly a Lower and Middle Silurian coral. The genus was reported from the Llandoverian red marls below the Gotland Visby Marl by Lindström (1884, p. 7), and in North America it ranges up-ward to the Brownsport and the Louisville Formations. In the Great Basin, *Arachnophyllum* has been found thus far only in Silurian coral zone A, which is considered Early Silurian Llandoverian.

Arachnophyllum kayi, n. sp.

Plate 5, figures 7, 8

Type material.—Holotype USNM 159392; lower part of the Silurian section, Ikes Canyon, Toquima Range, Nev.

Diagnosis.—Corallites small for the genus, with no lonsdaleioid dissepiments; septa thin, continuous into adjacent corallites, with numerous angulation carinae increasing in complexity toward the axis. Dissepiments mostly small; tabularium poorly differentiated.

External features.—Upper surface of colony with medial crateriform rims; no elevated rims observed between corallites.

Transverse section.—Ten major septa, most extending to axis; minor septa long, terminating just within tabularium margin. Angulation or zigzag carinae numerous, especially pronounced toward inner edge of dissepimentarium. Septal extensions wavy or twisted, but noncarinate in tabularium. Dissepiment traces vaguely defined, none are lonsdaleioid.

Longitudinal section.—Multiple columns of small, low dissepiments with more or less horizontal bases; larger globose dissepiments uncommon, and pattern more uniform than in most other described species. No arching of tabellae or indication of arching at rims between corallites. Septal traces showing carinal spurs. Shadowy near-vertical trabeculae defining septal traces; shadowy trabeculae present elsewhere in larger groups.

Comparison with related forms.—The upper surface of *Arachnophyllum speciosa* (Dybowski) from Kattentak, Estonia, resembles that of *kayi*, but Dybowski's figure does not show the minutely zigzag septa. Soshkina's (1937, pl. 16, fig. 5) figure of a similar form also referred to Dybowski's *speciosa* comes from the Ural Mountains in strata reported to be Wenlockian.

Arachnophyllum typus (McCoy) of the British Wenlock, as figured by Edwards and Haime (1850–54, p. 293, pl. 71, figs. 1–1b), differs in having wall rims on the upper surface and sporadic larger globose dissepiments.

Of American species, the Brownsport *pentagonum* of Amsden (1949, p. 104, pl. 26, figs. 1–6) also differs in having wall rims and sporadic large globose dissepiments. Of the six species described from the Louisville Limestone (Stumm, 1964, p. 30, pls. 20, 21), most have wall rims, discontinuous septa, and large globose or lonsdaleioid dissepiments in a wide peripheral zone.

Occurrence.—Lower part of the Silurian limestone section, in Masket Shale of Kay and Crawford (1964); Silurian coral zone A. Ikes Canyon, Toquima Range, Nev., locality M1088.

Study material consists of two partial coralla and fragments of other coralla from Ikes Canyon (M1088) and a partial corallum from Whitetop Mountain, northern Panamint Range (M1096).

Family LYKOPHYLLIDAE Wedekind, 1927

Representative genus and species.—*Phaulactis cyathophylloides* Ryder, 1926. Silurian, Wenlockian, Slite Group, Vastergarn, Gotland, Sweden.

Diagnosis.—Medium and large solitary rugose corals with multiple columns of small to medium dissepiments, a tabularium which may not be abruptly differentiated at margin from dissepimentarium, with septa commonly thickened and laterally in contact into or beyond neanic growth stage, and with no well-defined fossula in advanced growth stages.

Remarks.—These well-dissepimented Silurian corals have some features of the Devonian Halliidae, but in the advanced growth stages they do not, like the Halliidae, have a well-defined fossula, and they lack the lonsdaleioid dissepiments of the *Papiliophyllum* subgroup. The Devonian Bethanyphyllidae are also very similar to these Silurian genera and may be difficult to distinguish; in general, the Bethanyphyllidae of the Great Basin province have more irregular, wavy, thin mature septa, a more distinct though not always sharp fossula, and more numerous straight tabulae; among Bethanyphyllidae, the early septal thickening does not persist in growth beyond fairly early neanic stages.

Genera classified under the Lykophyllidae are as follows:

Phaulactis Ryder, 1926
Pycnactis Ryder, 1926
Holophragma Lindström, 1896
Desmophyllum Wedekind, 1927
Cyathactis Soshkina, 1955
Ryderophyllum Tcherepnina, 1965

Neocystiphyllum Wedekind, 1927, may also belong here. Too little is known of the structure of *Lamprophyllum* Wedekind, 1927, to warrant placing it, at present, in this family. Genera otherwise qualifying for assignment to the Lykophyllidae are doubtless synonyms, such as *Mesactis* Ryder, 1926, and *Lykophyllum* Wedekind, 1927.

Genus RYDEROPHYLLUM Tcherepnina, 1965

1965. *Ryderophyllum* Tcherepnina, p. 31, pl. 2, figs. 1a, 1b.

Type species.—*Ryderophyllum kasandiensis* Tcherepnina; by author designation. Ludlovian, Altai Mountains, Siberia.

Diagnosis.—Small and medium-sized ceratoid to trochoid rugose corals with numerous long, usually thin, smooth major septa; no septal stereozone or fossula. Dissepimentarium wide, with several columns of small to medium globose dissepiments. Tabularium wide, with close-spaced, mostly incomplete, axially flattened tabulae.

Remarks.—*Ryderophyllum* is not known to pass through a *Pycnactis*-like neanic growth sequence with septa thickened and laterally in contact, differing thus from *Phaulactis,* in which thickened septa may persist in cardinal quadrants well into mature growth (Ryder, 1926; Smith, 1930; Minato, 1961). *Ryderophyllum* may be a junior synonym of *Cyathactis* Soshkina, 1955. An anguloconcentric pattern of chevron dissepiments develops in *Cyathactis tenuiseptatus* Soshkina and lonsdaleioid dissepiments in *C. socialis* Soshkina, neither feature appearing in the type species (*C. typus* Soshkina) or in *Ryderophyllum.* Other lycophyllids assigned to *Cyathactis* reveal, in longitudinal section, a depressed zone at the outer tabularium margin; among these are *Cyathactis pegramense* (Foerste) and *Cyathactis catilla* (Sutherland). As in the genus *Phaulactis,* species of *Ryderophyllum* may have adult major septa thickened axially within the tabularium but attenuated in the dissepimentarium.

The type species, *kasandiensis,* was reported by Tcherepnina (1965) to occur in beds of Ludlovian age at Kasandi, Altai Mountains, U.S.S.R. Great Basin representatives are in coral zone B, which is early Wenlockian in age. The probably related *Phaulactis* of Gotland is abundant in the Wenlock (Wedekind, 1927; Minato, 1961) and ranges elsewhere from Llandoverian to upper Ludlovian (Smith, 1930; Bulvanker, 1952; Hill, 1956; Oliver, 1962a). *Cyathactis* is known in beds of Middle and Late Silurian age.

Ryderophyllum ubehebensis, n. sp.

Plate 6, figures 1–7

Type material.—Holotype USNM 159396; paratypes USNM 159394, 159395, 159397, 159398, 159399. Hidden Valley Dolomite, Ubehebe district, California; locality M1094.

Diagnosis.—Medium-sized ceratoid and trochoid *Ryderophyllum* with wide tabularium in which some of the axially flattened tabulae are nearly complete. Peripheral dissepiments steeply inclined. Calice deep and acutely conical.

External features.—Available material is silicified and weathered such that external details are poorly shown. Exteriors appear to have been rather even and smooth, with few rugae. Rejuvenescence rims may be developed in mature growth stages. Longitudinal grooves of weathered specimens interseptal, not true septal grooves. Outer wall probably very thin and without a septal stereozone.

Transverse sections.—Long major septa numbering about 46 in larger adult individuals; some septa extending to axis in early ephebic stage. Minor septa long, commonly more than half the length of major septa. In ephebic stages, all septa usually rather uniformly thinned, unbroken, and only slightly wavy. Close-set dissepiment traces of outer zone making the anguloconcentric chevron pattern of this genus and some species of *Phaulactis.*

Neanic stages well enough preserved for sectioning are not available. The possibility that this species passes through a *Pycnactis* stage with thickened septa cannot be entirely eliminated.

One mature specimen shows thickening of major septa within the tabularium only.

Longitudinal sections.—Eight or 10 dissepiment columns on each side; most of these steeply inclined axially, including those near the periphery. Wide tabularium sharply set off from dissepimentarium in most places; some tabulae nearly complete. Wider tabulae nearly straight or with slight axial sag, bending down peripherally at the depression which lies between the tabularium and dissepimentarium. In parts of the tabularium wide tabellae combined with the more continuous tabulae.

Comparison with related forms.—*Ryderophyllum ubehebensis* has a slightly narrower tabularium than *kasandiensis,* the type species. *Cyathactis* of the Gazelle Formation in the Klamath Mountains has a narrower tabularium and a crowded chevron dissepiment pattern not present in *ubehebensis. Cyathactis pegramense* of the Brownsport Formation in Tennessee differs in having laterally depressed tabulae as in the Gazelle species. The northern British Columbia *Ptycophyllum* sp. (Norford, 1962, pl. XIV, figs. 5–8), from the Silurian Sandpile Group, is probably very similar to *ubehebensis.* Material showing early growth stages is needed to compare *R. ubehebensis* with *Phaulactis*, the adult stages of which commonly resemble this new species.

Occurrence.—Hidden Valley Dolomite; Silurian coral zone B. Ubehebe Peak area, northern Panamint Range, locality M1094. Andy Hills, northern Panamint Range, localities M1095, M1109. Funeral Mountains, locality M1098. Study material of this species consists of 14 coralla (M1094), five coralla (M1095), one corallum (M1109), and two coralla (M1098).

Genus PYCNACTIS Ryder, 1926

1820. *Hyppurites mitratus* Schlotheim, p. 352 (in part).
1850-54. *Aulacophyllum mitratum*. Edwards and Haime, p. 280, pl. lxvi, figs. 1, 1a, 1b.
1926. *Pycnactis* Ryder, p. 386-390; pl. ix, figs. 1-8.
1927. *Aulacophyllum angelini* Wedekind, pl. 24, figs. 3-5.
1937. *Pycnactis* Ryder. Butler, p. 93-95.
1940. *Pycnactis* Ryder. Lang, Smith and Thomas, p. 112.
1956. *Pycnactis* Ryder. Hill, p. F272, fig. 185.5.

Type species.—Hyppurites mitratus Schlotheim, 1820; by original designation (Ryder, 1926). Silurian, Gotland, Sweden.

Diagnosis.—Solitary trochoid rugose corals with long thickened major septa laterally in contact and pinnately arranged; cardinal septum long, minor septa very short or suppressed. Tabulae and dissepiments suppressed.

Remarks.—The ontogeny of *Pycnactis mitratus* was elucidated by Ryder (1926, p. 389), and the supposed genetic relationships of *Pycnactis, Mesactis*, and *Phaulactis* were further examined by Butler (1937). *Phaulactis* and other lykophyllids are believed to pass through early growth stages, such as *Pycnactis* (Minato, 1961); however, the *Pycnactis* stages are not known in *Ryderophyllum* and *Cyathactis*.

Occurrence.—According to Ryder (1926, p. 389), the Gotland and British *Pycnactis mitratus* is from beds of Wenlockian age. Hede (in Regnéll and Hede, 1960, p. 70, 73, 77) listed this species from the Slite Group, which is higher Wenlockian. Great Basin *Pycnactis* occurs in coral zone B, considered early Wenlockian.

Pycnactis sp. k

Plate 6, figures 10-12

Silicified corals assigned to *Pycnactis* occur in association with *Ryderophyllum ubehebensis*. Because of their large size, they are probably not immature growth stages of this lykophyllid.

From 36 to 48 septa, arranged pinnately with reference to cardinal plane. Minor septa not distinguishable in transverse section. Epitheca or outer wall absent in available specimens, which externally show pinnate pattern of thickened septa.

Occurrence.—Hidden Valley Dolomite; early Middle Silurian, coral zone B. Andy Hills, northern Panamint Range, locality M1109. Funeral Mountains, locality M1098. Study material consists of two coralla (M1109) and one corallum (M1098).

Family CYSTIPHYLLIDAE Edwards and Haime, 1850

Reference form.—Cystiphyllum siluriense Lonsdale,[6] 1839; Silurian, Wenlock Limestone, Dudley, England.

Remarks.—Silurian cystiphylloid corals include species which reveal trabecular septal spines in transverse thin section; some, however, lack these spines interally. In some individuals septal traces have been observed only on the calice floor, where they show as weak, radiating, spiny septal ridges or striations (Počta, 1902). Edwards and Haime's (1850-54, p. 298, pl. 72, fig. 1a) description and figure of the trochoid *Cystiphyllum siluriense* suggest that the type species has faint calicular septal ridges. However, the internal features of *siluriense* from the type area remain to be elucidated. *Cystiphyllum cylindricum* Lonsdale (Lang and Smith, 1927, p. 477, pl. 36, figs. 1-5; Hill, 1956, fig. 214.1a, 1b), another British Silurian species, shows numerous trabecular septal spines more or less radially alined. Wedekind's figures of Gotland corals referred to Lonsdale's *C. siluriense* also reveal abundant short trabecular septal spines. In the Gotland *Holmophyllum* Wedekind and *Hedströmophyllum* Wedekind the trabecular spines are much longer and heavier than in the genus *Cystiphyllum*.

Cystiphylloids thus far studied by the writer from the Silurian of western North America reveal few or no trabecular spines. However, *Cystiphyllum* cf. *C. tubiforme* Poulson figured by Norford (1962, pl. 13, figs. 8-11) from the Silurian of British Columbia clearly shows such features. *Cystiphyllum*? *henryhousense* Sutherland (1965, p. 24, pls. 13-16) shows sporadic trabecular spines in some individuals, but, otherwise, it may be generically distinct from *Cystiphyllum*.

Cystiphylloids of the Devonian undoubtedly represent many homoeomorphic lineages not closely related to the Silurian *Cystiphyllum* and are placed in other families, such as the Cystiphylloidae and Digonophyllidae, the last with strong septal crests and discrete septa.

Microplasma Dybowski of the western North American Silurian shows trabecular septal spines only in the wall and is, with reservation, assigned to this family.

Forms here provisionally assigned to the family Cystiphyllidae are as follows:

- *Cystiphyllum* Lonsdale,[7] 1839
- *Hedströmophyllum* Wedekind, 1927
- *Holmophyllum* Wedekind, 1927
- Group of *Cystiphyllum*? *henryhousensis* Sutherland, 1965
- (?)*Microplasma* Dybowski, 1873

[6] In Murchison (1839, p. 675-699, 5 pls.).

[7] In Murchison (1839, p. 675-699, 5 pls.).

Genus MICROPLASMA Dybowski, 1873

Type species.—Microplasma gotlandicum Dybowski; by subsequent designation, Wedekind (1927, p. 64). Silurian, Gotland, Sweden.

Diagnosis.—Slender cylindrical corallites; in longitudinal thin section, interior occupied by two to four columns of large globose dissepiments or tabellae which are not readily distinguishable. Wall a stereozone in which septal trabeculae are embedded and from which very short septal ridges project inward. No trabecular septal spines on dissepiments or tabellae as in *Cystiphyllum.*

Remarks.—Microplasma may be a fasciculate colonial genus, but ordinarily only isolated corallites are found.

Microplasma? sp. R

Plate 7, figures 10,11

Small and presumably solitary cystiphylloid corals occurring in the Silurian Roberts Mountains Formation of the type section are known only from fragmentary material referred provisionally to this genus.

A transverse thin section 11 mm in diameter shows an outer ring of large lonsdaleioid dissepimental traces with two larger tabellar traces occupying the interior. In longitudinal thin section, all these chambers are defined by axially inclined, usually continuous tabulae or tabellae, disposed in such manner that the term "dissepiment" may not be entirely appropriate.

The wall is laminar stereome in which are embedded septal trabeculae, spaced about four per millimeter; these trabeculae support very short abruptly tapering septa which cannot be distinguished as major and minor.

Occurrence.—Top of unit 2, just above limestones with abundant *Conchidium*-like pentameroid brachiopods, and at base of Silurian coral zone C, type section of Roberts Mountains Formation. Ridge between south and middle forks of Pete Hanson Creek, locality M1089.

Family GONIOPHYLLIDAE Dybowski, 1873

Representative genus and species.—Goniophyllum pyramidalis (Hisinger); Silurian, Gotland, Sweden.

These extraordinary operculate rugose corals have a worldwide distribution in the Silurian and Devonian (Lindström, 1883). Most of the American forms initially assigned to *Calceola* have, on careful study, been recognized as the genus *Rhizophyllum,* which is largely Silurian but ranges upward into strata of Devonian age. Oliver (1964) restudied several of the American species and described new species of *Rhizophyllum.*

The following genera are included in this family:

Goniophyllum Edwards and Haime, 1850
Rhizophyllum Lindström, 1866
Teratophyllum Lang, Smith, and Thomas, 1940
Rhytidophyllum Lindström, 1883
Calceola Lamarck, 1799

Of these genera, only *Rhizophyllum* has been found in the Great Basin and in western North America generally.

Genus RHIZOPHYLLUM Lindström, 1866

1866. *Rhizophyllum* Lindström, p. 287.
1940. *Rhizophyllum* Lindström. Hill, p. 394.
1956. *Rhizophyllum* Lindström. Hill, p. F314.
1964. *Rhizophyllum* Lindström. Oliver, p. D149–D158.

Type species.—Calceola gotlandica Roemer, 1856; by monotypy. Silurian, Gotland, Sweden.

Diagnosis.—Calceoloid rugose corals with operculum; interior occupied by cystiphylloid dissepiments and tabellae. Septa short and limited to flat side; counter septum commonly longer and more prominent. Radiciform processes occasionally present.

Remarks.—Calceola differs in having a stereoplasm-filled interior and is, insofar as known, confined to Devonian rocks.

Rhizophyllum sp. D, Oliver

Plate 7, figures 12–14

1930. *Calceola sandalina* Lamarck. Stauffer, p. 107, pl. 12, figs. 2, 3.
1964. *Rhizophyllum* sp. D, Oliver, p. D155.

This somewhat compressed species has its greatest diameter of about 35 mm at the calice rim and a cardinal-counter diameter of about 15 mm; the length is about 43 mm. The flat thick septate wall projects as a tongue 16 mm above the calice rim; this wall is notched medially to accomodate the counter septum. The position of the medial counter septum is evident on the flat exterior where it lacks the strong longitudinal fold of *R. gotlandicum*; there are no indications of radiciform processes.

In mature transverse section this form resembles *Rhizophyllum* sp. A of Oliver (1964, p. D153, fig. 153.1) in general features of size, proportions, and distribution of dissepiments and tabellae. This southeastern Alaska species comes from the higher Silurian of Kosciusko Island. *Rhizophyllum* sp. cf. *R. enorme* of Oliver from Late Silurian coral facies of the Roberts Mountains Formation at Coal Canyon, Simpson Park Mountains, Nev., appears to be a somewhat less compressed form than sp. D.

Occurrence.—Middle part of the Vaughn Gulch Limestone about 800 feet above its base. Mazourka Canyon, northern Inyo Mountains, Calif., near locality M1092. The float specimen is probably from a horizon near the bottom of coral zone E.

Family KYPHOPHYLLIDAE Wedekind, 1927

Reference genus and species.—Kyphophyllum lindströmi Wedekind. Silurian, Gotland, Sweden.

The Kyphophyllidae are mostly colonial, phaceloid and cerioid forms among which the fasciculate species with long subcylindrical corallites predominate.Long lamellar septa are characteristic, with one to several dissepiment columns, the outer of which are lonsdaleioid in some genera. Tabulae are fairly wide and arched in some of the genera, and in a few a flaring calice rim is known.

Genera provisionally included in this family are as follows:

Kyphophyllum Wedekind, 1927
Strombodes Schweigger, 1819
Petrozium Smith, 1930
Entelophyllum Wedekind, 1927
Entelophylloides Rukhin, 1938 (as a subgenus)
Entelophylloides (*Prohexagonaria*), n. subgen.
Neomphyma Soshkina, 1937
(?)*Tonkinaria*, n. gen.

Genus KYPHOPHYLLUM Wedekind, 1927

1927. *Kyphophyllum* Wedekind, p. 18–22.
1940. *Cyphophyllum*, Lang, Smith, and Thomas, p. 47.
1956. *Kyphophyllum* Wedekind. Hill, p. F276.

Type species.—*Kyphophyllum lindströmi* Wedekind (1927, explanation pl. 2); by original desegnation. Silurian, Gotland, Sweden.

Diagnosis.—Phaceloid and solitary rugose corals with elongate subcylindrical corallites; three or more columns of dissepiments, the outer of which are in part lonsdaleioid; moderately wide, partly continuous tabulae, and a rather narrow septal stereozone.

Remarks.—Lang, Smith, and Thomas (1940, p. 47) and Smith (1945, p. 57) noted the similarity of internal structure between Wedekind's *Kyphophyllum lindströmi* and the phaceloid *Strombodes stellaris,* type species of *Strombodes* Schweigger, 1819. That the two are actually congeneric is somewhat doubtful at present, and suppression of *Kyphophyllum* as a synonym on this basis should await comparison of adequate Gotland topotype material.

In *Kyphophyllum* the septa are long, major septa approaching the axis, and are peripherally discontinuous as septal crests in the lonsdaleioid areas. The tabulae are typically arched but may be flat or even sagging. *Entelophyllum* differs by lacking the lonsdaleioid dissepiments, having a narrower septal stereozone, and having fairly numerous lateral radiciform connections between corallites. *Pilophyllum* Wedekind, with lonsdaleioid marginarium, has a heavier septal stereozone and a much wider tabularium comprising many overlapping tabellae and few complete tabulae.

Wedekind's type species *K. lindströmi* is reported from a locality north of Stenkyrke huk, Gotland, in the "untere Mergel"; this map occurrence suggests Visby Marl, probably the lower part, and therefore late Llandoverian age. Undescribed *Kyphophyllum* from the Gazelle Formation, Klamath Mountains, Calif., occurs in strata believed to be high in that formation and is therefore either Ludlovian or very early Devonian. The Great Basin occurrences are also high in the Silurian (Ludlovian).

Kyphophyllum nevadensis, n. sp.

Plate 13, figures 1–4

Type material.—Holotype USNM 159425; Upper Silurian, Ikes Canyon, Toquima Range, Nev.

Diagnosis.—*Kyphophyllum* forming large phaceloid or bushy colonies; corallites with narrow stereozone, medium-wide closely spaced tabulae, and irregular, wide peripheral segments of lonsdaleioid dissepiments.

Transverse sections.—About 22 major septa, most of which reach the axis, where they may be somewhat twisted; septa smooth and straight to wavy, in places having sharp zigzag carinae. Minor septa nonuniform and discontinuous, varying from short projections at the stereozone to broken septa more than half as long as major septa. All septa discontinuous in the lonsdaleioid areas. Dissepiment trace pattern very irregular. Septal stereozone narrow.

Longitudinal sections.—Tabulae closely spaced, partly complete with downward sag and averaging about one-quarter width of corallite. Dissepimentarium with three to five columns of nonuniform dissepiments ranging from small and globose to large and elongate, the outer ones being partly lonsdaleioid; most dissepiments steeply inclined, the inner ones near vertical. No discrete axial structure.

Reproductive offsets.—Probably develop laterally from calice rim.

Microstructure.—Trabeculae not clearly shown in walls and stereozone of well-preserved specimens.

Comparison with related forms.—A similar undescribed *Kyphophyllum* from Late Silurian or Early Devonian strata of the Gazelle area, northeast Klamath Mountains, Calif., has a narrower tabularium and more extensive development of large lonsdaleioid dissepiments; some of the Klamath specimens have a wider stereozone. *Kyphophyllum lindströmi* of the Gotland Silurian shows a narrower dissepimentarium, and its wider tabulae are arched with median sag and marginal depression not present in either *nevadensis* or the Klamath species. The Gotland form is reported to be a solitary coral.

Occurrence.—In lower part of McMonnigal Limestone of Kay and Crawford (1964); coral zone E. Northwest side of Copper Mountain, Ikes Canyon, Toquima Range, locality M1114. Study material consists of one large, nearly complete corallum and fragments of other coralla.

Genus PETROZIUM Smith, 1930

Type species.—*Petrozium dewari* Smith (1930, p. 307, pl. XXVI, figs. 20–28) by original designation. Lower Silurian, Valentian, Shropshire, England.

Diagnosis.—Phaceloid rugose corals having long slender cylindrical corallites without connecting processes. Long axially thin major septa, some of which meet at the center, where they may be involved in an incipient axial structure. Dissepiments in several columns, small, globose, steeply inclined toward axis. Tabularium wide, comprising arched tabellae mostly inclined toward the periphery. Septal stereozone thin or absent.

Remarks.—True carinae, though mentioned in Smith's generic diagnosis, are not present in the American species; however, the septa may possess zigzag features. An Alaskan species of *Petrozium* from Kuiu Island, southeastern Alaska, has a discrete axial structure reinforced by stereoplasm to form a small bladelike columella.

Petrozium probably ranges through most of the Silurian System; the type species is Valentian (Llandoverian) Early Silurian. *P. mcallisteri*, n. sp., of the Great Basin occurs in coral zone B, which is Wenlockian. An undescribed *Petrozium* in the Gazelle Formation of the Klamath Mountains in California is high Wenlockian or Ludlovian. As *Petrozium* is a rather specialized genus, such a long range is surprising.

Petrozium mcallisteri, n. sp.

Plate 9, figures 6–10

Type material.—Holotype USNM 159411.

Diagnosis.—*Petrozium* with major septa slightly thickened peripherally, tapering to very thin where meeting axially. Septa have minute zigzag features.

Transverse sections.—About 20 major septa, some of which reach the axis; septa mostly wavy and commonly zigzag peripherally. Major septa slightly thickened peripherally, attenuated axially. Minor septa rather long, some exceeding half the length of major septa. Septal stereozone weakly developed or absent. Symmetry entirely radial; no suggestion of a fossula.

Longitudinal sections—Tabularium about half the width of corallum, comprising arched tabellae without complete tabulae. Tips of major septa intersect, suggesting an incipient axial structure, but no development of true columella.

Comparison with related forms.—*Petrozium mcallisteri* has fewer septa than *dewari,* the type species, but it is otherwise very similar, especially in longitudinal section. An undescribed *Petrozium* in the Silurian Gazelle Formation of the Klamath Mountains has more even, less tapering septa without zigzag features; some corallites of the Gazelle species have a suggestion of a fossula not recognized in *mcallisteri.*

Occurrence.—Lower part of the Hidden Valley Dolomite; 1½ miles north of Ubehebe Peak, Northern Panamint Range, locality M1111. The large silicified head of the coral here described was collected as float below the main in situ locality (M1094), but it is believed to have come from the bed of silicified corals which is the type occurrence of Great Basin coral zone B. Study material consists of a single large corallum.

Genus ENTELOPHYLLUM Wedekind, 1927

1927. *Entelophyllum* Wedekind, p. 22–24; pl. 2, figs. 11, 12; pl. 7, figs. 7–10; pl. 29, figs. 18–51.
1927. *Xylodes* Lang and Smith, p. 461, 462, figs. 13, 14.
1929. *Xylodes* Lang and Smith. Smith and Tremberth, p. 362–367; pl. 7, figs. 1–6; pl. 8, figs. 2–4.
1940 *Entelophyllum* Wedekind. Lang, Smith, and Thomas, p. 57–58.
1940. *Entelophyllum* Wedekind. Hill, p. 411.
1956. *Entelophyllum.* Duncan, pl. 23, figs. 5c, 5d.
1956. *Entelophyllum* Wedekind. Hill, p. F275, fig. 187,2a–c.
1962. *Entelophyllum* Wedekind. Stumm, p. 2, 3.
1962a. *Entelophyllum* Wedekind. Oliver, p. 15.
1964. *Entelophyllum* Wedekind. Stumm, p. 32.

Type species.—*Madreporites articulatus* Wahlenberg = *Entelophyllum articulatum* (Wahlenberg). By subsequent designation, Lang, Smith, and Thomas (1940, p. 57, 140). Silurian, Gotland, Sweden. According to Smith and Tremberth (1929, p. 366), this species occurs at several localities in strata of Wenlockian and Ludlovian age on Gotland; it is recorded in England from Wenlock Limestone.

Diagnosis.—Phaceloid or solitary rugose corals with elongate subcylindrical mature corallites. Major septa thin or slightly thickened only near outer wall, approaching or slightly withdrawn from axis. Tabularium wide, typically with closely spaced flat tabulae and tabellae and a narrow peripheral, proximally depressed zone bordering the dissepimentarium. Dissepimentarium having from a few to many columns of small steeply inclined globose dissepiments. Outer wall thin and without stereozone. No fossula or indication of bilateral symmetry in mature stages. Septa slightly to moderately wavy, but well-developed angle-carinae not present in typical form. Lateral attachment outgrowths from wall characteristic of some species. Five or six reproductive offsets developed marginal to the calice.

Remarks.—Not all species placed in *Entelophyllum* have the strongly depressed peripheral zone of the tabularium shown by the type species. The English Wenlock representatives of *E. pseudodianthus* (Weissermel) have zigzag, thickened, highly carinate septa and less elongated cylindrical corallites (Smith and Tremberth, 1929, p. 361–362; Lang and Smith, 1927, p. 475, text fig. 15).

Disphyllum of the Middle Devonian is similar to *Entelophyllum.* However, it is usually very slender, lacks the numerous coarse or thick attachment outgrowths of some species of *Entelophyllum,* has more even septa without carinae, and commonly has a somewhat wider tabularium. The transverse sections of *Disphyllum* show a more uniformly even concentric distribution of axially concave dissepiment traces. Some forms of *Entelophyllum* have several reproductive offsets marginal to the calice, a condition not known in *Disphyllum.*

Entelophyllum eurekaensis, n. sp.

Plate 10, figures 1, 2, 14, 15

Type material.—Holotype USNM 159412; paratype USNM 159419.

Diagnosis.—Subcylindrical to ceratoid *Entelophyllum* with wide tabularium and closely spaced, straight, nearly continuous tabulae and flat peripheral tabellae, peripheral zone of tabularium proximally depressed as in typical *Entelophyllum.* Septa slightly thickened, with longer major septa approaching axis. Small- to medium-sized dissepiments appearing in transverse sections as axially concave and chevron traces.

External features.—Known only from isolated pieces but assumed to be phaceloid, like the related species *E. engelmanni* of the same interval in the Lone Mountain Dolomite. Available specimens ceratoid rather than subcylindrical.

Transverse sections.—About 30 major septa, most of which are withdrawn, but a few approach the axis; minor septa from short wedgelike stumps to about half the length of major septa. Septa not as thin as in most species of *Entelophyllum* and only slightly wavy. No carinae recognized. Dissepiments include herringbone and chevron traces as well as those that are concentric and axially concave. Septa wedge out markedly at outer wall, but no thickened stereozone; epitheca rather thin.

Longitudinal sections.—Tabularium width nearly two-thirds the diameter. Tabulae, in part, nearly continuous, axially and periaxially flat, peripherally depressed. Flat peripheral tabellae also present. Small to fairly large, steeply inclined dissepiments.

Comparison with related forms.—This species has a wider tabularium than *engelmanni* of the upper Lone Mountain Dolomite; the tabulae are medially flat with peripheral sag, conditions less characteristic of *engelmanni.* Elongate cylindrical corallites with lateral growths and the bushy growth habit of *engelmanni* are unknown in *eurekaensis.*

Occurrence.—Late Silurian, upper part of the Lone Mountain Dolomite; upper Lone Mountain–Laketown biofacies containing *Howellella pauciplicata.* Southern Fish Creek Range, Nev. locality M1113; associated with a silicified brachiopod assemblage including *Howellella pauciplicata, Protathyris hesperalis,* and *Camerotoechia pahranagatensis.* Study material of this species consists of 22 disassociated corallites.

Entelophyllum engelmanni, n. sp.

Plate 10, figures 5-13

Type material.—Holotype USNM 159413; paratypes USNM 159414, 159415, 159416, 159417; figured specimen USNM 159418.

Diagnosis.—Phaceloid *Entelophyllum* forming large bushy colonies of nearly straight subcylindrical corallites joined by lateral outgrowths. Tabularium wide, tabulae mostly complete and subparallel, not always with peripheral sag as in typical *Entelophyllum;* some tabulae with axial and periaxial sag or with slight distal arching. Tabellae not common. Major septa withdrawn from axis, slightly wavy, and with no carinae. Minor septa short, usually less than half the length of major septa. Septa thin internally but with wedge thickening at wall. No stereozone.

External features.—Elongate mature corallites large for this genus, with well defined septal grooves crossed by annular incremental striations but without coarse annular folds or rugae. Some corallites with thick irregular lateral attachment outgrowths along one side with vertical distribution.

Transverse sections.—About 28 major septa, thin internally and slightly withdrawn from the axis. Minor septa short, less than half the length of major septa. All septa wedges thickening at very thin outer wall. Septa slightly wavy and lacking carinae. Dissepiments not numerous, rather irregular as chevrons, forks, and simple traces which are either almost straight or slightly concave axially.

Longitudinal sections.—Tabularium wide, about two-thirds of the diameter. Tabulae mostly complete, varying from straight or slightly arched axially and periaxially with or without peripheral depression to those with axial-periaxial sag and no peripheral depression. Dissepiments globose in one to three columns, steep and of small, medium, and large size. A few broad flat tabellae peripherally.

Comparison with related forms.—*Entelophyllum engelmanni* differs from *eurekaensis* in the unevenness of its tabulae, which commonly lack the peripheral depression; its very elongate cylindrical corallites have lateral processes not observed in *eurekaensis.*

Occurrence.—Late Silurian, upper part of the Lone Mountain Dolomite; upper Lone Mountain–Laketown biofacies. Southern Mahogany Hills, Nev. locality M1112. Southern Fish Creek Range, Nev., locality M1087. A similar form occurs in Silurian dolomite of the Ruby Mountains, Nev. (pl. 15, figs. 12-16).

Study material of this species consists of several hundred corallites from numerous coralla (locs. M1087, M1112).

Genus ENTELOPHYLLOIDES Rukhin, 1938 (as subgenus of ENTELOPHYLLUM)

1938. *Entelophyllum (Entelophylloides) inequalum (Hall),* Rukhin, p. 23.

Type species.—*Columnaria inequalis* Hall (in part), 1852, p. 323, pl. 72, figs. 3, 4; by author designation. Silurian, Cobleskill Limestone, New York.

Diagnosis.—Cerioid rugose corals with long, even septa, several columns of small and medium dissepiments, and tabulae of medium width. Lonsdaleioid dissepiments inconspicuous or lacking. No axial structure.

Remarks.—Carinae were not observed in transverse thin sections of the type species, but longitudinal thin sections reveal numerous delicate spinose bars or spurs extending laterally from the tabularium septal extensions. In the type species the number of major septa, being about 12, is small for the compound Rugosa. Some major septa reach the axis; minor septa are only a little shorter. The outer dissepiments are more irregular and nonuniform than the more concentric inner ones and may be sporadically sub-lonsdaleioid in the largest corallites.

Entelophylloides, erected by Rukhin as a subgenus under *Entelophyllum,* is here considered an independent genus.

The genus is Late Silurian.Specimens collected by Jean Berdan from the Silurian Cobleskill Limestone in the vicinity of Shutters Corners, Schoharie quadrangle, New York, are considered topotype material of Hall's *inequalis*.

Similar corals from the Keyser Limestone of the Evitts Creek area, Maryland, collected by Jean Berdan and Helen Duncan, appear to be a distinct species with thicker septa and fewer septal spines within the tabularium.

Subgenus ENTELOPHYLLOIDES, sensu stricto

Type species.--Entelophylloides (Entelophylloides) inequalis (Hall).

This subgenus has the characters of the genus *Entelophylloides* in the strict sense. Its members include species with small corallites, a small average number of major septa (about 12), straight unarched tabulae, and numerous lateral spines or spurs on major septa within the tabularium.

Subgenus PROHEXAGONARIA, new subgenus

Type species.—Entelophylloides (Prohexagonaria) occidentalis, n. sp.; here designated. Silurian, bottom of unit 3 of the Roberts Mountains Formation; Roberts Creek Mountain, Nev.

Diagnosis.—Cerioid rugose corals with numerous long thin septa, some reaching the axis; minor septa three-fourths the length of major septa. Tabularium less than one-third the corallite diameter; tabulae close spaced, some complete and straight, some arched as tabellae. Dissepimentarium wide, with eight or more columns of small- and medium-sized dissepiments which are nearly flat peripherally. Elbow or zigzag carinae inconspicuous. Septa with no lateral spines.

Remarks.—This subgenus has about 18 major septa, averaging 12 in typical *Entelophylloides.* Another significant distinction is absence of septal spines or spurs, which show well in longitudinal thin sections of the type species.

Hexagonaria of the Devonian has more evenly and uniformly globose dissepiments, a more uniform pattern of concentric dissepimental traces in transverse section, and a broader tabularium. The typical *Hexagonaria* is characterized by yardarm carinae not present in *Entelophylloides.* The septal spines or spurs of the latter are absent in *Hexagonaria.*

Prohexagonaria resembles the Silurian cerioid *Tenuiphyllum* Soshkina; the latter has an arched axial development more like *Petrozium.* Somewhat closer morphologically are Silurian cerioid forms heretofore classified as cerioid "*Xylodes*" or cerioid *Entelophyllum.*

Undescribed cerioid Silurian Rugosa of the Gazelle Formation, Klamath Mountains, Calif., superfically resemble *Entelophylloides,* sensu stricto, but the tabularium is narrower, tabulae are weakly developed, the septa are thickened toward the wall, and larger lonsdaleioid dissepiments are sporadically developed.

Entelophylloides (Prohexagonaria) occidentalis, n. sp.

Plate 9, figures 1-4

1940. *Strombodes.* Merriam, p. 12, 92.
1963b. *Strombodes.* Merriam, p. 38.

Type material.—Holotype, USNM 159410; Silurian, unit 3 of the Roberts Mountains Formation. Roberts Creek Mountain, Nev.

Diagnosis.—Prohexagonaria with numerous, somewhat wavy, unthickened septa. In transverse thin section, the dissepiment pattern includes many peripheral angulo-concentric and nearly straight traces. Tabulae close spaced and arched or flat. Corllite wall fairly straight.

External features.—Occurs in compact cerioid heads exceeding a diameter of 10 inches.

Transverse sections.—Major septa 18–20, unthickened throughout, with waviness increasing peripherally. Some incipient angulation carinae developed, but none showing in depth as true carinae in longitudinal thin sections. Pattern of dissepiment traces mostly concentric, but peripherally these traces changing to irregularly anguloconcentric or nearly straight with increasing septal waviness. A slight tendency to develop scattered small sublonsdaleioid dissepiments near walls.

Longitudinal sections.—Mostly small globose dissepiments developed in eight or more columns. Combinations of close-spaced complete tabulae and tabellae which are more commonly uparched than flat in the tabularium.

Reproductive offsets.—Small interstitial reproductive offsets developed from the calice margin (seen in transverse sections).

Comparison with related forms.—Entelophylloides (Prohexagonaria) sp. from Visby, Gotland, figured by

Smith and Tremberth (1929, pl. 8,fig. 1) as "*Xylodes* sp." resembles *occidentalis* in transverse section. (See pl. 9, fig. 5.) The cerioid "*Acervularia mixta*" Lindström (1882b) from reported Silurian rocks of the central Siberian uplands differs in having a zigzag wall, and in longitudinal section it shows an axial structure more like that of *Petrozium*. Other than this species, American Late Silurian forms assigned to *Entelophylloides* for the most part have the subgeneric features of *inequalis* (Hall), as outlined above. A species from the New Jersey Decker Ferry Formation assigned by Weller (1903, p. 219, pl. 17, figs. 12, 13) to Hall's species is similar to *occidentallis* in transverse section, but, as illustrated in longitudinal section, it lacks straight or complete tabulae.

Entelophylloides from the Keyser Limestone of Maryland assigned by Swartz (1913, pl. 20, figs. 1–4) to Hall's *inequalis* presumably falls in the subgenus *Entelophylloides,* sensu stricto; this species differs from *occidentalis* in its peripherally wedge-thickened septa and in its scattered large peripheral dissepiments.

Occurrence.—Lower beds of unit 3 in the Roberts Mountains Formation; Middle Silurian coral zone C. Northwest side of Roberts Creek Mountain, Nev., locality M1102. Study material consists of two large coralla and pieces of other coralla from same coral bed.

Genus NEOMPHYMA Soshkina, 1937

1937. *Neomphyma* Soshkina, p. 76, 98; pl. XV, figs. 3, 4.
1940. *Neomphyma* Soshkina. Lang, Smith, and Thomas, p. 88.
1956. *Neomphyma* Soshkina. Hill, p. F298, fig. 203.4a–b.

Type species.—*Neomphyma originata* Soshkina, 1937; by original designation. Silurian, Petropavlovsky region, east slope Ural Mountains. Reported as "Upper Ludlow."

Diagnosis.—Solitary and fasciculate rugose corals with slender cylindrical mature corallites having a narrow peripheral stereozone, large irregular peripheral lonsdaleioid dissepiments, and a few thin nonuniform discontinuous septa, which may extend to the axis. Tabularium usually narrow; tabulae very unevenly developed, either widely spaced or closely set.

Remarks.—Some corallites show almost no septa except for short spinose projections from the stereozone.

The type species is reported by Soshkina to occur in beds of upper Ludlovian age. *Neomphyma crawfordi*, n. sp., from the Toquima Range, Nev., is associated with *Arachnophyllum* and *Cyathophylloides fergusoni* in strata which probably represent Great Basin coral zone A of Early Silurian (Llandoverian) age.

Neomphyma crawfordi, n. sp.

Plate 13, figures 5–8

Type material.—Holotype USNM 159426.

Diagnosis.—Phaceloid, cylindrical *Neomphyma* with a few very large and irregular lonsdaleioid dissepiments in mature stages. Septal lamellae smooth. Primary septa highly irregular, nonuniform and wavy, most not reaching axis, commonly few or lacking medially, but always appearing at wall as crests. Outer wall a moderately thick stereozone. Dissepiments near vertical; tabulae mostly narrow, widely spaced, and nearly flat.

External features.—Bushy phaceloid colonies 8 or more inches in diameter comprising close-set cylindrical, fairly straight corallites. No connecting processes observed. Surface marked by septal grooves and not very pronounced transverse rugae. Numerous small offsets originate from parental calice, especially at outer wall; one calice may have as many as four of these marginal offsets.

Transverse section.—Neanic stages with about 16 smooth simple wavy major septa, most of which do not reach the axis; minor septa very short. In ephebic stages, with appearance of the large lonsdaleioid dissepiments, the major septa increasing to 20 or more but commonly suppressed medially, showing only as the peripheral crests in some cystiform individuals. Peripheral stereozone about $^1/_{10}$ or $^1/_{12}$ the diameter of the ephebic corallite. With some individuals, major septa discontinuous, appearing as short radial crests.

Longitudinal section.—Large, steeply inclined to vertical nonuniform dissepiments arranged in one or two columns and occupying most of the corallite width. Few tabulae, widely spaced, more or less straight, and usually narrow. Walls of contiguous corallites commonly coalescing.

Reproductive offsets.—(See external features.)

Microstructure.—Trabecular structure poorly defined in stereozone, inclined peripherally a few degrees from horizontal.

Comparison with related forms.—*Neomphyma originata* Soshkina (1937, p. 98, pl. XV, figs. 3, 4) differs from *crawfordi* in having longer, more continuous major septa and a more irregular pattern of dissepiments, as observed in longitudinal section. The Russian species is reported from beds of Ludlovian age in the Urals and may accordingly be considerably younger than *crawfordi* of coral zone A.

Occurrence.—Lower Silurian, coral zone A; in the Masket Shale of Kay and Crawford (1964). Ikes Canyon, Toquima Range, Nev., locality M1088. In association with *Arachnophyllum kayi*, n. sp., and *Cyathophylloides fergusoni*, n. sp. Study material consists of one nearly complete corallum and pieces of other coralla.

Genus TONKINARIA, new genus

1956. (?)*Entelophyllum*. Duncan, pl. 23, figs. 5a, 5b.

Type species.—*Tonkinaria simpsoni,* n. gen., n. sp.; here designated. Silurian; unit 3 of the Roberts Mountains Formation.

Diagnosis.—Solitary and loosely phaceloid rugose corals with flaring trumpet-shaped calice, ceratoid to turbinate corallites, and narrow tabularium. Wall a narrow stereozone; septa thin, major septa reaching or slightly withdrawn from axis. Some dissepiments large, elongate, and steeply inclined. Multiplication by three or more peripheral calice offsets.

Remarks.—Unlike *Entelophyllum,* the new genus *Tonkinaria* does not have a cylindrical growth habit. The tabularium also differs from that of typical *Entelophyllum,* which commonly has several columns of smaller dissepiments. The internal structure of *Tonkinaria* resembles that of *Neomphyma* Soshkina (1937, p. 98), which differs in its cylindrical shape and larger dissepiments.

Tonkinaria simpsoni is associated at its type occurrence with phaceloid Rugosa of comparable exterior growth form but is otherwise unrelated. Placed in the new genus *Stylopleura,* these externally similar colonial corals are nondissepimented and possess cylindrical mature corallites.

Tonkinaria simpsoni, n. sp.

Plate 7, figures 1-8

Type material.—Holotype USNM 159403; paratypes USNM 159402, 159404; figured specimen USNM 159405.

Diagnosis.—Small *Tonkinaria* with ceratoid or trochoid corallites and usually a flaring calice; reproductive offsets developed at the calice rim. Attachment by talons.

External features.—The calice deeply conical to very widely flaring with peripheral platform and central pit. Broadly flaring or reflected types with a thin rim to which reproductive offsets are attached; septa extending to rim as broad slightly rounded to nearly flat ribs separated by sharp grooves. Septal grooves not strongly defined externally.

Transverse sections.—Septa thin, somewhat wavy, and numbering about 8; most extending more than half the radius, and some reaching the axis. Short minor septa commonly present. Septa thickened peripherally toward the narrow septal stereozone. Dissepimental traces rather irregularly concentric and axially concave to straight.

Longitudinal sections.—Tabularium narrow, less than one-third of diameter. Tabulae poorly defined in available specimens but, where shown, very narrow, irregularly concave distally, and rather closely spaced. Dissepiments in three or more columns, steeply inclined, many of them relatively large and elongate.

Reproductive offsets.—Offsets characteristically growing laterally or vertically from the calice rim, as illustrated on plate 7, figures 1 and 2. Asexual progeny commonly attached to successive parents, resulting in complex colonial growth (pl. 7, fig. 9).

Occurrence.—Late Silurian, coral zone D; unit 3 of the Roberts Mountains Formation. Roberts Creek Mountain, Nev., locality M1100. Ikes Canyon reference section, Toquima Range, Nev., locality M1103. Provisionally assigned to *Tonkinaria* is the Hidden Valley specimen (pl. 7, fig. 9) from locality M1097, Funeral Mountains (Ryan quadrangle).

Study material consists of 21 coralla (loc. M1100), one corallum (loc. M1103), and one compound corallum (loc. M1097).

Family CHONOPHYLLIDAE Holmes, 1887

Reference genus.—*Chonophyllum* Edwards and Haime, 1850.

These corals are commonly very rugate externally, because of their numerous rejuvenescence flanges and cone-in-cone growth habit. They have been frequently confused with the platelike nondissepimented Mycophyllinae because of taxonomic complications involving the identity of the type species of *Chonophyllum* (Smith, 1945, p. 19). As interpreted at present, the Chonophyllidae include only solitary species with a strong dissepimentarium comprising medium and large elongate lonsdaleioid dissepiments; most of the septa are discontinuous. Tabulae are flat medially, and most are continuous.

Only the two genera *Chonophyllum* Edwards and Haime, 1850, and *Ketophyllum* Wedekind, 1927, are with assurance included in this family.

Genus CHONOPHYLLUM Edwards and Haime 1850

1826. *Cyathophyllum plicatum* Goldfuss, p. 59, pl. xviii, fig. 5.
1850. *Chonophyllum* Edwards and Haime, pl. lxix.
1851. *Chonophyllum perfoliatum* (Goldfuss manuscript). Edwards and Haime, p. 405.
1902. *Chonophyllum pseudohelianthoides* Sherzer. Počta, pl. 109, figs. 3-6.
1926. Not *Chonophyllum* Lang, p. 428-434, pl. xxx, figs. 4-6.
1927. Not *Chonophyllum* Lang and Smith, p. 454.
1927. Not *Chonophyllum patellatum* Schlotheim. Wedekind, pl. 7, fig. 1.
1927. Not *Chonophyllum planum* Wedekind, pl. 7, figs. 2, 3.
1927. *Omphyma flabellata* Wedekind, p. 59; pl. 17, figs. 3, 4; pl. 18, figs. 10, 11.
1940. *Chonophyllum* Edwards and Haime. Lang, Smith, and Thomas, p. 36.
1945. *Chonophyllum* Edwards and Haime. Smith, p. 19; pl. 30, fig. 3.
1949. *Chonophyllum* Edwards and Haime. Stumm, p. 48 (in part); pl. 23, fig. 4, ?fig. 3, not figs. 5, 6.
1956. *Chonophyllum* Edwards and Haime. Hill, p. F300; fig. 204.3a, 3b.

Type species.—*Cyathophyllum perfoliatum* Goldfuss; Edwards and Haime, 1850; by original designation. Silurian, Gotland. *Cyathophyllum perfoliatum* Goldfuss is *C. plicatum* Goldfuss (1826, p. 59; pl. xviii, fig. 5), not *C. plicatum* Goldfuss (1826, p. 54, pl. xv, fig. 12).

Diagnosis.—Large solitary trochoid, ceratoid, and turbinate rugose corals with poorly defined wall and rough, uneven outer surface showing distally repeated edges of superposed growth cones. Septa numerous, long, somewhat thickened; some major septa reaching axis. Tabularium narrow (¼-⅕ mature corallite diameter); dissepimentarium wide, with nonuniform large and small dissepiments, most of which are elongate. Peripheral dissepiments nearly flat, commonly very elongate, and in part lonsdaleioid. Calice shallow with broad, commonly reflected rim and central pit.

Remarks.—Identity of the *Chonophyllum* type species has long remained in doubt. According to Lang, Smith, and Thomas (1940, p. 36) and Smith (1945, p. 19), the species name *perfoliatum* was personally substituted by Goldfuss for the name *plicatum* on the label of the Gotland type specimen in question, the name *plicatum* having been used also by him for another coral under the genus *Cyathophyllum* (Edwards and Haime, 1851, p. 405). Usage of *Chonophyllum perfoliatum* as set forth by Edwards and Haime (1850, pl. lxix; 1851, p. 405) is accordingly adopted here.

A transverse section of the type specimen of *Chonophyllum perfoliatum* (Goldfuss manuscript) in the Goldfuss collection at the University of Bonn was figured by Smith (1945, p. 19–20, pl. 30, fig. 3), but the longitudinal section of this species remains unknown, leaving some uncertainty about the status of *Chonophyllum.* Hill (1956, p. F300) noted, however, that the longitudinal section of *perfoliatum* has not been figured, but that the transverse section illustrated by Smith (1945, pl. 30, fig. 3) is very similar to that of the Gotland *Omphyma flabellata* Wedekind (1927, pl. 17, figs. 3, 4), which is known and illustrated in vertical section. Longitudinal sections of the Great Basin *Chonophyllum simpsoni* are very much like the section of Wedekind's *flabellata,* which was erroneously placed by him in *Omphyma.*

Chonophyllum is probably related to *Ketophyllum* Wedekind, 1927, but has a narrower tabularium and septa that are more dilated. *Ketophyllum* usually has large lonsdaleioid dissepiments; these are less common or less conspicuous in *Chonophyllum* but are strongly developed in certain of the Great Basin corals assigned provisionally to this genus.

Chonophyllum as used here is distinct from the large turbinate to patelloid nondissepimented Silurian corals with which it has been confused and which are now correctly placed in *Mucophyllum* or in *Schlotheimophyllum. Chonophyllum* is copiously dissepimented, has septa which are far less dilated and which form a wide stereozone in these two genera, and lacks the axial structure of *Schlotheimophyllum.* Corals belonging in *Chonophyllum* or *Ketophyllum* have in the past been erroneously assigned to *Omphyma,* the type of which, as noted by Hill (1956, p. F300), is unknown.

Occurrence.—The range of *Chonophyllum* in the Gotland Silurian is poorly known. Wedekind's (1927, pl. 17, figs. 3, 4) record of *Chonophyllum flabellata* at "Othem, Solklint" suggests the Slite Group of Wenlockian age. Smith (1945, p. 19) recorded an occurrence of *C. perfoliatum* at Kräklingbo, Gotland, which may well be from strata of the Klinteberg Limestone, which is considered Ludlovian.

Great Basin occurrences are in the higher part of the Silurian column and are doubtless Ludlovian.

Chonophyllum simpsoni, n. sp.

Plate 8, figures 1–4

Type material.—Holotype USNM 159408; paratype USNM 159409.

Diagnosis.—Large trochoid to ceratoid *Chonophyllum* with major septa reaching axis, irregular lonsdaleioid peripheral dissepiments, and narrow tabularium with close-spaced undulant incomplete tabulae and marginal tabellae. Inner dissepiments commonly anguloconcentric in transverse section.

External features.—This form possibly ceratoid in later mature stages of growth. Uneven projecting rims of closely spaced superposed rejuvenescence growth cones typical of the genus.

Transverse sections.—About 32 major septa; minor septa generally more than half the length of major septa. Septa slightly thickened, smooth, straight to slightly wavy, not extending to periphery as spines in lonsdaleioid parts. Indications of stereoplasmic thickening of axial ends of septa, but no discrete axial structure. Some inner dissepiment traces with anguloconcentric chevron pattern. Lonsdaleioid pattern highly irregular, occupying most of dissepimentarium or narrow.

Longitudinal sections.—Tabularium sharply set off from dissepimentarium. Undulant tabulae spaced three to seven per millimeter; all tabulae incomplete and combined marginally with tabellae. Most of the peripheral dissepiments very elongate and either nearly horizontal or inclined axially at a low angle. Stereoplasmic thickenings on upper surfaces of dissepiments.

Reproductive offsets.—*Chonophyllum simpsoni* probably a solitary species, as none of the study specimens show offsets.

Comparison with related forms.—*Chonophyllum simpsoni* has smoother, more even septa than appear in Smith's (1945, pl. 30, fig. 3) transverse figure of the type species, *perfoliatum,* which may also have broken septa and septal spines in the lonsdaleioid parts. *C. flabellata* (Wedekind) shows discontinuous septa in lonsdaleioid patches throughout the wide dissepimentarium; the longitudinal section of this form is, however, very similar to that of *C. simpsoni,* although the tabulae are more nearly complete and less undulant in *flabellata. C. pseudohelianthoides* Sherzer of Počta (1902, pl. 109, figs. 3-6) is similar but has less undulant tabulae and has lonsdaleioid dissepiments throughout the wide dissepimentarium. This Bohemian form is reported from Barrandian Stage F or f of the Koneprus, which is presumably Early Devonian.

Occurrence.—Upper part of the Roberts Mountains

Formation; Upper Silurian, coral zone E. Coal Canyon, northern Simpson Park Mountains, Nev., locality M1108. The study material from this locality consists of two incomplete mature coralla and unsectioned fragmentary specimens probably representing this species.

Family ENDOPHYLLIDAE Torley, 1933

Reference forms.—Endophyllum bowerbanki Edwards and Haime and *E. abditum* Edwards and Haime, 1851; Devonian, Torquay, England.

Cerioid and aphroid rugose corals with wide corallites, a broad marginarium with some large lonsdaleioid dissepiments, and a narrow to very wide tabularium comprising closely spaced tabulae (Jones, 1929). No axial structure.

Genera provisionally assigned to the Endophyllidae are as follows:

Endophyllum Edwards and Haime, 1851
Yassia Jones, 1930
Australophyllum Stumm, 1949
Australophyllum (*Toquimaphyllum*), n. subgen.

An undescribed cerioid genus similar to *Toquimaphyllum* in the Silurian Gazelle Formation of the Klamath Mountains, Calif., also belongs in the Endophyllidae. *Pilophyllum* Wedekind of the Gotland Silurian, a solitary or phaceloid genus, may likewise be a member, but it differs from the others in having a wider septal sterozone and a noncompact subcylindrical growth habit.

Some corals here placed in the Endophyllidae have previously been assigned to *Spongophyllum. Spongophyllum* is typified by *S. sedgwicki* Edwards and Haime; this genus is not included in the Endophyllidae as here redefined by reason of its slender corallites, rather narrow tabularium, and narrower, simpler, and possibly only sparingly lonsdaleioid dissepimentarium. It is proposed that the generic name *Spongophyllum* be confined to species agreeing in general structure and proportions with the Devonian *S. sedgwicki* as originally illustrated by Edwards and Haime (1853, pl. 56, figs. 2, 2a-c, 2e). These illustrations show a thickened wall and little suggestion of lonsdaleioid dissepiments in four of the five transverse views. A single figure (2d) of Edwards and Haime's plate 56 shows a lonsdaleioid pattern. There is no assurance that the specimen so illustrated (2d) is conspecific. (See also Stumm, 1949, p. 31, pl. 14, figs. 10, 11; Birenheide, 1962, p. 68-74, pl. 9, fig. 8, and pl. 10, fig. 10).

Lonsdaleioid dissepiments occur in several rugose coral families and by themselves are not regarded as indicative of genetic relationships. In the Silurian rocks, dissepiment patterns of this kind characterize the Endophyllidae and genera of other families, such as *Strombodes, Kyphophyllum, Pilophyllum, Spongophylloides,* and *Ketophyllum.* Of the various Devonian rugose coral groups so characterized, several of cerioid growth habit have rather indiscriminately been classified as *Spongophyllum.* Some of these, may more appropriately be assigned to *Australophyllum,* whereas others are perhaps allied to *Hexagonaria.* The rather abundant Late Paleozoic columellate corals of Lonsdaleioid habit are typified by *Lonsdaleia.*

Abbreviation and loss of septa is a tendency manifested by the later Silurian Endophyllidae; among these are *Yassia,* which lacks septa, *Australophyllum* (*Toquimaphyllum*), with septa reduced or lost in some corallites, and the undescribed Klamath Mountains genus with similarly reduced or obsolete septa.

Genus AUSTRALOPHYLLUM Stumm, 1949

1911. *Spongophyllum cyathophylloides* Etheridge, p. 7, 8, pl. A, fig. 3; pl. C, figs. 1, 2.
1949. *Australophyllum* Stumm, p. 34, pl. 16, figs. 1, 2.
1956. (?)*Australophyllum cyathophylloides* (Etheridge). Hill, fig. 207.4a, 4b.

Type species.—Spongophyllum cyathophylloides Etheridge; by author designation. "Lower Middle Devonian: Douglas Creek, Clermont, Queensland, Australia."

Diagnosis.—Cerioid endophyllid corals with medium-wide to narrow, closely spaced, proximally sagging tabulae, and a wide to very wide dissepimentarium with scattered to wholly lonsdaleioid dissepiments, some of which are large.

Remarks.—Australophyllum differs from *Spongophyllum* in possessing multiple columns of lonsdaleioid dissepiments and more closely spaced sagging tabulae which lack a peripheral depression. Stumm's diagnosis of *Australophyllum* includes carinate septa, although his figures of the type species do not show these features convincingly. The wall of typical *Australophyllum* is somewhat thickened stereoplasmically. Septal crests do not appear to be characteristic of *Australophyllum* sensu stricto, as they are of the new subgenus *Toquimaphyllum.*

Subgenus TOQUIMAPHYLLUM, new subgenus

1888. *Endophyllum* (*spongophylloides*?) Foerste, p. 131, pl. 13, figs. 16, 17.
1940. *Spongophyllum spongophylloides* (Foerste). Hill, p. 408, pl. xiii, figs. 3-5.
1956. *Spongophyllum.* Hill, p. F298 (in part).

Type species.—Australophyllum (*Toquimaphyllum*) *johnsoni,* n. sp.; here designated. Late Silurian coral zone E, Toquima Range, Nev.

Diagnosis.—Cerioid rugose corals possessing mature corallites with wide, almost wholly lonsdaleioid dissepimentarium, predominantly large dissepiments, and moderately wide to rather narrow, closely spaced, sagging tabulae without peripheral depression. Septa usually smooth, discontinuous peripherally as septal crests. In some mature corallites, septa greatly shortened or obsolete.

Remarks.—*Australophyllum* (*Toquimaphyllum*) differs from *Australophyllum* sensu stricto in the greater development of large lonsdaleioid dissepiments, in having an almost wholly lonsdaleioid mature dissepimentarium, in the presence of septal crests peripherally, and in the tendency to abbreviate and to lose septa in some corallites. Septa of *Toquimaphyllum* lack true carinae. *Endophyllum* differs in having a much wider tabularium, the tabulae being nearly flat to slightly arched medially with a peripheral sag not found in other described genera of this family (Jones, 1929). The type species of *Endophyllum* shows a tendency to lose the outer wall, thus becoming aphroid or partly aphroid. Insofar as known, *Endophyllum* does not have the tendency to shorten and lose septa, as do *Toquimaphyllum* and other members of this family.

Australophyllum (Toquimaphyllum) johnsoni, n. subgen., n. sp.

Plate 11, figures 1, 2, 5–7; plate 15, figure 17

Type material.—Holotype USNM 159420, Toquima Range, Nev.; paratype USNM 159422, Simpson Park Mountains, Nev. Late Silurian, coral zone E.

Diagnosis.—*Toquimaphyllum* with major septa extending to axis of normal corallites, breaking up peripherally as septal crests. Mature corallites with widest dissepimentaria having correspondingly narrow tabularia. Partially aseptate corallites retain only short inner-tip segments of major septa.

Exterior.—Mature coralla compact globular heads with diameter commonly exceeding 1 foot. Individual corallites ranging from small to large at distal surface; calices moderately deep with no fossula and with raised rims formed by the thickened wall. A few corallites with a single peripheral calice offset bounded externally by a wall angulation. Corallite wall prominently grooved longitudinally.

Transverse sections.—About 38 septa in large normal corallites; in those with suppressed septa, number reduced to 24 or fewer. Only axial tips of major septa retained in some reduced corallites. All septa discontinuous peripherally, appearing only as crests in the lonsdaleioid band. Minor septa less continuous than major septa and commonly exceeding half the length of major septa. All septa more wavy and irregular toward axis; may be slightly thickened in tabularium. Wall moderately thickened stereoplasmically, forming obtuse wall crests. No true carinae. Symmetry entirely radial. Large and very large lonsdaleioid dissepiments predominate.

Longitudinal sections.—In widest corallites, eight or more lonsdaleioid dissepiment columns on each side. Outer dissepiments of large mature corallites nearly flat; innermost three smaller and steeply inclined. In wide corallites with narrow tabularium, tabulae from ⅕ to ⅛ the diameter. Tabulae delicate, crowded, complete or incomplete; proximal sag may be pronounced. No flat tabulae with peripheral sag. Tabularium sharply set off from dissepimentarium. Some axial parts of septa with small lateral spines. Some longitudinal sections with numerous septal crests rising vertically from upper surfaces of large nearly flat dissepiments.

Fine structure.—Trabeculae nearly normal to wall in stereoplasmic thickening; internal trabecular projections present but uncommon.

Reproductive offsets.—A single offset in some calices. Small interstitial corallites common, in various stages of lonsdaleioid development and septal suppression; most interstitial corallites with septa continuous to wall

Comparison with related forms.—Closely related *Toquimaphyllum* occurs in the upper part of the middle unit of the Vaughn Gulch Limestone of the northern Inyo Mountains. *Australophyllum* (*Toquimaphyllum*) *spongophylloides* (Foerste) of the Yass-Bowning area, Australia (Hill, 1940, p. 408, pl. xiii, figs. 3–5), has wider tabulae but is otherwise very similar to *johnsoni*. *Australophyllum* (*Toquimaphyllum*) *fritschi* (Novak) of the Czechoslovakian Late Silurian as figured by Počta (1902, pl. 102) does not reveal septal crests except for the wall crests and has a somewhat thicker wall and wider tabularium. The more distantly related endophyllids of the Silurian in the Klamath Mountains, Calif., have much wider, flat tabulae with peripheral sag and are viewed as a distinct genus. *Australophyllum* of the Early Devonian Rabbit Hill Limestone is not classified in this subgenus.

Occurrence and age.—Late Silurian, coral zone E. Uppermost 200 feet of the Silurian, Coal Canyon, northern Simpson Park Mountains, Nev., localities M1026, M1106, M1108, M1335; Ikes Canyon, Toquima Range, Nev., locality M1114. Upper part of middle unit of Vaughn Gulch Limestone, Mazourka Canyon, Inyo Mountains, Calif.; locality M1115; these differ slightly from typical *johnsoni*. *Australophyllum* possibly belonging in this species occurs in the Antelope Peak section 12 miles north of Wells, Elko County, Nev.

Study material of this new form consists of 14 nearly complete and partial coralla, as follows: Locality M1114 (six), locality M1106 (three), locality M1108 (three), locality M1026 (one), locality M1335 (one). Five partial coralla were collected in the vicinity of locality M1115.

Family ACERVULARIIDAE Lecompte, 1952

Reference genus and species.—*Acervularia ananas* (Linnaeus); Silurian, Wenlock, England.

This family includes phaceloid and cerioid forms which have a fairly discrete inner wall dividing the dissepimentarium from the tabularium; the inner wall is formed by stereoplasmic addition near ends of minor septa. Major septa may continue to axis. Tabulae either are complete and slightly arched or comprise tabellae with overall sag.

The genera included in this family are *Acervularia* Schweigger, 1819, and *Diplophyllum* Hall, 1852. In the past, several Devonian species now classified as

Hexagonaria were erroneously placed in *Acervularia*. Gotland Silurian species placed in *Rhabdophyllum* Wedekind, 1927, also belong here as synonyms of *Acervularia* and possibly of *Diplophyllum* (Oliver, 1963, p. G2).

Genus DIPLOPHYLLUM Hall, 1852

1956. *Diplophyllum* Hall. Hill, p. F277, fig. 188.6a, 6b.
1963 *Diplophyllum* Hall. Oliver, p. G1; pls. 1-3.

Type species.—Diplophyllum caespitosum Hall, by monotypy. Silurian, Lockport Dolomite, New York.

Diagnosis.—"Compound rugose corals with a distinct inner wall of septal origin, separating the tabularium from a narrow peripheral dissepimentarium. The tabulae are mostly complete; dissepiments are flat to gently arched, forming a single series in each space bounded by the inner and outer walls and two adjacent septa."

Remarks.—The diagnosis here given is that of Oliver (1963, p. G1), who has reviewed the systematics of this genus in the light of restudy of the type species and Hall's original material.

Diplophyllum? sp. m

Plate 4, figures 10-14

Slender cylindrical corallites of a probable colonial form provisionally assigned to *Diplophyllum*? occur in the topmost beds of the Vaughn Gulch Limestone at Mazourka Canyon, northern Inyo Mountains. Some corallites of this weakly dissepimented species have more the character of *Palaeophyllum* than of *Diplophyllum* in lacking the false inner wall and peripheral column of dissepiments.

A normal corallite in longitudinal thin section shows an outer column of rather flat dissepiments between a thin discontinuous false inner wall and the outer stereozone. Tabulae are straight or slightly arched and may bend sharply toward the periphery. In transverse thin section, the minor septa of a normal corallite may terminate against the thin false inner wall or may bend abruptly to meet an adjacent major septum near the false inner wall. As pointed out by Oliver (written commun., 1969), the false inner wall of sp. m appears to be of tabular origin and is not actually a true inner wall.

As in some forms of *D. caespitosum* (Hall), the major septa of sp. m are continuous toward the axis of some corallites. However, the stereoplasmic swellings near tips of minor septa in *caespitosum* were not recognized in the Vaughn Gulch species. (See Oliver, 1963, pl. 2, fig. 1.) The *Palaeophyllum*-like corallites of this western form in transverse thin section resemble those of *P. margaretae* Flower (1961, pl. 48) but have much less arching of tabulae.

Occurrence.—Northern Inyo Mountains, west side at mouth of Mazourka Canyon; locality M1090, within 20 feet of top of Vaughn Gulch Limestone. These beds are here considered to be either Late Silurian or Early Devonian.

Genera with no family designation

Genus SALAIROPHYLLUM Besprozvannikh, 1968

Salairophyllum? sp.

Plate 12, figures 6-8

A solitary coral referred provisionally to the Russian genus is characterized by wide, more or less complete, close-spaced tabulae, a relatively narrow dissepimentarium and fairly wide septal stereozone. Septa of mature growth stages number about 56; some of the greatly thinned major septa reach the axis, longer minor septa are half the length of major septa. Septa are thickened stereoplasmically to a point beyond the stereozone, thinning markedly thence toward the axis. Some septa are minutely wavy with well-developed lateral spines which are not true carinae.

Observed in longitudinal thin section, some of the wide close-set tabulae are nearly flat. Peripherally inclined trabeculae are especially well shown in the stereozone; some of these extend into the dissepimentarium as long spines like those of Tryplasmatidae. The small dissepiments are steeply inclined in two or three columns.

The fully mature calice of the figured specimen shows four peripheral offsets.

This coral is most closely related to undescribed *Salairophyllum*? from Kuiu Island, southeastern Alaska (loc. M1186), where it occurs with *Conchidium alaskense*. Septa are more numerous in the Alaskan species. The Russian *S. angustum* (Zheltonogova) has fewer septa and a wider stereozone. It occurs in strata reported by Shurygina (1968, p. 123) as Early Devonian; however, the Silurian-Devonian boundary fauna listed in association has a distinctly Gotlandian Silurian aspect.

Occurrence.—Probably from upper Silurian coral zone E, upper beds of the Roberts Mountains Formation. Coal Canyon, northern Simpson Park Mountains, Nev. Float material, locality M1117, collected by R. J. Roberts.

Genus DENAYPHYLLUM, new genus

Type species.—Denayphyllum denayensis, n. gen, n. sp. Here designated. Silurian, type section of the Roberts Mountains Formation, Roberts Creek Mountain, Nev., upper 600 feet.

Diagnosis.—Slender phaceloid rugose corals with about 12 fairly thin major septa which are slightly withdrawn from the axis; a wall which is thin to only moderately thickened; a single column of large, partly horizontal and fairly uniform dissepiments; and rather widely spaced, complete tabulae which are straight or have an axial sag.

Remarks.—Denayphyllum resembles *Battersbyia* Edwards and Haime, 1851, the type species of which—*B. inaequalis* Edwards and Haime—is reported from the Devonian of Teignmouth, Devonshije, England. The figures of Edwards and Haime (1853, pl. 47, figs. 2-2b, transverse sections only) represent *B. inaequalis* to have a thicker wall. Glinski (1957, p. 91–106) has reviewed in detail the classification and structure of Devonian corals of this kind from the Rhine River valley, Germany, pointing out that *Fasciphyllum* Schlüter, 1885, is a subjective synonym of *Battersbyia*. Glinski's longitudinal sections of *Battersbyia* show a thick wall and a more irregular arrangement of large elongate and small steeply inclined dissepiments which double here and there to form two columns, though in other places dissepiments are absent, as in *Dendrostella* Glinski, 1957. *Denayphyllum* differs from *Columnaria* Goldfuss in having much larger and more uniform, nearly horizontal dissepiments in a single column, and narrower tabulae.

Denayphyllum denayensis, n. sp.

Plate 7, figures 15–18

Type material.—Holotype USNM 159407.

Diagnosis.—*Denayphyllum* with few or no minor septa and fairly straight corallites without connecting processes. Nearly horizontal dissepiments about one-third the diameter, or about same as width of tabulae.

Transverse sections.—Average of 12 septa, but ranging from 10 to about 15, most slightly withdrawn from the axis, but some reaching the axis. Short minor septa uncommon. Wall normally thickened slightly as a narrow stereozone. Septa usually thickened moderately and progressively toward the periphery and somewhat wavy. Few dissepiments, only at the border of the tabularium.

Longitudinal sections.—Characteristically, a single column of large dissepiments which are either almost horizontal or inclined axially; no specimens with doubling of dissepiments or places where these structures are lacking, as in *Columnaria.* Tabulae complete, widely spaced, most with a slight sag. In longitudinal section, corallite is divided into three columns, each one-third of the diameter, the tabulae being the middle third.

Reproductive offsets.—None observed.

Comparison with related forms.—No similar rugose corals are known from the American Silurian or Devonian. Only European species of the Middle Devonian assigned to *Battersbyia* are structurally comparable; the generic differences have been dealt with above.

Occurrence.—Unit 3 in type section of the Roberts Mountains Formation, Middle Silurian, coral zone C. Roberts Creek Mountain, Nev. locality M1102. At locality M1102 this coral occurs in large tabular colonies. The study material consists of six pieces broken from one large colony collected in place.

LOCALITY REGISTER

North-central Great Basin

Tuscarora Mountains, northern Eureka County, Nev.:

Locality M287.—Near Elko-Eureka County line on east side of road between Dunphy and Tuscarora. Talus slope at base of hill. Limestone with abundant silicified fossils of Silurian age, including *Coelospira.* Collected by R. J. Roberts, 1954.

Locality M1120.—Tuscarora Mountains, at north end of Eureka County, Nev.; "Round Mountain," southwest end. Probably the "Lynn Window" vicinity of R. J. Roberts. Silurian limestone with rugose corals. Collected by R. J. Roberts, June 1958.

Southern Ruby Mountains, Nev.:

Locality M1124.—Sherman Mountain quadrangle, Nevada. North of Sherman Mountain, 3 miles southeast of Mitchell Ranch on northeast side of Sherman Creek; altitude 8,400 feet. Silicified corals collected by Ronald Willden and R. W. Kistler, 1967.

Northern Simpson Park Mountains, Nev.:

Coal Canyon area; Horse Creek Valley quadrangle:

Locality M1026.—East side of Coal Canyon near its mouth, SE¼ sec. 17, T. 25 N., R. 49 E.; altitude 6,320 feet. Coarse limestone breccia in upper part of the Silurian section, about 100 feet stratigraphically below the contact with the Lower Devonian (Helderberg) Rabbit Hill Limestone.

Locality M1105.—Bottom of Coal Canyon, four-tenths of a mile south of its mouth; float material from upper part of the Silurian limestone on east side of canyon.

Locality M1106.—Near mouth of Coal Canyon on east side; altitude 6,300 feet. Silurian coral-rich limestone breccia.

Locality M1107.—About one-quarter of a mile south of mouth of Coal Canyon on east side; 200 feet above canyon bottom. Silurian coral-rich limestone breccia below Rabbit Hill Limestone.

Locality M1108.—Near mouth of Coal Canyon, on east side; float material below Silurian limestone breccia.

Locality M1110.—Vicinity of locality M1026. Collections made by A. J. Boucot, 1964.

Locality M1117.—NE¼ sec. 20, T. 25 N., R. 49 E.; probably about six-tenths of a mile south of Coal Canyon mouth on east side of canyon. Collections made by R. J. Roberts, 1954.

Central Great Basin

Roberts Creek Mountain, Nev.; Roberts Creek Mountain quadrangle:

Locality M1089.—Northwest side of Roberts Creek Mountain; measured section on top spur between south and middle forks of Pete Hanson Creek, 2,500 feet N. 79° W. of summit 9219; altitude 8,500 feet. Base of unit 3 of type section of Roberts Mountains Formation.

Locality M1101.—Same horizon and locality as locality M1089.

Locality M1102.—Same measured section as locality M1089, about 100 feet stratigraphically above locality M1089. Lower beds of unit 3 with rugose coral fauna.

Locality M1100.—Same measured section as locality M1089. 1,800 feet N. 79° W. of summit 9219; altitude 8,680 feet. Upper beds of unit 3 of Roberts Mountains Formation.

Southern Sulphur Spring Range, Nev.; Garden Valley quadrangle:

Locality M1121.—Dolomite hills 2 miles south-southwest of Romano Ranch, at east edge of range; eight-tenths of a mile S. 60° W. of bench mark 5825, on top of easternmost ridge; altitude 6,440 feet. Lone Mountain Dolomite, lower part with silicified fossils.

Lone Mountain, Eureka County, Nev.; Whistler Mountain quadrangle:

Locality M1122.—South side of Lone Mountain. Lone Mountain Dolomite with fragmentary rugose corals, four-tenths of a mile due south of summit 7360; altitude 6,840 feet.

Southern Mahogany Hills, Nev.; Bellevue Peak quadrangle:

Locality M1112.—About 1½ miles due north of top of Wood Cone Peak, half a mile north-northwest of bench mark 7201 in lower foothills; altitude 7,350 feet. Upper part of Silurian Lone Mountain Dolomite with rugose coral fauna in dark-gray dolomite facies.

Southern Fish Creek Range, Nev.; Bellevue Peak quadrangle:

Locality M1087.—West side of range at south boundary of quadrangle, about 2,000 feet due south of summit 7232; altitude 7,000 feet. Lone Mountain Dolomite, upper part with silicified rugose coral fauna.

Locality M1113.—At south boundary of quadrangle, four-tenths of a mile south-southeast of hill 7232; altitude 7,080 feet. Lone Mountain Dolomite, upper part with silicified coral and brachiopod fauna.

West-central Great Basin

Toquima Range, Ikes Canyon, Nev.; Dianas Punch Bowl quadrangle:

Locality M1088.—About 1 mile up Ikes Canyon from mouth; north side of canyon, 150 feet above bottom; altitude 7,840 feet. Silurian Masket Shale of Kay and Crawford (1964).

Locality M1103.—Same locality and section as locality M1088, about 250 feet above canyon bottom; altitude 7,900 feet. Silurian Masket Shale of Kay and Crawford (1964).

Locality M1104.—Collections made by Kay and Crawford (1964) from their McMonnigal Limestone Ikes Canyon area. Probably from beds north of Ikes Cabin, north side Ikes Canyon, 1¼ miles northwest of mouth of this canyon.

Locality M1114.—Ikes Canyon area, one-eighth of a mile northwest of summit 8474 (Copper Mountain); altitude 8,300 feet. Probably in McMonnigal Limestone of Kay and Crawford (1964). Coral fauna of Silurian coral zone E.

South-central Great Basin

Monitor Range, Dobbin Summit area, Nye County, Nev.:

Locality M1123.—About 1 mile southeast of East Dobbin Summit Spring, on east side of canyon. Silurian beds below Rabbit Hill Limestone.

Hot Creek Range, Tybo area, Nye County, Nev.:

Locality M1125.—Ridge north of town of Tybo; probably about 2,000 feet north of Cunningham prospect. Silurian dolomite above Eureka Quartzite.

Southwestern Great Basin

Northern Inyo Mountains, Calif.; Independence quadrangle:

Locality M1086.—Mouth of Mazourka Canyon; foothills on north side Vaughn Gulch, in NE¼ sec. 8, T. 13 S., R. 36 E. Northeast-southwest measured section. Lower unit of Silurian Vaughn Gulch Limestone, 550 feet stratigraphically above top of quartzite of Ordovician Johnson Spring Formation. (See fig. 3.)

Locality M1090.—Same measured section as locality M1086; beds of Late Silurian or Early Devonian age within 20 feet of top of Vaughn Gulch Limestone.

Locality M1091.—Same measured section as locality M1086; near east line of sec. 8, T. 13 S., R. 36 E.; altitude 4,840 feet. About 150 feet stratigraphically above chert unit at base of Vaughn Gulch Limestone.

Locality M1092.—Same measured section as locality M1086; west of east line of section 8; altitude 4,880 feet. Middle unit of Vaughn Gulch Limestone, about 1,000 feet stratigraphically above Barrel Spring Formation.

Locality M1093.—Same measured section as locality M1086; upper unit of Vaughn Gulch Limestone between localities M1090 and M1092, about 1,350 feet stratigraphically above Barrel Spring Formation, 450 feet stratigraphically below top of Vaughn Gulch Limestone.

Locality M1115.—Same measured section as locality M1086; about 110 feet stratigraphically below horizon of locality M1093.

Locality M1116.—Same measured section as locality M1086; coral bed 30 feet stratigraphically below locality M1093.

Locality M1118.—Same measured section as locality M1086; fossil collections made between localities M1092 and M1093. Upper part of middle unit of Vaughn Gulch Limestone.

Locality M1119.—Same measured section as locality M1086; middle unit of Vaughn Gulch Limestone, below locality M1092.

Southern Inyo Mountains:

Locality M1126.—New York Butte quadrangle, California; 13,000 feet due north of Cerro Gordo mine, south side of Bonham Canyon; altitude 7,200 feet. Silurian dolomite with fossils.

Northern Panamint Range:

Locality M1094.—Ubehebe Peak quadrangle, California; 1½ miles north of top of Ubehebe Peak, eight-tenths of a mile west of bench mark 3765. About 200 feet stratigrpcally above base of Hidden Valley Dolomite in Silurian coral zone B.

Locality M1095.—Quartz Spring area of J. F. McAllister; 22,600 feet S. 15° W. of Rest Spring, south side Andy Hills, in lower part of Hidden Valley Dolomite. Silurian coral fauna.

Locality M1096.—Quartz Spring area of J. F. McAllister; 9,600 feet N. 86° E. of Rest Spring at Whitetop Mountain. Silurian corals in lower part of Hidden Valley Dolomite.

Locality M1109.—Quartz Spring area of J. F. McAllister; 22,500 feet S. 18° W. from Rest Spring, south side of Andy Hills. Lower part of Hidden Valley Dolomite with Silurian corals.

Locality M1111.—Ubbehebe Peak quadrangle, California; about 1½ miles north of Ubehebe Peak, at east foot of range and two-tenths of a mile east of locality M1094. Silurian coral float from lower beds of Hidden Valley Dolomite.

Funeral Mountains:

Locality M1097.—Ryan quadrangle, California; 1.95 miles N. 51° W. of Pyramid Peak. Lower part of Hidden Valley Dolomite with Silurian corals.

Locality M1098.—Ryan quadrangle, California; 3 miles S. 22° E. of Schwaub Peak. Silurian corals, lowest fossil collections in Hidden Valley Dolomite.

Locality M1127.—Ryan quadrangle, California; 1.9 miles N. 59° E. from Pyramid Peak. Silicified Silurian fossils from cherty dolomite 100–150 feet above base of Hidden Valley Dolomite.

Bare Mountain, Nevada:

Locality M1085.—Bare Mountain quadrangle, Nevada; northeast side of Bare Mountain; south side of Tarantula Canyon near its head; near north edge sec. 36, T. 12 S., R. 47 E.; altitude 5,000 feet. Corals in lower part of Silurian section.

Locality M1099.—Bare Mountain quadrangle, Nevada; Chuckwalla Canyon near mouth, on north side; altitude about 4,300 feet. Dark-gray Silurian limestone with corals, about 150 feet stratigraphically below contact with light-gray dolomite.

Eastern Great Basin

Confusion Range, Utah:

Locality M1129.—Southern part of Confusion Range; NW¼ sec. 23, T. 18 S., R. 16 W. /Isolated dolomite exposure containing *Palaeocyclus* and other Silurian Fossils. Collected by R. K. Hose.

Locality M1137.—Kings Canyon on U.S. Highway 6 and 50, near top of Confusion Range; Conger Mountain quadrangle. South side of road about 1,700 feet east of bench mark 5949; altitude 6,200 feet. Upper dark-gray Laketown Dolomite with *Rhabdocyclus*. Collected by A. J. Boucot.

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PLATES 1–16

[Contact photographs of the plates in this report are available, at cost, from the U.S. Geological Survey Photographic Library, Federal Center, Denver, Colorado 80225]

PLATE 1

FIGURES 1–3. *Dalmanophyllum* sp. A.

1, 2. Lateral and calice views (× 2); USNM 159360. Lower Silurian, coral zone A, lower unit of Vaughn Gulch Limestone; locality M1091, Mazourka Canyon, northern Inyo Mountains, Calif.

3. Calice view (× 2); USNM 159361. Lower Silurian, coral zone A, lower member of Hidden Valley Dolomite; locality M1096, Whitetop Mountain, Ubehebe district, California.

4. *Dalmanophyllum dalmani* (Edwards and Haime).

Lateral view (× 2); Flint Ridge, Ohio. Copy of Edwards and Haime holotype figure (1851, pl. 1, fig. 6).

5, 6. *Brachyelasma* sp.

Transverse and longitudinal thin sections of same individual (× 2), USNM 165355. Middle Silurian, coral zone B, lower part of Hidden Valley Dolomite; locality M1098, Ryan quadrangle, Funeral Mountains, Calif.

7, 8. *Rhegmaphyllum* sp. h.

Calice and lateral views (× 2); USNM 159362. Lower Silurian, coral zone A, lower member of Hidden Valley Dolomite; locality M1096, Whitetop Mountain, Ubehebe district, California.

9–11. *Brachyelasma* sp. B.

9, 10. Transverse and longitudinal thin sections of same individual (× 2); USNM 159363. Middle Silurian, coral zone B, lower part of Hidden Valley Dolomite; locality M1094, Ubehebe district, California.

11. Longitudinal thin section (× 2), USNM 165352. Coral zone B, lower part of Hidden Valley Dolomite; locality M1097, Ryan quadrangle, Funeral Mountains, Calif.

12–15, 17. *Palaeocyclus porpita* subsp. *mcallisteri*, n. subsp.

12. Edge view of paratypes (× 3); USNM 159364.

13, 14. Bottom and calice views of holotype (× 3); USNM 159365.

15. Calice view of paratype (× 2); USNM 159366.

17. Calice view of paratype (× 2); USNM 159367.

Lower Silurian, coral zone A, lower member of Hidden Valley Dolomite; locality M1096, Whitetop Mountain, Ubehebe district, California.

16. *Palaeocyclus porpita* cf. subsp. *mcallisteri*, n. subsp.

Calice view (× 2½); USNM 159368. Lower Silurian, coral zone A; locality M1129, Confusion Range, Utah.

18–21. *Palaeocyclus porpita* (Linnaeus).

18, 21. Calice and edge views, same individual (× 2); USNM 159369.

19. Edge view (× 2); USNM 159370.

20. Edge view of broken individual (× 3), showing calice and trabeculae; USNM 159371. Lower Silurian, Visby, Gotland, Sweden.

22, 23. *Rhabdocyclus* sp. d.

22. Calice view (× 4), showing trabecular spines; USNM 159372.

23. Lateral view of broken individual (× 2), showing calice and trabecular spines; USNM 159373.

Lower Silurian, coral zone A; locality M1096, Whitetop Mountain, Ubehebe district, California.

24, 25. *Rhabdocyclus* sp. B.

Calice views of two large individuals (× 1½); USNM 165353a, 165353b. Silurian; locality M1099, Chuckwalla Canyon, Bare Mountain quadrangle, Nevada.

26–28. *Tryplasma duncanae*, n. sp.

26. Lateral view of holotype (× 2); USNM 159374.

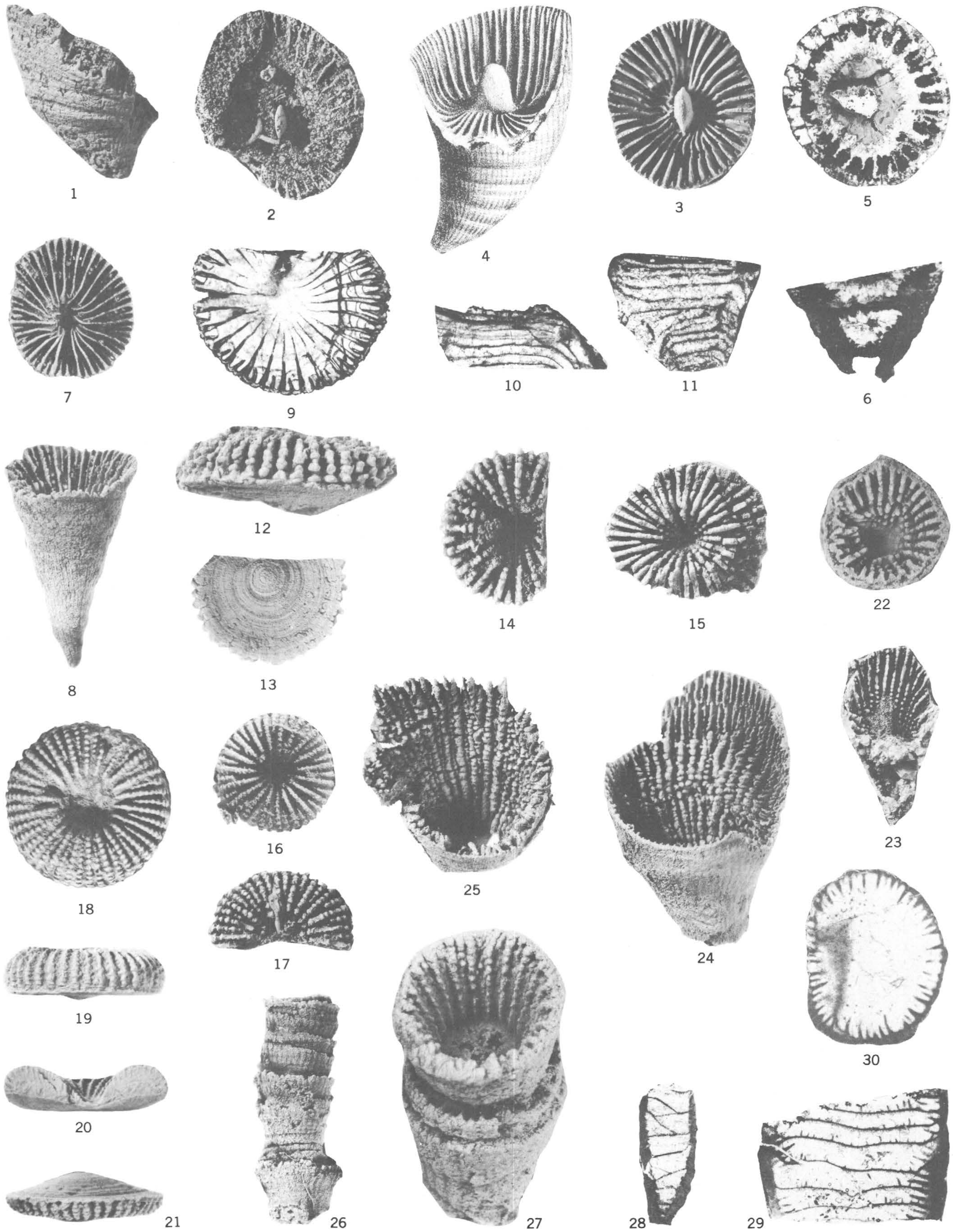
27. Calice view of paratype (× 5); USNM 159375.

28. Longitudinal thin section (× 2½); USNM 159376.

Middle Silurian, coral zone D, unit 3 of Roberts Mountains Formation; localitv M1100, Roberts Creek Mountain, Nev.

29, 30. *Tryplasma* sp. R.

Longitudinal and transverse thin sections (× 4); USNM 165354. Middle Silurian, bottom of coral zone C, base of unit 3 of Roberts Mountains Formation; locality M1101, Roberts Creek Mountain, Nev.



DALMANOPHYLLUM, BRACHYELASMA, RHEGMAPHYLLUM, PALAEOCYLUS, RHABDOCYCLUS,
AND *TRYPLASMA*

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PLATE 2

FIGURES 1–4. *Tryplasma newfarmeri*, n. sp.

1. Longitudinal thin section (× 3); holotype, USNM 159377.
2, 3. Longitudinal views of a single thin section (× 4); holotype, USNM 159377.
4. Transverse thin section (× 2); holotype, USNM 159377.

Silurian, coral zone C, unit 3 of Roberts Mountains Formation; locality M1102, Roberts Creek Mountain, Nev.

5, 6. *Palaeophyllum*? sp. c.

Longitudinal and transverse thin sections (× 2). Lower Silurian, lower unit of Vaughn Gulch Limestone; locality M1086, northern Mazourka Canyon, Inyo Mountains, Calif.

7–10. *Stylopleura*? sp. T.

Transverse and longitudinal sections of USNM 159378.

7. Smoothed surface photographed in water (× 1).
8–10. Thin sections (× 1½).

Silurian or Lower Devonian limestone; locality M1104, Ikes Canyon vicinity, Toquima Range, Nev.

11, 12. *Stylopleura nevadensis*, n. gen., n. sp.

Transverse and longitudinal thin sections of paratype (× 4); USNM 159379. Middle Silurian, coral zone D, Masket Shale of Kay and Crawford (1964); locality M1103, Ikes Canyon, Toquima Range, Nev.

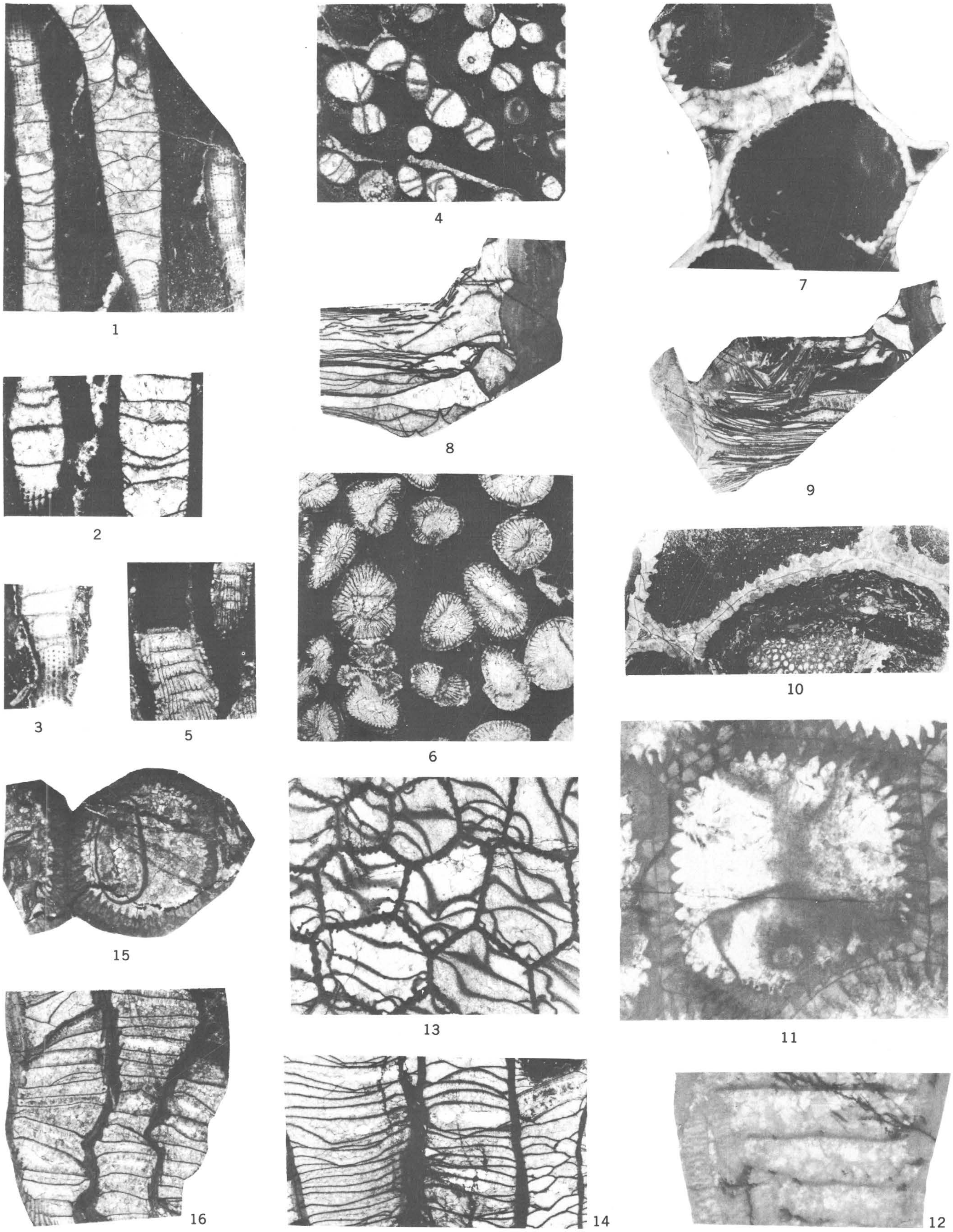
13, 14. *Maikottia* sp., cf. *M. turkestanica* Lavrusevich.

Transverse and longitudinal thin sections (× 2) of large massive colony. Upper Silurian or Lower Devonian; Porcupine River, half a mile upstream from mouth of Salmontrout River, Alaska.

15, 16. *Stylopleura nevadensis*, n. gen., n. sp.

15. Transverse thin section (× 2); paratype, USNM 159440.
16. Longitudinal section (× 1½); paratype, USNM 159440a.

Upper part of the Silurian section; locality M1105, Coal Canyon, northern Simpson Park Mountains, Nev.



TRYPLASMA, PALAEOPHYLLUM?, STLOPLEURA, AND *MAIKOTTIA*

PLATE 3

FIGURES 1–3. *Stylopleura* cf. *S. berthiaumi.*

1. Lateral view of part of a fasciculate colony (× 1); USNM 165356.

2, 3. Transverse and longitudinal sections (× 2).

Silurian; locality M1099, Chuckwalla Canyon, Bare Mountain quadrangle, Nevada.

4, 5. *Palaeophyllum* sp. b.

Transverse and longitudinal sections (× 2½); USNM 165357. From large phaceloid colony. Lower part of Silurian section; locality M1085, Bare Mountain quadrangle, Nevada.

6–8. *Stylopleura berthiaumi*, n. gen., n. sp.

Calice and two lateral views (× 1); USNM 159380. Upper Silurian, coral zone D; locality M1103, Ikes Canyon, Toquima Range, Nev.

9–17. *Stylopleura berthiaumi*, n. gen., n. sp.

9, 10. Calice view and longitudinal polished section of paratype (× 1); USNM 159381.

11. Partial lateral view of holotype (× 1½); USNM 159382.

12. Calice view of paratype (× 2), showing multiple calice budding; USNM 159383.

13. View of broken calice interior, showing three offsets (× 2).

14. Partial lateral view of paratype (× 1), showing lateral pillar attached to *Cladopora* branch; USNM 159384.

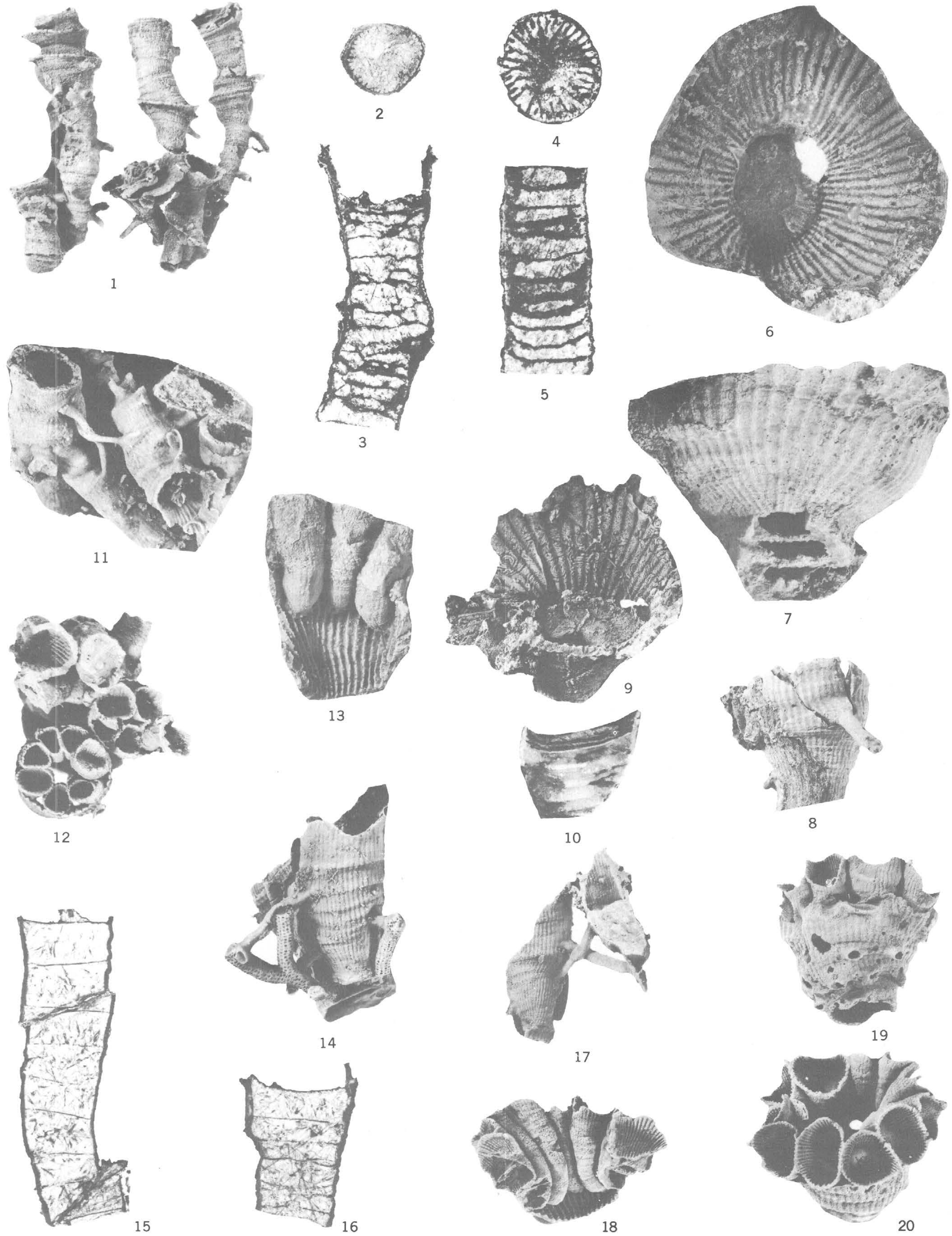
15, 16. Longitudinal thin sections (× 2); USNM 165358a, 165358b.

17. Lateral view of a piece of a large colony (× 1), showing connecting pillars; USNM 165359.

Upper Silurian, coral zone D, unit 3 of Roberts Mountains Formation; locality M1100, Roberts Creek Mountain, Nev.

18–20. *Stylopleura berthiaumi*, n. gen., n. sp.

Partial interior view of calice offsets and lateral view and calice view of same individual (× 1), showing multiple calice budding and bases of lateral pillars; USNM 159385. Upper Silurian, coral zone E; locality M1106, Coal Canyon, northern Simpson Park Mountains, Nev.



STYLOPLEURA AND *PALAEOPHYLLUM*

PLATE 4

FIGURES 1, 2. *Kodonophyllum truncatum* (Linnaeus).

1. Transverse thin section (× 2). Silurian, Wenlock Limestone; Dudley, England.
2. Longitudinal thin section (× 3). Silurian; Lilla Karlsö Island (off Gotland), Sweden.

Both figures copied from plate viii, Smith and Tremberth, 1929.

3–7. *Kodonophyllum mulleri*, n. sp.

3. Longitudinal thin section (× 2) of holotype; USNM 159386.
4. Longitudinal thin section (x4) of holotype; USNM 159386. Enlargement of part of fig. 3.
5. Transverse thin section (× 2) of holotype; USNM 159386a.
6. Transverse thin section (× 4) of holotype; USNM 159386b.

Upper Silurian, coral zone E; locality M1108, Coal Canyon, northern Simpson Park Mountains, Nev.

7. Transverse thin section (× 1½) of paratype; USNM 159389.

Upper Silurian, coral zone E; locality M1107, Coal Canyon, northern Simpson Park Mountains, Nev.

8, 9. *Kodonophyllum* sp. a.

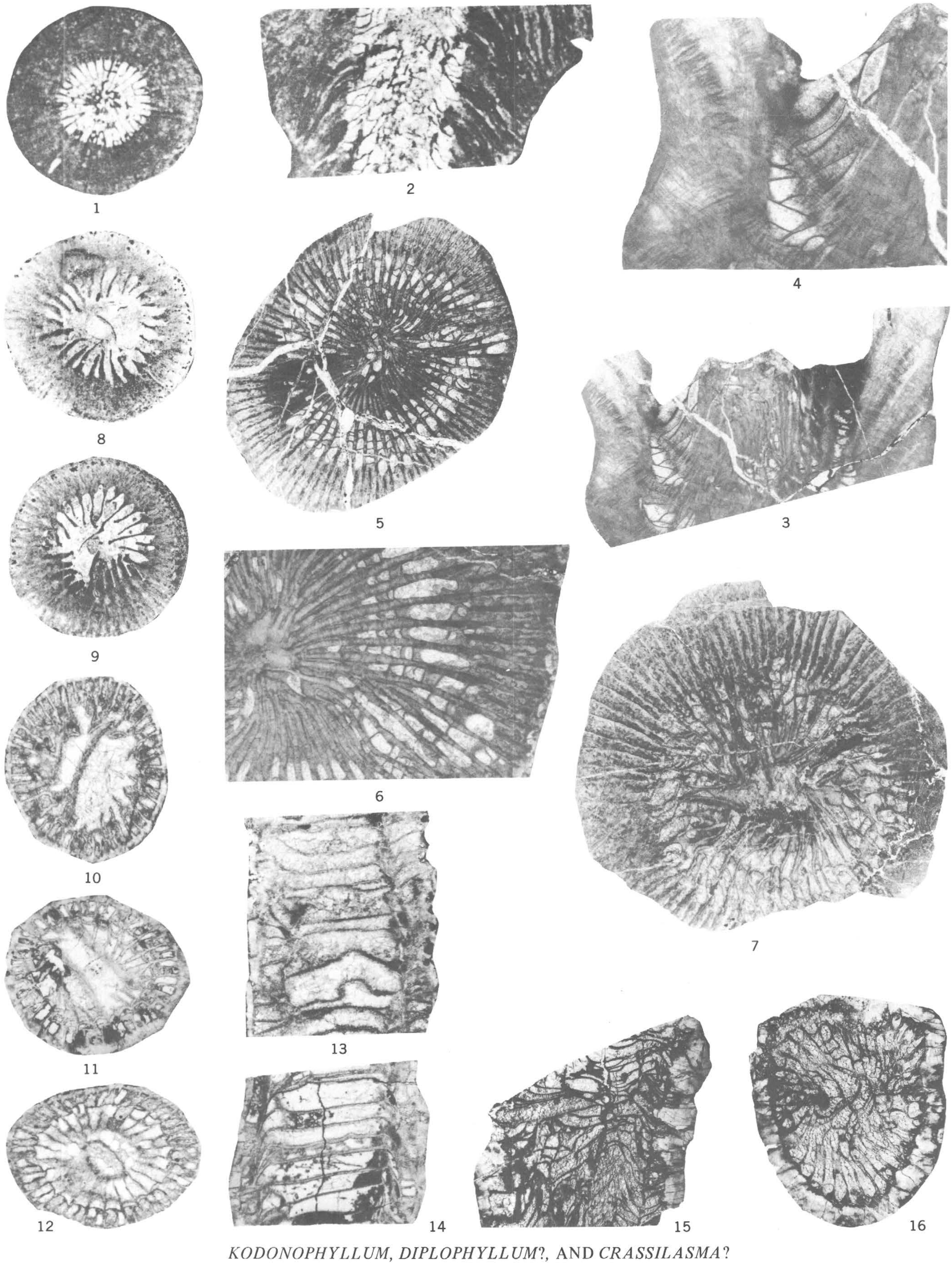
Transverse sections of ephebic stage (× 4). Silurian; Gotland, Sweden. Both figures copied from plate X, Minato, 1961.

10–14. *Diplophyllum*? sp. m.

Transverse and longitudinal thin sections (× 3½), USNM 165350. Upper Silurian or Lower Devonian, topmost beds of Vaughn Gulch Limestone; Mazourka Canyon, Inyo Mountains, Calif.

15, 16. *Crassilasma*? sp.

Longitudinal and transverse thin sections (× 2), USNM 165351. Middle Silurian, middle unit of Vaughn Gulch Limestone; Mazourka Canyon, Inyo Mountains, Calif.



KODONOPHYLLUM, *DIPLOPHYLLUM*?, AND *CRASSILASMA*?

PLATE 5

FIGURES 1-6. *Mucophyllum oliveri*, n. sp.

1. Transverse section of holotype (× 1); smoothed surface photographed in water; USNM 159390.
2. Longitudinal thin section of holotype (× 2); USNM 159390.
3. Enlargement of part of same thin section as fig. 2 (× 4), showing trabeculae; USNM 159390.
4. Part of transverse thin section of holotype (× 4), showing pattern of trabeculae; USNM 159390.
5. Calice view (× 1) of paratype; USNM 165349.
6. Longitudinal section of paratype (× 1), showing depth of calice pit; photographed in water; USNM 159391.

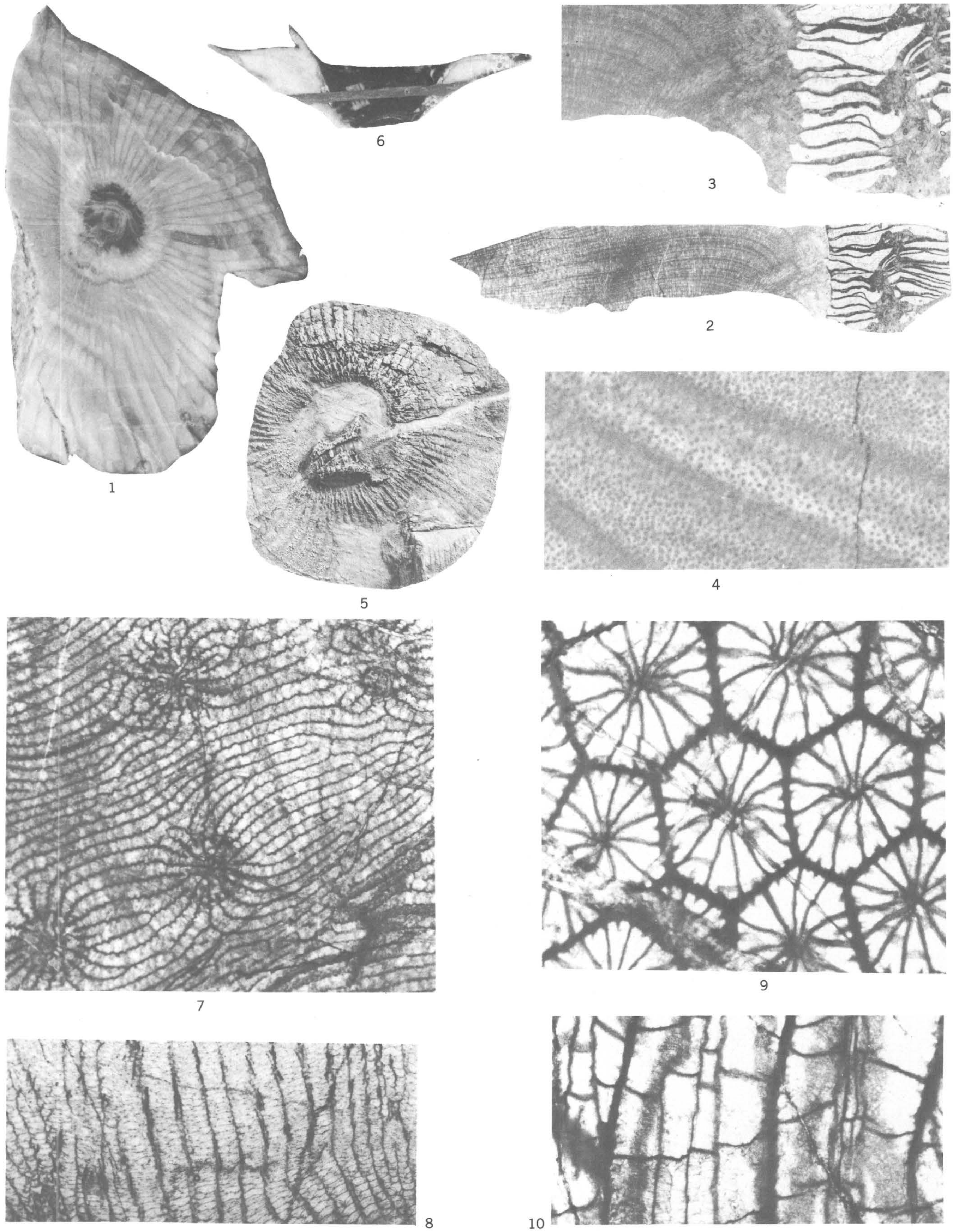
Upper Silurian, coral zone E; locality M1108, Coal Canyon, northern Simpson Park Mountains, Nev.

7, 8. *Arachnophyllum kayi*, n. sp.

Transverse and longitudinal thin sections of holotype (× 8); USNM 159392. Lower Silurian, coral zone A, Masket Shale of Kay and Crawford (1964); locality M1088, Ikes Canyon, Toquima Range, Nev.

9, 10. *Cyathophylloides fergusoni*, n. sp.

Transverse and longitudinal sections of holotype (× 8); USNM 159393. Lower Silurian, coral zone A, Masket Shale of Kay and Crawford (1964); locality M1088, Ikes Canyon, Toquima Range, Nev.



MUCOPHYLLUM, ARACHNOPHYLLUM, AND *CYATHOPHYLLOIDES*

PLATE 6

FIGURES 1-7. *Ryderophyllum ubehebensis*, n. sp.

1. Transverse thin section of paratype (× 2); USNM 159394.
2. Longitudinal thin section of paratype (× 3); USNM 159395.
3. Transverse thin section of holotype (× 2); USNM 159396.
4. Longitudinal thin section of paratype (× 2); USNM 159397.
5. Longitudinal thin section of paratype (× 1); USNM 159398.
6. Lateral view of paratype (× 1); USNM 159441.
7. Transverse thin section of paratype (× 4); USNM 159399.

Lower Middle Silurian, coral zone B, lower part of Hidden Valley Dolomite; locality M1094, Ubehebe district, California.

8. *Ryderophyllum* sp.

Transverse thin section (× 2). Upper Silurian or Lower Devonian, upper unit of Vaughn Gulch Limestone; locality M1093, Mazourka Canyon, Inyo Mountains, Calif.

9. *Crassilasma*? sp.

Transverse thin section (× 2). Same locality as fig. 8.

10-12. *Pycnactis* sp. k.

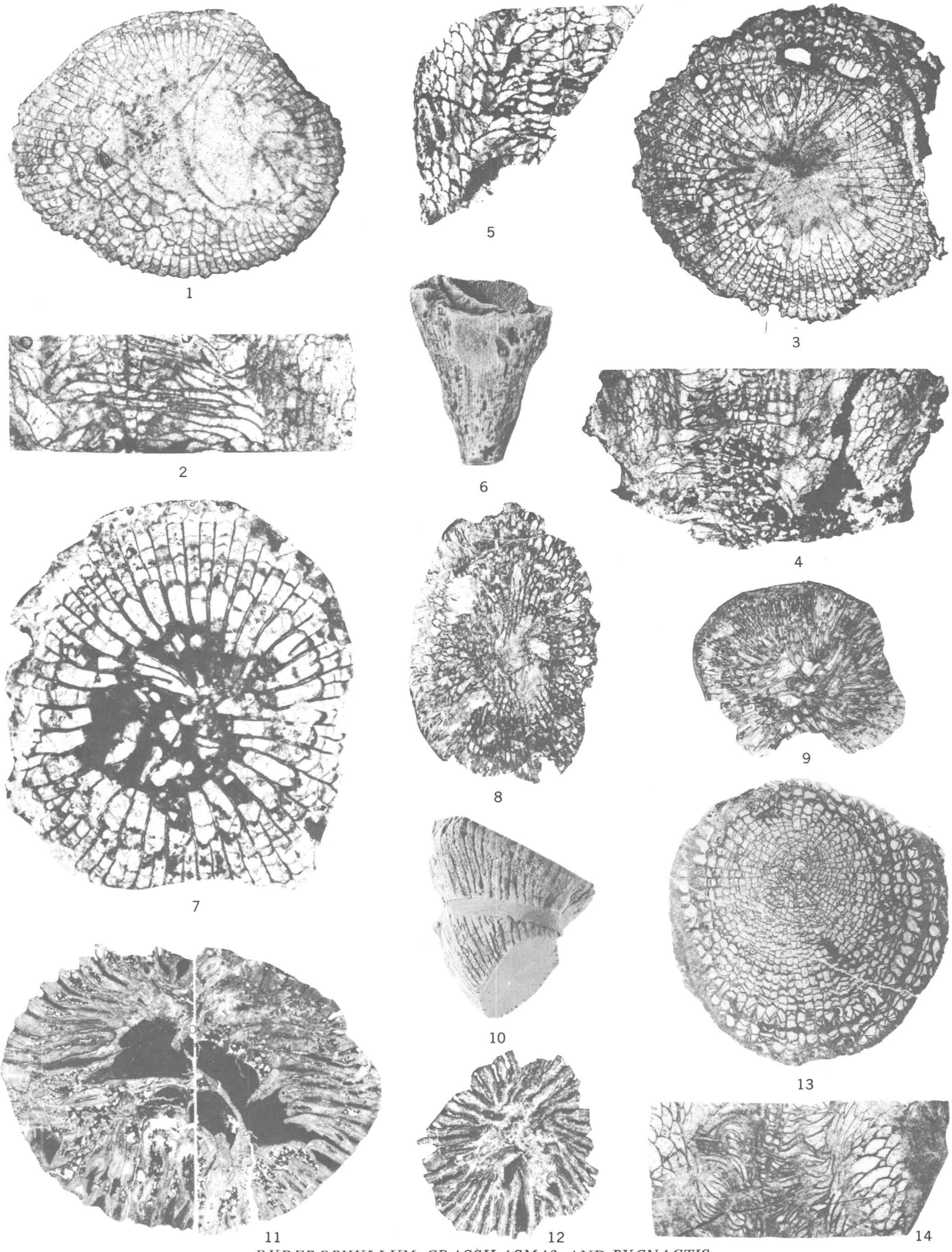
10, 12. Lateral view (× 1) and transverse thin section (× 2) of same individual; USNM 159400.

11. Transverse thin section (× 2); USNM 150401.

Lower Middle Silurian, coral zone B, lower part of Hidden Valley Dolomite; locality M1109, Andy Hills, Ubehebe district, California.

13, 14. *Ryderophyllum*? sp.

13. Transverse thin section (× 2). Upper Silurian, coral zone E; locality M1106, Coal Canyon, northern Simpson Park Mountains, Nev.
14. Longitudinal thin section (× 4). Upper Silurian, coral zone E; locality M1110, Coal Canyon, northern Simpson Park Mountains, Nev.



RYDEROPHYLLUM, CRASSILASMA?, AND *PYCNACTIS*

PLATE 7

FIGURES 1–8. *Tonkinaria simpsoni*, n. gen., n. sp.

1, 2 Lateral view (× 1½) of paratype; USNM 159402.

3, 4. Calice and lateral views of holotype (× 1½); USNM 159403.

5, 6. Transverse thin section (× 4) and longitudinal thin section (× 3½) of paratype; USNM 159404.

7. Transverse thin section (× 2); USNM 159405.

8. Calice view (× 2).

Upper Silurian, coral zone D, unit 3 of Roberts Mountains Formation; locality M1100 Roberts Creek Mountain, Nev.

9. *Tonkinaria* cf. *T. simpsoni*.

Lateral view of colony showing peripheral calice offsets (× 2); USNM 159406. Lower part of Hidden Valley Dolomite; locality M1097, Ryan quadrangle, Funeral Mountains, Calif.

10, 11. *Microplasma*? sp. R.

Transverse and longitudinal thin sections (× 2). Middle Silurian, bottom of coral zone C, base of unit 3 of Roberts Mountains Formation; locality M1089, Roberts Creek Mountain, Nev.

12–14. *Rhizophyllum* sp. D.

Calice view (× 1), view of flat side (× 1), and transverse thin section (× 2) of same individual; USNM 121346. Upper Middle Silurian, middle unit of Vaughn Gulch Limestone; near locality M1092, Mazourka Canyon, northern Inyo Mountains, Calif.

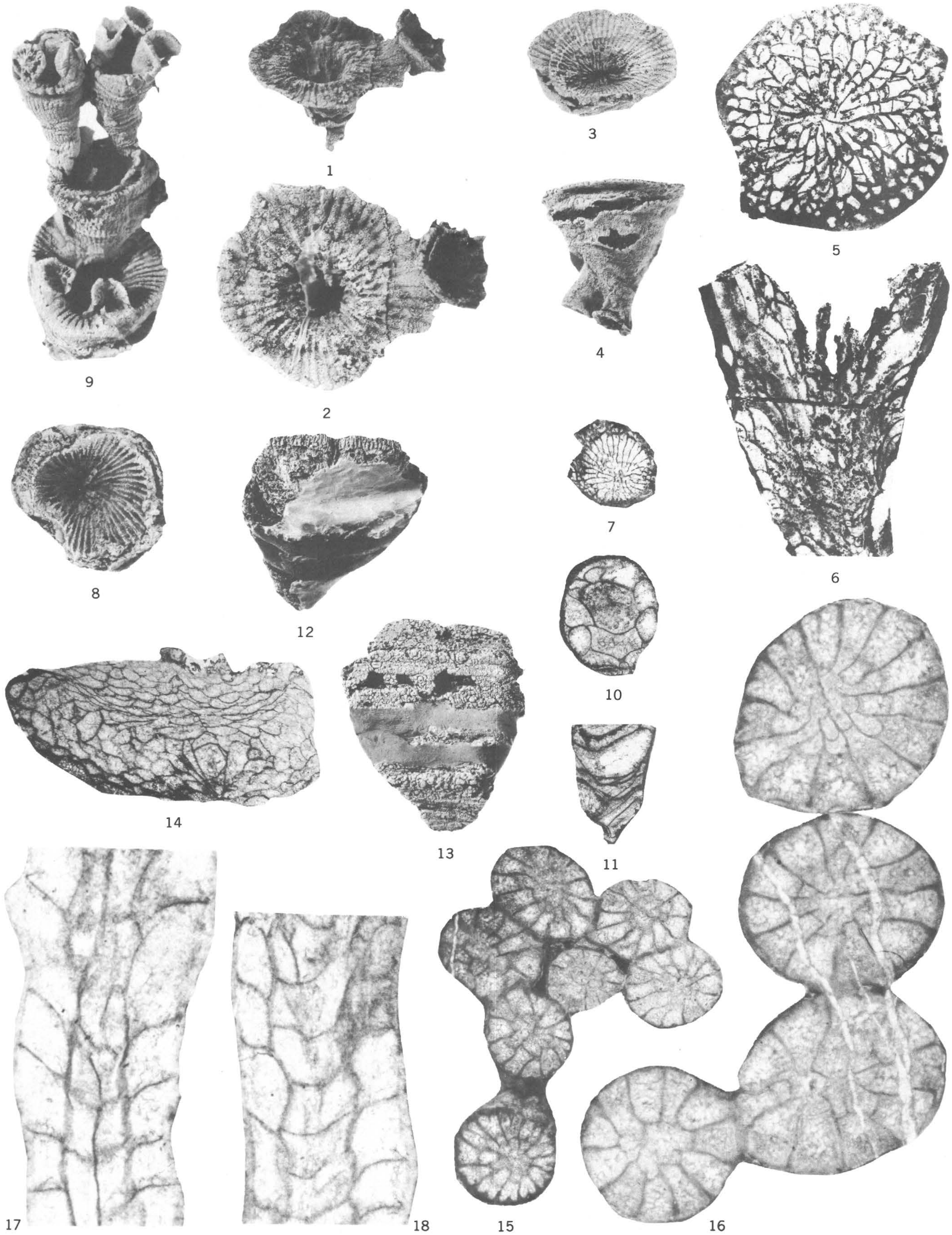
15–18. *Denaphyllum denayensis*, n. gen., n. sp.

15. Transverse thin section of holotype (× 7½); USNM 159407.

16. Transverse thin section of holotype (× 15); USNM 159407.

17, 18. Longitudinal thin sections of holotype (× 15); USNM 159407.

Middle Silurian, coral zone C, unit 3 of Roberts Mountains Formation; locality M1102, Roberts Creek Mountain, Nev.



TONKINARIA, MICROPLASMA?, RHIZOPHYLLUM, AND *DENAYPHYLLUM*

PLATE 8

FIGURES 1-4. *Chonophyllum simpsoni*, n. sp.

1, 2. Transverse and longitudinal thin sections of holotype (× 1½); USNM 159408.

3. Enlargement of part of same longitudinal thin section as fig. 2 (× 4); USNM 159408.

4. Longitudinal thin section of paratype (× 2); USNM 159409.

Upper Silurian, coral zone E; locality M1108, Coal Canyon, northern Simpson Park Mountains, Nev.

5, 6. *Cyathactis*? sp.

5. Transverse thin section (× 4).

6. Longitudinal thin section (× 4).

Upper Silurian, coral zone E; locality M1106, Coal Canyon, northern Simpson Park Mountains, Nev.

7. *Chonophyllum* sp., cf. *C. simpsoni*, n. sp.

Transverse thin section (× 4). Upper Silurian, coral zone E; locality M1110, Coal Canyon, northern Simpson Park Mountains, Nev.

8. *Chonophyllum* sp.

Side view of weathered specimen (× 1). Upper Silurian or Lower Devonian, upper unit of Vaughn Gulch Limestone; locality M1093, Mazourka Canyon, northern Inyo Mountains, Calif.

9. *Chonophyllum*? sp.

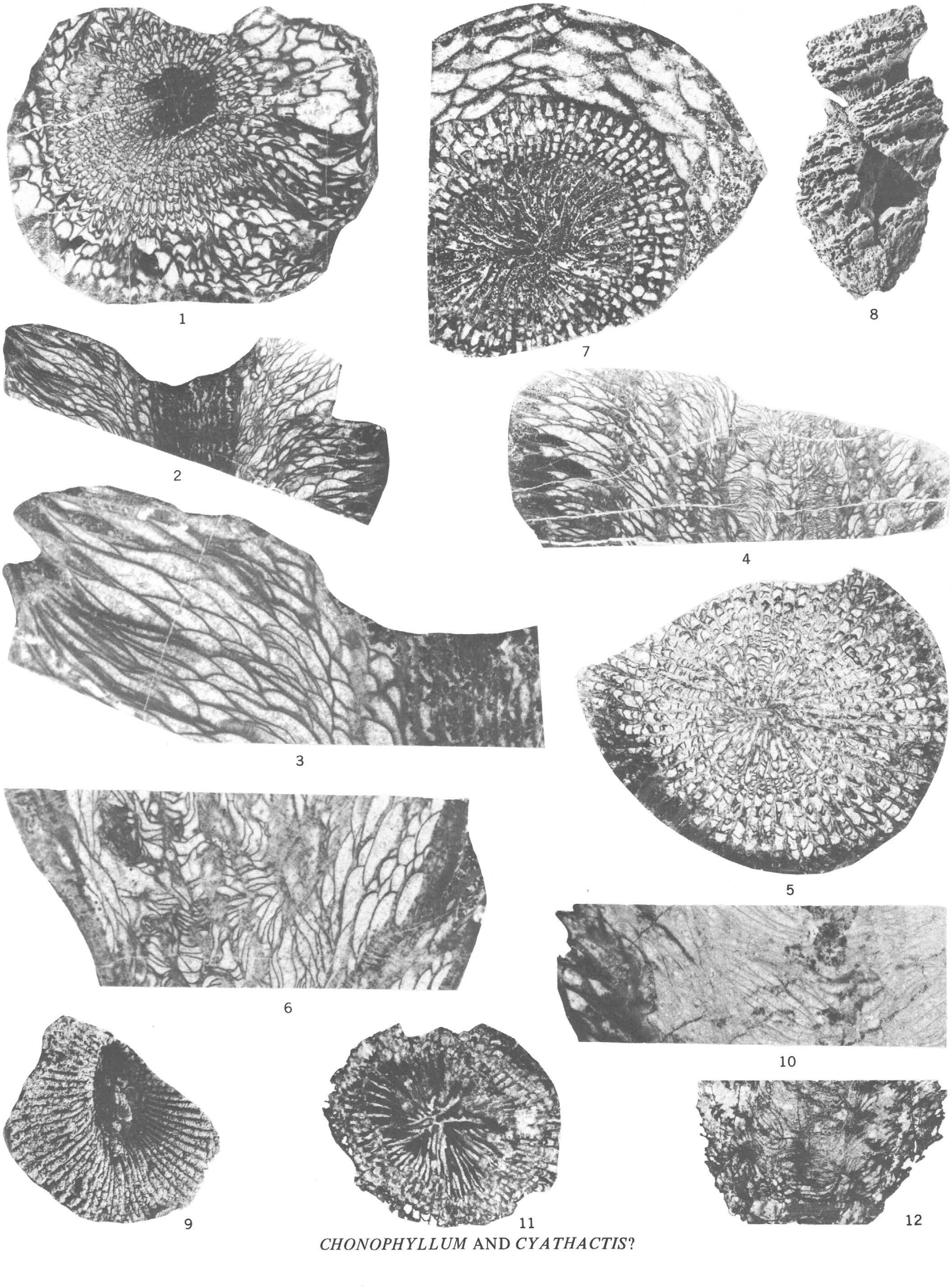
Calice view (× 1½). Middle Silurian, middle unit of Vaughn Gulch Limestone; locality M1092, Mazourka Canyon, northern Inyo Mountains, Calif.

10. *Chonophyllum* sp.

Longitudinal thin section (× 4). Upper Silurian or Lower Devonian, upper unit of the Vaughn Gulch Limestone; locality M1093, Mazourka Canyon, northern Inyo Mountains, Calif.

11, 12. *Chonophyllum*? sp.

Transverse and longitudinal thin sections (× 2). Upper Silurian or Lower Devonian, upper unit of the Vaughn Gulch Limestone; locality M1093, Mazourka Canyon, northern Inyo Mountains, Calif.



CHONOPHYLLUM AND *CYATHACTIS*?

PLATE 9

FIGURES 1–4. *Entelophylloides (Prohexagonaria) occidentalis*, n. subgen., n. sp.

1. Transverse thin section of holotype (× 3); USNM 159410.
2. Enlargement of part of transverse thin section of holotype (× 6); USNM 159410.
3. Longitudinal thin section of holotype (× 3½); USNM 159410.
4. Longitudinal thin section of holotype (× 6); USNM 159410.

Middle Silurian, coral zone C, unit 3 of Roberts Mountains Formation; locality M1102, Roberts Creek Mountain, Nev.

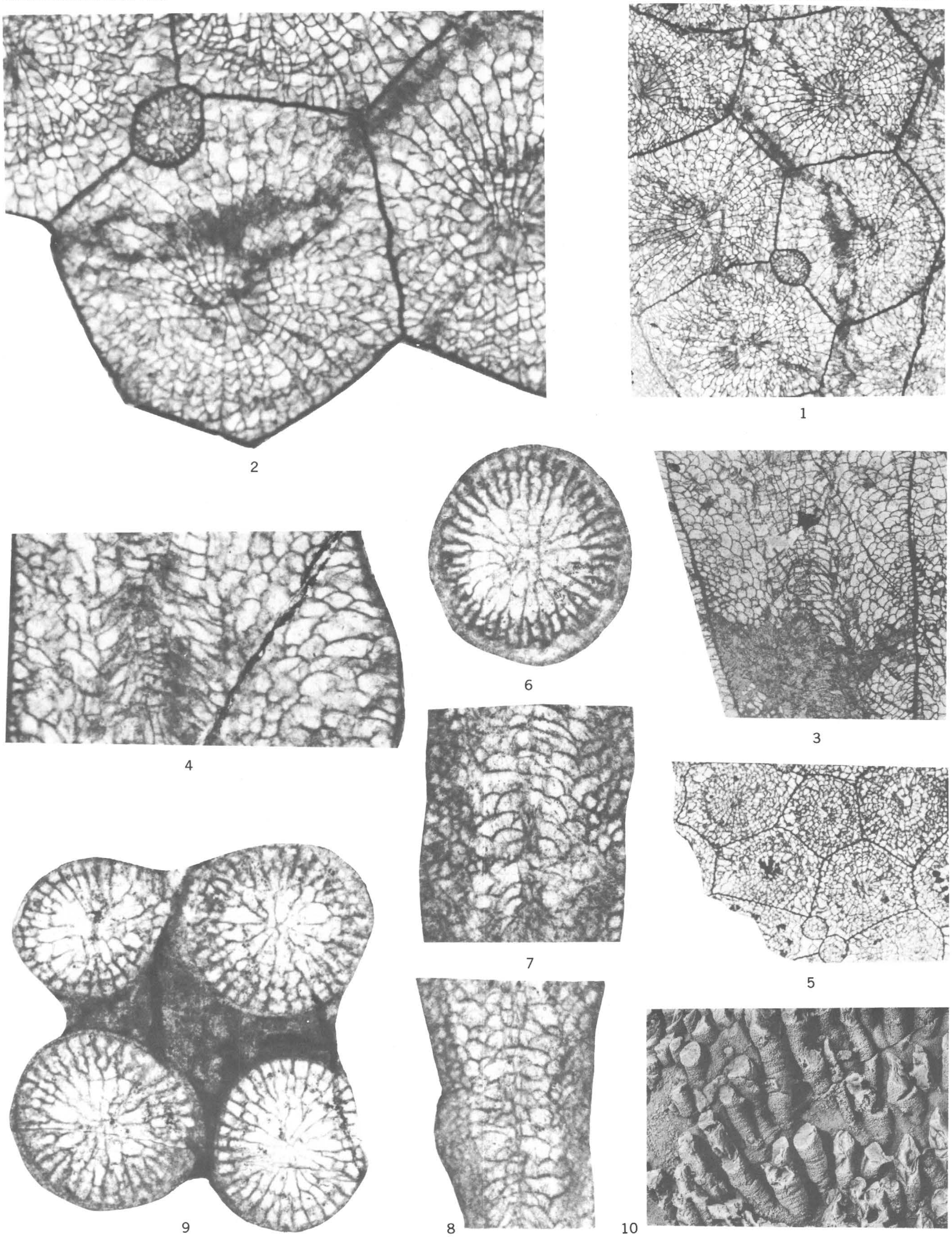
5. *Entelophylloides (Prohexagonaria)* sp.

Transverse thin section (× 1½). Copied from pl. VIII, Smith and Tremberth, 1929. Visby, Gotland, Sweden.

6–10. *Petrozium mcallisteri*, n. sp.

6–9. Transverse and longitudinal thin sections of holotype (× 6); USNM 159411.
10. View of part of fasciculate colony which is the holotype (× 1); USNM 159411.

Lower Middle Silurian, coral zone B, lower part of Hidden Valley Dolomite; locality M1111, Ubehebe district, California.



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ENTELOPHYLLOIDES (PROHEXAGONARIA) AND *PETROZIUM*

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PLATE 10

FIGURES 1, 2. *Entelophyllum eurekaensis*, n. sp.

Transverse and longitudinal thin sections (× 4) of holotype; USNM 159412. Upper Silurian, upper part of Lone Mountain Dolomite; locality M1113, southern Fish Creek Range, Nev.

3, 4. *Tryplasma* sp.

Transverse and longitudinal thin sections (× 2). Upper Silurian, upper part of Lone Mountain Dolomite; locality M1087, southern Fish Creek Range, Nev.

5–8. *Entelophyllum engelmanni*, n. sp.

5. Transverse thin section of holotype (× 4); USNM 159413.
6. Longitudinal thin section of paratype (× 2½); USNM 159414.
7. Part of same thin section as fig. 6 enlarged (× 4); USNM 159414.
8. Longitudinal thin section of paratype (× 3½); USNM 159415.

Upper Silurian, upper part of Lone Mountain Dolomite; locality M1112, southern Mahogany Hills, Eureka County, Nev.

9–11. *Entelophyllum engelmanni*, n. sp.

9. Transverse thin section of paratype (× 2); USNM 159416.
10. Lateral view of corallite (× 1½); USNM 159492.
11. Lateral view of two attached corallites (× 1).
    Shows attached shell of *Howellella*.

Upper Silurian, upper part of Lone Mountain Dolomite; locality M1087, southern Fish Creek Range, Nev.

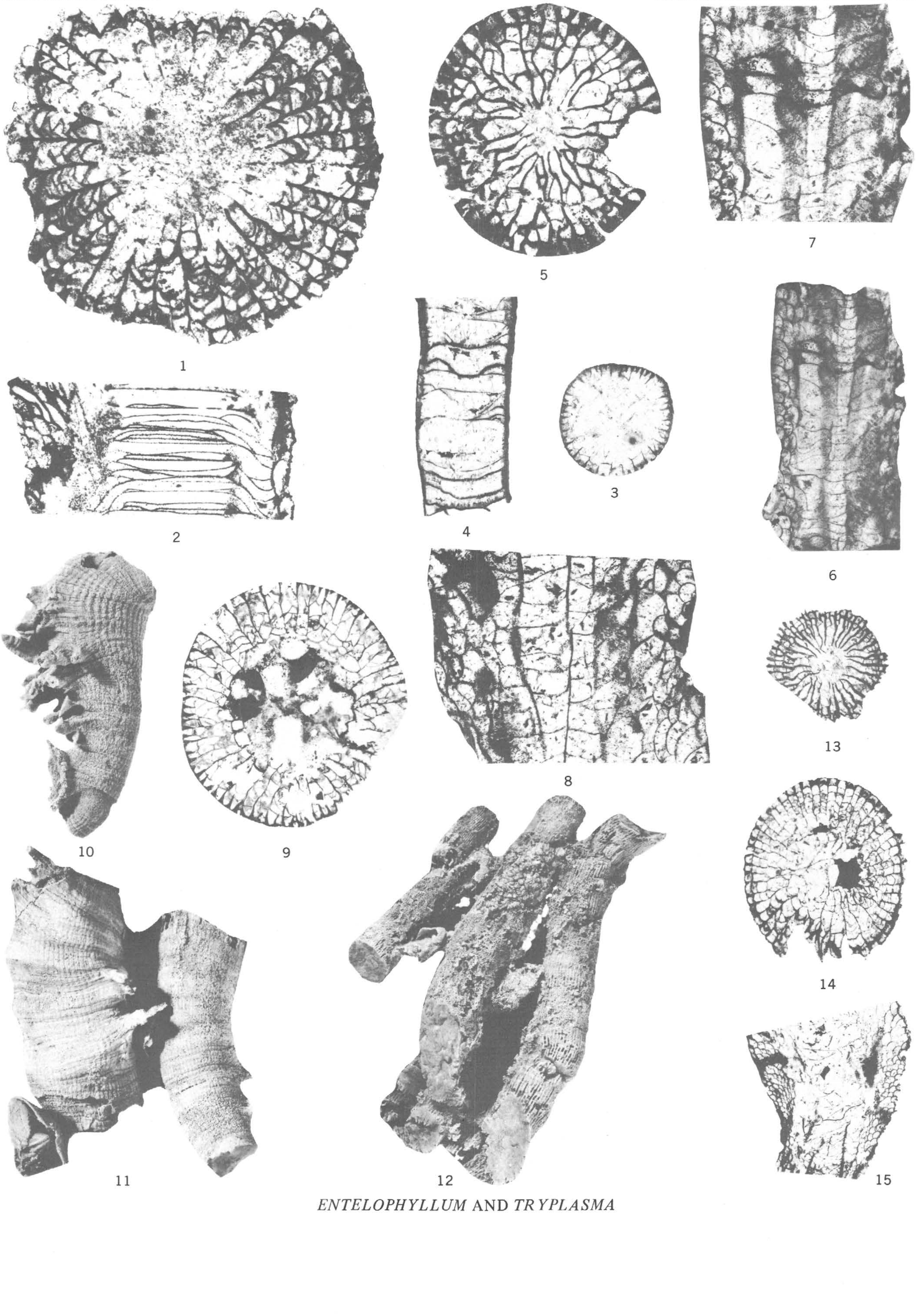
12, 13. *Entelophyllum engelmanni*, n. sp.

12. Oblique view of three corallites from large paratype colony, slightly reduced; USNM 159417.
13. Transverse thin section (× 2); USNM 159418.

Upper Silurian, upper part of Lone Mountain Dolomite; locality M1112, southern Mahogany Hills, Eureka County, Nev.

14, 15. *Entelophyllum eurekaensis*, n. sp.

Transverse and longitudinal sections of paratype (× 2); USNM 159419. Upper Silurian, upper part of Lone Mountain Dolomite; locality M1113, southern Fish Creek Range, Nev.



ENTELOPHYLLUM AND *TRYPLASMA*

PLATE 11

FIGURES 1, 2. *Australophyllum (Toquimaphyllum) johnsoni*, n. subgen., n. sp.

Transverse and longitudinal thin sections of holotype (× 4); USNM 159420. Upper Silurian, coral zone E; locality M1114, Ikes Canyon, Toquima Range, Nev.

3, 4, *Australophyllum (Toquimaphyllum)* cf. *johnsoni*, n. subgen., n. sp.

Calice view (× 1) and transverse thin section (× 2); USNM 159421. Upper Silurian, coral zone E; locality M1108, Coal Canyon, northern Simpson Park Mountains, Nev.

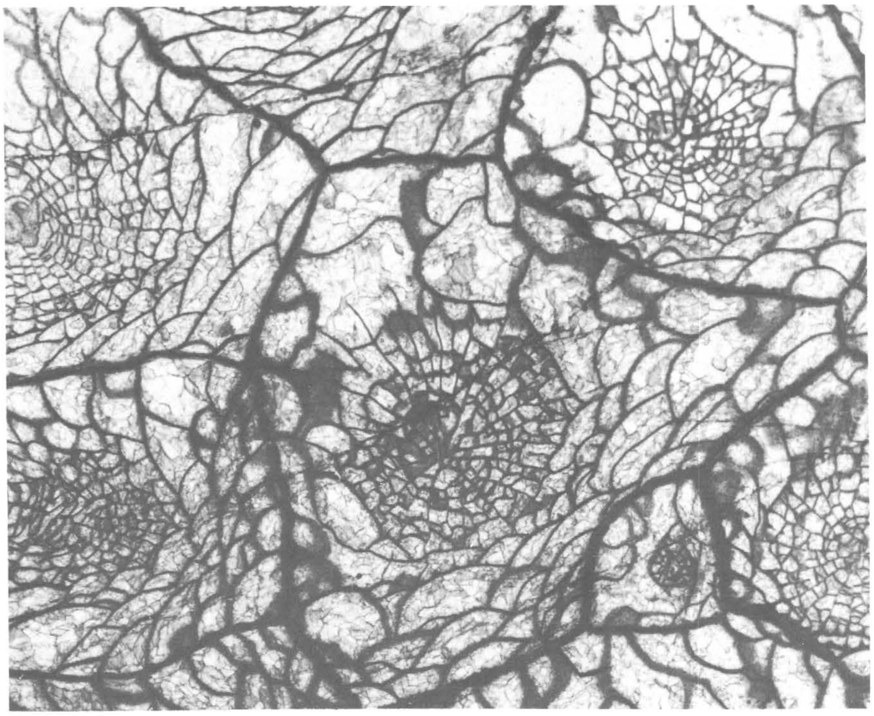
5, 6. *Australophyllum (Toquimaphyllum) johnsoni*, n. subgen., n. sp.

5. Longitudinal thin section of paratype (× 4); USNM 159422.
6. Transverse thin section of same paratype (× 1½); USNM 159422.

Upper Silurian, coral zone E; locality M1106, Coal Canyon, northern Simpson Park Mountains, Nev.

7. *Australophyllum (Toquimaphyllum) johnsoni*, n. subgen., n. sp.

Transverse thin section of holotype (× 2); USNM 159420. Same locality as figs. 1, 2.



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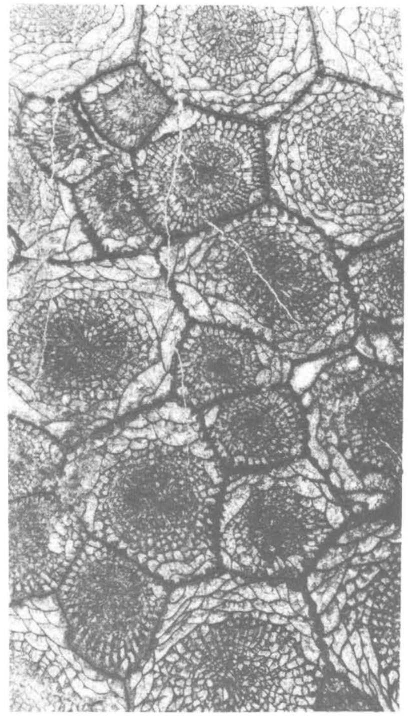

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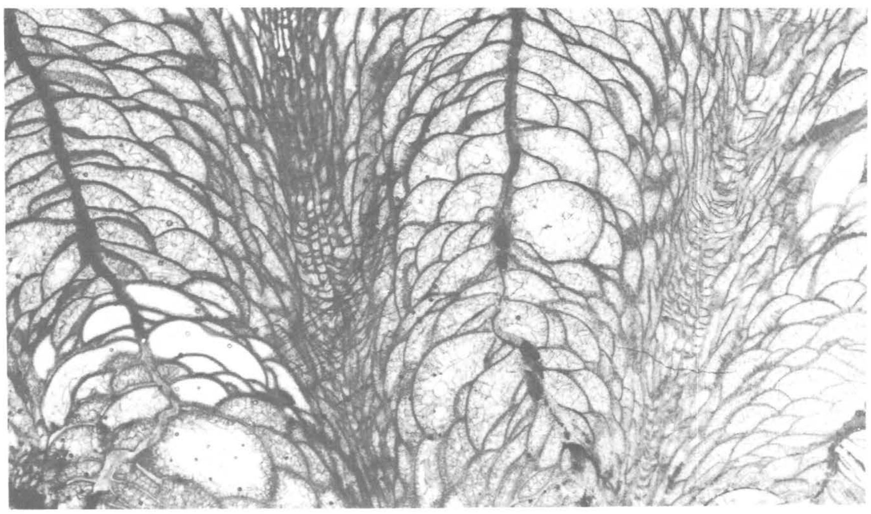

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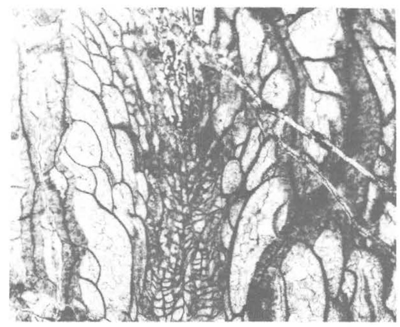

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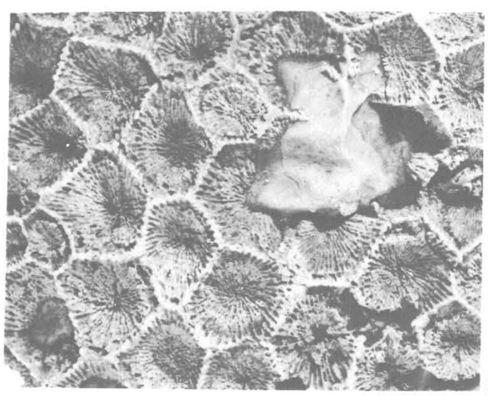

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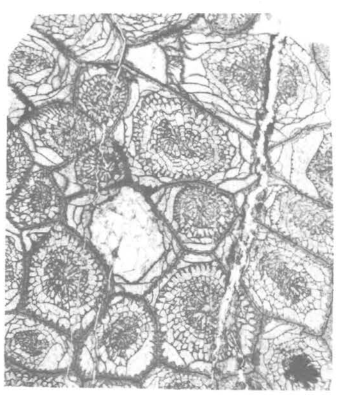

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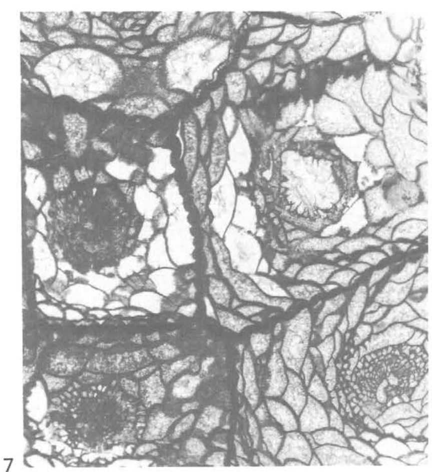

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AUSTRALOPHYLLUM (TOQUIMAPHYLLUM) JOHNSONI, N. SUBGEN., N. SP.

PLATE 12

FIGURES 1-3. *Australophyllum (Toquimaphyllum)* cf. *johnsoni*, n. subgen., n. sp.

Transverse thin section (× 2), transverse thin-section enlargment (× 3½), longitudinal thin section (× 4); USNM 149423. Upper Silurian, coral zone E, middle unit of Vaughn Gulch Limestone; locality M1115, Mazourka Canyon, northern Inyo Mountains, Calif.

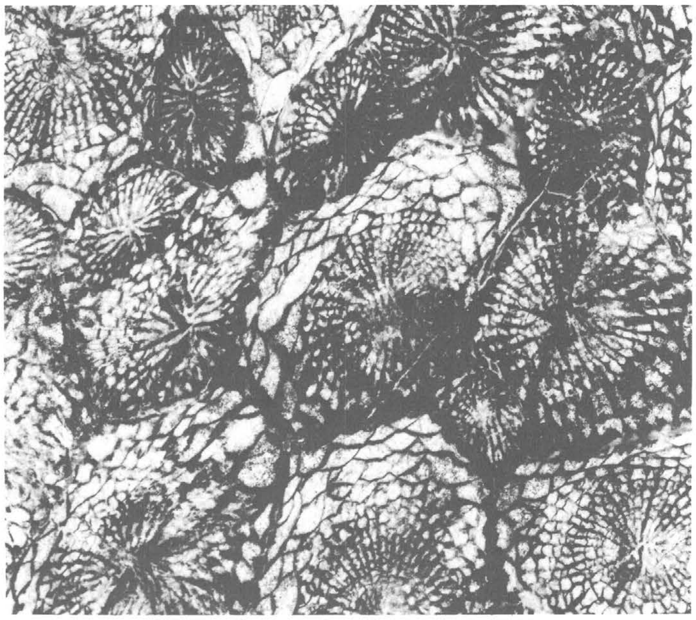
4, 5. *Australophyllum* sp.

4. Transverse thin section (× 4). Middle unit of Vaughn Gulch Limestone; locality M1116, Mazourka Canyon, northern Inyo Mountains, Calif.
5. Transverse thin section (× 3½). Upper Silurian or Lower Devonian, upper unit of Vaughn Gulch Limestone; locality M1093, Mazourka Canyon, northern Inyo Mountains, Calif.

6-8. *Salairophyllum*? sp.

6. Transverse thin section (× 3); USNM 159424.
7. Longitudinal thin section (× 4); USNM 159424.
8. Transverse thin section (× 1½); USNM 159424.

Note four peripheral calice offsets. Probably from Upper Silurian, coral zone E; locality M1117, Coal Canyon, northern Simpson Park Mountains, Nev.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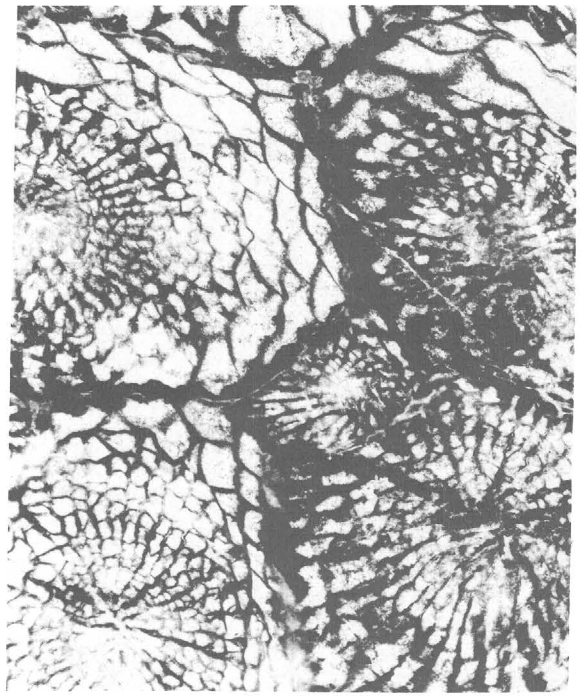
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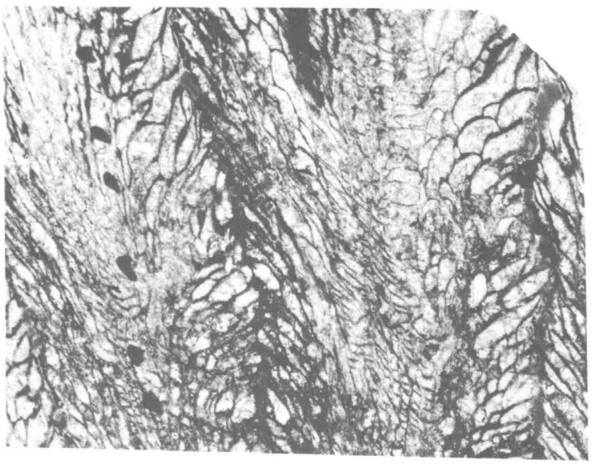
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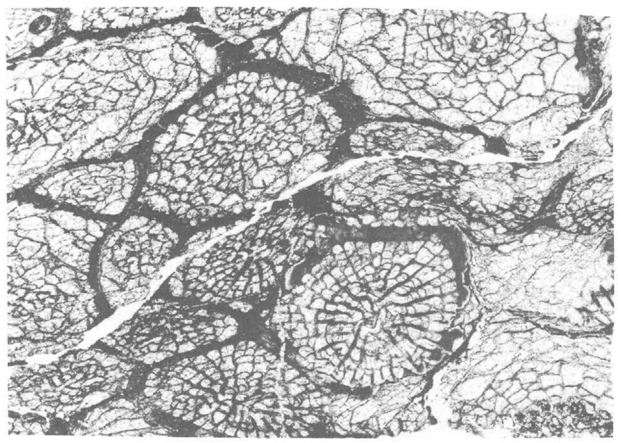
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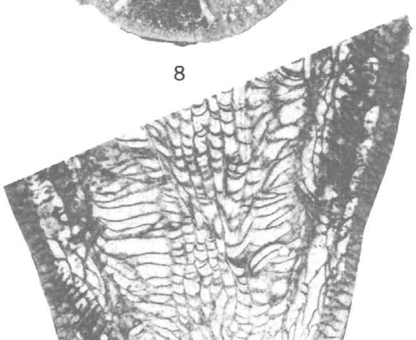
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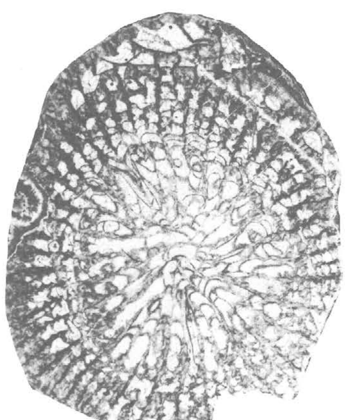
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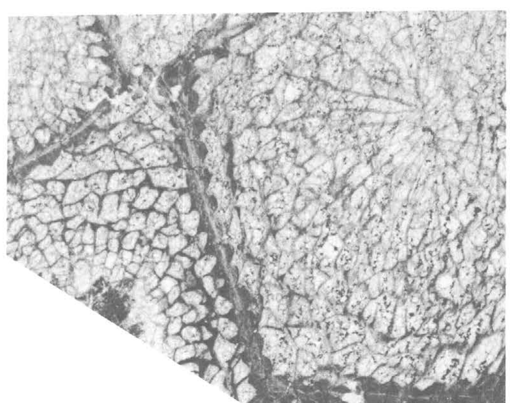
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AUSTRALOPHYLLUM (TOQUIMAPHYLLUM), AUSTRALOPHYLLUM, AND *SALAIROPHYLLUM*?

PLATE 13

FIGURES 1–4. *Kyphophyllum nevadensis*, n. sp.

1, 2. Transverse and longitudinal thin sections of holotype (× 4); USNM 159425.

3. Transverse thin section of holotype (× 2); USNM 159425.

4. Transverse thin section of holotype (× 4); USNM 159425.

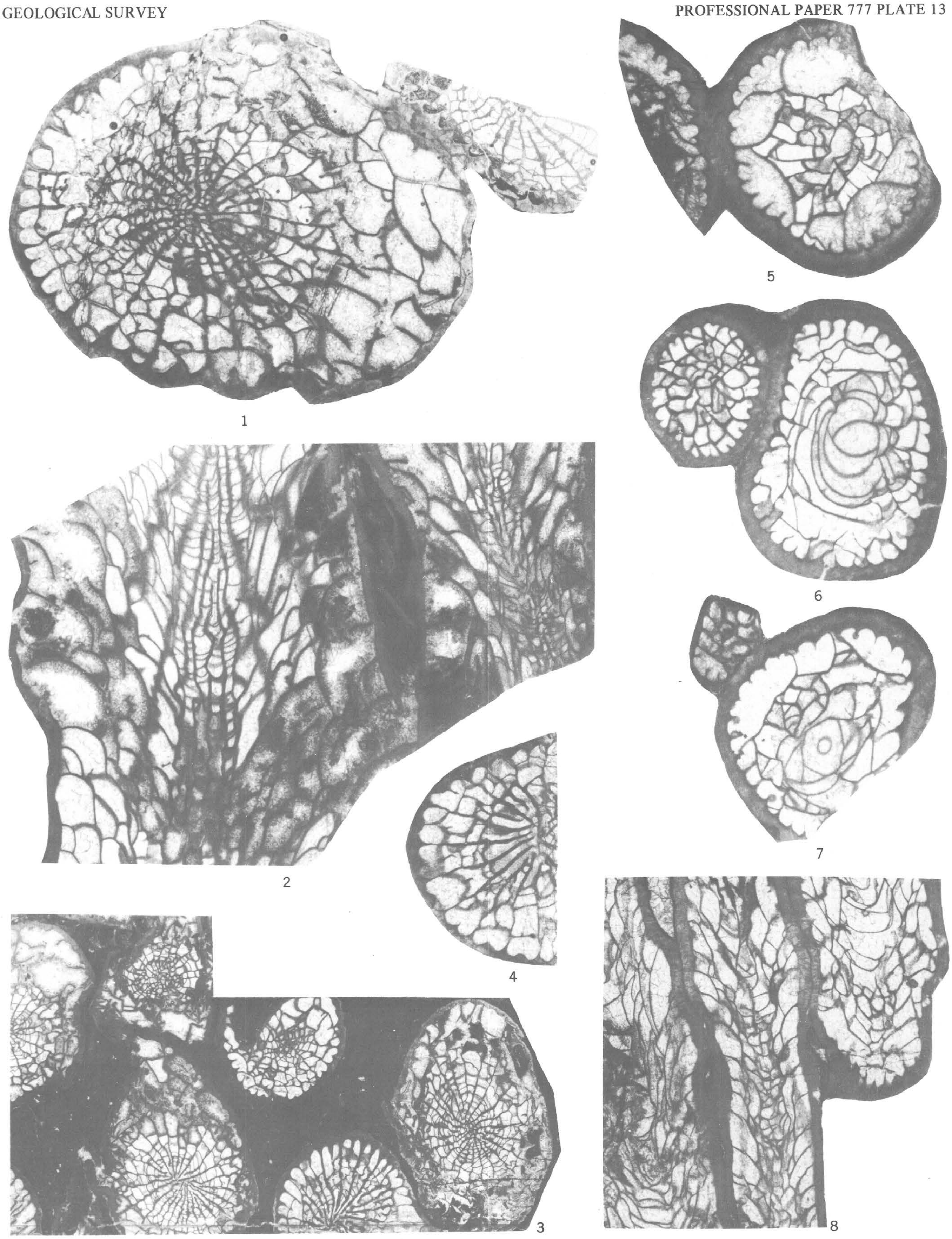
Upper Silurian, coral zone E; locality M1114, Ikes Canyon, Toquima Range, Nev.

5–8. *Neomphyma crawfordi*, n. sp.

5–7. Transverse thin sections of holotype (× 4½); USNM 159426.

8. Longitudinal thin section of holotype (× 4); USNM 159426.

Lower Silurian, coral zone A; locality M1088, Ikes Canyon, Toquima Range, Nev.



KYPHOPHYLLUM NEVADENSIS, N. SP., AND *NEMOPHYMA CRAWFORDI*, N. SP.

PLATE 14

FIGURES 1, 2. *Kyphophyllum* cf. *K. nevadensis*, n. sp.

Transverse and longitudinal thin sections (× 4); USNM 159427. Upper Silurian or Lower Devonian, upper unit of the Vaughn Gulch Limestone; locality M1093, Mazourka Canyon, northern Inyo Mountains, Calif.

3, 4. *Australophyllum* sp.

Transverse and longitudinal thin sections (× 4); USNM 159428. Middle Silurian, middle unit of the Vaughn Gulch Limestone; locality M1119, Mazourka Canyon, northern Inyo Mountains, Calif.

5. *Australophyllum* sp.

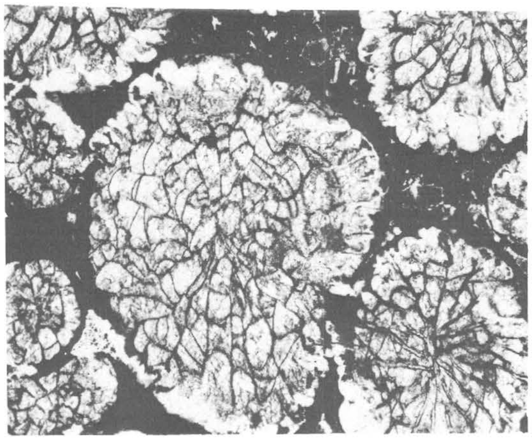
Longitudinal thin section (× 7). Upper Silurian or Lower Devonian, upper unit of the Vaughn Gulch Limestone; locality M1093, Mazourka Canyon, northern Inyo Mountains, Calif.

6. *Kyphophyllum* cf. *K. nevadensis*, n. sp.

Transverse thin section (× 2); USNM 159429. Middle unit of the Vaughn Gulch Limestone; locality M1118, Mazourka Canyon, northern Inyo Mountains, Calif.

7. *Kyphophyllum* cf. *K. nevadensis*, n. sp.

Lateral view (× 1) of colony USNM 159427 from which thin sections shown in figs. 1, 2 were cut. Locality M1093.



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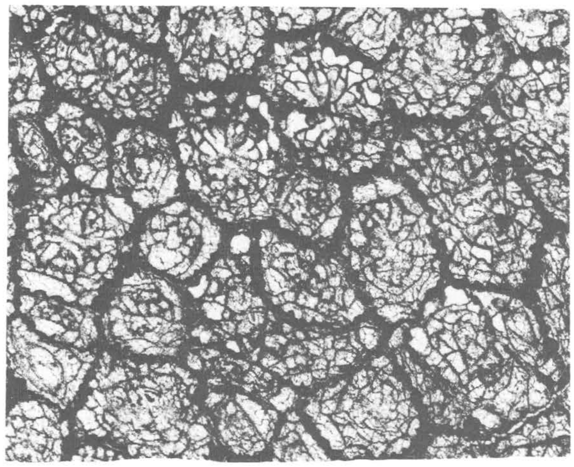

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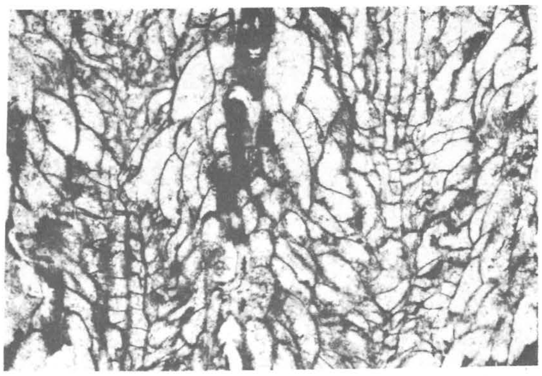

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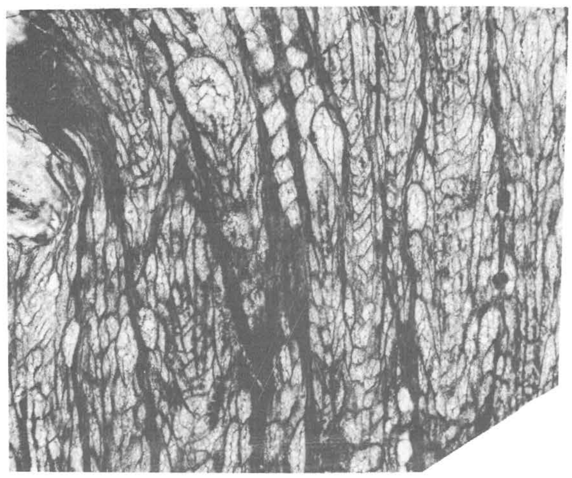

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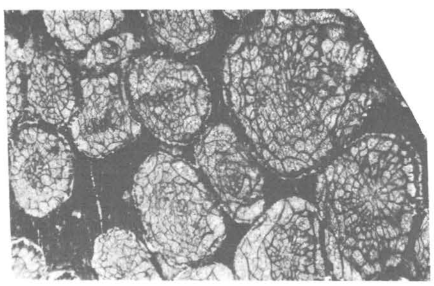

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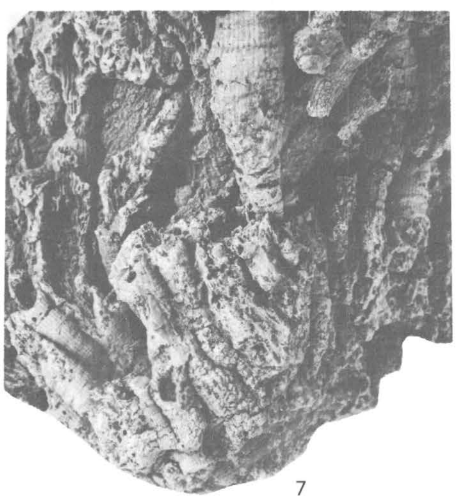

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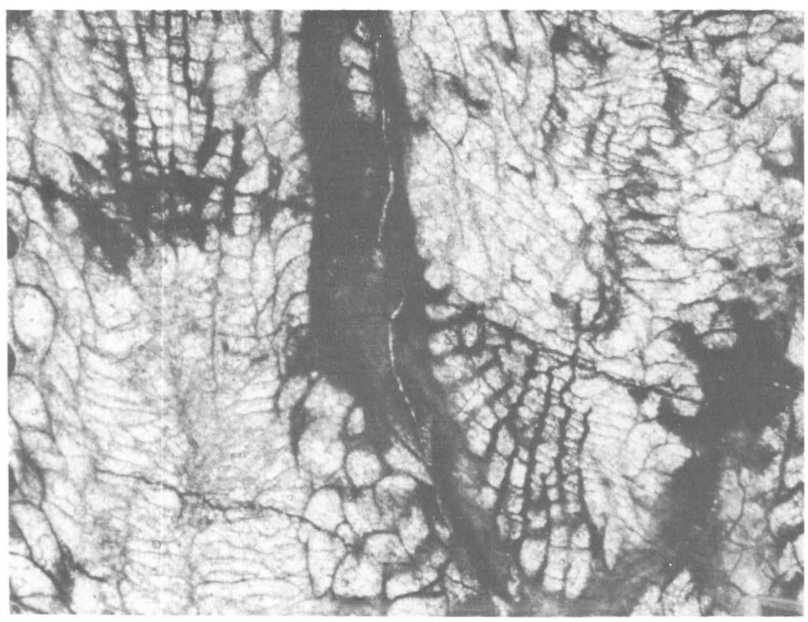

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KYPHOPHYLLUM AND *AUSTRALOPHYLLUM*

PLATE 15

FIGURES 1–4. *Stylopleura nevadensis*, n. gen., n. sp.

1. Upper surface of corallum (× ½); holotype USNM 159431.

2–4. Transverse thin section (× 2), longitudinal thin section (× 2), and longitudinal thin section (× 2) showing a connecting pillar; holotype USNM 159431.

Upper Silurian, coral zone E; locality M1107, Coal Canyon, northern Simpson Park Mountains, Nev.

5–9. *Rhabdocyclus* sp. K.

5. 6. Calice and lateral views (× 2½), USNM 159432; note excentric apical cone.

7, 8. Calice and lateral views (× 4), USNM 159433.

9. Calice view (× 2), USNM 159434.

Silurian, Laketown Dolomite; locality M1137, Kings Canyon, Conger Mountain quadrangle, Confusion Range, Utah.

10. *Palaeocyclus* cf. *P. porpita* (Linnaeus).

Calice view (× 2); USNM 159435. Silurian dolomite; locality M1336, 3 miles northeast of Mitchell Ranch, Sherman Mountain quadrangle, Ruby Mountains, Nev.

11. *Pycnostylus* sp.

Longitudinal sections (× 1½); USNM 159436. Silurian, Lone Mountain Dolomite; locality M1148, 3 miles south of Romano Ranch, Garden Valley quadrangle, southern Sulphur Spring Range, Nev.

12–16. *Entelophyllum* cf. *E. engelmanni*, n. sp.

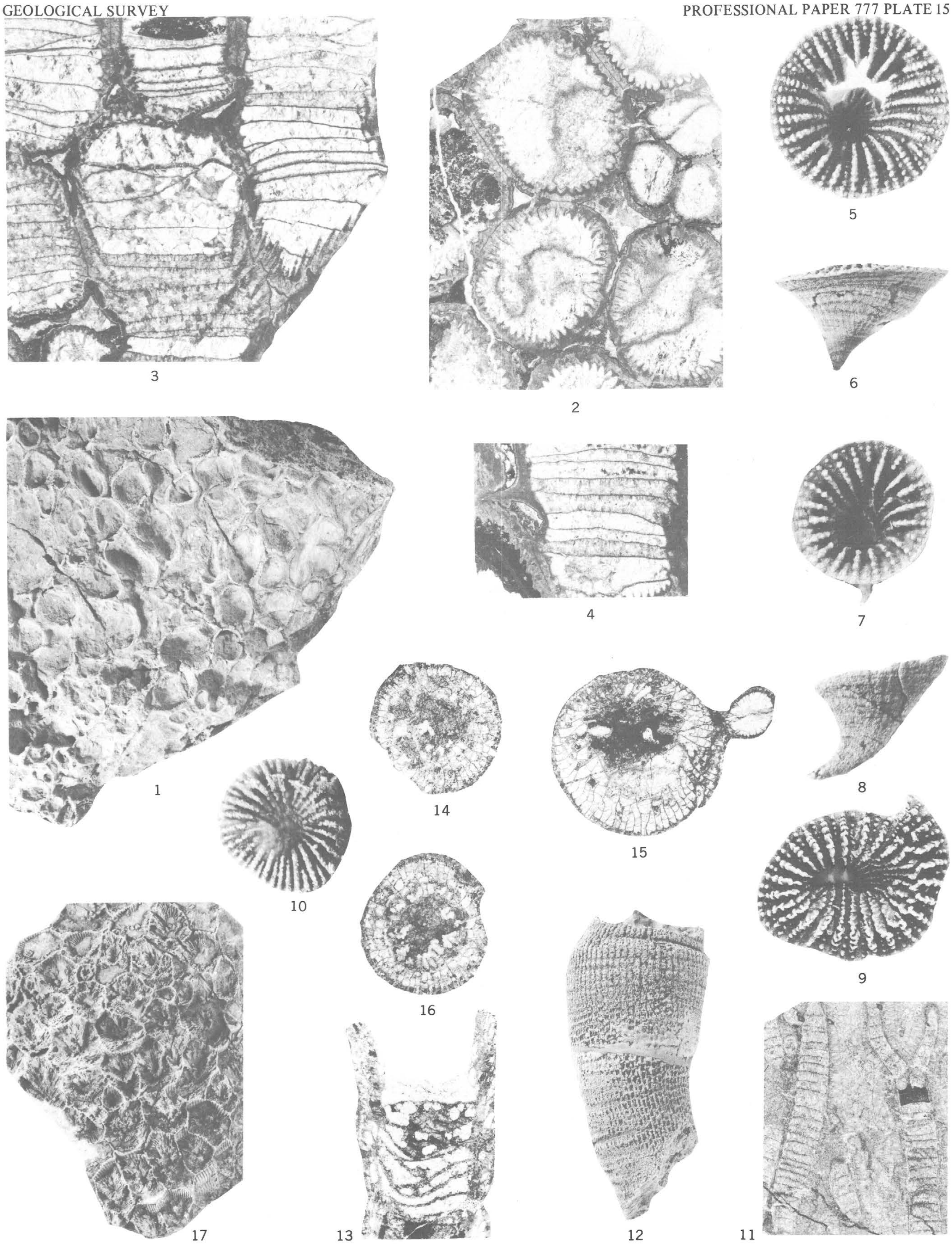
12. Lateral view of large corallite (× 1); USNM 159437.

13–16. Longitudinal and transverse thin sections (× 2) of corallite; USNM 159438.

Silurian dolomite; 3 miles southeast of Mitchell Ranch, Sherman Mountain quarangle, southern Ruby Mountains, Nev.

17. *Australophyllum (Toquimaphyllum) johnsoni*, n. subgen., n. sp.

Calice view (× ½) of part of colony; paratype USNM 159439. Upper Silurian, coral zone E; locality M1026, Coal Canyon, northern Simpson Park Mountains, Nev.



STYLOPLEURA, *RHABDOCYCLUS*, *PALAEOCYLUS*, *PYCNOSTYLUS*, *ENTELOPHYLLUM*, AND *AUSTRALOPHYLLUM (TOQUIMAPHYLLUM)*

PLATE 16

FIGURES 1, 2. *Brachyelasma* sp. B.

Longitudinal thin section and calice view of same individual (× 2); thin section shows incrustation by probable bryozoa on right. Middle Silurian, coral zone B, lower part of Hidden Valley Dolomite; locality M1127, Ryan quadrangle, Funeral Mountains, Calif.

3, 4. *Stylopleura*? sp.

Lateral and calice views (× 1½). Silurian, lower part of the Lone Mountain Dolomite; locality M112l, southern Sulphur Spring Range, Nev.

5, 6. *Verticillopora annulata* Rezak.

5. Weathered interior (× 1½) showing ray bases.
6. Weathered specimen (× 2) showing internal stipe cavity.

Upper Silurian, coral zone D, unit 3 of Roberts Mountains Formation; locality M1100, Roberts Creek Mountain, Nev.

7–13, 17. *Verticillopora annulata* Rezak.

7, 8. Longitudinal and transverse thin sections of same individual (× 2) showing internal stipe cavity and rays.

9, 10. Lateral and transverse views of same individual (× 1½).

11, 12. Lateral views of two large individuals (× 1½).

13. Lateral view of fragmentary individual (× 2) showing external pattern of pore cycles.

17. Longitudinal interior (× 3) showing ray pore cycles.

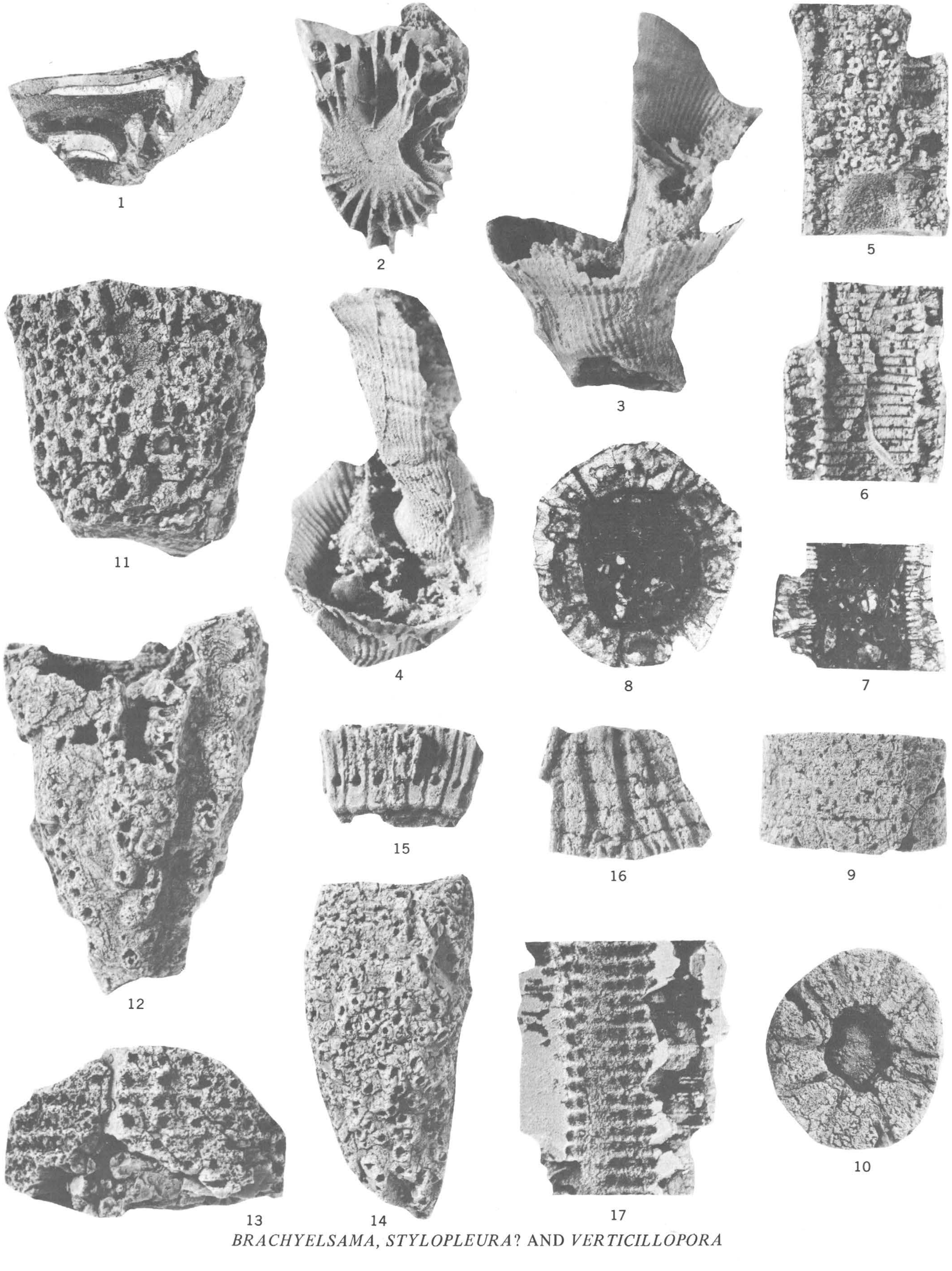
Upper Silurian, coral zones D and E, upper part of middle unit of Vaughn Gulch Limestone; Mazourka Canyon, northern Inyo Mountains, Calif.

14. *Verticillopora annulata* Rezak.

Lateral view (× 1). Upper Silurian, coral zones D and E, upper part of middle unit of Vaughn Gulch Limestone; Mazourka Canyon, northern Inyo Mountains, Calif.

15, 16. *Verticillopora annulata* Rezak.

Exterior and transverse views of part of an annular segment (× 2) showing rays and ray pores. Upper Silurian or Lower Devonian, upper unit of Vaughn Gulch Limestone; locality M1093, Mazourka Canyon, northern Inyo Mountains, Calif.



BRACHYELSAMA, *STYLOPLEURA*? AND *VERTICILLOPORA*

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