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Rugose Corals of the Livingston Limestone Member, Bond Formation, Coles and Edgar County, Illinois

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ABSTRACT

The rugosan coral species *Lophophyllidium proliferum* (McChesney, 1860) has long been associated with the Pennsylvanian (Missourian) strata of the Illinois Basin. The neotype established by Jeffords (1942) and associated specimens collected near Springfield, IL are nearly identical to the study samples from the Livingston Limestone member exposure at the Charleston Stone Company quarry in Coles County, IL and a similar site behind St. Aloysius Church in Edgar County, IL. Previous studies described *L. proliferum* as the only identified coral species in the local exposures. New data verify the existence of two additional rugosan species: *Lophamplexus westii* (Beede, 1898) and *Geyerophyllum* sp. cf. *G. broilii* Heritsch, 1936. The presence of these additional species indicates a more diverse faunal community than previously described and verifies the faunal correlation between the Bond Formation of Illinois and the Zone 4 Missourian Rocks of Kansas as expressed by Cocke (1974).

INTRODUCTION

The genotype for *Lophophyllidium* Grabau, 1928: *Cyathaxonia prolifera* McChesney, 1860, neotype: *Lophophyllidium proliferum* (McChesney, 1860), was first described in Pennsylvanian shale near Springfield, IL in the northwest section of the Illinois Basin. Jeffords (1942, p. 214) borrowed nine specimens from the Worthen collection at the Illinois Geological Survey to establish the neotype, as there is no record of the original specimens used by McChesney. The Worthen specimens were collected from beds above the No. 8 coal, now known as the Chapel Coal (ISGS, 2005, fig. 2), near Springfield, placing them in the Patoka Formation (Lower Missourian), below the Bond Formation stratigraphically (Jacobson, 2004) (Figure 1).

The Livingston Limestone Member of the Bond formation (Mid-Missourian) has also yielded specimens of *L. proliferum* (McChesney). Gilliam (1973) and Stratton (1991) reported the presence of this species locally at the Charleston Stone Company quarry; no other species had been described from this site. In contrast, studies of similar faunal zones in Iowa, Nebraska and Kansas have yielded multiple genera including: *Lophamplexus*, *Stereostylus* (Jeffords, 1947), *Caninia* and *Geyerophyllum* (Cocke, 1970).

STRATIGRAPHY

The type section for the Livingston Limestone member is located in Clark County, IL along exposures near Big Creek, SE1/4, NW1/4, sec. 6, T. 11 N., R. 11 W, consisting of an upper limestone, 1.5 to 2.5 m of shale, which locally includes a thin coal bed, and a lower limestone (Giffin, 1978, p. 3-4). The Livingston Limestone is now recognized as correlative to the Millersville Limestone (Stratton, 1991, p. 48) and the La Salle Limestone (Jacobson, 1983), members of the Bond Formation (Jacobson, 2004); original reference by A. H. Worthen (1895), Illinois Geological Survey, v. 6, p. 11-19 (Keroher, 1966). The Charleston Stone Company quarry is located in Coles County, IL at NE1/4, SW1/4, NW1/4, sec. 5, T. 12 N, R. 10 E (Stratton, 1991, p. 48), and St. Aloysius Church is located in Edgar County about 5 miles northeast of Paris, IL, SW1/4, SE1/4, NE1/4, sec. 10, T. 14 N, R. 11 W (Giffin, 1978, p. 166). Strata exposed at the two study sites are on opposite flanks of the LaSalle Anticlinorium (Weller, 1906), which trends southward through the heart of the Illinois Basin (Stratton, 1991, p. 48). The Charleston quarry is located on the western slope of the uplift and St. Aloysius Church sits on the eastern slope.

Coles County, IL. The Charleston Stone Company quarry exposure consists of upper and lower limestone benches separated by a narrow layer of shale (Figure 2). The upper limestone section is fine grained, light-gray in color, massive and contains large crinoid columns and brachiopods. The lower limestone section is medium light gray in color, very fine grained, dense and massive (Stratton, 1991, fig. 28) and is the primary quarried material. Both benches are classified as Algal Bank limestones (Fraser, 1991). The shale separating the two limestone sections is greenish in color, calcareous and the main source of fossils from the quarry, which Stratton (1991, p. 50-51) described as yielding the most diverse, abundant and best preserved marine faunas in the Illinois Basin; however, fossiliferous areas seem to be localized. While old quarry pits on the east side of the Embarrass River contained highly fossiliferous bed sets, newly exposed sections five hundred meters away lack macro fossils and seem anoxic.

Edgar County, IL. The St. Aloysius exposure of the Livingston Limestone Member is correlative to the Charleston site (Giffin, 1978, fig. 8). At the waterfall behind the church, the upper limestone bench has been eroded down to about a foot in thickness and overhangs the underlying shale. The shale unit at this site is crumbly and unconsolidated with numerous finely detailed corals and brachiopods. Specimens of *Lophamplexus westii* (Beede, 1898) are more common in the St. Aloysius exposure than in the Charleston quarry and are generally more intact.

METHODS

Field observation and collection. Sample material for the study came from three sources: the spoil piles at the Charleston Stone Company quarry, a stream cut exposure behind St. Aloysius Church in Edgar County and the Livingston Collection at Eastern Illinois University. The bulk of the sampling is from the quarry; however, some of the more diverse specimens were gathered from the St. Aloysius exposure. Over 150 samples were obtained with several representative specimens from each of the three morphologically dissimilar groups chosen for thin sectioning.

Material examined. Ninety-three specimens of *L. proliferum* (McChesney) were recovered; all but seven coming from the spoil piles at the Charleston quarry site. Many of the samples are extremely small, immature and complete at the apex. Nine reasonably intact mature corallites were selected for thin sectioning. Nine transverse and five longitudinal sections were prepared from the samples.

Fifty-five specimens of *L. westii* (Beede), many consisting of broken middle segments, were recovered (twenty of these collected at the St. Aloysius site) with eleven specimens from the lot selected. In all, ten transverse and nine longitudinal sections were prepared.

Seven specimens of *Geyerophyllum* sp. cf. *G. broilii* Heritsch were acquired for the study. Two previously unidentified and relatively intact corallites came from the EIU Livingston collection. The other five samples are partial corallites recovered from the Charleston quarry spoil piles. Five transverse and four longitudinal sections were prepared with specimens 075, 084 and 101 photographed and preserved intact for future study.

Two recently collected and unidentified specimens demonstrate extreme flaring and complete calices. A third intact specimen located in the EIU collection and labeled *Geyerophyllum rude* is complete with holdfasts in a limestone matrix. All three specimens were preserved intact.

SYSTEMATIC PALEONTOLOGY

Systematics used in agreement with the *Treatise on Invertebrate Paleontology Part F* (Hill, 1981a, 1981b). All study specimens are reposited in the Livingston Collection at Eastern Illinois University, Charleston.

***Lophophyllidium proliferum* (McChesney, 1860)**

Type species. There is no record of the holotype used by McChesney in his original description (Jeffords, 1942, p. 214). The neotype was established by Jeffords (1942) and is reposited in the Illinois State Geological Survey Collections, Urbana as W46064 (?or 4064a), but is probably lost (Hill, 1981a, p. F335). Syntype KUM 52878, as chosen by Jeffords (1942) is reposited at the University of Kansas Museum (Fedorowski, 1974, pl. 60, fig. 1).

Diagnosis. Corallite conical, except in gerontic sections, having a strong oval or plate-like columella with median lamella, formed as an extension of the counter septum, extending the entire length of the corallite and sometimes projecting distally. A reduced cardinal septum lies in a conspicuously shaped fossula, with 20 to 22 rhopaloid major septa in a bilateral arrangement common to lophophyllid corals and illustrated by Jeffords (1942, pl. 1, figs. 1-3) (Figure 3.1). In longitudinal sections, thin tabulae slope upwards from a moderately thick theca to a strong axial structure (Figure 3.2).

External description. Corallites generally maintain a conical shape that gently curves in the plane of the counter-cardinal septa (Figure 3.3). The epitheca is marked by distinct longitudinal interseptal ridges and transverse growth wrinkles. Rejuvenation is not evi-

dent in any of the samples; however, one specimen did demonstrate evidence of regeneration after damage.

In a certain number of study specimens the columella distally projects several millimeters above the floor of the calice. Only on the uppermost edge of the calice does *L. proliferum* enter a somewhat breviseptal stage. Intact specimens sometimes reveal a deep calice with shortened septa and a solitary or reduced columella. The damage sustained during burial provides an incomplete picture of the mature upper corallite.

Occurrence. The holotype and neotypes were collected from the beds over Coal No. 8, Trivoli cyclthem (sic), Missouri series near Springfield, IL (Jeffords, 1942, p. 214, 219). This roughly correlates to the Lower Missourian faunal zones of the Patoka Formation (Jacobson, 2004). The Livingston samples are from the younger Upper Bond Formation of the Middle Missourian Series (Figure 1). Shimer and Shrock (1944, p. 87) described *L. proliferum* as widespread and common in Pennsylvanian rocks from the Mississippi Valley to Texas and New Mexico.

Discussion. The distinguishing feature of this species is the strong, laterally compressed and vertically striated axial column (Grabau, 1922, p. 47) extending the length of the corallite. The neotype of the species is 30.0 mm in length and 12.7 mm in diameter at the calice. Eight other specimens in the same lot ranged from 12.1 to 33.3 mm in length and 8.2 to 10.4 mm in diameter (Jeffords, 1942, p. 215). These values agree well with the Livingston test samples, having a range from 15 to 48 mm in length and 8 to 10 mm in diameter (Table 1), with some of the wider specimens having been laterally compressed. The large number of *L. proliferum* samples in the study contained one unique specimen (032) that accounted for the increased range. Some immature quarry specimens had diameters of 5 to 6 mm and lengths between 10 and 12 mm.

Jeffords (1942) described the calice as moderately deep with the laterally compressed columella projecting into the lower part. In several weathered specimens, the columella extended a few millimeters above the rest of the corallite (p. 215).

***Lophamplexus westii* (Beede, 1898)**

Type species. The University of Kansas Museum houses the type material studied by Beede. The holotype is No. 811021a from the "Upper Coal Measures" of the Hertha Limestone of Kansas City (Jeffords, 1947, p. 72).

Diagnosis. Corallites appear conico-cylindrical with rejuvenation occurring early and often in mature individuals. Specimens display an overall cylindrical shape and inconsistent curvature, with surface features similar to *L. proliferum*. Points of rejuvenation are usually marked by a change in the direction of growth. Thin attenuate septa are generally short, although they lengthen and join together in rejuvenation structures (Figure 3.4). The axial column is thin and discontinuous after early growth, only to reappear during rejuvenation and at the base of the calice in mature specimens. Some individuals have a column that extends for prolonged distances. Tabulae are complete, flat-topped and intersected by the axial column when present (Figure 3.5). Most specimens display some amplexoid tendencies.

External description. Corallites are narrow and cylindrical in mature regions, conical and similar to *L. proliferum* in early stages. Onset of cylindrical shape is sometimes accompanied by the first rejuvenation. Mature specimens show either extreme curvature or variations in growth direction, especially during rejuvenation. Areas of rejuvenation are highlighted by thick transverse growth wrinkles followed by a narrowing of the corallite. The epitheca is marked by distinct longitudinal interseptal ridges similar to *L. proliferum* (Figure 3.6).

The similarities in external morphology between *L. westii* and *L. proliferum* are enough to require thin sectioning for positive identification in some cases. A general field diagnosis can be made for *L. westii* if the corallite demonstrates rejuvenated sections corresponding with deeply incised transverse growth wrinkles, changes in growth direction for rejuvenated sections and an overall cylindrical shape. *L. westii* samples have a greater variability in growth curvature when compared to *L. proliferum*, which generally maintains a gently curved and conical shape; in addition, *L. westii* corallite diameters are generally 1-2 mm less than *L. proliferum* (Table 1).

Occurrence. The type materials are from the Hertha Limestone of the Bronson Group, Missourian Series (Pennsylvanian), at Kansas City, Missouri (Jeffords, 1947, p. 72), placing them in Zone 1 of the Missourian Limestones of Kansas (Cocke, 1970, table 1). Additional specimens have been recognized from the Bethany Falls Limestone in Bourbon County, Kansas and from a Bronson Group exposure in Neosho County, Kansas (Jeffords, 1947, p. 72). In an earlier study, Jeffords (1942, table, p. 253) reported the occurrence of (syn) *Lophophyllum westi* (sic) Beede in the Missourian rocks of Kansas.

Discussion. The figured specimens illustrated by Jeffords (1947, pl. 24) demonstrate the inherent variability in the septal layouts during various stages of *L. westii*. Repeated periods of rejuvenation are described in which adolescent characters reappear immediately above a breviseptal stage (Jeffords, 1947, p. 70). *L. westii* differs structurally from other *Lophamplexus* Moore and Jeffords species with its long, crooked cylindrical shape and frequent rejuvenations (Jeffords, 1947, pls. 25.4-25.5). The axial structure reappears just before rejuvenation and disappears during sporadic amplexoid growth stages. A persistent columella separates this species from *L. vagus*, *L. spanius*, *L. phractus*, and *L. brevifolis* (Jeffords, 1947, pls. 22-24, 27, 28); however, internal morphology revealed during the sectioning of the study samples contained a range of structural variation suggesting that either multiple *Lophamplexus* species are present in the quarry, or *L. westii* corallites are inherently variable as to indicate subjunctive synonymy. Longitudinal sections reveal the breviseptal morphology that is characteristic of the genus and constitutes a major ontological and phylogenetic difference between *L. westii* and *L. proliferum*. Although *L. proliferum* septa shorten in gerontic stages, the columella is strong and persistent; unlike the weak, sporadic nature of the columella in *L. westii* (Table 2).

***Geyerophyllum* sp. cf. *G. broilii* Heritsch, 1936**

Type species. ?*Geyerophyllum broilii* Heritsch, 1936, was first described in the Pennsylvanian (Missourian) rocks of Kansas (Hill, 1981b, p. F406).

Diagnosis. This species generally contains corallites with gently flaring shapes; however, the study samples flare strongly, similar to some of the Cocke (1970) study samples (pl.

8, figs. 2, 8). The epitheca is marked by longitudinal ridges and variable transverse growth wrinkles (Figures 4.1, 4.4). Septal layout is similar to lophophyllid corals in nepionic stages (Cocke and Cocke, 1969, p. 942). Mature sections are distinguished by long thin septa and a narrow dissepimentarium with moderate lonsdaleoid characteristics (Figure 4.2). Septa are attenuate and somewhat crooked. Minor septa are reduced in the tabularium; while major septa project axially, almost to the column when present. The axial structure is strong and oval in ephebic sections, has a spinose or denticulate appearance and is connected to the cardinal septum. Dissepiments are elongated, irregular in size and bounded by an inner wall that separates the dissepimentarium from the tabularium (Figure 4.3). Tabulae are rare to absent in mature sections.

External description. Corallites strongly flare in ephebic stages. Longitudinal interseptal ridges and transverse growth wrinkles are similar to *L. proliferum*; however, the strongly flaring shape is in sharp contrast to both *L. proliferum* and *L. westii*. The calice of mature corallites is sometimes found preserved without the lower sections.

Occurrence. Cocke (1970) described *Geyerophyllum* sp. cf. *G. broilii* as occurring in the Wyandotte and Plattsburg Formations of the Zone 4 Missourian limestones of Kansas. Specimens from the Argentine Limestone of the Wyandotte Formation possess gently flaring shapes, a stellate columella and lanceolate major septa (p. 49).

Discussion. Cocke (1970, p. 46) described *Geyerophyllum* sp. cf. *G. broilii* as differing from other *Geyerophyllum* corals by having a moderately flaring shape and lacking a prominent lonsdaleoid dissepimentarium. Some lonsdaleoid characteristics are present in the quarry sections, especially above the axial column; no sections displayed prominent lonsdaleoid features as in *G. patulum* Cocke (1970, pl. 7, figs. 6a, 7a). A highly denticulate axial column is indicated for *Geyerophyllum* sp. cf. *G. broilii* (Cocke, 1970, p. 8, figs. 4-5). Cocke (1970) noted that when specimens are in an algal-rich calcilutite, they tend to have flaring shapes, a strongly denticulate columella and rather well developed lonsdaleoid dissepiments (p. 42). The Charleston study samples demonstrate all three characteristics (Table 2).

Geyerophyllum sp. cf. *G. broilii* differs from *G. rude* in having a strongly oval and denticulate axial column; however, if it can be demonstrated that the axial column varies due to environmental conditions, then the two may be conspecific.

Geyerophyllum specimens are rare in the Livingston Limestone Member. Only seven partial corallites were collected out of over 150 total rugosan samples. No dissepimental corals have presently been recovered from the St. Aloysius exposure; although one sample in the Eastern Illinois University Livingston Collection is labeled as having been recovered from the site in 1971. Cocke (1974) later commented that the Livingston Limestone in Illinois has corals that are similar to those of Zone 4 of the Missourian rocks of Kansas. *Geyerophyllum* sp. cf. *G. broilii* is one of three *Geyerophyllum* genera identified in Zone 4 (Cocke, 1970, table 1).

SUMMARY

Agreement between the structural morphology of the study specimens and historic descriptions of Paleozoic corals by Jeffords (1942, 1947), Moore and Jeffords (1945), Cocke (1970), Hill (1981a,b) and Fedorowski (1974, 1987) demonstrates that multiple phylogenetic lineages exist in the rugosan corals of the Livingston Limestone member, revealing a more diverse fauna than earlier described. The lack of specific studies on previously collected Charleston Stone Company quarry and St. Aloysius samples have led previous researchers to label most collected specimens as either *Lophophyllidium* sp. or *Lophophyllidium proliferum*. Clearly, three distinct genetic lines: *Lophophyllidium* Grabau, *Lophamplexus* Moore and Jeffords and *Geyerophyllum* Heritsch flourished in the warm, near offshore epeiric sea that covered central Illinois during the Mid-Missourian (Gilliam, 1973, p. 32).

ACKNOWLEDGMENTS

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Figure 1. Relative Illinois Pennsylvanian stratigraphy with formations and common members adapted and modified from Willman et. al, 1975 (Jacobson, 2004).

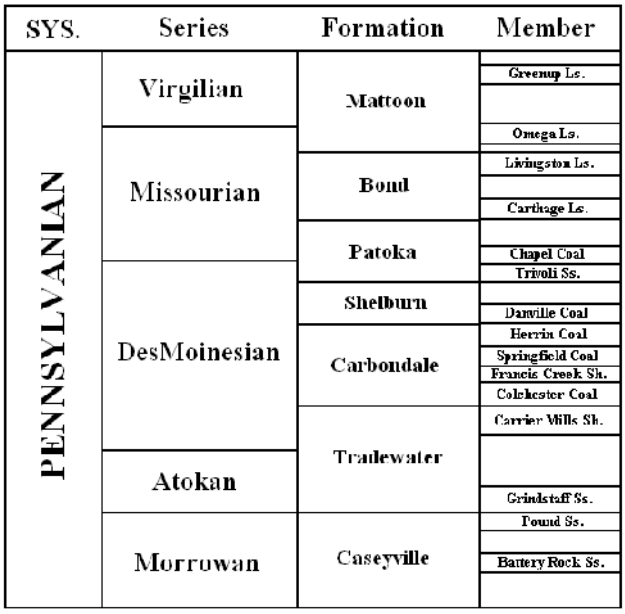


Figure 2. Charleston Stone Company quarry stratigraphic column (adapted from Giffin, 1978, p. 38).

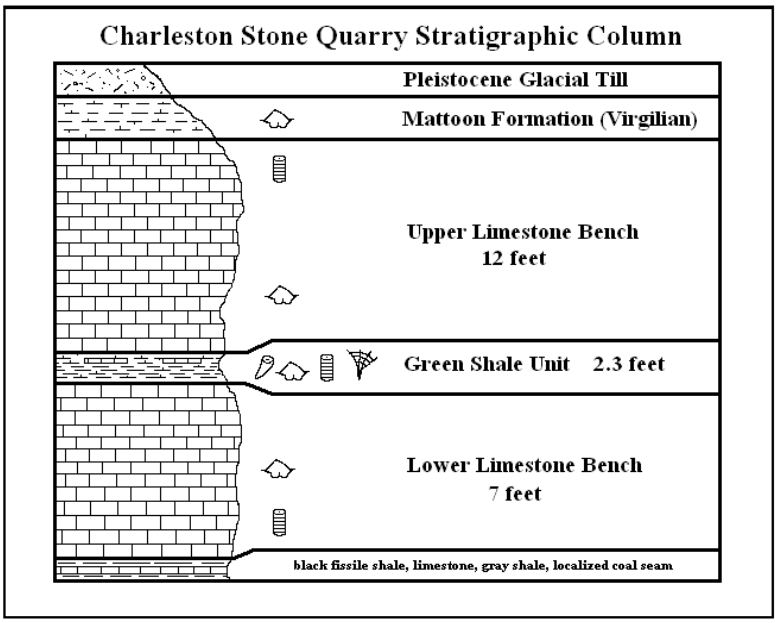
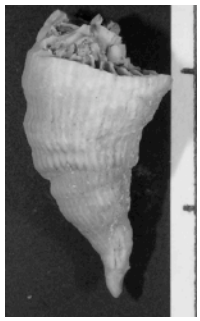
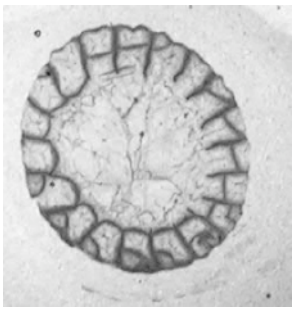


Figure 3. Images of study samples. Scale is in centimeters. (1.) Specimen 027, *L. proliferum*, transverse section, note median lamella. (2.) 011, *L. proliferum*, longitudinal section, note strong axial structure. (3.) 027, *L. proliferum*, external view, projecting columella broken off. (4.) 077, *L. westii,* transverse section, one of several septal variations. (5.) 077, *L. westii*, longitudinal section, note breviseptal region and tabulae morphology. (6.) 077, *L. westii*, external view.

1. 

2. 

3. 

4. 

5. 

6. 

Table 1. Summary table of corallite dimensions. All measurements are in millimeters. N/A listing is due to lack of data either from damage during preparation or initial condition of the specimen prevented further testing.

Specimen	CD	Length	NS	ID	Locale	Notes
001*	10	20	24	*L. proliferum*	CSQ	
011	9	19	24	*L. proliferum*	CSQ	
021	7	15	n/a	*L. proliferum*	CSQ	extended column
022	10	18	25?	*L. proliferum*	CSQ	compressed calice
027	10	21	24	*L. proliferum*	CSQ	complete apex
032	10	48	24	*L. proliferum*	CSQ	upper LS
071	10	20	24	*L. proliferum*	CSQ	
082	9	15	24	*L. proliferum*	CSQ	
Average	9	22				
Range	7-10	15-48				
006	7	30	n/a	*L. westii*	CSQ	compressed calice
018	6	20	n/a	*L. westii*	CSQ	mid section
029	9	15	20	*L. westii*	CSQ	complete apex
034	7	20	20	*L. westii*	CSQ	conical shape
043	6	17	16	*L. westii*	CSQ	
076	7	22	20	*L. westii*	St. A	highly curved
077	8	42	19-22	*L. westii*	St. A	partial
080	10	n/a	23	*L. westii*	CSQ	upper calice only
094	8	37	22	*L. westii*	St. A	partial
096	9	41	24	*L. westii*	St. A	partial
Average	8	27				
Range	6-10	15-42				
068	13	14	n/a	sp. cf. *G. broilii*	CSQ	partial
069	16	n/a	23	sp. cf. *G. broilii*	CSQ	upper calice only
072	14	12	23	sp. cf. *G. broilii*	CSQ	partial
075	24	10	49?	sp. cf. *G. broilii?*	CSQ	highly flared
084	19	n/a	n/a	sp. cf. *G. broilii*	CSQ	upper calice only
100	20	13	n/a	sp. cf. *G. broilii*	CSQ	mostly complete
101	20	12	47?	sp. cf. *G. broilii?*	CSQ	nicely polished
Average	12	18				
Range	13-24	10-14**				

*Specimens reposited under the catalog number EIU/LC 121613

**poor data due to incomplete specimens

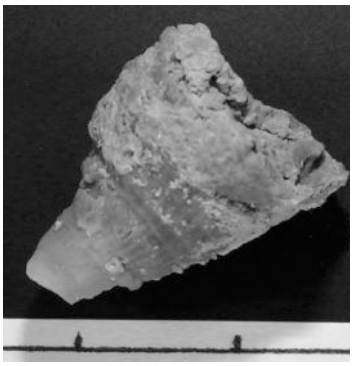
CD: corallite diameter NS: number of major septa

Table 2. Summary of major corallite characteristics.

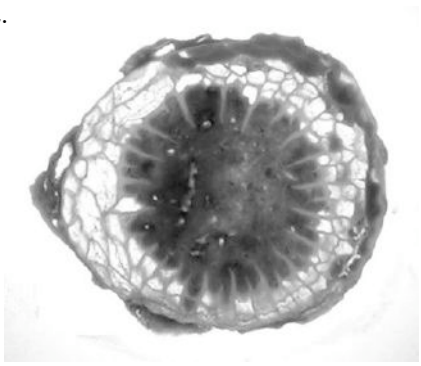
TABLE OF CORALLITE CHARACTERISTICS			
Character	*L. proliferum*	*L. westii*	sp. cf. *G. broilii*
Shape	conical, gently curved	conico-cylindrical, straight to bent	flaring, upright
Axial Column	solid, oval, projecting	weak, thin, sporadic	strong, oval, spinose, shortened distally
Major Septa	strong, rhopaloid	weak, shortened, highly variable	thin, crooked, attenuate
Minor Septa	absent or greatly reduced	reduced	thin, crooked, reduced in tabularium
Tabulae	short, thin, sloping upward into column	complete, flat topped domes, flair w/ column	none above early ephebic stages
Dissepiments	none	none	narrow dissepimentarium moderate lonsdaleoid dissepiments
Rejuvenation	none	frequent	none

Figure 4. Images of study samples. Scale is in centimeters. (1.) Specimen 072, *Geyerophyllum* sp. cf. *G. broilii*, external view. (2.) 072, sp. cf. *G. broilii*, longitudinal section. (3.) 072, sp. cf. *G. broilii*, transverse section, note sporadic lonsdaleoid dissepiments. (4.) Specimen 100, sp. cf. *G. broilii*, highly flaring specimen. (5.) 100, sp. cf. *G. broilii*, oblique longitudinal section.

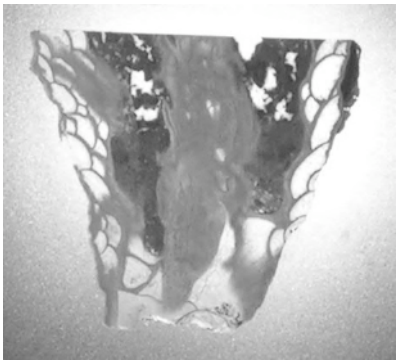
1.



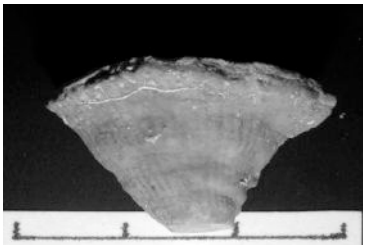
2.



3.



4.



5.