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A New Triassic Coral Fauna from Idaho

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Although upper Triassic coral reefs have been reported from many areas in North America, the corals living on or forming the reefs have received little attention. The basic references for North American Triassic corals are J. Perrin Smith's monograph on the "Upper Triassic marine invertebrate faunas of North America" (Smith, 1927) and a study by Clapp and Shimer (1911) on the Scleractinia of Cowichan Island, Vancouver. These works provide coverage of a broad area, as corals from several localities in California, Nevada, Oregon, British Columbia, and Alaska are discussed. Both are somewhat difficult to use because of the brief descriptions and inadequate illustrations for which the poor preservation of the material described was largely responsible. Those faunas were studied in section and by examination of weathered specimens, neither being a completely satisfactory method. It is of some importance, then, that a collection of well-silicified upper Triassic invertebrates was discovered in Idaho. Study of the coral fauna reveals evidence of even closer relationships between the Norian of North America and the classic coral provinces of central Europe than previously indicated. It is presumed that study of the other, not less abundant, elements of the Idaho fauna will prove to be of equal significance. Thus far, published reports have indicated the presence of *Spondylispira* Cooper, 1942, and a remarkable collection of gastropods, mentioned by Haas (1953). Unstudied elements include a variety of pelecypods, sponges, and bryozoans, as well as representatives of other groups.

The locality, first collected in 1936 by Williams and Reed of the United

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States Geological Survey, was visited in 1948 by N. D. Newell of the American Museum, who collected several blocks of limestone which yielded the corals described here. The outcrop from which Newell collected is just above a limestone quarry on the east side of Mission Creek, Lapwai Indian Reservation, Nez Perce County, Idaho. The area is more commonly referred to as the Lewiston, Idaho, locality. There is little published information on the geology of the area, but Newell (N. D. Newell, field notes) notes that it represents an inlier of somewhat metamorphosed blue limestone underlying a cap of Tertiary lava and that it may represent a roof pendant in the Idaho Batholith. Only a few weather surfaces indicated the presence of fossils in the limestone, while unweathered blocks show no sign of the potential fossil content. This may possibly account for paleontological neglect of the locality.

The age of the inlier is fairly certain. Cooper (1942, p. 232), in the first record of fossils from this locality, gave the horizon as the Seven Devils formation of Norian age. Haas (1953, p. 304, footnote; p. 310) suggested a Norian to Rhaetian age, based on his preliminary examination of some of the gastropods. The corals described here are strongly indicative of a Norian age for the fauna.

It is a pleasure to acknowledge the assistance of Dr. G. A. Cooper and Dr. John B. Reeside, Jr., for granting permission to examine the collection of types and figured specimens of J. P. Smith, in the United States National Museum, and their collections from the Lewiston locality. Dr. N. D. Newell has supplied information on the nature of the locality and its fauna. Dr. John W. Wells, Cornell University, has critically read this manuscript and has made many helpful suggestions. The photographs were made by Mr. Edward J. Hawkins.

PRESERVATION OF THE CORALS

Superficially, the isolated, matrix-free coralla are exquisite. Closer inspection reveals vagaries of silicification presenting problems in interpretation. Etching of the limestone produced, in a majority of cases, hollow coralla with all surface features preserved. These are extremely fragile, and in some instances explanate colonies have been reduced to fragments during the etching process. Silicification of septa proceeded along the trabeculae and has resulted in a beaded or spinose condition on both upper and proximal margins, and in instances of dentate septa this condition is sharply emphasized. With exceptions, little can be determined of the internal structure, and unetched material was not available for sectioning and study. Comparison with corals of other areas, then, is somewhat difficult because of the stress placed on various features depending on differing modes of preservation. It is fortunate that a varied collec-

tion of corals from the Zlambach beds (Norian) of the Fischerwiese, Austria, was available in the collections of the American Museum for comparison of external features and study of internal features.

DISTRIBUTION OF UPPER TRIASSIC CORALS

Many authors have called attention to the close similarity between North American and European Triassic faunas; there are many species in common, and apparent differences in faunal content are minimized as more and better material is studied. The Idaho fauna contributes much. European coral species reported from the North American continent for the first time are: *Astrocoenia schafhäutli, Stylina norica, Stylophyllum paradoxum, Oppelismilia zitteli, Coccophyllum acanthophorum,* and *Elysastraea major.* As indicated in table 1, only 18 of the 33 species known from North America are of local distribution. Many of these are in turn closely related to European forms and may prove conspecific. There are gaps in the knowledge of the distribution of coral species within North America, but continued study will considerably clarify the picture. On the basis of current knowledge, there is no strong faunal differentiation northward from California to Alaska.

South American Triassic coral faunas are inadequately known at present, but a suite of silicified corals collected by William Jenks is currently under study, and indications are that many of the species found in North America and Europe may range southward to Peru. Relationships between Asia and North America are not readily apparent, but the general faunal composition is much the same.

NOTES ON THE ECOLOGY

Although the Idaho assemblage of corals is quite typical of the Norian of North America, several elements are conspicuously absent. Perhaps most significant of these are the spongiomorphid corals, which as indicated by Smith (1927) and Frech (1890) are of common occurrence and widespread distribution. It is improbable that these forms were not preserved, as specimens in the Smith collection, at the United States National Museum, were at least in part silicified. Several masses superficially resembling the spongiomorphid corals were found to be true sponges. Other forms found in North America but missing from the Idaho samples are *"Stromatopora," Palaestraea,* and *Heterastridium.*

Evidence afforded by quantitative considerations of the occurrence of several of the genera is indicative of unusual conditions. Only three species are abundant: *Montlivaltia norica, Elysastraea profunda,* and *Thamnasteria smithi;* and only the first of these is found in exceptional numbers. In general, all species are marked by small size of the coralla. The excep-

TABLE 1

DISTRIBUTION OF NORTH AMERICAN NORIAN CORALS

	Idaho	California	Nevada	Oregon	Vancouver	Alaska	Austria	
							Fischerwiese	Gosau
Pinacophyllum parviseptum	x							
Astrocoenia schafhäutli	x						x	x
Astrocoenia idahoensis	x							
Astrocoenia martini		x				x		
Astrocoenia shastensis		x	?					
Stylina norica	x							x
Thamnasteria smithi	x	x				x		
Thamnasteria rectilamellosa		x					x	x
T. (Astraeomorpha) cuneata	x					?		
Stylophyllum paradoxum	x						x	x
Oppelismilia zitteli	x						x	x
Coccophyllum acanthophorum	x						x	
Montlivaltia norica	x	x		x			x	x
Montlivaltia ? martini						x		
Thecosmilia suttonensis	?		?		x			
Thecosmilia dawsoni	?				x			
Thecosmilia norica				x				

TABLE 1—(*Continued*)

	Idaho	California	Nevada	Oregon	Vancouver	Alaska	Austria Fischerwiese	Austria Gosau
Dimorphastrea ? triadica						x	x	x
Palaeastraea decussata		x				x	x	x
Elysastraea profunda	x	x			x	x	x	x
Elysastraea major	x						x	x
Elysastraea parva						x		
Elysastraea vancouverensis		x			x	x		
Margarastraea eucystis		x				x		x
Margarastraea grandissima						x	x	x
Heptastylis aquilae				x				
Heptastylis oregonensis				x				
Spongiomorpha dendriformis		x						
Spongiomorpha tenuis		x						
Spongiomorpha gibbosa						x	x	x
Spongiomorpha ramosa						x	x	
Stromatomorpha californica		x				x		
Heterastridium congoblatum						x		

tions to this are found in the case of the three abundant forms, *Montlivaltia norica* commonly attaining proportions similar to those reached in the Zlambach beds of Austria. Colonial coralla such as *Thamnasteria smithi* and *Elysastraea profunda* are with notable exceptions small, and all other species of colonial corals are represented only by small, possibly immature coralla.

Corallum development in all species was marked by sharply defined periods of polyp contraction. Among the solitary forms, rejuvenescence is initiated from the central portion of the calice, or the stomodeal cavity of the polyp. Colonial coralla also show marked periods of contraction, with renewed growth commencing from the central portion of the upper surface. Of the species found in the Zlambach beds, only *Stylophyllum paradoxum* commonly shows rejuvenescence in its growth. Therefore, the periodic cessation of growth, with sudden redevelopment of the corallum, is strongly suggestive of the periodic onset of unfavorable conditions for growth. The nearly constant character of the rejuvenation is strongly suggestive of widespread conditions rather than isolated accidents, although there are instances in which relatively large coralla develop without apparent changes in the rate of corallum formation.

Overturning was not uncommon among these corals, and in some instances a series of events may be interpreted from the development of one colony. Particularly interesting is the history of one *Elysastraea profunda* corallum of rather large proportions. Two periods of growth occurred before the first overturning which caused the corallum to lie on its side. A rejuvenation of growth occurred along a new axis of growth at right angles to the first. Three periods of growth followed, and then a second overturning occurred. New growth of the corallum proceeded along an axis inclined to the second axis at a 30-degree angle.

Associated with the corals is a varied fauna composed principally of gastropods, pelecypods, and sponges. The snails have been commented upon briefly by Haas (1953) and are of an unusual nature. Few of them reach a size of more than several centimeters. The pelecypods are chiefly attached types, apparently growing in clusters and anchored to the larger sponge masses. The sponges are in general small hemispherical bodies, but the larger specimens were apparently populated by a rather impressive fauna of which only the attached elements are found remaining. Minor constituents of the fauna include Bryozoa, cidaroid echinoids, and several brachiopods, most of which are found embedded in the convoluted surface of the sponges.

Remnants from the etching process contain several interesting features. There are large platy masses with no apparent structure on which is found almost every element of the fauna capable of attachment. The

nature of these features is uncertain, but apparently they represent unusual substrate conditions which have been preserved by silicification. All elements of the fauna, as well as the inorganic (?) silicified material, are covered by an extremely fine black powder. An X-ray diffraction test of this material indicates that it is 95 per cent finely disseminated quartz and 5 per cent talc (Brian Mason, personal communication). The talc in all probability represents a metamorphic product and may be indicative of earlier partial dolomitization of the limestone. The color may be due to organic material, the nature of which is as yet undetermined.

The ecologic significance of these many factors cannot be satisfactorily determined without further study of the outcroppings. Several generalizations may be made, however, on the basis of the information now available. The prevalence of attached organisms and the evidence of overturning of coralla are suggestive either of wave action or a shifting substrate. In either case, the possibility that a reef or reef-like structure was present is rather unlikely. More probably, the environment was one of a shoal or bank. Periodic rejuvenescence of the coralla cannot be interpreted as the result of seasonal fluctuations, as it is not a regular occurrence, but spasmodic. Not all individuals of the fauna were affected by the fluctuations, which perhaps indicates that depth was a factor enabling these individuals to escape the detrimental environmental influences. These influences were not sufficiently long in duration to kill the coralla, but were of sufficient intensity or duration to limit the polyp to rather insignificant proportions. Fluctuating temperatures, exposure to air, influx of sediments, or appreciable changes in the salinity of the waters are among the factors that might account for this result. Wells (1937, pp. 8, 11) has suggested that instability caused by rejuvenation of corallum growth was responsible for contortions in coralla of *Heliophyllum halli,* a Devonian rugose coral. Instability caused by this factor could account for overturning in the case of *Elysastraea profunda,* particularly if the substrate were of such character that structural support of the corallum was not sufficient to counteract the instability caused by growth. The abundance of organisms attached to one another is a further indication of unsuitable substrate conditions.

SYSTEMATIC DESCRIPTIONS

ASTROCOENIIDAE

PINACOPHYLLUM FRECH, 1890

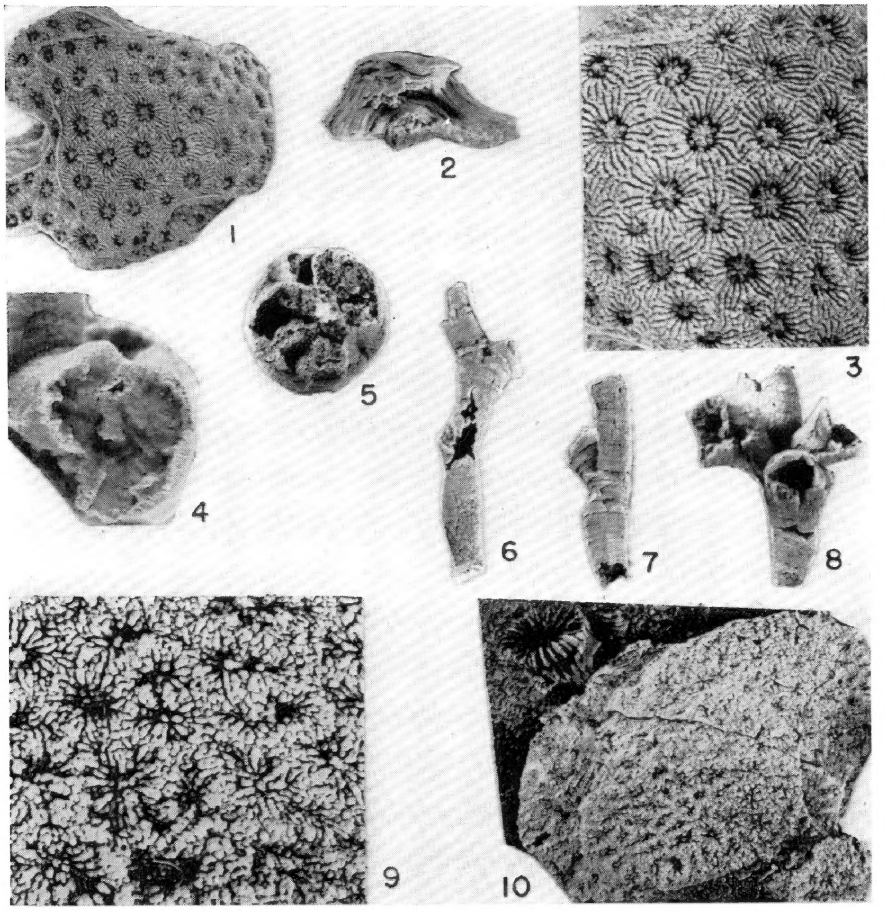
Pinacophyllum parviseptum, new species

Figures 4–8

HOLOTYPE: A.M.N.H. No. 27956.

PARATYPES: A.M.N.H. Nos. 27957–27959.

DESCRIPTION: Coralla forming bushy clumps by extratentacular budding, as alternate lateral budding, with the branches tending to spiral; bifurcation in a plane, or by multiple budding at a single point. In one example of the latter case, four individuals budded at one point. Budding first appears as a slight infolding of the wall, forming a shallow, V-shaped



FIGS. 1–3. *Astrocoenia schafhäutli* (Winkler), A.M.N.H. No. 27961. 1. Surface of corallum, × 3. 2. Side view of corallum, × 1.5. 3. Calices, × 5.

FIGS. 4–8. *Pinacophyllum parviseptum*, new species. 4. Calicular view showing septa on left side, A.M.N.H. No. 27956, × 5. 5. Broken section of corallum showing infoldings of wall preliminary to budding, A.M.N.H. No. 27959, × 3. 6–8. Side views of coralla, × 1. 6. A.M.N.H. No. 27958. 7. A.M.N.H. No. 27956. 8. A.M.N.H. No. 27957.

FIGS. 9, 10. *Astrocoenia idahoensis*, new species, A.M.N.H. No. 27963. 9. Calices, × 4. 10. Holotype corallum, × 1.

depression from which develops a longitudinally transverse partition extending across the corallum to the corresponding infolding on the opposite side of the corallite. Often a slight thickening of the central portion of the transverse partition is found, a feature grossly resembling the columella of *Gigantostylis*. Corallites are of moderate size, 2.5 to 4.0 mm. in diameter. The tallest specimen measures 35 mm., but it is broken at both the top and the bottom; the colonies apparently were appreciably higher. Septa are poorly preserved and are apparent only in several isolated portions of a few calices. No indication of their number or arrangement can be determined. They appear to have been short, laminar ridges, with a series of isolated trabecular spines on the proximal margin projecting inward and upward at a low angle of divergence. The corallites are traversed by bowl-like, tabular, endothecal dissepiments at frequent intervals. The septa appear to have been vertically discontinuous and perhaps best developed immediately above endothecal partitions.

REMARKS: The delicate septal structure of these primitive astrocoeniids appears not to have been amenable to preservation, while the relatively stout epithecal wall is, in general, well preserved. Those septa that were preserved are indicative of the genus.

The species differs from *P. parallelum* (Frech), 1889 (Frech, 1890, p. 86, pl. 21, figs. 1–1c, 5–6), in that the corallum of that species forms phaceloid masses in which the branches are approximately parallel and vertical in extent. The branches are also more closely spaced than in the new species. *Pinacophyllum annulatum* (Reuss), 1855 (Frech, 1890, p. 87, pl. 21, figs. 7–7e), has about the same colonial form as *P. parallelum,* but differs in that it has numerous, apparently short septa which appear as thin ridges on the wall, while *P. parallelum* has fewer septa, many of which extend to the center of the calice. The epitheca is also somewhat more rugose than in *P. parallelum*. The lack of septal detail in the Idaho species makes comparison difficult, but the mode of colony formation is quite different and the epitheca is not so rugose as in the other species.

ASTROCOENIA MILNE-EDWARDS AND HAIME, 1848

Astrocoenia schafhäutli (Winkler), 1861

Figures 1–3

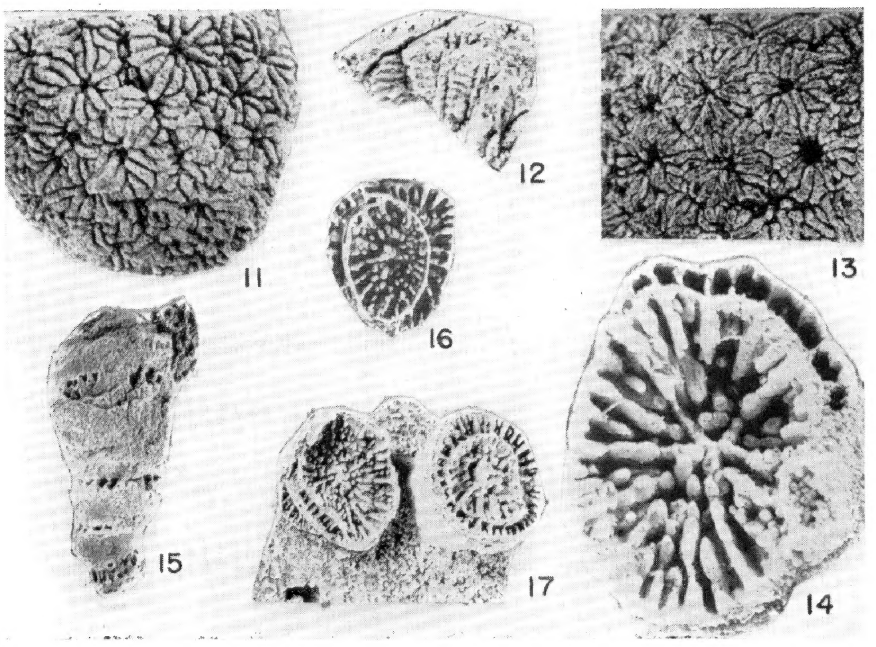
Stephanocoenia schafhäutli (Winkler) FRECH, 1890, Paleontographica, vol. 37, p. 37, text figs.

FIGURED SPECIMEN: A.M.N.H. No. 27961.

DESCRIPTION: Coralla are not completely preserved, but are apparently

platy or hemispherical masses. The surface of either type of colony is convex. Calices about 1 mm. in diameter, circular in outline, and 1.0 to 1.5 mm. apart. Costae are non-confluent between corallites, often meeting at a sharp angle or alternating in position with those of adjacent corallites. The fossa is shallow; the calices are broad and open. The center of the corallite is dominated by a large stelliform columella, formed by the mingling of the larger septa and by the prominent dentation of the proximal ends of the septa. Large septal lobes are often developed just before the columella, forming a somewhat irregular crown about it. Septa number from 18 to 27, but the majority of the calices have 24, all of which reach the columella.

REMARKS: Only in the size and spacing of the corallites does the suite differ from *A. schafhäutli* (Winkler), the calices of which are 1.5 to 2.0 mm. in diameter and are usually 0.5 to 1.0 mm. apart. *Astrocoenia waltheri* Frech (1890, p. 34, text figs.), also collected from the Zlambach



FIGS. 11–13. *Thamnasteria* (*Astraeomorpha*) *cuneata*, new species. 11. Calices of holotype, A.M.N.H. No. 27973, × 4. 12. Natural cross section showing septal ridges, A.M.N.H. No. 27973, × 5. 13. Surface of corallum, A.M.N.H. No. 27974, × 4.

FIGS. 14–17. *Stylophyllum paradoxum* Frech. 14. Calice with bud on lip at right, A.M.N.H. No. 27981, × 3. 15. Side view of corallum, A.M.N.H. No. 27980, × 1. 16. Calicular view, A.M.N.H. No. 27978, × 1. 17. View of calice, A.M.N.H. No. 27979, × 1.

beds, is similar in appearance, but the septa are arranged in groups of 10, and the beading of their upper margin is more pronounced.

Astrocoenia martini Smith (1927, p. 132, pl. 115, fig. 5) is a distinctive species which was rather inadequately described. The arrangement of the septa in this species is superficially pentameral. Five of the first cycle of septa are thicker than the sixth, which in its proportions is similar to septa of the second cycle. Third-cycle septa usually appear in three or four of the systems and reach nearly the same degree of development as the second cycle. Thus, the appearance is of one group of five stout septa and 10 lesser, usually thinner, septa. Additional third-cycle septa are sometimes present but appear then as a third, shorter, group. The calices of this species are 3 to 4 mm. in diameter and are circular and closely united. The coenenchyme separating the calices bears a raised polygonal ridge surrounding each corallite. Three of the specimens figured by Smith (1927, pl. 112, figs. 7, 8, 9) as *Stephanocoenia juvavica* Frech clearly belong to *A. martini.*

Astrocoenia shastensis Smith (1927, p. 132, pl. 112, figs. 11–13) is also quite different, as it lacks a prominent columella and has more numerous, finer septa and large calices. *Astrocoenia shastensis* is more closely allied with *A. juvavica* Frech (1890, p. 38). The specimen that is the basis for Smith's figure 10 (1927, pl. 112) is probably not *S. juvavica* but *A. shastensis.*

Astrocoenia idahoensis, new species

Figures 9, 10

HOLOTYPE: A.M.N.H. No. 27963.

PARATYPES: A.M.N.H. No. 27964 (10 specimens).

DESCRIPTION: Coralla form low explanate masses with epithecal walls. Surfaces of coralla are flat to slightly convex, the surface appearing hirsute because of spinulose costae and exert septa. Calices small, 1.5 to 2.5 mm. in diameter, circular but often elongate. The fossa is shallow; the calices are broad and open. Septa number 16 to 28, arranged in a confused manner. The center of the calice is occupied by a columella which rises above the level of the proximal edges of the septa and appears to be styliform. A varying number of septa reach the columella, six to 12 in most cases. Irregularly intercalated between these are smaller septa which often unite with the larger septa midway to the center of the calice. Larger septa may join before the columella. Septa of the first (?) cycle are highly exsert and draw up adjacent lower-cycle septa with them, a feature that emphasizes the general spinose character of the upper coral-

lum surface. All septa are beaded on their upper margin and many bear a prominent bulb at the point of juncture with other septa. The proximal margin of the septa is highly spinulose. The calices are closely united; the surface of the thick wall separating them is not costate, but bears granules arranged in a generally linear fashion, sometimes being so aligned as to give the appearace of a continuous costa.

REMARKS: The species appears to differ from other Triassic astrocoeniids by the character of the surface of the wall. In this respect, it is not unlike *Platycoenia* in which the peritheca separating the corallites is echinulate, but which is characteristically plocoid, while the Idaho specimens are cerioid. The arrangement of the septa is somewhat unusual but occurs also in *A. juvavica* Frech, 1890. The relationship between this

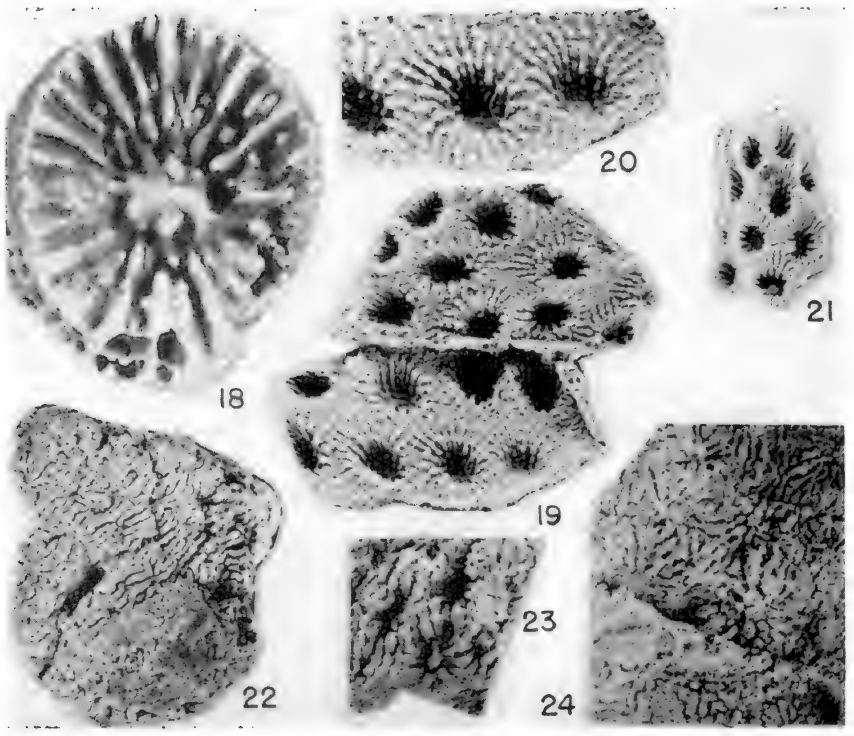


FIG. 18. *Oppelismilia zitteli* (Frech), A.M.N.H. No. 27984. Calicular view, × 3.

FIGS. 19–21. *Coccophyllum acanthophorum* Frech. 19, 20. Calicular views, A.M.N.H. No. 27987, × 3, × 5. 21. Side view of terminal portion of branch, A.M.N.H. No. 27986, × 3.

FIGS. 22–24. *Stylina norica* Frech. 22. Unworn corallum surface, A.M.N.H. No. 27967, × 3. 23. Natural section of calice. Note styliform columella at lower right, A.M.N.H. No. 27966, × 4. 24. Surface of worn corallum, A.M.N.H. No. 27965, × 4.

species and *A. shastensis* Smith (1927, p. 132, pl. 112, figs. 11–13, pl. 112, fig. 10 [as *A. juvavica*]) is difficult to determine; although the number of septa, their arrangement, and the size of the corallites are about the same, the shape of the corallites is somewhat different. Because *A. shastensis* is known only from thin sections, the surface characters of the wall are unknown. Additional study may indicate that *A. idahoensis* and *A. shastensis* are synonymous and perhaps identical with *A. juvavica*.

STYLINIDAE

STYLINA LAMARCK, 1816

Stylina norica Frech, 1890

Figures 22–24

Stylina norica FRECH, 1890, Paleontographica, vol. 37, p. 33, pl. 11, figs. 1–1b.

FIGURED SPECIMENS: A.M.N.H. Nos. 27965–27967.

DESCRIPTION: The form of coralla is unknown, but the surface is irregularly hummocky. Calices are about 2 mm. in diameter and separated by 2 to 6 mm. of costate peritheca, the costae being confluent between calices. Septa almost always number 12, but some calices have 14. All septa reach the center of the corallite but do not join the prominent styliform columella. The corallites tend to be more widely spaced in one direction than in others with the septocostae aligned in long parallel bands between them.

REMARKS: The identification of the species is based on the resemblance of the external features to the specimen figured by Frech (1890, pl. 11, figs. 1–1b). Particularly striking is the prominent styliform columella (this paper, fig. 23) and the relatively long costae connecting the calices. Broken surfaces of coralla of this species show no indication of tabular peritheca, but rather display the smooth, dense, fracture surface characteristic of this type of preservation. The species is neither abundant nor well preserved.

THAMNASTERIIDAE

THAMNASTERIA LESAUVAGE, 1823

Thamnasteria smithi, new species

Figures 25–28

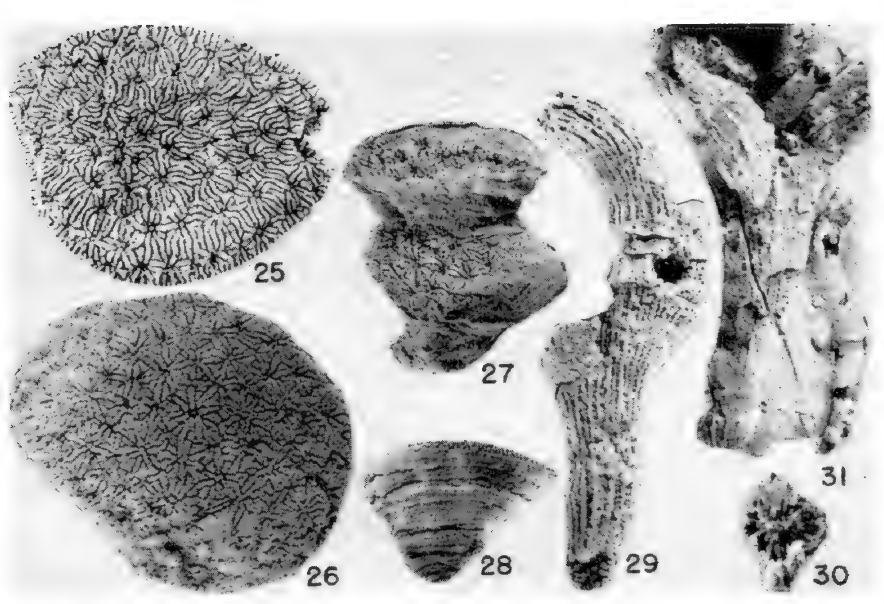
Thamnasteria rectilamellosa Winkler *var. minor* Frech, SMITH, 1927, U. S. Geol. Surv., Prof. Paper 141, p. 131, pl. 116, fig. 3, pl. 118, figs. 5, 6.

HOLOTYPE: A.M.N.H. No. 27969.

PARATYPES: A.M.N.H. Nos. 27970–27975.

DESCRIPTION: Coralla large, foliaceous, expanding rapidly from a nearly circular base. Upper surfaces of coralla are flat or slightly convex. Young coralla are mushroom shaped, with a convex or flat surface, the boundary between the rugose epithecate wall and upper surface being sharply defined. Calices are small, 2 to 3 mm. in diameter, and poorly defined. Septa are thinner than interseptal loculi and very slightly exsert with a rounded convex profile from the septocostae to the fossa. The septa range in number from 13 to 23, usually in two alternating groups. Septa of the first group reach the columella, while those of the second are shorter. The columella appears as a raised button but is not prominent. Septa and septocostae are bent, sometimes sharply, in the passage between adjoining corallites.

REMARKS: The closest alliance of this species would be with *T. rectila-*



FIGS. 25–28. *Thamnasteria smithi*, new species. 25. Surface of holotype corallum, A.M.N.H. No. 27969, × 3. 26. Surface of corallum, A.M.N.H. No. 27971, × 4. 27. Side view of rejuvenated corallum, A.M.N.H. No. 27975, × 2. 28. Side view of holotype corallum, A.M.N.H. No. 27969, × 2.

FIGS. 29, 30. *Thecosmilia* cf. *T. dawsoni* (Clapp and Shimer). 29. Side view of corallum, A.M.N.H. No. 28010, × 2. 30. Calicular view, A.M.N.H. No. 28009, × 3.

FIG. 31. ?*Thecosmilia* cf. *T. suttonensis* (Clapp and Shimer), side view of corallum. Note *Pinacophyllum parviseptum* on right. A.M.N.H. No. 28007, × 1.

mellosa var. *minor* Frech (1890, p. 62, pl. 7, fig. 12). However, comparison of Frech's description with a rather large suite of material from Idaho, supplemented by material from the Smith collection, indicates some fundamental differences.

Two factors must be compared in distinguishing between *T. smithi* and *T. rectillamellosa* var. *minor*. Frech (1890, p. 62) gives the number of septa in the latter as 18 to 20. Specimens from the Idaho collection have 13 to 23, while those assigned to *T. rectilamellosa* var. *minor* by Smith (1927, p. 131, pl. 116, fig. 3, pl. 118, figs. 5, 6) have 13 to 18 septa. Second, the diameter of the calices as indicated by Frech for *T. rectilamellosa* var. *minor* is 2 to 3 mm., by Smith, 3 to 4 mm., and in the Idaho material, 2 to 3 mm.

Specimens from North America have fewer septa and tend to have larger calices. In addition, the arrangement of the septocostae is somewhat different than in *T. smithi* and *T. rectilamellosa* var. *minor*. The value of these differences may be slight, perhaps of subspecific rank. However, *T. rectilamellosa* var. *minor* is not contemporaneous with *T. smithi*, having been described only from the Rhaetian "Starmberger facies." The coeval *Thamnasteria* to which the new species may be directly compared is *T. rectilamellosa* Winkler (Frech, 1890, p. 60, pl. 16, figs. 1–15, pl. 17, figs. 7, 8), which differs by having larger corallites (4 to 6 mm.) and more septa (20 to 26).

A specimen figured by Körner (1937, pl. 10, figs. 2a, 2b) from the upper Triassic of Peru may belong to the new species, although it is difficult to determine the number of septa present.

Thamnasteria (Astraeomorpha) cuneata, new species

Figures 11–13

?*Thamnastrea borealis* SMITH, 1927 (part), U. S. Geol. Surv., Prof. Paper 141, p. 131, pl. 115, figs. 8, 9, 10.

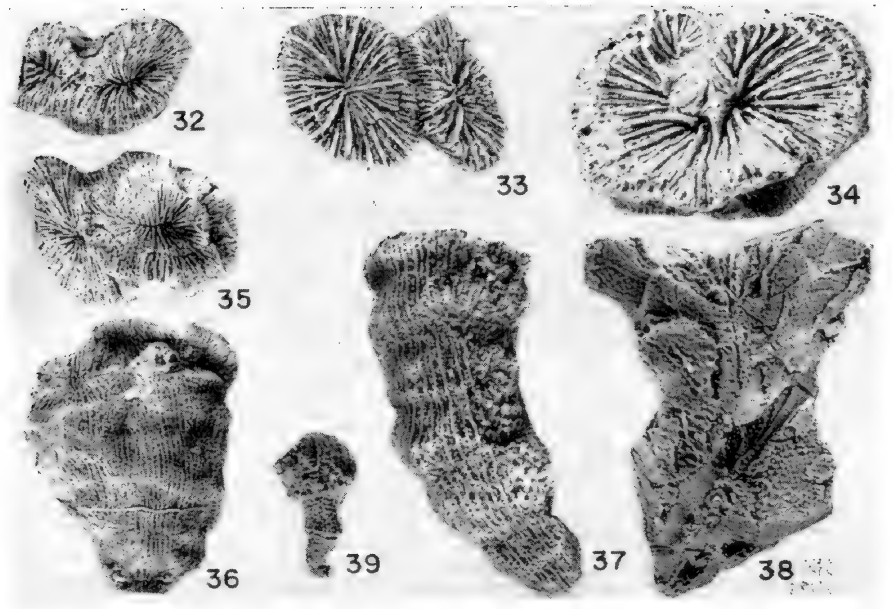
HOLOTYPE: A.M.N.H. No. 27973.

PARATYPES: A.M.N.H. Nos. 27974 and 27976.

DESCRIPTION: Coralla are small and nodular. Calices are small, 2 to 3 mm. in diameter, fairly well defined. Septa are at least twice the thickness of the interseptal loculi, tend to be cuneiform, and are exsert, giving the corallum a hirsute appearance. The fossa is a deep pit, sharply defined, in which a rod-like columella is situated. Septa number 16 to 21 and are arranged in no apparent pattern, with distinct distal thickening that makes interpretation difficult. Usually seven major septa reach the columella, the remainder alternating in size. Major septa are confluent between

calices, but shorter septa usually do not extend far enough as septacostae to reach the neighboring calices. Ridges developed on the lateral portions of the septa are strong and continuous.

REMARKS: This suite of specimens was placed in the subgenus *Astraeomorpha,* although in only one instance were the lateral portions of the septa sufficiently exposed for the presence of the ridges characteristic of the subgenus to be determined. The septa of this specimen were distinctly cuneiform and had the sharply defined calicular pit characteristic of the species. On the basis of the two latter features, the remainder of the specimens were included in the species. The character of the septa sharply separates this species from *T. smithi.* The hirsute appearance of the upper surface of the corallum is also distinctive, but may be a feature of preservation. It is possible that the form of the corallum described for the species is misleading and represents only immature forms. It is for this reason that the species is tentatively allied with *T. borealis* Smith.



FIGS. 32–39. *Montlivaltia norica* Frech. 32. Incompletely separated calices, A.M.N.H. No. 27997, × 1. 33. Dicentric condition with calices completely separated, A.M.N.H. No. 27996, × 1. 34. Irregular growth and calicular development caused by injury, A.M.N.H. No. 27995, × 2. 35. Calicular view of rejuvenated dicentric individual with complete separation, A.M.N.H. No. 27998, × 1. 36. Side view of the same specimen, × 1. 37. Side view of corallum, A.M.N.H. No. 27989, × 1. 38. Natural longitudinal section of corallum, A.M.N.H. No. 27992, × 2. 39. Side view of corallum, A.M.N.H. No. 28000, × 1.

Thamnasteria borealis Smith is somewhat problematical. The type (U.S.N.M. No. 74243; Smith, 1927, pl. 115, figs. 6, 7) is not *Thamnasteria,* but *Palaeastraea decussata* (Reuss). The paratypes, U.S.N.M. No. 74244 (Smith, 1927, pl. 115, figs. 8, 9), are clearly allied to *T. (Astraeomorpha)*. The specimen figured as plate 115, figure 10 could not be definitely identified in the collection but may be the same specimen as that illustrated as figures 8 and 9 on the same plate. The mode of growth in *T. borealis* is quite different from that of the Idaho specimens. The corallum forms large parallel branches which may anastomose along their length, a feature that distinguished the species from the Idaho material. As these coralla are quite large, it is quite possible that the Idaho specimens are only early stages in the development of this form.

Thamnasteria (A.) crassisepta (Reuss) (Frech, 1890, p. 66, pl. 19, figs. 14–18) has a greater number of septa, almost double the number typically found in the Idaho material. *Thamnasteria (A.) confusa* Winkler (Frech, 1890, p. 67, pl. 19, figs. 2, 3, 5, 6, 8, 10, 13) differs in that it has eight to 10 septa reaching the center of the calice. *Thamnasteria (A.) confusa* var. *minor* Frech (1890, p. 68, pl. 19, figs. 1, 4, 7, 11, 12) has much smaller calices than *T. (A.) cuneata. Thamnasteria (A.) pratzi* Volz (1896, p. 61, pl. 6, figs. 17–19) is distinguished by the smaller number of septa present in the calices but is similar to the Idaho species in the appearance of the corallum and in the thickness of the septa.

STYLOPHYLLIDAE

STYLOPHYLLUM REUSS, 1854

Stylophyllum paradoxum Frech, 1890

Figures 14–17

Stylophyllum paradoxum FRECH, 1890, Paleontographica, vol. 37, p. 54, pl. 14, figs. 1–24, pl. 15, fig. 12.

FIGURED SPECIMENS: A.M.N.H. Nos. 27978–27981.

DESCRIPTION: Coralla are solitary, moderately large, 9 to 35 mm. in height, 8 to 16 mm. in diameter and variable in form. Young specimens are often tympaniform, but subcylindrical individuals are not unusual. Height of the corallum is usually less than the diameter of the calice, but several imperfectly preserved specimens are digitiform. The wall is epithecate and rugose, with basal talons prominently developed in some tympaniform specimens. The calice is broad and open, with a shallow fossa. Septa number from 24 to 46, depending on calice size. Two groups may be defined: longer septa which are distally and basally laminar and spinose proximally, and shorter, less well-developed septa which are only

laminar immediately adjacent to the wall, the principal portions being spinose. These latter do not extend more than half of the distance to the columella. The first- and second-cycle septa comprise the first group.

The second group is formed of the third cycle and those septa of the fourth cycle present as spines intercalated between third-cycle septa.

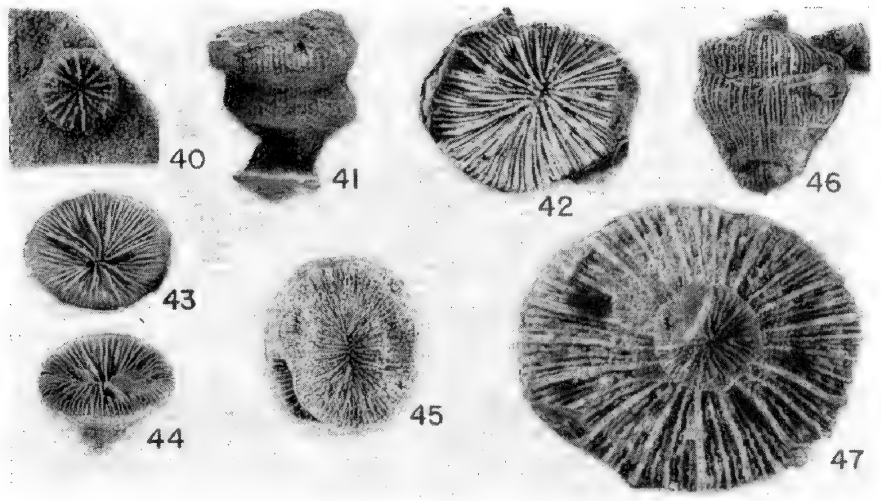
REMARKS: The most striking feature of this species is its variability as illustrated by Frech, both in the Zlambach and Idaho occurrences. Periodic contraction of the corallum is very common, and only rarely is a specimen found in which the wall of the corallum is continuous and smooth. Budding from the calicular lip is not uncommon, and one example has been illustrated.

OPPELISMILIA DUNCAN, 1867

Oppelismilia zitteli (Frech), 1890

Figure 18

Stylophyllopsis zitteli FRECH, 1890, Paleontographica, vol. 37, p. 49, pl. 13, figs. 9–15, 17–24. Not Smith, 1927, U. S. Geol. Surv., Prof. Paper 141, p. 127, pl. 111, figs. 7–9.



FIGS. 40–47. *Montlivaltia norica* Frech. 40. Calicular view of young specimen, A.M.N.H. No. 28003, × 3. 41. Side view of corallum, A.M.N.H. No. 28001, × 0.75. 42. Calicular view, A.M.N.H. No. 27991, × 1. 43, 44. Calicular and oblique calicular views, A.M.N.H. No. 27993, × 1. 45. Calicular view, A.M.N.H. No. 27990, × 1. 46. Calicular view of rejuvenated individual, A.M.N.H. No. 27994, × 2. 47. Side view of same specimen, × 1.

FIGURED SPECIMEN: A.M.N.H. No. 27984.

DESCRIPTION: Coralla moderately large, 15 to 20 mm. high, 10 to 15 mm. in diameter. The form is basically conical, but there is often slight compression of the calice. The base is slightly expanded, often bearing epithecal talons. Calices are broad and open, with a shallow fossa. Septa are non-exsert, 24 to 29 in number, those of the first cycle distinctly laminar and broadly dentate on the upper margins, while those of the second cycle are more sharply dentate both on the upper margin and on the proximal edge. Septa of the third cycle are almost completely spinose, but the spines are fused at the floor of the calice. First- and second-cycle septa reach the columella, mingling there to form a mass which extends upward in the calice; often the septa are proximally thickened into a bulb at this point. Endotheca is abundant and commonly forms a shallow floor in the calice.

REMARKS: The three specimens referred to the species are somewhat different from those figured by Frech, but comparison with topotype material indicates that the axial development of the septa is somewhat stronger than he indicated.

Smith (1927, p. 127) recorded the occurrence of *O. zitteli* from Oregon, and figured three isolated calices which are actually from a single block also containing numerous specimens of *Thecosmilia norica* Frech of Smith. There is no difference between the calices and septa of these two "species," and the specimens of *O. zitteli* show none of the characters of *Oppelismilia*. The identification of *Stylophyllopsis mojsvari* Frech by Smith (p. 127) is also incorrect. The specimen figured (pl. 118, fig. 10) is an unprepared calice and shows none of the characters of *Oppelismilia*. With suitable preparation, the true affinities of the specimen could be determined, but in all probability it is *Montlivaltia norica* Frech.

COCCOPHYLLUM REUSS, 1865

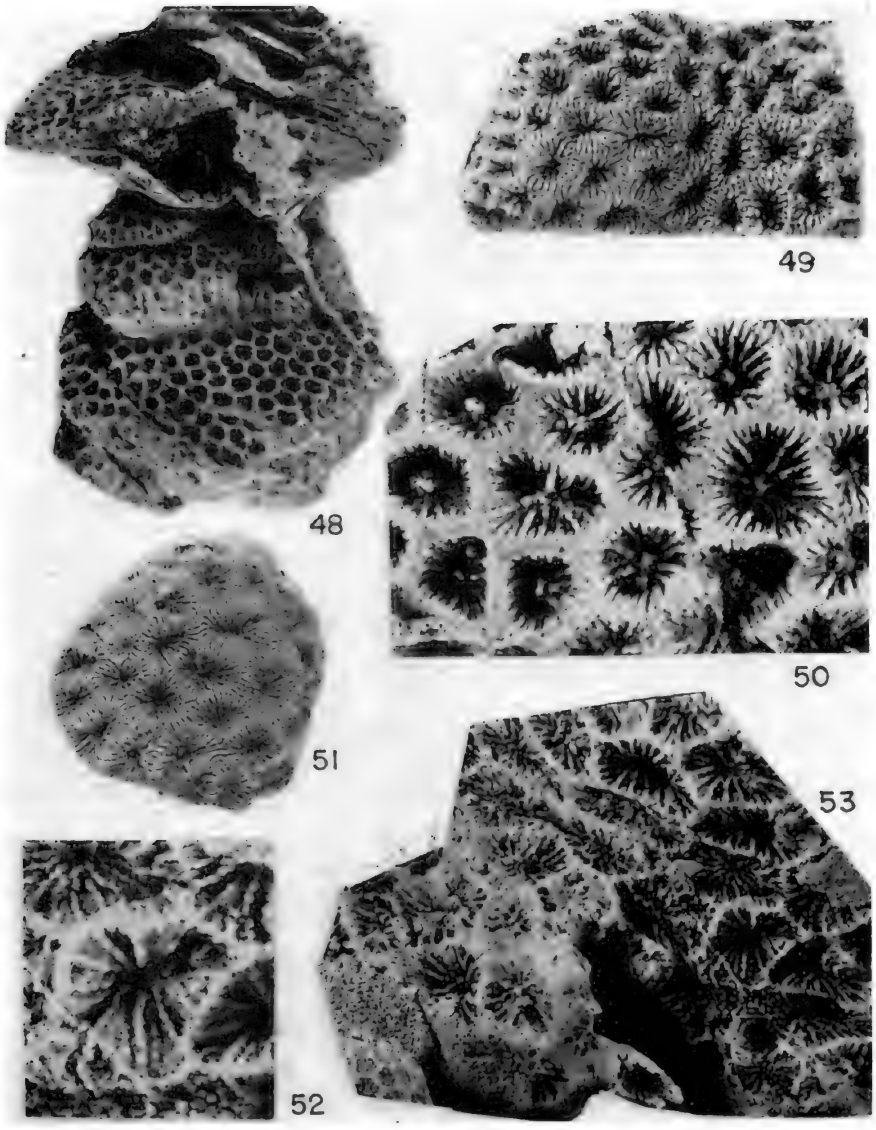
Coccophyllum acanthophorum Frech, 1890

Figures 19–21

Coccophyllum acanthophorum FRECH, 1890, Paleontographica, vol. 37, p. 89, pl. 29, figs. 4–11.

FIGURED SPECIMENS: A.M.N.H. Nos. 27986 and 27987.

DESCRIPTION: The form of the coralla is unknown, but two types of growth are represented in the collection: small specimens that are explanate and larger specimens that apparently were branched. In the single distal portion of a branch in the collection, the corallites are arranged



FIGS. 48–51. *Elysastraea profunda* (Reuss). 48. Corallum showing periodic rejuvenated growth, A.M.N.H. No. 28013, × 0.5. 49. Surface of partially worn corallum, A.M.N.H. No. 28016, × 3. 50. Calices of worn specimen with apparent deep calicular pit, A.M.N.H. No. 28013, × 3. 51. Surface of unworn corallum, A.M.N.H. No. 28015, × 3.

FIGS. 52, 53. *Elysastraea major* (Frech), A.M.N.H. No. 28018. 52. Calice, × 4. 53. Corallum, × 2.

spirally in the manner of the oculinids. Corallites are small, oval, and arranged linearly in the explanate portions and spirally on the branches. Diameter of the corallites varies from 0.75 to 2.0 mm., with the average about 1.5 mm. The fossa is moderately deep, but the calicular pit is broad and open. Septa number from 18 to 24 and are arranged in two groups. The first two cycles of septa comprise the first group, which is well developed, appearing as low ridges on the corallite wall, with two or three spines projecting from the ridge into the calice. The second group, which alternates in position with the first, appears only as spinose projections from the wall, and is composed of the third cycle of septa, incompletely developed. Corallites are separated by 1.5 to 2.0 mm. of peritheca which is smooth on the surface. Arranged about the corallites are granulose to spinose costae which are not completely confluent between calices, the corallites being sharply defined.

REMARKS: The distance between corallites separates the species from *C. sturi* Reuss (Frech, 1890, p. 88, pl. 20, figs. 1–3) in which the corallites are closely adpressed. Topotype material indicates that the relationships between the Idaho material and the Zlambach specimens is much closer than the data given by Frech would indicate. The corallites are somewhat more widely spaced, and on unweathered surfaces of the Zlambach specimens the same costate appearance may be seen. The septa of *C. acanthophorum* are spinose but are secondarily thickened by stereome so that they appear laminar, particularly when sectioned below the level of calice.

MONTLIVALTIIDAE

MONTLIVALTIA LAMOUROUX, 1821

Montlivaltia norica Frech, 1890

Figures 32–47

Montlivaltia norica FRECH, 1890, Paleontographica, vol. 37, p. 34, pl. 3, figs. 9a, 9b, pl. 10, figs. 1–5, pl. 13, figs. 1–7, pl. 18, figs. 17, 17a. SMITH, 1927 (as *Montlivaultia*), U. S. Geol. Surv., Prof. Paper 141, p. 126, pl. 111, fig. 6.

Stylophyllopsis mojsvari Frech, SMITH, 1927, U. S. Geol. Surv., Prof. Paper 141, p. 127, pl. 118, fig. 10.

FIGURED SPECIMENS: A.M.N.H. Nos. 27989–27998, 28000, 28001, 28003.

DESCRIPTION: Coralla are highly variable in form, with equally variable dimensions in comparable growth stages. The monocentric condition is most prevalent, although dicentric and tricentric forms are represented.

Septa are numerous, usually about 10 in 5 mm., but ranging from seven to 13 in 5 mm. This character could be used to split the group into three components, but the value of such a basis for classification is questionable, as all other characters intergrade. Septa are arranged in three groups: the first reaching the columella, the second slightly shorter and thinner, the third thinnest and extending about one-half of the distance to the columella. Septa are laterally granulose, with the granules arranged in lines paralleling the proximal and upper margins of the septa. The columella is formed by the trabecular fusion of the proximal ends of the septa, and is about one-quarter to one-eighth of the diameter of the calice in extent. Usually the columella is arranged so that it lies in the plane of the long axis of the calice. Endotheca is abundant, particularly near the margin of the corallite.

REMARKS: The fine suite of specimens present in the Idaho collections is indicative of the abundance of the species and the great variation that occurs within the species. Without doubt, slight effort would result in the splitting of the group into numerous finer morphological groups, but the value of such an action is questionable.

Marked rejuvenation in the development of the corallum is one of the most conspicuous features of the Idaho assemblage. This is not so common among specimens from other areas and is apparently a reflection of the environmental conditions.

Smith's specimen of *S. mojsvari* is an unprepared specimen in the center of a limestone block. Details of minor septa and of form of corallum must have been taken from Frech's work or accessory specimens, as they could not be derived from the figured specimen. There is little doubt that it is *M. norica,* as several other specimens referred to this species from the same collection exhibit the same general appearance.

The relationships of Smith's *Montlivaultia martini* (1927, p. 126, pl. 121, fig. 6) are uncertain. Apparently the species was based on the single figured specimen (U.S.N.M. No. 74263). Two characters are unique: the lack of diffuse endotheca such as found in *M. norica,* and the presence of the three concentric rings of endotheca or stereome on the inner portion of the columella.

THECOSMILIA MILNE-EWARDS AND HAIME, 1848

?Thecosmilia cf. *T. suttonensis* (Clapp and Shimer), 1911

Figure 31

Calamophyllia suttonensis CLAPP AND SHIMER, 1911, Proc. Boston Soc. Nat. Hist., vol. 34, p. 431, pl. 40, figs. 5–7, pl. 41, fig. 15.

Thecosmilia fenestrata Ruess, SMITH, 1927, U. S. Geol. Surv., Prof. Paper 141, p. 128, pl. 105, figs. 1, 9.

FIGURED SPECIMEN: A.M.N.H. No. 28007.

DESCRIPTION: Four poorly preserved specimens are tentatively placed with this species. The general form of the fragments is thecosmiliid, but none of the grosser features are preserved. None of the calices are preserved, and no septa may be seen except for their trace on the wall, as viewed from the exterior. The corallum was apparently formed by elongate, upright, bifurcating branches in which the angle of divergence is great. Diameter of corallites ranges from 5 to 10 mm., with the majority of specimens falling at the lower limit. Apparently 16 septa were present, but nothing is known of their arrangement. Endotheca abundant and preserved.

REMARKS: Because of the poor preservation of the material, only the external features of the corallum can be compared. *Thecosmilia clathrata* (Emmrick), 1853 (Frech, 1890, p. 15, pl. 9, figs. 1–5, 7–11), is similar in the form of the corallum and in the total number of septa. *Thecosmilia fenestrata* (Reuss) (1894, p. 105, pl. 5, figs. 20, 21) is similar in many of these characters but differs in the angle at which the branches diverge and by having more septa.

Smith (1927, p. 128) placed *C. suttonensis* Clapp and Shimer in synonymy with *T. fenestrata*. From the figures of Clapp and Shimer (1911), it is probable that the relationship to *T. clathrata* suggested by them is much more apt. The widely diverging branches set the species apart from *T. fenestrata*.

Thecosmilia norica Frech, described by Smith (1927, p. 128, pl. 111, figs. 1–4), is quite different, as the corallites are much larger, more robust, have many more septa, and evidently have much more endotheca. The specimens described by Smith differ from Frech's in the same manner and may represent a new species.

Thecosmilia cf. *T. dawsoni* (Clapp and Shimer), 1911

Figures 29, 30

Calamophyllia dawsoni CLAPP AND SHIMER, 1911, Proc. Boston Soc. Nat. Hist., vol. 34, p. 431, pl. 40, fig. 1, pl. 42, fig. 16.

Thecosmilia delicatula (Frech) SMITH, 1927, U. S. Geol. Surv., Prof. Paper 141, p. 127, pl. 105, fig. 4.

FIGURED SPECIMENS: A.M.N.H. Nos. 28009 and 28010.

DESCRIPTION: Coralla apparently irregularly branching, but the appearance of a complete corallum is unknown, as the only specimens representing the species are detached fragments. Diameter of the corallites is

3 to 4 mm. Epitheca missing, perhaps owing to attrition. Septa are over 48 in number, but their arrangement is not clear because of poor preservation. The arrangement comprises two groups, one of which reaches the columella.

REMARKS: The species is quite close to *T. dawsoni* in general features, but a more detailed description and comparison must await complete specimens.

Smith's inclusion of *T. dawsoni* in synonymy with *T. delicatula* is not appropriate, as the corallites are much smaller in the latter, and the method of branching is quite different. There are certain similarities between *T. recondita* (Laube) (1865, p. 255, pl. 4, fig. 3) from the St. Cassian beds, which has about the same mode of budding, corallites of the same size, and about the same number of septa.

PALAEASTRAEA KÜHN, 1936

Palaeastraea sp.

REMARKS: Surprisingly, no specimens referable to this genus have been well preserved. Three fragmentary specimens have tentatively been related to the genus. The genus is, however, well represented in the Norian of North America, and some notes on the distribution of the species are in order.

Palaestraea decussata and *P. incrassata* have both been recognized by Smith (1927). After examination of material from the Fischerwiese Zlambach beds, I am in agreement with the conclusion of Haas (1909, p. 146) that the two are synonymous. *Palaeastraea decussata* (Reuss) of Smith (1927, p. 130, pl. 113, fig. 7, pl. 115, figs. 1–3) is correctly placed. The disposition of the specimen figured as plate 121, figure 2 is questionable, but probably it belongs here, as does the specimen called *P. incrassata* (Smith, 1927, pl. 130, pl. 121, fig. 3). The latter two are poorly preserved and recrystallized.

Confusastrea borealis Smith (1927, p. 129, pl. 116, figs. 1, 2) belongs in this genus and may not be separable from *Isastraea cowichanensis* Clapp and Shimer (1911, p. 429, pl. 41, fig. 11). Both species show very close resemblance to the *P. decussata* type and differ only in the apparent greater development of the anastamosing parallel stocks. The specimens referred to *C. cowichanensis* Clapp and Shimer by Smith (1927, pl. 114, figs. 10–13, pl. 121, fig. 1) are not correctly placed in that genus but are more properly *Elysastraea.*

ELYSASTRAEA LAUBE, 1864

Elysastraea profunda (Reuss), 1854

Figures 48–51

Isastraea profunda REUSS, 1864, Denkschr. K. K. Akad. Wiss., Vienna, vol. 7, p. 116, pl. 9, figs. 5, 6. FRECH, 1890, Paleontographica, vol. 37, p. 21, pl. 5, figs. 1–3a. SMITH, 1927, U. S. Geol. Surv., Prof. Paper 141, p. 128, pl. 105, fig. 8, pl. 112, figs. 5, 6, pl. 114, figs. 1–3.

Confusastrea cowichanensis (Clapp and Shimer), SMITH (part), 1927, U. S. Geol. Surv., Prof. Paper 141, p. 127, pl. 114, figs. 10–13.

Isastraea whiteavesi CLAPP AND SHIMER (part), 1911, Proc. Boston Soc. Nat. Hist., vol. 34, p. 429, pl. 40, fig. 9.

FIGURED SPECIMENS: A.M.N.H. Nos. 28013, 28015, 28016.

DESCRIPTION: The form of coralla is unknown, but apparently elongated stocks with convex surfaces were formed. Corallites are moderately large, 2.0 to 3.5 mm. in diameter, closely adpressed and polygonal in outline. Walls are narrow, with confluent septa continuous over them. Septa are exsert at juncture of corallites, then slope downward into the calice at an angle of 30 degrees with the horizontal. The septa are commonly broken away, so that the calice appears to be deep and open, in which case the septa appear as vertical laminae on the walls of the corallite. Septa are numerous, 24–42 in number, arranged in two groups: the larger, accounting for nearly all septa, are long, reaching the center of the calice; alternating between them, in some portions of the calices, are shorter septa. Septal dentations are more apparent on the proximal ends of the septa, where they often form prominent beads. Immediately before the columella, the larger septa may bear lobes which appear to mingle with the columella. In those corallites in which the septa are broken away, the columella appears to be styliform.

REMARKS: The species is apparently a member of a series characterized by increasing size of corallites. The differences between these species are slight, and eventually they may be shown to be identical.

Isastraea parva Smith (1927, p. 128, pl. 114, figs. 7–9) is the first of the series. As indicated by Smith, the corallites are about 1 mm. in diameter but may range from 0.75 to 2.0 mm. Septa are not so numerous as indicated by Smith, there being six to 12 major septa extending to the center of the corallite and a second smaller group alternating between these. *Isastraea vancouverensis* Clapp and Shimer (1911, p. 43, pl. 40, fig. 8, pl. 42, fig. 17) also recorded by Smith (1927, p. 128, pl. 105, fig. 10, pl. 112, figs. 1–4, pl. 114, figs. 4, 6, pl. 121, figs. 4, 5) has corallites 2 to 4 mm. in diameter and 20 to 30 septa. Several of the specimens figured

by Smith (pl. 114, fig. 6, pl. 112, figs. 3, 4) may be intermediate between *E. parva* and *E. vancouverensis. Elysastraea profunda* (Reuss) differs from *E. vancouverensis* in that the corallites are 2.0 to 3.5 mm. in diameter and the septa number 24 to 42. The final stage in the development is *E. major* (Frech), in which the corallites may be 5 to 9 mm. in diameter, and there may be as many as 90 septa.

Elysastraea major (Frech)

Figures 52, 53

Isastraea profunda var. *major* FRECH, 1890, Paleontographica, vol. 37, p. 22, pl. 5, figs. 4, 5.

FIGURED SPECIMEN: A.M.N.H. No. 28018.

DESCRIPTION: A single fragmentary portion of a corallum referable to this species was found in the Idaho collection. The corallites tend to be elongate, measuring 5 to 8 mm. in the greater, 4 to 6 mm. in the lesser, diameter. Corallites are closely packed, more so than in *E. profunda,* with a very thin wall across which the septa are confluent between corallites. Septa vary in number from 40 to 60, all dentate on their upper margin. Septa are arranged in two broad groups: the first are long, reaching the center of the calice; the second, irregularly interspersed between septa of the first group, are very short, not extending halfway to the center.

REMARKS: The chief differences between *E. major* and *E. profunda* are in the size of the corallites, the number of septa present within them, and the thin-walled appearance of the corallites.

Because of the method of silicification, various calices of the specimen show two types of septal structure. The more general appearance is that of laminar septa with pronounced beading on the upper margin. Other calices have septa which appear stylophyllid in structure, a resemblance attributed to pronounced and localized trabecular silicification. These two septal types or found in taxonomically widely separated genera. *Elysastraea* typically has laminar septa bearing strong beads on the upper margin. *Heterastrea,* a styllophyllid coral, has many of the same generic characters as *Elysastraea* but possesses septa composed of trabecular spines fused with stereome so that they appear, in some instances, sublaminar. The single specimen in the collection is interpreted as having montlivaltid septa, but should further collecting reveal the stylophyllid nature, it will be of great interest, for the genus *Heterastrea* is not known from either the Norian or North America.

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