CALCAREOUS GREEN ALGAE FROM UPPER CRETACEOUS OF TRIPOLI (NORTH AFRICA)

BY

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CALCAREOUS GREEN ALGAE FROM THE UPPER CRETACEOUS OF TRIPOLI (NORTH AFRICA)

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ABSTRACT

The flora described by Miss Rita Raineri in 1922 is revised on the basis of the original material. Seven species are discussed, of which two are considered new and one is rejected as an echinoid radiole.

It is well known to students of fossil algae that investigation of these forms is seriously hindered by insufficient knowledge of one of the richest and most important floras, that of the Upper Cretaceous of North Africa. This flora was described more than ten years ago by Miss Rita Raineri (1922). She was kind enough to lend me for examination her slides, from which I made notes and drawings, but I did not publish my results, except for short references in various papers (Pia, 1925; Hirmer, 1927; Pia, Pfender, and Termier, 1932; Rama Rao and Pia, 1935). The present paper is a redescription of Miss Raineri's material, based entirely on her slides.

The age of the flora seems not accurately known. It is Cenomanian or Turonian. Heinz (1934, p. 721) recently proposed the term "Lüneburgian" as a comprehensive name for the Cenomanian and Turonian strata. It is adopted as useful in the present instance.

The localities from which the specimens were collected are in the Italian colony of Libya, not far from the city of Tripoli.

THE FLORA

Most of the algae are comparatively small and not well preserved. I was able to distinguish the following species:

Dissocladella undulata (Raineri), a primitive small species without clear adaptation of the primary branches to their function as sporangia.

Trinocladus tripolitanus Raineri, an interesting transitional type between the genera *Dissocladella* and *Thyrsoporella*.

Neomeris, at least two species, in poor preservation.

Acicularia antiqua Pia, n. sp., the oldest and most primitive representative of the genus, showing a certain resemblance to *Terquemella*.

Boueina pygmaea Pia, n. sp., distinguished from *B. hochstetteri* by its smaller size.

"*Actinoporella cretacica* Raineri," an echinoid radiole.

I am not dealing here with the Corallinaceae of the Libyan Cretaceous limestones, which were described by Raineri in a separate paper (1920).

The flora of the Lüneburgian of Libya resembles that of the Danian of South India (Rama Rao and Pia, 1935) in the frequent occurrence of *Dissocladella* and *Acicularia*. It differs in the presence of *Neomeris* and

Boueina as well as in the absence of *Indopolia* and *Orioporella.*

In Morocco a small flora was discovered a few years ago, the age of which was fixed as Danian. In my opinion it is perhaps Paleocene (Pia, Pfender, and Termier, 1932). It contains *Neomeris*, numerous *Acicularia* more highly specialized than the Libyan and Indian forms, and *Halimeda* instead of *Boueina.*

Many of the differences in these floras are certainly accidental. Much more work will be needed before the Cretaceous Dasycladaceae can be used for stratigraphic correlation in the same way as the Triassic species are used, but I trust that this will be possible at some future date.

Acknowledgments.—I take this opportunity of thanking Miss Raineri again for her kindness and magnanimity. I also wish to thank Professor Erling Dorf for his help in the preparation of my manuscript.

The manuscript was received by the editor of the Journal May 2, 1935.

SYSTEMATIC DESCRIPTIONS

In the following descriptions these abbreviations are used: D, diameter of skeleton. d, diameter of axial cavity. p_1, maximum diameter of primary pores. p_2, maximum diameter of secondary pores. l_1, length of primary pores. In "*Actinoporella cretacica*": d', outer diameter of the central tube. n, number of radial plates.

DISSOCLADELLA UNDULATA (Raineri) var.

Plate 1, figures 1–12

Neomeris cretacea var. *undulata* RAINERI, *1922*, p. 74.
Trinocladus undulatus (Raineri), PIA in Hirmer, *1927*, p. 77.
Dissocladella undulata (Raineri), RAMA RAO and PIA, *1935*.

Thallus cylindrical. Greatest length of the calcareous incrustation measured in a slide 1.4 mm. This is, of course, only a lower limit for the real length, as the section was not strictly longitudinal. Other measurements are shown in the table.

Measurements in millimeters of Dissocladella undulata *(Raineri) var.*

D	d	$= D\%$	p_1	p_2
0.24	0.08	33	—	—
0.25	0.09	34	0.04	0.056
0.25	0.10	37	0.04	—
0.28	0.09	31	—	—
0.29	0.10	32	0.032	0.024
0.29	0.10	33	—	—
0.29	0.10	36	0.056	0.032
0.32	0.10	33	0.049	0.056

The relative width of the axial cavity, as expressed in percentage, varies very slightly, which seems to indicate that the incrustation was in direct contact with the axial cell, for it is to be assumed that the central cavity would show greater variability if its width were controlled only by the deposition of more or less calcium carbonate on the inner surface of the skeleton. This supposition is strengthened by the very regular, smooth inner surface of the skeleton, which can best be explained as being modeled directly by the axial cell. In cross sections the axial cavity appears circular (Pl. 1, figs. 3, 6, 9); in longitudinal sections (Pl. 1, figs. 1, 4) it is broadly constricted between the whorls of branches, which originate upon rather sharply defined swellings of the axial cell. The name given to the species by Miss Raineri was derived from this character. The shape of

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EXPLANATION OF PLATE 1

FIGS. *1–12*—Sections through the skeleton of *Dissocladella undulata* (Raineri) var., ×60, from the Upper Cretaceous of Teghrenna (Garian), near Tripoli, Libya, North Africa. *2, 11* from Miss Raineri's slide 5; *8* from slide 16; *1, 9* from slide 17; *6, 10* from slide 18; other figures from slide 21. Drawings by the author. (p. 4)


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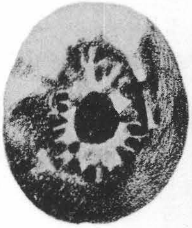
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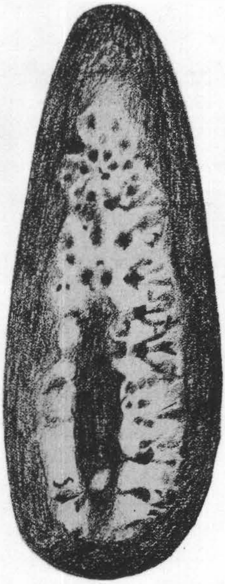
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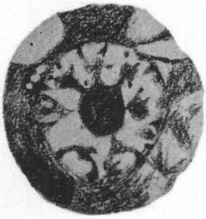
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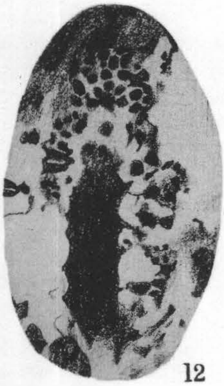
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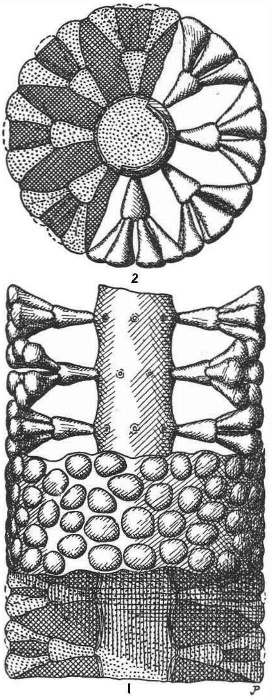
Pia, Cretaceous Algae

the axial cell deduced from the axial cavity very much resembles that in *Triploporella fraasi* (Steinmann, 1899, p. 138).

There are about eight primary pores in a whorl (Pl. 1, figs. 6, 9), narrow where they open into the axial cavity and expanding outward. Their diameter (not to be measured very exactly) is 11 to 19 per cent of the total thickness of skeleton. About six secondary pores originate from the distal end of a primary pore (Pl. 1, figs. 4, 8, 12), resembling the primary pores in shape and dimensions. On the surface of the skeleton their broad distal ends are closely crowded together. The living plant seems to have been covered by a sort of cortical layer (Pl. 1, figs. 3, 12). No trace of tertiary pores could be discovered in this species.



FIGS. *1, 2*—*Disocladella undulata* Raineri var. ×120. *1*, Reconstruction of part of the thallus. In the upper third of the figure the calcareous skeleton and part of the branches are removed. The middle zone shows the appearance of the complete alga. The lower part of the figure gives a diagrammatic longitudinal section through the soft body and the skeleton. The protoplasm is marked by dots, the calcareous skeleton by cross-hatching. *2*, Reconstruction of whorl seen from above.

As shown by Raineri's description and figures, as well as by the labels on the slides, at least the majority of her specimens of *Neomeris cretacea undulata* belong to the species under consideration. I am fairly certain that her figures 8, 9, 10 and 11 represent this species; figure 5 might be a *Boueina;* I am not able to name figures 6 and 7; the latter is possibly some other fossil, not an alga.

The genus *Dissocladella* has been discussed in more detail elsewhere (Rama Rao and Pia, 1935). The species under examination does not show separate sporangia, and the spores were probably produced in the primary branches. There were many more than two secondary twigs attached to a branch. I can therefore not agree with Miss Raineri concerning the generic position of her species.

Localities: Teghrenna (Garian) and police-barracks of Msellata-Homs.

TRINOCLADUS TRIPOLITANUS Raineri

Plate 2, figures 1–10

Trinocladus tripolitanus RAINERI, *1922*, p. 79, pl. 3, figs. 15, 16.

According to Raineri the greatest length of a section of this species is 3.36 mm. I thought it superfluous to search the slides for a still longer specimen, for the real length of the thallus was probably much greater. I am under the impression that it was of a rather slender, cylindrical shape. Measurements are as follows:

1. Specimen in which only the primary branches were encompassed by the calcareous skeleton:

$D=0.47$ mm. $d=0.16$ mm. $=34\%$ of D.

2. Specimen with primary and secondary pores:

$D=0.61$ mm. $d=0.14$ mm. $=23\%$ of D.

3. Specimen with tertiary pores clearly visible:

$D = 0.68$ mm. $d = 0.19$ mm. $= 28\%$ of D.
$l_1 = 0.135$ mm. $= 20\%$ of D.
$p_1 = 0.087$ mm. $= 13\%$ of D.

The arrangement of the primary pores in whorls in easily recognisable in the slides. The branches in successive whorls generally do not alternate; on the contrary, they show a tendency to form longitudinal rows (Pl. 2, fig. 8). In a specimen 2.2 mm. long I counted 20 whorls, in another of the same length 21. The distance of the whorls (from center to center) is therefore a little more than 0.1 mm. The primary pores are filled with a very dark sedimentary material, which probably owes its color to carbonaceous matter derived from the soft body of the alga. The branches were approximately club-shaped and rather thick. Generally a cluster of secondary pores arises from the external end of a primary pore. In some specimens, however, the stout primary pores open directly on the surface of the skeleton (Pl. 2, figs. 2, 5). Sections like that shown in Pl. 2, fig. 4, prove that these specimens belong to *Trinocladus tripolitanus*. They show the ramification of some branches, while others obviously divided into secondary twigs beyond the calcareous incrustation. I was not able to determine exactly the number of secondary pores belonging to a primary pore. Sections like Pl. 2, figs. 1, 3, and 9, indicate that the clusters contained at least 5 or 6 pores.

The secondary pores repeat on a smaller scale the shape of the primary pores, narrow at their bases, expanding outward, and generally opening on the outer surface. Some, however, divide again immediately below this surface, giving rise to tertiary pores, an important fact already recognised by Miss Raineri. The tertiary pores are short and slender (Pl. 2, figs. 6, 10), and about six of them formed a cluster. About 30 tertiary twigs were attached to a primary branch and about 250 to a whorl. Miss Raineri gives a much smaller figure, about 60, but she seems to have overlooked the fact that a longitudinal section of a branch never shows the full number of the twigs attached to it. This can only be seen in a cross-section of the basal part of a cluster.

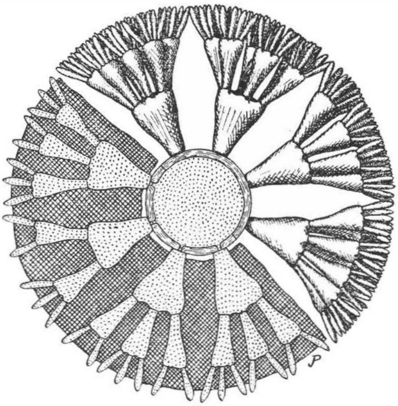


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FIG. *3*—*Trinocladus tripolitanus* Raineri. Reconstruction of a whorl with tertiary twigs, seen from above, ×80. The protoplasm is marked by dots, the calcareous skeleton by cross-hatching.

Raineri explains the frequent occurrence of sections lacking tertiary, or even secondary, pores as an effect of mechanical erosion, the removal of the outer part of the skeleton, which may have been less compact from the beginning. Under this assumption specimens showing primary pores only ought to agree fully with the inner part of specimens that

EXPLANATION OF PLATE 2

FIGS. *1–10*—Sections through the skeleton of *Trinocladus tripolitanus* Raineri, ×42, from the Upper Cretaceous of the Wadi Msaaba, near Tripoli, Libya, North Africa. *2* from Miss Raineri's slide 7; *5–7* from slide 9; other figures from slide 12. *2*, *5*, specimens with primary pores only; in *4* two main pores bear secondary ones; *6*, *10*, specimens with tertiary pores; *10* probably a section near the apex of the plant; *3*, two fragments of different orientation closely packed together. Drawings by the author. (p. 5)


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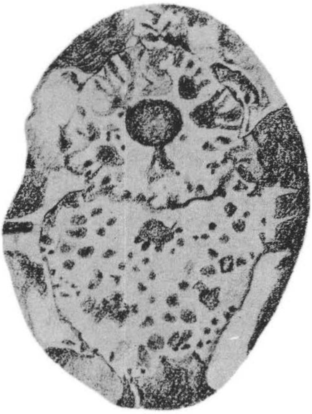
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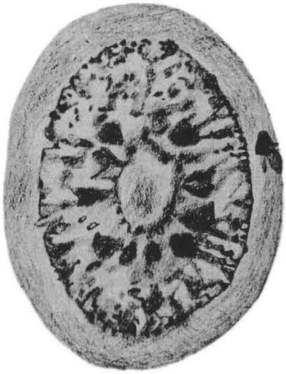
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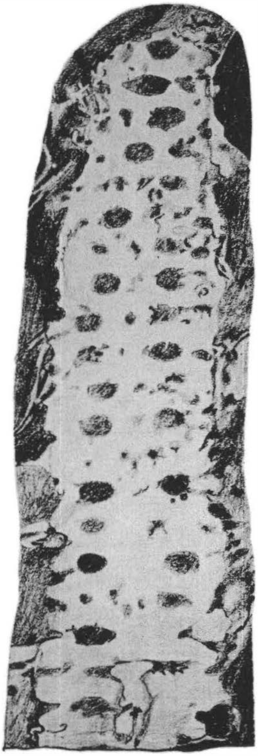
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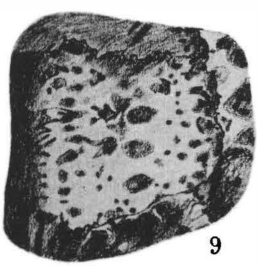
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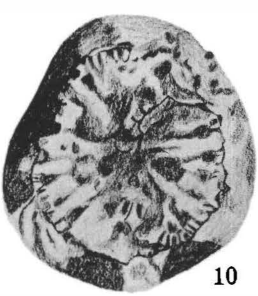
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Pia, Cretaceous Algae

show a richer development of pores. I tried to test this hypothesis by a series of measurements. Under (*a*) are given below the diameters of specimens without secondary pores; under (*b*) the distances between the distal ends of opposed primary pores of specimens showing branching.

(*a*). 0.47 mm., 0.50 mm., average, 0.48 mm.

(*b*). 0.35 mm., 0.44 mm., 0.47 mm., 0.48 mm., 0.36 mm., 0.34 mm.; average, 0.41 mm.

Considering the small number of specimens the difference between the two series of measurements is of little real value. In any case, however, we have to keep another possibility in mind—that some whorls never had secondary and tertiary twigs. Probably this was not a peculiarity of certain plants, but of certain parts, presumably the lower ones, of each plant. Sections showing this simple type are not numerous in the slides. Probably the part of the alga with primary twigs only was not of great extension; above it, perhaps, was the part with primary and secondary pores, apparently the major part, as sections of it are common. In the uppermost region of the alga primary, secondary and tertiary branches were encompassed by the calcareous envelope. On a former occasion I gave a similar interpretation of the structure of *Palaeodasycladus* (Pia, 1920, p. 120).

It seems very probable that the primary branches contained uncalcified spores, at least where they bore secondary twigs. The dark color of their contents may be an indication of a former rich accumulation of protoplasm. Sections with primary pores only may correspond to a sterile, lower region of the alga, such as is well known in the Recent *Neomeris*. In the region with tertiary twigs the secondary twigs likwise may have contained spores.

I was not able to fix exactly the shape of the tertiary twigs. They may have formed a cortex, or possibly they bore assimilatory trichomes.

Trinocladus tripolitanus may be distinguished from *Dissocladella undulata* by the following characters: The diameter of the skeleton is decidedly larger. Tertiary pores are occasionally present. The secondary pores are much smaller than the primary ones.

Trinocladus tripolitanus is an excellent transitional type between the genera *Dissocladella* and *Thyrsoporella*.

I consider Raineri's figure 15 to be the type of our species. Figure 16 very probably also belongs to it, though it does not show tertiary twigs.

All the slides containing *Trinocladus tripolitanus* are labelled "Wadi Msaaba" (near Msellata).

NEOMERIS, several spp.

Plate 3, figures 18–22

As already explained, the algae assigned by Raineri to *Neomeris cretacea* do not belong to that genus. This does not mean however, that the genus *Neomeris* is not represented in the Luneburgian of Tripoli. I think it highly probable that fragments of at least two species are present in the slides. It is not surprising that only fragments rather difficult to determine were found, for the skeleton of *Neomeris* is always rather frail.

A few tangential sections through fragments of skeletons show two kinds of pores, larger pores of a very regular, circular shape, probably sporangia; and smaller pores, often somewhat irregular. The smaller pores seem to be more numerous than the larger pores (Pl. 2, figs. 18, 20). The diameter is about 0.095 mm. and 0.03 to 0.04 mm. respectively. Probably two small pores belong to a large pore, a relation characteristic of the genus *Neomeris*.

My interpretation is confirmed by cross-sections like that shown on Pl. 3, fig. 19, which shows the larger cavities to be spherical (obviously opened on the external side by attrition), whereas the smaller pores pierce the skeleton. The thickness of the calcareous incrustation seems to be about 0.12 mm. in this specimen.

This species differs widely from *Neomeris cretacea* Steinmann. The sporangia are spherical, not pear-shaped, the wall of the skeleton is much thinner, etc. Sections of this character are visible in slides from Teghrenna, Msellata-Homs, and perhaps also from the Wadi Msaaba.

A second, much rarer species probably belonging to *Neomeris* occurs in the rock-specimens from Teghrenna. It is represented by fragmentary cross-sections, no tangential sections referable to it having been observed. Pl. 3, fig. 21 shows a sporangium encircled by two secondary branches. A third twig observable in the same fragment may belong to another primary branch. The fact that the primary branches were not calcified and are, therefore, not preserved is indicative of the genus *Neomeris*. It was not possible to observe the decisive character of this genus, the number of twigs in a cluster. Pl. 3, fig. 22 seems to hint at a more obovate than spherical shape of the sporangium; the size is much larger than in the specimens described above: breadth of the sporangium, 0.14 mm.; thickness of the shell, 0.23 mm. It seems therefore that the second species was larger than *Neomeris cretacea* (Steinmann 1899, p. 150). The calcareous incrustation is thinner than in Steinmann's species.

Until more complete specimens are at our disposal, it does not seem advisable to give specific names to the specimens of *Neomeris* from Tripoli.

ACICULARIA ANTIQUA Pia, n. sp.

Plate 3, figures 1–14

The genus *Acicularia* was not mentioned by Miss Raineri in her paper, but it occurs rather commonly in the slides. The problem of the determination of *Acicularia* in sections has been thoroughly discussed elsewhere (Rama Rao and Pia, 1935), so that I do not need to go into much detail now.

In the slides the spicules of *Acicularia* appear as bright, roundish or somewhat oblong discs with circular, generally very dark, dots along the periphery, corresponding to the sporangial cavities. The central part of the disc as a rule is devoid of sporangia. Sections that show traces of them in the middle part may be supposed to be more or less tangential. In considering the sections represented on Pl. 3 and many others in the slides, I was at once struck by the absence of long, narrow figures, such as would correspond to longitudinal sections of the more familiar spicules of *Acicularia* from the Tertiary. I have shown (Rama Rao and Pia, 1935, p. 45) that this can not be explained by pure chance. My mathematical deductions are confirmed by the empirical fact that in the echinoid radioles to be described below very long sections are fairly common. It is therefore evident that the spicules of the Cretaceous Aciculariae were not needle-shaped, their length probably not exceeding twice the thickness in *A. antiqua*. Small sections

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EXPLANATION OF PLATE 3

FIGS. *1–14*—Sections through spicules of *Acicularia antiqua* Pia, n. sp., ×38, from the Upper Cretaceous of Teghrenna (Garian), near Tripoli, Libya, North Africa. *3* from Miss Rainer's slide 5; *6, 10* from slide 15; *12* from slide 16; *1, 2, 4, 7, 14* from slide 17; *13* from slide 18; *5, 8, 9, 11* from slide 21. (p. 8)

15–17—Sections through more or less "anomalous" specimens of "*Actinoporella cretacica*" Raineri (radioles of Holasteridae or Spatangidae), ×92, from the Upper Cretaceous of Teghrenna. *15* from Miss Raineri's slide 4; *16* from slide 18; *17* from slide 5. (p. 9)

18–22—Sections through fragments of the skeleton of *Neomeris* sp., ×42, from the Upper Cretaceous of Teghrenna. *18, 20,* tangential sections; *19, 21, 22,* cross-sections of the calcareous incrustation. *18, 20* from Miss Rainer's slide 17; *19* from slide 21; *21* from slide 5; *22* from slide 6. Drawings by the author. (p. 7)


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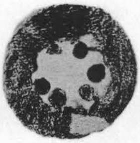
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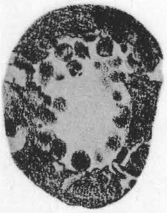
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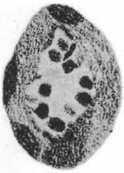
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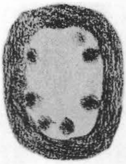
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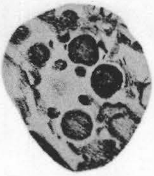
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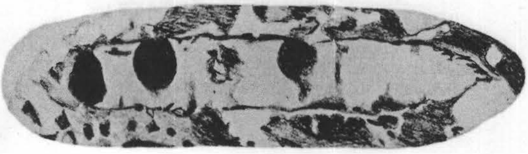
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Pia, Cretaceous Algae

like that shown in Pl. 3, fig. 14 are most probably cross-sections through the pointed end.

The greatest diameter of spicule observed is about 0.33 mm. The diameter of the spore-cavities varies between 0.04 and 0.055 mm. Theoretically the sections never show the true diameter of the spore-cavities, as the probability of a cavity being cut exactly through its center is very small. Sections not too distant from the center are, however, practically equal to central sections; moreover the thickness of the rock-slices must not be neglected, for this increases the possibility of finding the real diameter. In any case the different specimens show differences in the size of the sporangia that can hardly be explained by casual differences in the direction of the sections. Whether they are of any systematic value is quite another question. In my material from the Danian of South India the Aciculariae could be grouped according to size of the sporangia, but this does not seem possible in the African slides.It may be that the name *Acicularia antiqua* covers more than one species, but I am not able at present to distinguish them.

A. antiqua closely resembles *A. dyumatsenae* from the Niniyur strata (Danian) of South India. The spore-cavities are of about the same size, though the African species is perhaps a little stouter. No hooked sections, such as occur in the Niniyur strata, were observed in the material from Tripoli.

A full description of *A. antiqua* can not be given until it is found in rocks from which it can be isolated by washing. It may be that together with *A. dyumatsenae* it represents a new genus transitional between *Terquemella* and *Acicularia.* I found it only in slides from Teghrenna.

"ACTINOPORELLA CRETACICA" Raineri

Plate 3, figures 15–17; Plate 4, figures 1–16

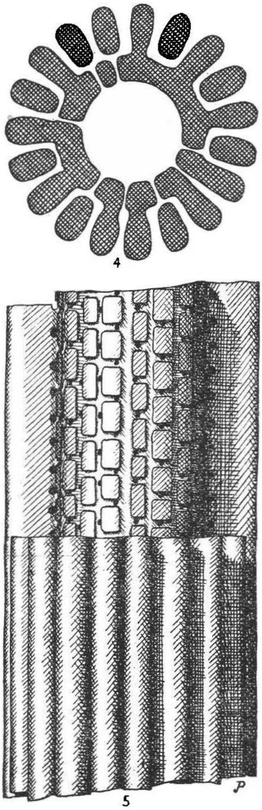
Actinoporella cretacica RAINERI, *1922*, p. 76, pl. 3, figs. 12–14.

This fossil is very common in the slides. Miss Raineri's description was one of the chief reasons for asking her to lend me her material. In particular her figure 14 seemed to look rather strange for one of the Dasycladacea. By carefully studying the slides and accurately drawing 20 microscopical figures I convinced myself that "*Actinoporella cretacica*" cannot be a calcareous alga. To prove this conviction, it is necessary to give a thorough description of the structure of the fossil —which might also be of some general, methodological interest.

We may start from transverse cross-sections like Raineri's fig. 12 and my Pl. 4, figs. 7–10. The center of the fossil is occupied by a cavity filled with dark rock-material. The skeleton itself consists of white, translucent calcite. It may be described as a star-like figure or as a ring with radial projections. The breadth of the furrows separating the projections varies in different sections—generally they are decidedly narrower than the prominences. Such a section perpendicular to the axis of the fossil gives a very incomplete insight into the structure—a point too often neglected in micropaleontological descriptions, for the general shape of the fossil may just as well be spherical as cylindrical; the radial prominences may be rods or plates. That the prominences in the present specimens are not rods is indicated by a streak of dark limestone separating some of them from the central ring. As they keep their regular position, they must have been connected with the ring above or below the level of the section. The central ring is also often interrupted by delicate dark lines corresponding to pores or fissures.

As in many analogous cases the real structure appears quite clearly in more or less oblique longitudinal sections. It seems that Miss Raineri did not recognise the connection between these long sections and those of star-like form. This connection is, however, clearly shown by the transitional sections, Pl. 4, figs. 1–6, in which the angle between the axis of the fossil and the slide becomes smaller and smaller.

The oblique sections show first of all that the "central ring" is a long tube, perforated by small, roundish pores (see especially figure 2). The pores are arranged alternately in longitudinal rows. They do not seem to be equally well and regularly developed in all the different specimens. The radial projections are plates attached to the tube; if they were rods, they ought to appear in the longitudinal sections as small circular or elliptical dots, not, as they really do, as long, slightly diverging strips. The plates increase slightly in thickness toward the outer margins, which in turn are well rounded. In their adaxial parts, close to the central cylinder, they are pierced by a single row of comparatively wide pores. If one of these pores is visible in a cross-section, it produces the dark streak separating the projection from the central ring, as described above. In a very slightly oblique longitudinal section quite a number of pores are visible (Pl, 4. figs. 1–3).



FIGS. *4, 5*—"*Actinoporella cretacica*" Raineri (a radiole of an holasterid or a spatangid echinoid), ×333. *4*, Diagrammatic cross-section. *5*, Side view of a fragment. In the upper half of the figure the radial plates are partly removed to show the pores.

From these observations we deduce the reconstruction shown in text-figures 4, 5. Briefly recapitulating the above description, the drawing shows first the central tube and the radial plates, then the following cavities: The axial cavity; the radial furrows separating the plates; the tangential pores perforating the plates in their basal part and thus connecting one furrow to the other; the radial pores leading from the axial cavity directly into the furrows or into the tangential pores.

No definite rule as to the position of the pores in neighboring plates could be detected. Sometimes they seem to alternate, sometimes not (Pl. 4, figs. 1–3).

The dimensions of the fossil may be shown in a few examples (see table).

The length of the fossil can not have been much less than 1 mm.; probably it was more. None of the specimens show the original end of the fossil. On the contrary, all the long, oblique sections are limited, at least on one side, by a frac-

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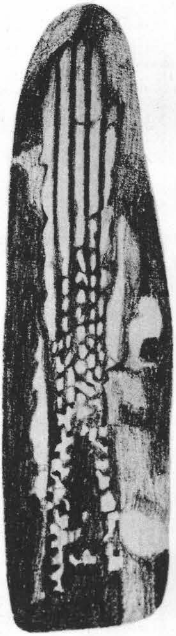
EXPLANATION OF PLATE 4

FIGS. *1–16*—Sections through "*Actinoporella cretacica*" Raineri (radioles of Holasteridae or Spatangidae), ×92. *1–10*, "normal specimens"; *11–15*, "anomalous specimens"; from the Upper Cretaceous of Teghrenna (Garian), near Tripoli, Libya, North Africa. *16*, a comparable section from Wadi Msaaba. *3, 10, 12* from Miss Raineri's slide 4; *4, 6–9* from slide 5; *1, 5, 11, 13, 14*, from slide 6; *16* from slide 13; *2* from slide 15; *15* from slide 16. Drawings by the author. (p. 9)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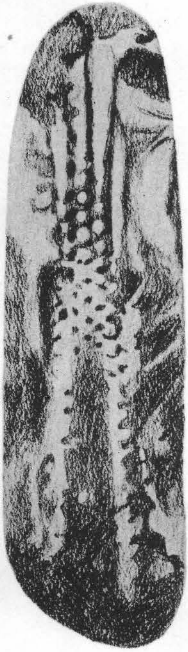
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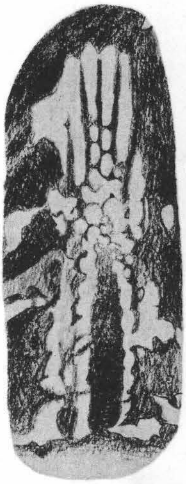
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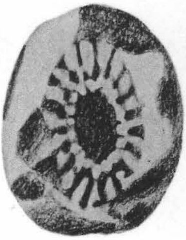
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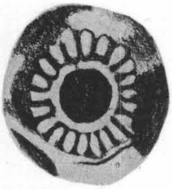
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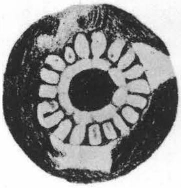
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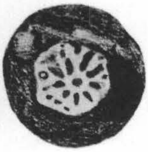
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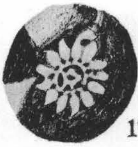
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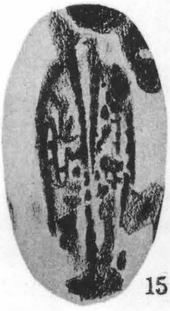
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16

Pia, Cretaceous Algae

Measurements in millimeters of "normal" sections of "Actinoporella cretacica" *Raineri*

Spec. no.	Pl. 4, fig.	D	$d' =$	$\% D$	$d =$	$\% D$	n
1	7	0.13	0.075	56	0.043	32	17
2	9	0.13	0.080	60	0.053	40	19
3	5	0.14	0.086	62	0.059	42	19
4	10	0.16	0.102	63	0.064	40	19
5	8	0.17	0.102	61	0.075	45	21
6	4	0.17	0.091	53	0.059	34	18

ture. The radial plates of the specimens recorded in this and the next table are present in an odd number, with but two exceptions. The type of section hitherto considered is the most common one and therefore may be taken as the normal section. Certain other sections are of a different sort, the relation of which to the normal type is discussed below. Among these "anomalous" sections two groups can be distinguished.

Pl. 3, figs. 15 and 16 show specimens in which the radial plates are only faintly discernible; they are mostly replaced by a system of quite irregular calcareous lamellae. Figure 15 is of special interest, for it shows on one side a structure closely approaching the normal one, and proves thereby that both structures belong to different parts of the same body. The section on Pl. 3, fig. 16 is much larger than all the others; for it (specimen 7), D is 0.32 mm., and d is 0.07 mm. or 23 per cent of D. Figure 15 also indicates that the portion with the irregular structure has a greater diameter than the normal one. One may conjecture therefore that the irregular sections correspond to the broader end of the problematical fossil.

The other group of anomalous sections is characterised by small size and by reduction of all the cavities, especially of the axial perforation. In Pl. 4, fig. 13 the axial cavity is represented by two small pores only; in fig. 12 it contains a starlike body of crystalline calcite, which may or may not belong to the fossil. In fig. 11 the radial furrows are transformed into closed canals. Raineri's fig. 14 also may represent this type (compare Pl. 4, fig. 14). Parts of the two long projections shown in Raineri's drawing do not belong to the fossil under consideration, but to another calcareous body of an uncertain nature. Pl. 4, fig. 15 seems to represent an oblique section without any trace of the axial cavity.

The dimensions of these small sections are shown in the next table.

Measurements in millimeters of small, "anomalous" sections of "Actinoporella cretacica" *Raineri*

Spec. no.	Pl. 4, fig.	D	$d' =$	$\% D$	$d =$	$\% D$	n
8	13	0.080	0.024	30	0.0053	7	10
9	14	0.080	0.032	40	0.019	23	9
10	11	0.107	0.032	30	0.013	12	9
11	12	0.107	0.051	48	0.032	30	13

It is not clear whether these anomalous sections of the second group belong to the same individuals as the normal sections. Some transitions are to be seen (Pl. 4, figs. 12, 14, 16). One could surmise that we are here dealing with the tapering, pointed end of the fossil. The more compact structure would agree with this hypothesis, though some difficulty arises from the fact that the number of radial plates is less in the small sections than in the normal sections. It seems, however, possible that new plates were intercalated in the transitional region or that some plates bifurcated.

The majority of the sections upon which my description is based are from Garian (Teghrenna). They are present also in rock from the barracks of Msellata-Homs, and very similar bodies are occasionally found in the rock from Wadi Msaaba (Pl. 4, fig. 16).

We have now to consider the question of the group of organisms to which "*Actinoporella cretacica*" may belong. It is quite obvious from the above description that the fossil is not a member of the Dasycladaceae nor any other calcareous alga. This possibility was excluded as soon as it was made clear that the radial projections are plates, not rods, and that they do not contain radial pores starting from the axial cavity and leading to the outer edges.

In searching the literature for similar

fossils I came across several figures in the beautiful *Album de microphotographies de roches sédimentaires* by Hovelacque. On Pl. 32 there appears near the center of fig. 2 a section comparable to the African fossil; it is called "Organisme indéterminé" in the explanation. A still closer resemblance is shown by some sections in fig. 2 of Pl. 37. One of them is distinguished by the letter *A* and named "Algue calcaire (?)" by Hovelacque; another in the right lower quadrant of the figure is very similar to the oblique sections of the African fossil. The specimens figured by Hovelacque are Urgonian, and are therefore older than the African fossil.

A certain similarity is also exhibited by a fossil figured by Parona (1910, fig. 7) and determined as a radiole of *Cidaris*. Radioles of Echinoidea have been mistaken repeatedly for Dasycladaceae. For instance, the Silurian *Bolboporites*, as originally described by Pander, was thought closely related to *Dactylopora*, to which it does not bear any resemblance (compare Wanner, 1920, p. 806). Rothpletz treats several similar cases thoroughly (1891). None of the radioles described in his paper are identical with our specimens, but they agree in the general structure, characterised by radial plates and an axial perforation. The conclusion, that "*Actinoporella cretacica*" is an echinoderm, is corroborated by examination in polarized light. All its parts show the same crystallographic orientation—the optical axis is parallel to the long axis of the fossil. (I have to thank Hofrat H. Michel for his help in establishing this fact.)

Having thus recognized that "*Actinoporella cretacica*" is the radiole of some echinoid, I tried to reach a closer determination with the help of the well known paper by Hesse (1901). Our fossil clearly belongs to his *Spatangus* type, characterised by one row of tangential pores only, by the lack of calcareous structures connecting the radial plates, by very small size, etc. Within this type three groups are distinguished. "*A. cretacica*" agrees best with the *Brissomorpha* group, the outer edge of the radial plates being rounded, not flat. Several Cretaceous genera bear radioles included in this group, e.g., *Micraster*, *Hemiaster* (common in the Cenomanian of Tripoli according to Checchia-Rispoli, 1921, p. 30), *Ananchytes*, *Hemipneustes*. All these genera seem to be distinguished from the present fossil by much larger pores arranged more regularly. In all probability, however, "*A. cretacica*" is a radiole belonging to some member of the families Holasteridae or Spatangidae.

A very similar type of radiole is common in Eocene rocks and has been occasionally submitted to me as one of the Dasycladaceae. Comparable fossils are present also in Paleozoic rocks (compare Kaisin, 1925, p. 1253, pl. 28, fig. 8).

BOUEINA PYGMAEA Pia, n. sp.

Plate 5, figures 1–9

Boueina hochstetteri RAINERI (not Toula), *1922*, p. 72, pl. 3, figs. 1–4.

The diameter of the thallus is between 0.5 and 0.9 mm., whereas the typical *Boueina hochstetteri* has a diameter of 2.5 to 3.5 mm. (Toula, 1883, p. 1322). The tubes in the center of the thallus hardly reach a width of 0.05 mm., being one-third to one-fourth of their greatest size in the type of the genus (Steinmann, 1901, p. 63). I can not agree with Miss Raineri, who considers these striking differences to be of no systematic value, and prefer to give a new name to the Libyan specimens. As no bifurcation of the thallus was ob-

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EXPLANATION OF PLATE 5

FIGS. *1–9*—Sections through the skeleton of *Boueina pygmaea* Pia, n. sp., ×42. *1, 2, 4–6, 9* from the Upper Cretaceous of Teghrenna, near Tripoli, Libya, North Africa; *3* from Msellata-Homs, *7, 8* from the Wadi Msaaba. *9* from Miss Raineri's slide 5; *2, 6,* from slide 6; *8* from slide 13; *7* from slide 14; *1, 5* from slide 17; *4* from slide 18; *3* from slide 20. Drawings by the author. (p. 12)


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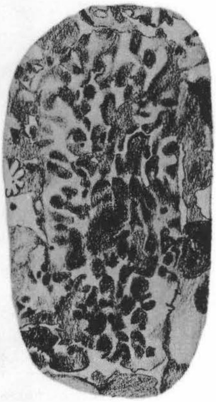
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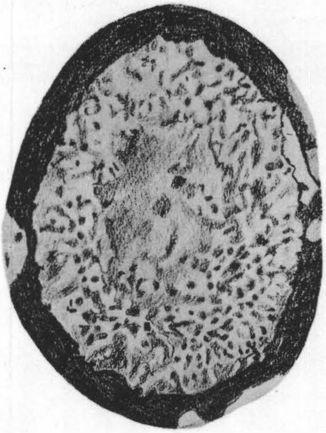
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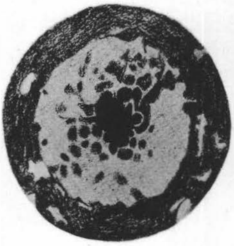
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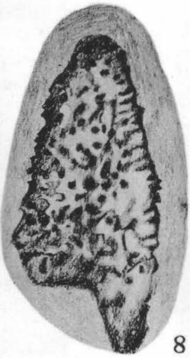
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Pia, Cretaceous Algae

served, the specimens probably belong to *Boueina*, not to *Halimeda*. As already mentioned (Pia, Pfender, and Termier, 1932, p. 16), they are distinguished from *Halimeda nana* by the smaller size of the tubes. I could not detect a well defined cortical layer, but this may be a matter of preservation. As Miss Raineri has already noted, the calcification is often incomplete, leaving the central part of the thallus uncalcified (Pl. 9, figs. 7, 9). This axial cavity is essentially different from the one found in the Dasycladaceae, as it certainly did not contain a single, large axial cell.

Boueina pygmaea has been found in the following localities: Teghrenna, Wadi Msaaba, and Msellata-Homs.

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