PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY B BIOLOGICAL SCIENCES

The Algal Sediments of Andros Island, Bahamas

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Phil. Trans. R. Soc. Lond. B 1932 **222**, 165-192
doi: 10.1098/rstb.1932.0015

VI. *The Algal Sediments of Andros Island, Bahamas.*

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(*Communicated by* O. T. Jones, *F.R.S.*)

(Received November 4, 1932—Read February 9, 1933.)

[Plates 21, 22.]

Contents.

I.—Introduction.

In the course of a geological reconnaissance of Andros Island, in the Bahamas, it was found that the lower forms of plant life, especially the Blue-green Algæ, play an important part in the process of sedimentation. In addition to those forms which

 [Published May 2, 1933.

actively contribute calcium carbonate to the sediment, there are other species which function primarily as sediment binders, without necessarily precipitating any lime themselves. Such sediment-binding algæ usually impart characteristic structures to the medium in which they grow; and in the interior of Andros, where such deposits are

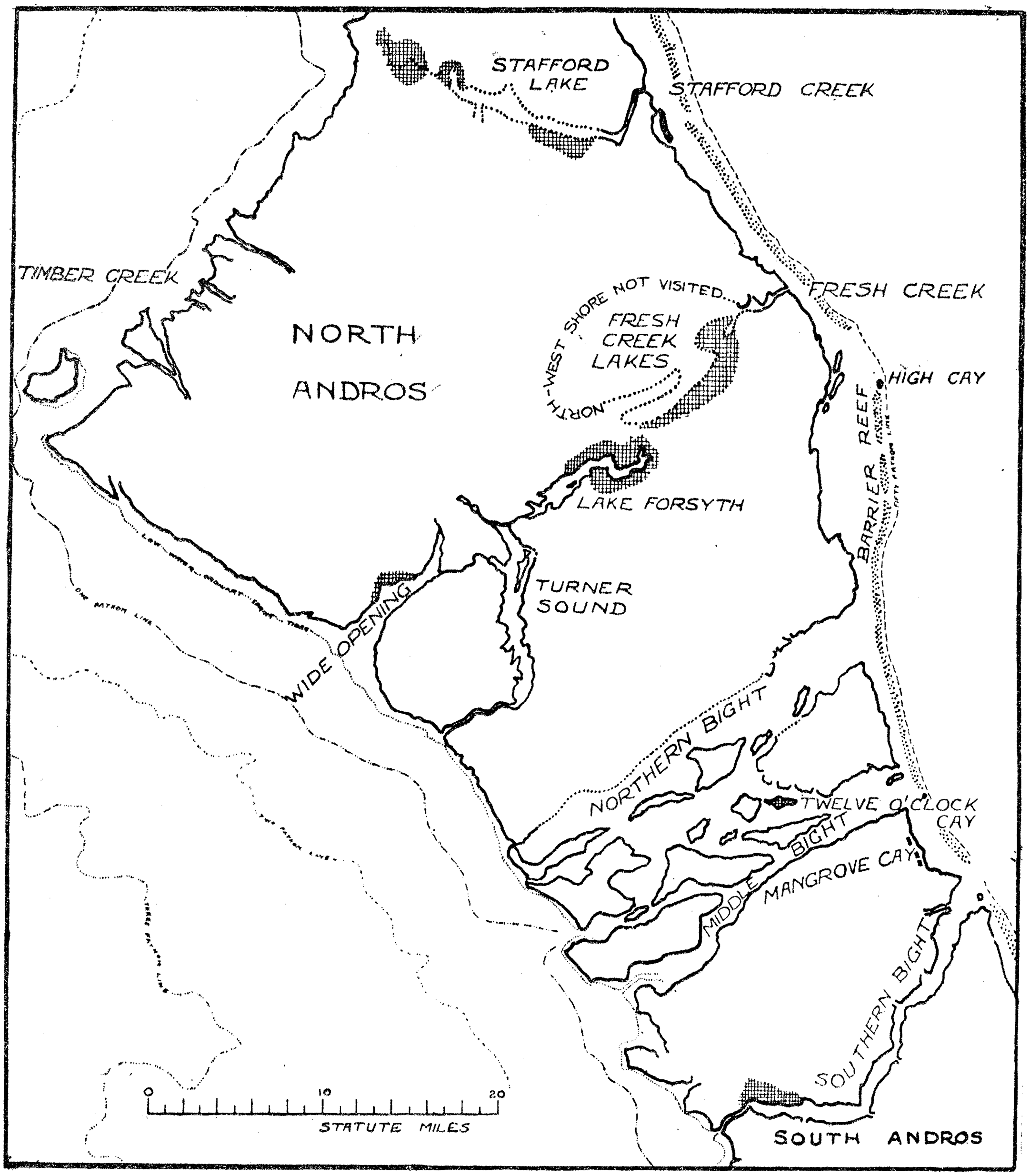

Fig. 1.—Map of North Andros Island. The localities from which algal sediments are described in this paper are shaded.

now accumulating over large areas, structures are being produced which are reminiscent of those found in some of the great limestone formations of the Lower Palæozoic and Upper Precambrian. In view of this, and of the supposed algal origin of certain of these limestone structures, it is felt that a detailed description of the Bahaman sediments will provide an example of a modern Cyanophyceous deposit, which may prove useful for comparison with older limestones of similar structure.

The field work on which this paper is based was undertaken during the spring of 1930, in the course of an expedition to Andros Island, made possible through the assistance of the Rouse Ball Fund of Trinity College, Cambridge, and of the Percy Sladen Fund of London. It is the author's pleasant duty to acknowledge his gratitude to the trustees of these two funds for their generous support. This expedition to the interior of Andros Island formed part of the programme of the International Expedition to the Bahamas, under the general direction of Dr. RICHARD M. FIELD, of Princeton, U.S.A.

The Bahama Bank is a region of shallow water limestone sedimentation. It consists of a great submarine plateau, standing almost at sea level, and thus forming a great stretch of shallow sea, surrounded on all sides by deep water. The rocks which form the islands are very pure limestones of Pleistocene Age, and the modern sediments on the bank are also entirely of calcite and aragonite, without any admixture of siliceous or argillaceous material. Thus the region is one of exclusively limestone sedimentation, and in this respect is closely comparable with some of the seas of Palæozoic and later Precambrian times, in which carbonate sediment prevailed over considerable areas.

Andros Island, in which the algal beds are found, has an area of some two thousand square miles, and is the largest island in the Bahamas. Along the east coast there is a well developed barrier reef, backed by a narrow ridge of limestone hills, but the interior and the western part of the island are of entirely different character. Low-lying, marshy plains, interspersed with shallow lakes and outcrops of limestone, are found in the interior, whilst in the westernmost part of the island, locally known as "The Marl," the limestone outcrops disappear, and the country consists of white, unconsolidated limestone-mud, known as *Drewite*. This is a desolate region, with bare white drewite flats, very sparsely covered with halophytic vegetation. The whole island, but especially the western part, is dissected by an intricate system of tidal creeks and mangrove swamps, which render it liable to heavy flooding under favourable circumstances. As this flooding has an important effect upon the growth of the algal deposits, by providing an intermittent supply of sediment, and possibly by causing an alteration in the salinity of the surface water, we shall return to this question in more detail later.

II.—ECOLOGY OF THE ALGAL FLORA.

(*a*) *Distribution of the Genera.*

The western edge of the Great Bahama Bank lies some eighty miles off the coast of Andros, and the intervening shallow water never reaches a depth greater than about four fathoms. The sea floor is mantled with bottom deposits of white, mostly fine-grained, calcium carbonate sediments, with occasional outcrops of Pleistocene limestone. Owing to the shallowness and clarity of the water, and to the whiteness of the bottom deposits, the light intensity on the sea floor is very great, and the bottom flora consists very largely of Chlorophyceæ and marine angiosperms. Dredgings between the edge of the bank and the west coast of Andros brought up mainly specimens of *Penicillus*, *Rhipocephalus*, *Udotea*, *Halimeda*, *Batophora* and *Caulerpa*. It was evident, in examining the dredgings, that the basal filaments of the algæ, in permeating the surface layers of the unconsolidated muds and sands upon which they grow, have a considerable binding effect upon the sediment. This is even more conspicuous in the zone between tides, where the purely filamentous forms, such as *Derbesia*, assist in producing the same effect. Although the sediment is by no means hard, it becomes tenaciously cohesive, and resists the erosive action of ordinary tidal currents.

Above the intertidal belt, the Chlorophyceæ are no longer dominant, and are almost completely replaced by the Cyanophyceæ. Wherever the surface sediments were examined, they were found to be permeated by algal filaments and cells, or to be covered by a skin consisting of algal colonies growing on the surface. In regions of intermittent sedimentation, such as the coastal belt, and some of the flat, low-lying areas in the interior of the island, these algæ were found to play an active part in the process of sediment accumulation. The colonization of newly deposited sediment by filamentous algæ first of all binds together the sediment, preventing its being easily washed away again, and then produces a felt of algal filaments, which is sometimes quite thick and dense. In nearly all the species involved, the filament is enclosed in a mucilaginous sheath, to which mineral particles very readily adhere. Thus any fresh sediment brought into the region is at once trapped amongst the filaments.*

The most important species in the Bahaman sediments are :—

Gloeocapsa atrata (TURPIN) KÜTZING.
G. granosa (BERKELEY) KÜTZING var. *chlora* nov.†
G. fusco-lutea (NAEGLI) KÜTZ.
G. gelatinosa KÜTZ.
G. magma (BREBISSON) KÜTZ.
G. rupestris KÜTZ.
G. viridis sp. nov.

Aphanocapsa grevillei (HASSAL) RABENHORST.
A. marina HANSGING.
Symploca læte-viridis GOMONT.
Phormidium tenue (MENEGHINI) GOMONT.
Schizothrix braunii GOMONT.
Plectonema atroviride sp. nov.
Scytonema androsense sp. nov.
S. crustaceum AGARDH. var. *catenula* nov.

It will be noticed that the Rivulariaceæ, so frequently associated with the formation of lake balls and water biscuits, are of no importance here.

These algæ were found to be growing, not in pure colonies, but in rather complex communities, which are still under investigation, and will not be described in detail

* This sediment-binding action of filamentous algæ is also of common occurrence in regions where the sediment consists of non-calcareous mud, and colonization of fresh sediment by such species as *Microcoleus chthonoplastes* and *Vaucheria thuretii* has been shown to be important in tidal salt marshes. For example, see CAREY and OLIVER, 1918, p. 173, and Plate XV, upper figure.

† The new species and varieties of algæ are described in section VII, p. 186.

until more of the species involved have been grown in artificial culture. Roughly speaking, it may be said that the communities in areas affected by the tides are dominated by *Symploca læte-viridis* and several non-filamentous forms; that as one goes from the tidal belt inland towards the less saline water, species of *Scytonema* appear, and grow intimately with a large number of other species, important amongst which are *Schizothrix* and *Aphanocapsa*; and finally, that in places where the ground water is not saline, or which are affected by rain-water alone, almost pure colonies of *Scytonema* are found, without admixture of any species belonging to the Oscillatoriaceæ. Thus we have the distribution shown in Table I.

Table I.

Maximum Salinity: parts per 1000.	Nature of Habitat.	Flora.
30–40	Shoal water below tides	Chlorophyceæ: *Udotea*, *Penicillus*, *Halimeda*.
15–36	Between tides, near H.W.M.	Cyanophyceæ: *Phormidium*, *Symploca*, and unicellular forms.
? ca. 2	Above H.W.M. Inland Marl flats	Cyanophyceæ: *Scytonema*, *Plectonema*, *Schizothrix*, and unicellular forms.
0	Above H.W.M. Limestone outcrops	*Scytonema* alone.

III.—Description of the Algal Sediments.

Where definite algal structures are developed in the sediments, their growth form depends to a large extent upon local conditions, and a different type of algal head is found in each of the geographical belts mentioned above.

Under the shoal waters of the Great Bahama Bank, no complex algal heads were observed, and the Cyanophyceæ, which are elsewhere responsible for these structures, were not found to be present in large numbers. The Chlorophyceæ, which make up the bulk of the flora here, were found to permeate the sediment and bind the particles together, without producing any banded or radial structure. It was only above low-water mark, where the Cyanophyceæ are the prevalent algæ, that alga-controlled lamination and algal heads with characteristic internal structures were found.

The simplest type, fig. 2, and figs. 21 and 22, Plate 22, was found in localities which were frequently flooded by sea water. Round the western entrance to Southern Bight, filaments of *Symploca læte-viridis* permeate the sediment as it is deposited, and play an important part in binding it, thus preventing re-erosion. During intervals of non-deposition the alga continues to grow in company with several other species, and a thin organic layer is produced. Beyond this, however, the alga does little to modify the structure of the sediment, except by accentuating the mechanically formed laminations.

Somewhat more distinctively alga-controlled sediments were found about high-water mark at Twelve O'clock Cay and in the Wide Opening, figs. 17 and 18, Plate 21, where, in addition to this kind of lamination, simple algal heads are developed, fig, 3, and fig. 24, Plate 22. These take the form of irregularly scattered domes usually an inch or two high, and four or five inches in diameter, each possessing a crude concentric lamination.

It was in the interior of Andros Island that the most highly developed type of algal head was found, and where the most extensive algal deposits were discovered. Bordering the fresh-water lakes, and forming the flat ground between the limestone ridges, are large stretches of drewite marshes, which are covered with circular algal heads possessing a peculiar structure of approximately concentric laminæ, fig. 5, and figs. 19 and 20, Plate 21.

In all these forms, parallel or concentric lamination is the dominant element in the structure of the algal heads, and the mineral matter is soft and uncemented sediment, mechanically entrapped by the algæ, without any perceptible addition of secondary crystals. On slightly more elevated ground, however, the algal heads assume an entirely different structure, fig. 28, Plate 22. The colonies consist of radiating filaments, without much interstitial sediment, and the whole algal head is often strongly cemented with carbonate crystals precipitated round the filaments. Two main factors are probably responsible for this difference in structure: firstly, the absence of sediment, which leaves the algal head porous, and secondly, the different properties of the water, which is rain-water with a certain amount of freshly dissolved calcium carbonate in solution, but practically no other dissolved salts.

The types of algal structures described below are restricted to the sedimentary forms; those algal heads in which the clastic sediment does not play an essential part are still under investigation, and will be dealt with in a later publication. In the paragraphs immediately following, only the positions of the localities are indicated, and the local conditions are described in more detail in Section V, p. 179, after the significance of the environment has been discussed.

(*a*) *Deposits of Type A.*

Locality.—Southern Bight, Andros Island, Bahamas, on the north shore near the western entrance to the bight. Lat. 24° 3′ N., and Long. 77° 49′ W.

Growth Form, fig. 2.—This is the simplest form of alga-controlled sediment which was recognized, and consists of drewite, with a strongly marked organic lamination parallel with the surface. In fresh specimens, the thin darker laminæ, fig. 21, Plate 22, have a greenish tinge, and the thicker ones are white; in older material the green colour is replaced by brown. The algal filaments do not seem to modify the form of the upper surface of the sediment, but they accentuate the mechanical lamination by producing a dark organic film between the layers of sediment. By permeating each layer as it is deposited, the filaments bind together the sediment and tend to preserve it from re-erosion.

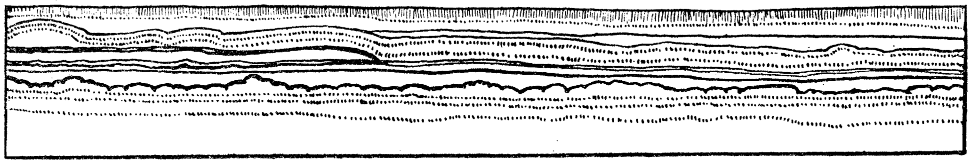

Fig. 2.—Diagrammatic Section of Algal Lamination of Type A, × 2. Layers consisting largely of algal material are shaded.

The Algæ.—The algal filaments are almost invisible in ordinary rock-sections, but are readily seen when the carbonate has been removed by acid; in such preparations, two filamentous forms are found—*Symploca læte-viridis* in conspicuous, bright grass-green tufts, and *Phormidium tenue*, in slender, solitary filaments of pale blue green cells. In the deeper layers of the sediment, the cell-contents are no longer present, and these two algæ are represented by colourless, empty sheaths. There are, in some of the laminæ, traces of *Scytonema*, but these remains are too badly preserved to be specifically identifiable; compared with the other two species, this form is rare. Of the Chroococcaceæ, *Gloeocapsa magma* and *G. fusco-lutea* are found, but not in any appreciable quantities.

Material which had been dried out at the time of collection gave, in the laboratory, a strong culture of *Symploca læte-viridis* and *Phormidium tenue*; under suitable conditions, the *Symploca* produced erect tufts of grassy-green filaments, closely similar to those found embedded in the sediment. It appears to be this species which gives the pale enamel-green colour to the more recently deposited layers of the sediment.

The Sediment.—The sediment occurs in two kinds of laminæ. The thicker laminæ are usually between 0·5 mm. and 1·75 mm. thick, and contain detrital grains of all sizes up to 0·1 mm., or a little more. The arrangement of the grains suggests that each lamina was deposited by a single process, for the grains grade from coarse at the bottom to finer on top within each lamina. Frequently there is a slight suggestion of a palisade structure resulting from a parallel arrangement of vertically growing filaments; this is restricted to the upper surface of the lamina. Interbedded with these obviously sedimentary laminæ, there are somewhat thinner layers of very fine-textured sediment, usually little more than one-tenth of a millimetre in thickness. These layers seem to represent the sediment entrapped in the mucilaginous sheaths of the algal filaments.

(*b*) *Deposits of Type B.*

Locality.—Twelve O'clock Cay, between Middle and Northern Bights, Andros Island. Lat. 24° 18′ N., Long. 77° 48′ W.; and in the mangrove flats bordering the northern shore of the Wide Opening, Lat. 24° 29′ N., Long. 78° 8′ W.

Growth Form, fig. 3.—The surface layers of the sediment, which is here rather sandy, are impregnated and bound together by a gelatinous substance formed from the mucilaginous investments of blue-green algæ. The characteristic algal heads in these localities consist of low, rounded, domes, rising above the normal surface of deposition of sediment. The domes are irregularly scattered, and are usually four or five inches across.

The algal heads contain a very small proportion of organic matter, and this can only be seen near the outer surface, where addition of new sediment and active algal growth are still going on. Although concentric laminæ appear to be present in the central parts of the dome, this structure is lost as soon as the sediment is disturbed, and it was only found possible to collect material from the other shell, to a thickness of about half an inch. These specimens, when sectioned, show the lamination to be due to sharp differences in grain size in successive layers in the sediment, fig. 24, Plate 22, in addition to the alternation of light and dark layers, in which the sand grains can be seen to be embedded in the remains of algæ.

The conspicuous dark layers in the sediment owe their colour to the presence of two deeply tinted species of *Gloeocapsa*—the copper red *G. magma*, and the brilliant green

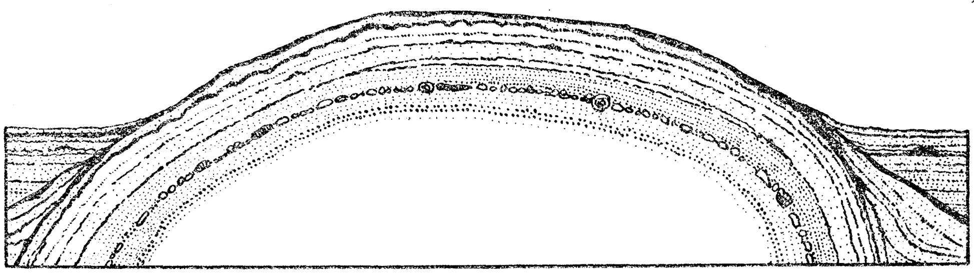

FIG. 3.—Diagrammatic Section of an Algal Head of Type B, natural size. Dark organic layers, made up of cells of *Gloeocapsa*, are represented by black lines. The intervening layers, consisting of sediment bound together by *Symploca* and *Aphanocapsa*, are dotted or unshaded.

G. viridis. Mixed with the cells of these two species are scattered colonies of *G. fusco-lutea* and *G. gelatinosa*. The lighter layers, which are not noticeably coloured in a hand specimen, are permeated by a remarkable, colourless gelatinous mass of *Aphanocapsa marina*, through which are threaded innumerable unconnected filaments of *Symploca læte-viridis*; at certain levels, the *Symploca* filaments are closely entwined, giving rise to bright green tufts, similar to those found in Type A. Remains of *Scytonema* are distinctly rare.

The Sediment.—The sediment in this kind of algal head is rather similar to that found in Type A, except that in the specimens examined it was found to be distinctly coarser, and grains up to one millimetre in diameter are quite frequent. The grains include well-rounded, almost spherical or ellipsoidal grains of limestone, fragments of molluscan shells, and tests of Foraminifera, especially of *Peneroplis proteus* D'ORBIGNY. Again the more organic layers are very much finer in grain size, and much thinner than the coarsely detrital laminæ.

(c) *Deposits of Type C.*

Locality.—The flat country bordering Lake Forsyth, Lat. 24° 35′ N., Long. 77° 56′ W., and also round Stafford Lake, Lat. 24° 50′ N., Long. 78° 0′ W., in North Andros.

Growth Form.—In their position of growth, algal heads of this type appear as regularly spaced, raised discs, usually four or five inches in diameter, figs. 19 and 20, Plate 21. They are entirely unlithified, and in their natural condition they have a somewhat rubber-like consistency. Cross sections show a colour banding, with laminæ parallel with the upper surface, the laminæ being alternately white and brown, fig. 25, Plate 22. This colour banding is found to go much deeper below ground than the surface discs.

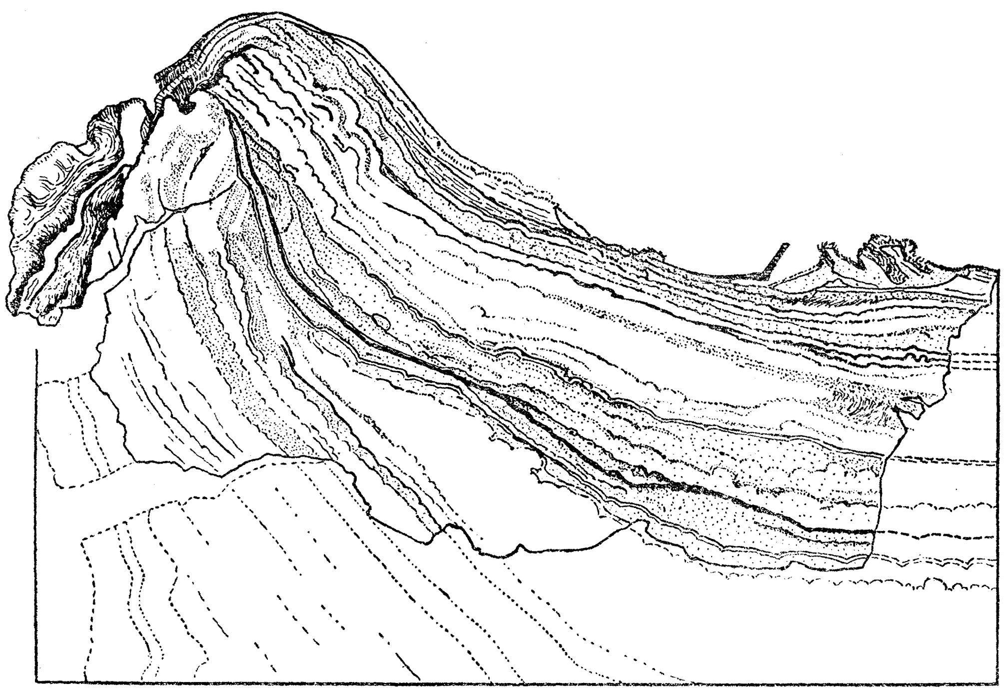

Fig. 4.—Section through the edge of an Algal Head of Type C, after a slight drying, showing the upturning of the edge. × 2.

This growth form is the resultant of two opposing tendencies. The growth process, by itself, gives rise to flat or smoothly rounded, convex forms, similar to those of Type B; this simple shape, however, is rarely retained for long, and is constantly liable to modification during periods of partial drying. Owing to the large proportion of organic matter, and the fine texture of the sediment in the algal heads, drying causes the upper layers to contract, fig. 4, and a concave shape results, fig. 8. Renewed growth of the algæ produces further layers, at first concentric with the concave surfaces of the older part of the algal head, but gradually re-establishing the convex form again. This process may continue for a considerable time, and unless the structure is interfered with, the algal heads develop into cylindrical columns, with transverse laminations, more or less concave upwards.

The Algæ.—The association of species found in these algal heads is a complicated one, remarkable for the intense jade-green colours of many of the species, and the absence or great rarity of species whose sheaths are not green, olive brown, or hyaline. The most important species are :—

Gloeocapsa atrata.	*Schizothrix braunii.*
G. fusco-lutea.	*Plectonema atroviride.*
G. viridis.	*Scytonema androsense.*
Aphanocapsa marina.	*S. crustaceum* var. *catenula.*

In thin sections the dark laminæ appear as translucent brown streaks, made up of algal filaments closely pressed together, and enclosing very little sediment amongst them. No orderly arrangement of the filaments is noticeable, except a rough parallelism induced by compression. In sections prepared as rock slices, it is impossible to recognize the individual filaments; they were investigated by cutting shavings from the hand specimen, swelling them in water, and then clearing with dilute acid. The residue is in the form of a felt of interlocking filaments, and with care can be removed to a slide and mounted. By this means, the algæ can be observed in a relatively uncompressed condition, and unobscured by sediment.

The brown laminæ consist of closely matted filaments of the two species of *Scytonema*, mingled with a few tangled sheaths of *Schizothrix*. The sediment between the dark layers consists of extremely small and irregularly shaped carbonate grains, which do not appear to be in contact with one another. The spaces between the carbonate crystals are occupied by algal material which is colourless and not visible in a petrological section. Sections cleared with acid at once reveal the organic matrix as a colourless, jelly-like material, which appears to be made up of an extended mass of *Aphanocapsa marina*, mixed with a profusion of filaments of *Schizothrix braunii*. Both of these have pale coloured cells, set in an abundance of clear, colourless mucilage.

Running through these laminæ of loosely packed sediment, there are occasionally narrow tubes, usually about sixteen microns in diameter, with walls of closely packed carbonate crystals, fig. 26, Plate 22. They are best seen in petrological sections examined between crossed nicols. There can be little doubt that these tubes also have an algal origin, for it is possible to tease out from untreated sediment, filaments of *Scytonema* with a similar calcareous investment made up of crystals embedded in the mucilaginous sheaths of the filaments.

The Sediment.—The sediment consists of rather angular grains of calcite, with no obvious crystal outlines, but rather with the shape of detrital grains. The average size is about four microns, and grains above eight microns in diameter are very rare in most samples. The sediment on the floor of Lake Forsyth includes somewhat coarser grades than this, and grains of ten microns form quite an appreciable proportion of the sediment. This seems to indicate that only the finer material is carried in suspension over the algal flats.

(*d*) *Deposits of Type D.*

Locality.—On the rocky flats bordering the lakes at the headwaters of Fresh Creek, Lat. 24° 38′ N., Long. 77° 54′ W.

Growth Form, fig. 5.—These algal bodies differ from the forms already described in their frequent occurrence in an unattached condition. In their early development, they are in the shape of circular, plano-convex lenses, some two or three inches in diameter. They resemble, in their internal structure, the earliest formed parts of algal heads of Type C, except in their having a larger proportion of organic material to sediment, and in the less orderly form of the laminations. They differ mainly in their behaviour during desiccation, when they roll up and become completely detached from the sediment below.

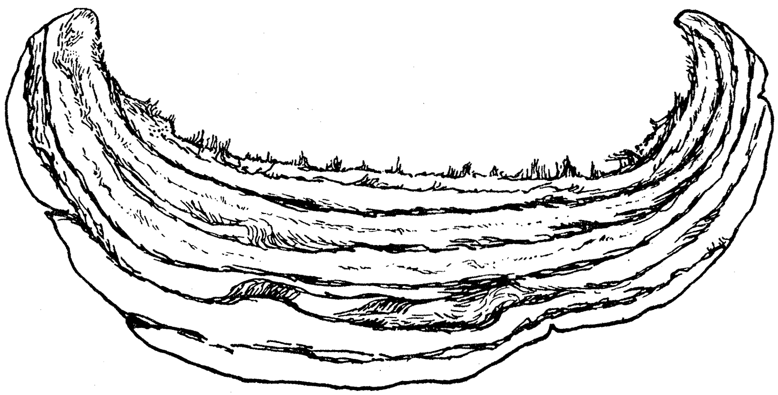

FIG. 5.—Diagrammatic Section of an Algal Head of Type D. × 2.

The Algæ.—The algæ in this type are of the same species as those found in Type C, but in the material under consideration, the proportion of *Scytonema* is very much greater than in the Type C specimens from either Lake Forsyth or from Stafford Lake, and the gelatinous matrix of *Aphanocapsa* is proportionately reduced.

The Sediment.—The sediment is of extremely fine grain size; most of the particles are two microns or less in diameter, and very few are as much as ten microns. The larger grains have angular or ragged outlines, whilst the shape of the smaller grains is difficult to determine.

IV.—THE SIGNIFICANCE OF THE LAMINATION.

Each of the four types of algal head described above is characterized by the possession of a laminated structure, which may arise in one or more of three ways:—

(1) Rhythmic variation in the quantity of filaments of one species or group of species, with relation to the quantity of sediment.

(2) Alternation of two species or of two groups of species.

(3) Sedimentary lamination in mineral particles enclosed between the filaments.

In each development of concentrically laminated sediment investigated on Andros Island, it was found that the presence of two of these laminating processes could be traced. Thus :—

The lamination in	Type A	arises from a combination of	1 and 3.
,, ,,	Type B	,, ,,	2 and 3.
,, ,,	Types C and D	,, ,,	1 and 2.

There can be little doubt that each of these laminating processes represents a response to some definite recurrent or rhythmic change in the environment, and it is a matter of considerable stratigraphical interest to know what these changes are, and to what extent we can rely upon the evidence of these laminated bodies to reconstruct the external conditions under which such sediments were formed. It is impossible to enter into the question exhaustively until more results of experimental work on the algæ in culture are available, but one or two of the more important environmental conditions as observed in the field may be discussed here.

(*a*) *Deposition of the Sediment.*

The simplest rhythm is that expressed in the sediment itself, but even here there are several factors involved. In the lower part of the tidal belt, shifting and redeposition of sediment takes place as a result of tidal scour, and as a result of storms. Our observations went to show that on the marl flats where the algal deposits are found, tidal action by itself was not responsible for any appreciable sedimentation, but may become quite important during violent storms, when large quantities of sediment are stirred up into the water. If the sediment in suspension is very fine grained, the mucilaginous sheaths of the algæ entrap quite an appreciable quantity, and appear to do this selectively for the smallest grains in suspension. Thus, if a mixture of mud, silt, and sand is drifted over the algal heads at a velocity sufficient to keep the sand grains moving, the mud particles cling to the mucilage of the filaments, but very little sand is retained. Laminæ which have the characteristics of ordinary gravity sedimentation are also formed in most algal deposits in the tidal belt of the island ; in these, each lamina begins with comparatively coarse grains, often between 0·1 mm. and 1·0 mm. in diameter, and passes upwards into fine mud. Such laminæ are frequently about one millimetre thick, but may vary considerably from this. They appear to effect a complete smothering of the algal head, probably by sediment settling out after a heavy storm ; we were not fortunate enough to observe the actual deposition of this kind of lamina in progress, but abundant examples were found where algal heads had quite recently been smothered by fresh deposits of mechanical sediment.

In the widespread algal deposits of the interior of Northern Andros Island, no trace of mechanical lamination was discernible, and the sediment is all extremely fine in texture. The interior lakes are not tidal, but here again the sediment is supplied to the algal marshes by a process of flooding. This takes place in two entirely different ways: by heavy rainfall, and by invasion by sea water from the banks to the west. In the first case the salinity of the ground water is reduced, and the transportation of sediment is very small, being a slight washing of material from the land into the lakes and creeks. There is possibly also a little transference of sediment from the lake floors on to submerged parts of the algal flats, when the bottom deposits are stirred up by waves, and drifted by wind-blown surface currents on to flooded areas bordering the lakes. The solution effects are probably more important.

In the second case conditions are quite reversed; vast quantities of sea water are piled up on the shoals, and are swept over the low-lying parts of Andros as a result of violent westerly winds. During such storms, the water over the banks is laden with churned-up sediment and the whole of the flooded area is liable to be smothered under a film of fine white mud, which is left behind when the flood water retreats. The prevailing winds are easterly in direction, and do not cause this kind of flooding. It is probably produced on a grand scale only by hurricanes, which are liable to visit this region during the autumn months. These are circular storms, revolving in an anti-clockwise direction, and travelling along a north-westerly course across the archipelago. Consequently, during the earlier part of a storm, the shoal water on the banks is violently agitated, and becomes strongly charged with suspended sediment. When the wind reverses, and blows from the west, a great wave of drewite-laden water is forced over the island. If the storm is particularly violent, this flood water crosses the island completely, and finds its way through the eastern creeks into the lagoon behind the barrier reef—a cross-country journey of some forty miles.

The sediment brought into the centre of the island by such flood water is extremely fine grained, since all the coarser constituents are deposited before the water has travelled far in from the west coast. This uniformity of grain size prevents any mechanical lamination, or any noticeable difference in size between the particles agglutinated round the mucilage of the algæ, and those particles which settled out under gravity.

(*b*) *Growth of the Algæ.*

The growth rate of any particular colony of algæ is probably controlled by a complex set of conditions, important variables amongst which are:—humidity, supply of carbon dioxide, temperature, salinity of the ground water, and deposition of sediment. These conditions are now being investigated experimentally with the algæ in culture but owing to the extremely slow growth rate of most of the species involved, and the difficulty of obtaining cultures free from bacteria and fungi, it will be some time before a satisfactory series of measurements can be made. Field observations were made on the variations of salinity, sedimentation, and water level, and the effects of rhythmic fluctuations of these upon the growth of the algal heads was qualitatively examined.

(i) *The Effect of Salinity.*—In this region, *Symploca læte-viridis* and *Phormidium tenue* seem to be characteristic of salt water, in the case of *Symploca* ranging up to 36 parts per thousand. Experimental work, however, indicates that these two species can tolerate considerable ranges of salt concentration, and can flourish both in nearly fresh water and in highly saline water. With *Scytonema* and *Plectonema*, on the other hand, the salinity has a strong controlling influence. Very little *Scytonema* was found in places liable to be washed by undiluted sea water. With salinities between 1·0 and 10·0 per thousand, there tends to be an alternation between *Scytonema* and the *Schizothrix-Aphanocapsa* association. Where the salt content of the water is appreciably less than one part per thousand, flourishing colonies of pure *Scytonema* were found. The growth habit assumed in these circumstances is quite unlike the forms already described in this paper; the filaments assume a radial arrangement, and deposit a finely crystalline cement of calcium carbonate between the filaments. In North Andros, this kind of structure is best developed in places where the main supply of water is fresh rain-water, and where there is only a negligible influx of water-borne sediment.

It is thus possible that an intermittent growth of *Scytonema* might be controlled by fluctuations in salinity; for instance, the layers with *Scytonema* in the high level mud flats at Southern Bight may represent periods during which the mud flats were free from flooding by sea water, and the salt leached out of the surface layer by rain.

(ii) *The Effect of Sedimentation.*—Experimental work on the two most important groups of species—those belonging to the Scytonemataceæ, and those belonging to the Oscillatoriaceæ—has already shown that whereas the former are extremely slow-growing, the Oscillatoriaceæ are capable of surprisingly rapid growth in a fresh culture. Indeed, an ordinary lamina of sediment, a few millimetres in thickness, could be permeated and bound fast by filaments of *Schizothrix*, *Symploca* or *Phormidium* in a few days, whereas it would be a matter of months before a skin of *Scytonema* could form over the new surface. Thus intermittent access of fresh sediment to a region equally advantageous to each of the two genera, would undoubtedly cause laminæ with a prepondernace of *Scytonema* to alternate with laminæ containing a preponderance of *Schizothrix*, which is, indeed, what occurs in the Lake Forsyth region.

The same kind of process is probably responsible for the dark organic layers in the specimens from Twelve O'clock Cay. Here the sedimentary layers contain chiefly a filamentous form (probably *Symploca* again), and the more organic layers consist of a complex colony of deeply coloured unicellular forms, which make a dense film over the whole surface of the structure. The filamentous forms probably grow comparatively quickly through the newly deposited sediment; the unicellular forms, however, do not do this, but only colonize the exposed outer surface, where they form a dark coloured, mucilaginous layer which protects the sediment underneath from re-erosion.

(iii) *Effect of Fluctuations in Water Level.*—The seasonal rise and fall of water level in the interior of Andros has the effect of alternately gently flooding and draining the algal flats, but desiccation is probably quite rare. The effect of partial drying is to suspend the growth of the algæ, and possibly induce the formation of resting spores. On re-wetting, *Scytonema* takes a very long time to begin a fresh growth, whilst *Schizothrix* produces an abundance of filaments comparatively quickly.

V.—Relationship to the Environment.

(*a*) *Lake Forsyth.*

The Lake Forsyth country forms part of the interior belt of low salinity which runs through the centre of Andros Island. Wide expanses of drewite flats surround the north-easterly part of the lake, and stretch for considerable distances north and south. They are colonized by algal heads of Type C, which form a closely set pavement of raised discs, and give a very characteristic appearance to the ground, figs. 19 and 20, Plate 21. To the north-east the algal flats are interrupted by a low outcrop of limestone, fig. 6, which separates this region from a series of brackish lakes draining into Fresh Creek. Towards this limestone ridge, upon which drewite deposits rest unconformably, the spermophyte vegetation becomes more important, and conditions become unsuitable for the formation of well-shaped algal heads. There are also regions within the marl flats where algal heads are not formed, and the algal beds give place to undifferentiated sediments, as, for instance, in local developments of mangrove swamp, where the ground is permanently under water. In these localities a greyish coloured ooze, consisting of drewite with a large proportion of organic matter, is being deposited.

The lake is not tidal, and appears to derive enough water from the drainage of the surrounding country to keep its outlet, the White River, in constant flow. For the same reason, although the surface of the lake is only a few feet above sea level, the salinity of its water is normally quite low, and our observations showed it to vary but little from 1·25 parts per thousand. The territory surrounding the lake is subject to a gentle seasonal flooding, caused directly by fluctuations in the rainfall. During the time when we were in camp on the shore of the lake, the water level was high enough to swamp parts of the algal flats, but a large proportion of the marshes still stood above water. The floor of the lake is covered with a very fine-grained deposit of calcium carbonate, and it is possible that storms such as ordinary Northers, which stir up sediment into the water, may also be responsible for depositing it over the marshes during these seasonal floods. However, this may be, the hurricane floods appear to be the most important agents in spreading subaqueous sediments over the land.

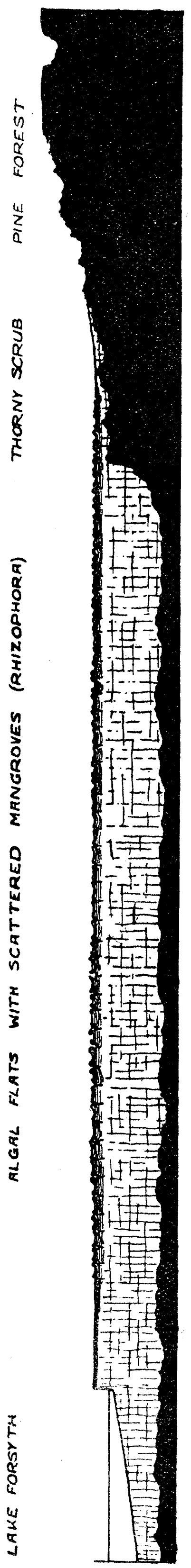

FIG. 6.—Section of the Algal Flats near the head of Lake Forsyth.

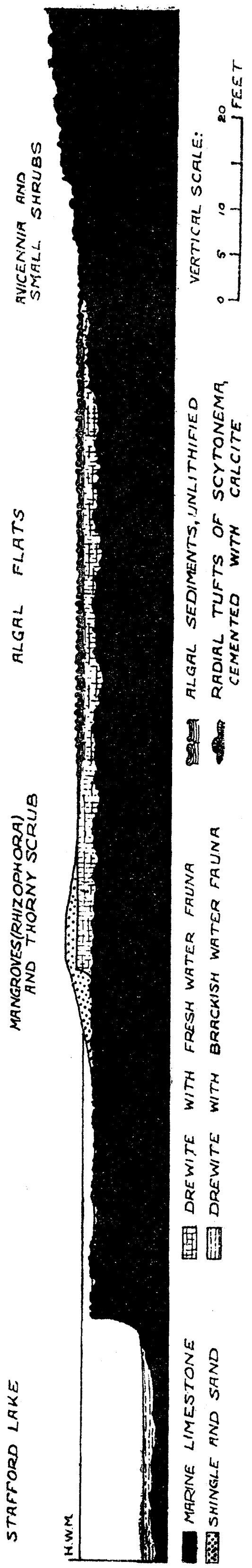

FIG. 7.—Section of the Algal Flats on the south side of Stafford Lake.

(*b*) *Stafford Lake.*

The eastern end of Stafford Lake is bordered at water level by a limestone platform which is locally covered by a thin deposit of peaty drewite, see fig. 7. At the junction between the drewite and the limestone, several distinct growth forms of algal colonies are to be found, but where the drewite is thick enough to mask the limestone completely, algal heads exactly like those of Lake Forsyth appear, with the same species of *Schizothrix* and *Scytonema*. At the eastern end of the lake, such deposits are restricted in area by the limestone outcrops, but further west, the thickness of unlithified sediment becomes greater, and the drewite flats increase in extent until they stretch completely across the lake. The ground water conditions appear to be more closely related to the fresh water areas in the south and west, rather than to Stafford Lake itself, which is in part tidal, and distinctly saline (14–20 parts per thousand at our camp, lat. 24° 50′ N., long. 78° 0′ W.). This difference is also borne out by the fossil fauna of the surface layers of drewite, which show a fresh-water (Amnicolid) assemblage, quite distinct from the brackish water assemblage in the sediments now accumulating on the floor of Stafford Lake. Consequently, although the drewite flats on which the algal beds are now being formed border a saline lake, it appears that the local conditions of growth are similar to those at the headwaters of Lake Forsyth. The algal flats are separated from the shores of Stafford

Lake by a ridge of partly cemented gravel, and where this is absent, it is found that there is an area with no algal deposits at all comparable with those of Lake Forsyth.

On the rugged outcrops of limestone which rise through the drewite marshes at the eastern end of the lake, the conditions for algal growth are quite different from those which prevail on the marshes themselves. The supply of sediment is negligible, the available moisture is restricted to rain-water, and the rock surface drains fairly rapidly. The algal heads found here are of the radial type mentioned on p. 170.

(*c*) *The Southern Bight.*

The north shore of Southern Bight is bordered by drewite mud flats which rise with an almost imperceptible slope from the bight to higher ground beyond the reach of flooding by ordinary spring tides. The lowest belt, which remains covered by a few inches of water at low tide, supports a vegetation dominated by green algæ; *Caulerpa paspaloides* on the soft mud, and *Batophora oestedi* where there is a solid substratum. Separated from this lower mud flat by a slight step in the surface of the ground, is a higher mud flat which is not reached by ordinary neap tides, but is slightly flooded by spring and other heavy tides. This forms an area of slow deposition, for if such flooding happens to coincide with rough weather, during which sediment is stirred up into the sea, this belt of land is covered by a thin film of mud which settles out before the water retreats again. This mud flat is colonized by *Symploca*, and the sediment takes on the conspicuously laminated structure (Type A) described on p. 171. Going further beyond the reach of ordinary tides, the surface of the drewite is found to be slightly lithified, presumably through the action of rain-water, and outcrops of Pleistocene limestones also appear; conditions here become favourable for the uninterrupted growth of *Scytonema*, and the sedimentary structures give place to partly calcified algal heads, similar to those found at Stafford Lake and near the headwaters of Fresh Creek.

(*d*) *Twelve O'clock Cay.*

Twelve O'clock Cay is a small island lying in the land-locked sea between Middle and Northern Bights. The algal heads, which are here all of Type B, are of particular interest because they occur on a mud flat which is washed at every tide by water of essentially the same salinity as the sea, 36–38 parts per thousand on the Great Bahama Bank. Although this region is normally sheltered from heavy wave action, the sediment is subjected to constantly shifting currents, and a considerable amount of the finer material is consequently winnowed away, leaving a sediment of a distinctly sandy texture. The tide rises over the algal flats quite gently, and with normal weather conditions there is no transport of sediment. It is probably only during quite severe storms that sediment is swept over the algal flats and deposited there. Towards low-water mark, the algal deposits pass laterally, with no abrupt transition, into loose submarine sediments with no organic matrix or structure.

(*e*) *The Wide Opening.*

The algal beds which occur on the north side of the Wide Opening are similar to those of Twelve O'clock Cay, except in their being colonized to a greater extent by mangroves. They are probably washed at every tide unless the wind sets strongly off shore, when the water is blown out of the Wide Opening. The salinity varies considerably, since there is a substantial amount of brackish water drainage entering this gulf. Our only determination gave a salinity of 17·87 parts per 1000, but as this sample was taken at lowest ebb tide, the figure is undoubtedly lower than the normal; with the rising tide, the Wide Opening fills up with sea water—37·8 per 1000—and by the time that the water level is high enough to flood the algal beds, the salinity must have risen to between 36 and 37 parts per 1000.

(*f*) *The Fresh Creek Lakes.*

The lakes at the head of Fresh Creek present an interesting series of algal deposits, which are still under investigation. In the localities examined, which are all along the southern shore of this lake system, there are extensive outcrops of limestone. The ground stands several feet above the surface of the lakes, and appears to receive sediment at very rare intervals. Although the lake water is slightly saline, the ground water is fresh, and the recent sediments have a hard, cemented crust. Most of the algal deposits are non-sedimentary, and resemble the cemented forms from Stafford Lake and Southern Bight. There is, however, one sedimentary form (Type D), which is remarkable because the algal heads become completely detached, and are transported by the wind until they are deposited finally in one of the lakes.

(*g*) *Review of Relationship to the Environment.*

Reviewing the geographical relationships of these algal deposits, we see that they mark a borderline facies between land and water—and, indeed, they often occupy territory which the cartographer hesitates to assign to either. Their structure depends upon several rhythmic processes, foremost amongst which is the alternate flooding and draining of the areas in which the algæ grow. Since they are essentially mechanical sediments, as opposed to the organic accumulations of coenoplase and calcareous algæ, they can only develop in regions where calcium carbonate is the dominant sediment. Thus, unlike the lime extracting algæ, they could not produce their characteristic forms in streams or lakes, unless there were also a sediment of solid carbonate in suspension.

(*h*) *Early Development of the Algal Heads, and Relation with the Sediment below.*

In all the localities examined, the surface of the sediment between the algal heads, no matter what its former irregularities, is completely covered by a mucilaginous algal skin, and there can be little doubt that the algal sediments described in this paper originated as algal films on mechanically deposited sediments. In the early stages of development, the form which an algal head may take seems to depend to some extent upon the nature of the sediment. In regions of sandy sediment, such as Twelve O'clock Cay, the characteristic, dome-shaped structure probably originates round some irregularity on the surface of the sediment; this becomes colonized by algæ, which begin to accumulate sediment around them. Once the domed structure has been initiated, the algal head will tend to increase its size by the addition of fresh layers deposited concentrically round the earlier ones, producing algal heads of Type B.

In the interior of Andros, round Lake Forsyth and Stafford Lake, the algal heads are initiated, most probably, in a different way. The sediment is of a fine enough

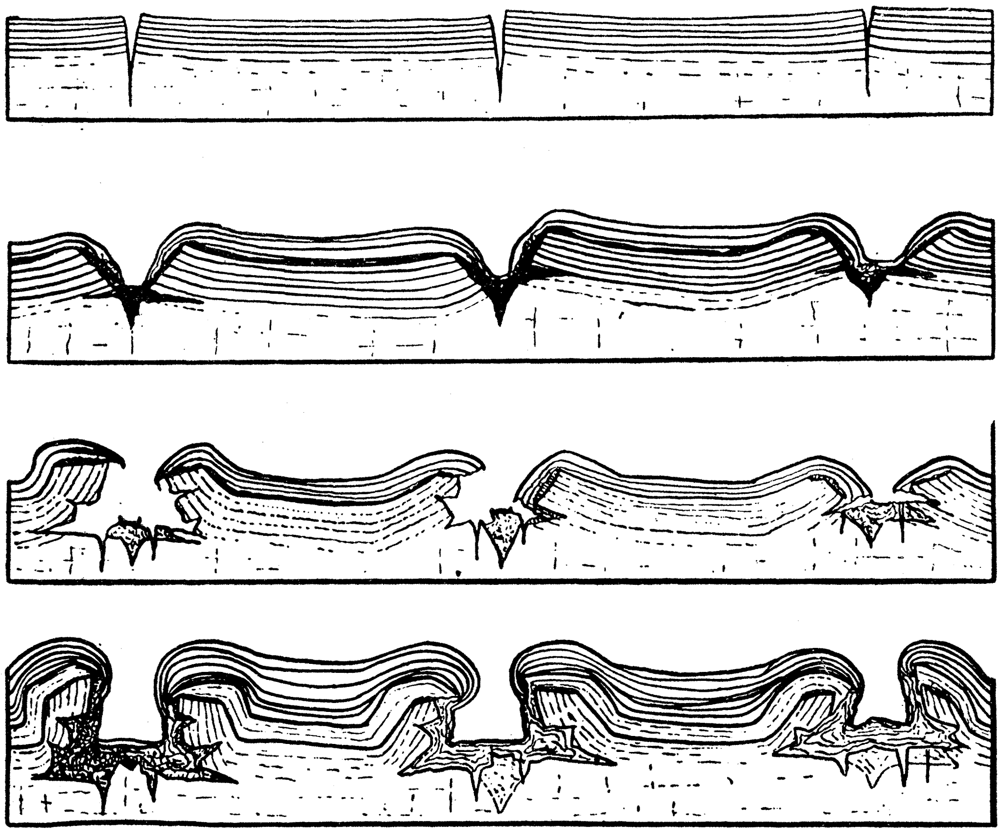

Fig. 8.—Early Stages in the Development of Algal Heads of Type C. × $\frac{1}{4}$. For explanation, see the text.

texture to produce desiccation cracks on a slight drying out of the surface layers, fig. 8. Once this has happened, each desiccation polygon becomes sheathed in a felt of algal filaments, and with further growth, the polygonal outline is lost, and a circular disc is produced. Further growth tends to fill up the gaps between the disks, and to cause a doming of the upper surface. A repetition of desiccation at this stage causes the upper layers of the algal head to shrink; the peripheral part then tears away from the material filling the interspaces between neighbouring algal heads, and a slight upward curling of the outer edge gives a concave or saucer-shaped form to the upper surface (see fig. 4). A renewal of growth then gives rise to the characteristic structure

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of Type C. The development of Type D probably follows the same plan, but does not appear to go so far as in that of Type C.

When algal heads of Type C attain a considerable thickness, it is often found that only the top inch or inch-and-a-half retains an appreciable quantity of organic matter, and although the earlier formed layers still retain their laminated appearance, the laminæ are now marked out as alternating grey and white bands, with relatively little plant material left. That the disappearance of this organic matter is brought about by bacterial decomposition, is made probable by the recent discovery of very active cellulose and hemi-cellulose destroying bacteria, and also of agar-liquefying bacteria, in the mangrove swamps of western Andros. (Bavendamm, 1931 and 1932.)

VI.—Comparison with other recent Cyanophyceous Deposits.

Amongst recent calcareous algal deposits, the Bahaman sediments stand apart from all other recorded examples in being completely unlithified, and in consisting of clastic material collected by, but not precipitated by, the algæ concerned. This tendency of the Cyanophyceæ to collect clastic material and retain it amongst the mucilaginous sheaths of the thallus, is no recent discovery, and the importance of these plants as pioneer colonizers of newly deposited mudflats has long been recognized. These phenomena have, however, mainly been observed in regions where argillaceous (and to a less extent, arenaceous) sediments are predominant, as for example on the shores of estuaries and deltas (Carey and Oliver, 1918, pp. 170–173), and the possibility of the development of this kind of algal colonization on a vaster and more elaborate scale in regions of limestone sedimentation has not fully been realized.

Numerous occurrences of calcareous concretions have been described in which the lime is believed to have been precipitated through the activity of blue-green algæ. In all these, the calcium carbonate is thrown out of solution because the physiological activities of the plant cells disturb the chemical equilibrium of the surrounding water; the solid carbonate, as a consequence, is completely external to the plant cells, and may either come down as a loose precipitate, or as a hard stony encrustation round the algal colonies. All the limestones which are known to originate in this way are being precipitated in fresh-water lakes and streams, in contrast with the Bahaman sedimentary deposits, which range from fresh lake water to water of ocean salinity. A further point of importance is that all the previously described cyanophyceous limestones either require a nucleus or hard substratum upon which to grow, or else they take the form of nodules with a structure of hard, concentric envelopes. The stratigraphical relationships of the Bahaman deposits are somewhat different, for here the algal beds themselves form an incident in the deposition of a series of stratified sediments, and they develop on the surface of completely unconsolidated material.

An example of a cyanophyceous deposit which shows some interesting points in common with the Bahaman material is described by W. Wetzel (1926) from the valley of the Rio Loa, where it flows through the Atacama Desert in Chile. The unlithified algal structures form a tough leathery coating (*Lederhäute*), on the granite blocks of the river bed. They are found to contain *Oscillatoria*, *Nostoc*, and a filamentous bacterium, *Crenothrix*. The river water is slightly saline (3·49 parts per 1000), which is a suggestive point when it is remembered that these *Lederhäute*, and the Bahaman deposits, which are also mostly in somewhat saline water, have in common the peculiarity of remaining unlithified. Another point of interest is that the Atacama *Lederhäute* also enclose clastic sediment, which, however, is non-calcareous, but consists of fine sand and mud, insoluble in hydrochloric acid. Consequently, if detrital calcite is assumed to be absent, it is possible to estimate the relative proportions of precipitated carbonate and clastic sediment. An analysis gave the following results, showing the clastic material and carbonate to be present in approximately equal amounts :—

Organic Matter	9·5
Clastic Sediment	45·0
Calcium Carbonate	37·8
Magnesium Carbonate	4·2

In the Bahaman deposits there is no such ready method of distinguishing between clastic and precipitated material, since both consist entirely of soluble carbonates. Nevertheless, in Type A and Type B the texture of the sediment is sufficiently coarse for many of the individual grains to be easily recognized as fragments of molluscan or foraminiferal shells, or as clastic grains derived from older limestones. Type B can thus be seen at a glance to consist almost entirely of clastic material, and Type A very largely so.

The hard, stony cyanophyceous limestones have much less in common with the Bahaman deposits. They generally occur as discoidal or spherical bodies, up to a foot or more in diameter ; internally they are often cavernous, and the general structure may be roughly radial, or, occasionally, concentric. " Water Biscuits " and " Lake Balls " have been recorded and described from many localities, amongst which are the Finger Lakes of New York State (Clarke 1900), various lakes in Michigan and Minnesota (Powell 1903), and streams in Pennsylvania (Roddy 1915). The concentric arrangement becomes more noticeable where a seasonal or other change in water-level causes alternate drying and moistening ; a roughly concentric structure is found in specimens from the flat gravel banks on the shore of the Rhine near Konstanz, where the algæ are covered only when the river is high (Pia 1926, pp. 45–47).

In an extremely interesting occurrence described by Sir Douglas Mawson from the Robe district, South Australia, the water biscuits have a well-developed concentric structure, owing to alternate desiccation and flooding (Mawson 1929). The region in which the deposits are found is flat and almost at sea level, and is subjected to seasonal flooding ; the conditions thus appear to have much in common with those prevailing in parts of Andros Island. The algal deposits, nevertheless, show interesting differences, for whereas the Bahaman algal heads are unlithified, and merely form a surface modification of the sediment upon which they grow, the water biscuits are formed each as a separate, lithified individual, completely detached from its substratum, and deriving its carbonate largely or entirely by precipitation. Thus each water biscuit consists of a series of concentric shells, each one entirely enclosing the previously-formed part of the structure—an arrangement in strong contrast with the construction of the Bahaman deposits.

The author knows of no records of modern cyanophyceous limestones in process of formation in the open sea. HØEG has recently described a series of post-glacial stromatolitic plates, discovered on the cliffs of Malmø and Svenør, in the Oslo Fjord, and has shown that they are probably of marine origin. Unfortunately, their growth appears to have ceased some considerable time ago, and it is difficult to reconstruct the conditions which favoured the deposition of calcite in this particular from. HØEG (1929) suggests that the carbonate was precipitated from sea water through the agency of blue-green algæ or of bacteria, and points out that the structure and arrangement of the stromatolitic plates is strongly in agreement with an origin by precipitation. In this they differ entirely from the Bahaman deposits, for they are thoroughly lithified and have a compact crystalline structure.

A comparison with the Precambrian and early Palæozoic stromatolites, to which the Bahaman sediments show a certain resemblance, is beyond the scope of this paper, and will be considered separately in a later communication.

VII.—Description of Species.

Gloeocapsa granosa (Berkeley) Kützing, fig. 9.—A plant resembling *G. granosa* in its habit was found in the marshes near Lake Forsyth. It differs from typical

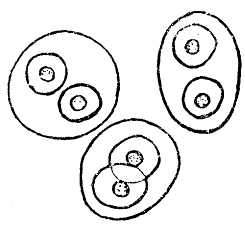

Fig. 9.

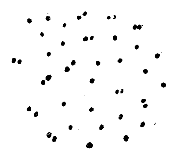

Fig. 12.

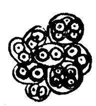

Fig. 10.

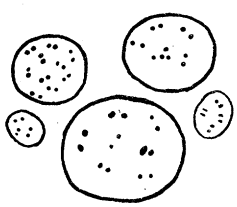

Fig. 11.

Fig. 9.—*Gloeocapsa granosa* var. *chlora*, Lake Forsyth. × 400. Fig. 10.—*Gloeocapsa viridis*, sp. nov., Twelve O'clock Cay. × 400. Figs. 11 and 12.—*Aphanocapsa marina*, in oval colonies from Lake Forsyth (fig. 11), and in the diffuse form, from Twelve O'clock Cay (fig. 12). × 1000.

material in its larger size, and also in the conspicuous jade-green pigmentation of the sheaths, especially in the case of families of four or more cells, in which the innermost sheaths are often deeply coloured. This form is therefore best regarded as a variety of *G. granosa*, for which the name *chlora* is proposed.

G. granosa (Berkeley) var. *chlora* nov. Cells apple-green, 4–6 microns in diameter; individual sheaths olive-green to jade-green in colour, more strongly pigmented in the older colonies, non-lamellose, 12–14 microns in diameter. Colonies up to 75 microns in size, the inner common sheaths pale green, the outer ones colourless.

Habitat.—Amongst other Cyanophyceæ on the moist surface of chalk marshes; at the type locality, the water is almost fresh.

Locality.—Lake Forsyth, Andros Island, Bahamas.

Gloeocapsa viridis sp. nov., fig. 10.—Cells 0·75–1·0 microns in diameter; sheaths 2·5–5·0 microns, bright grass-green, usually strongly lamellose; plants in clusters from a few cells to groups of about twenty microns.

Habitat.—On sandy ground, liable to be flooded by sea water; at the type locality, intimately associated with *G. magma.*

Locality.—Twelve O'clock Cay, Middle Bight, Andros Island, Bahamas.

Aphanocapsa marina Hansging, figs. 11 and 12.—The small *Aphanocapsa* which is found in great abundance at Lake Forsyth, and at Twelve O'clock Cay, only differs from the typical *A. marina* in the rather greater size of its cells, which range from 0·5 to 0·75 microns, as compared with 0·4 to 0·5 microns in the material described by Hansging and by Foslie (1890, p. 169). The cells of the Bahaman material are pale green; near Lake Forsyth, where the water is almost fresh, the plant is sometimes found in well-defined, oval colonies, up to 12 microns in diameter, but it is usually in the form of a gelatinous, shapeless, mass, filling the spaces between other blue-green algæ. At Twelve O'clock Cay, the plant was found abundantly near high-water mark, as a colourless extended mass, pervading the spaces between sand grains, or amongst other algæ.

Plectonema atroviride sp. nov., fig. 13.—Filaments 4–5 microns in diameter, straight, rarely with a slight spiral tendency, branched freely at first, but later sparingly; false branches usually solitary. Sheaths firm, the outermost one hyaline, the inner deeply coloured, dark jade-green, almost opaque. Trichome one micron broad, with cells 6–8 microns in length.

Habitat.—Growing amongst other Cyanophyceæ, especially in tufts of *Scytonema*, in chalk marshes which are liable to be flooded by fresh water.

Locality.—At the head of Lake Forsyth, and near the southern shore of Stafford Lake, Andros Island, Bahamas.

Remarks.—This species resembles *P. nostocorum* in its form and habit, but differs in its thick and deeply coloured sheaths, and also in the greater length of its cells. In its unusually long cells, it may be compared with *P. terebrans*, but differs again in its stout sheaths. It also shows some similarity to *P. radiosum*, but is a distinctly smaller plant. From all other species of *Plectonema* with a similar size or habit, it differs in the elongate shape of its cells.

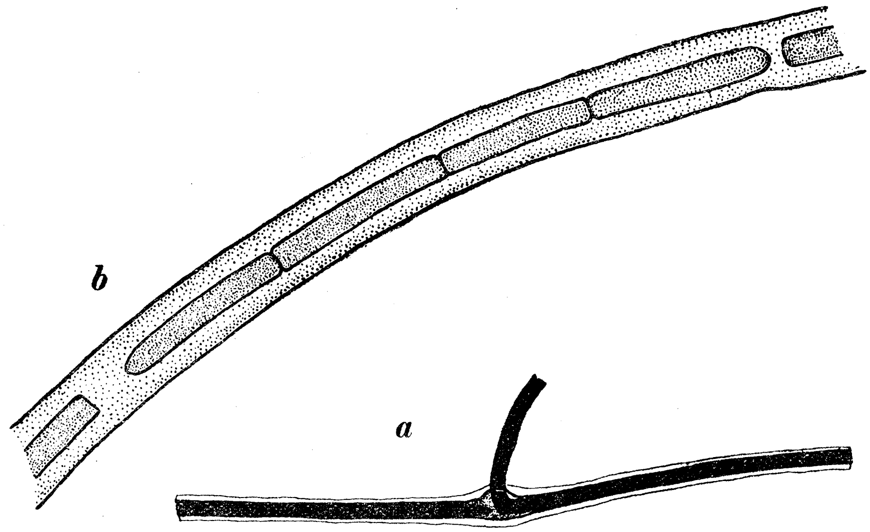

Fig. 13.—*Plectonema atroviride* sp. nov., Lake Forsyth, Andros. (*a*) Part of a filament, to show the two sheaths, the inner one deeply pigmented, and also the method of branching. × 700. (*b*) Part of a filament with the inner sheath bleached to show the trichome. × 3000.

Scytonema androsense sp. nov., fig. 14.—Plants forming matted strata and small woolly tufts, dark lead-grey to deep green in colour. Filaments with a very sharp outer edge, 15–30 microns in diameter, and up to a centimetre in length. Sheaths strongly lamellose; the innermost lamella is deep sage-green in colour, and is sometimes dark enough to obscure the trichome inside; outer sheaths, very pale green to colourless; at certain levels, the lamellæ are strongly divergent, and spread out to form broad, pale green or colourless funnel-shaped ocreae. Trichome 6–10 microns in diameter, with cells quadrate or slightly longer than broad; cell contents pale blue-green. Heterocysts the same width as the trichome, or a little wider, one-and-a-half times or twice as long as broad; outer wall of the heterocyst hyaline, enclosing an inner, golden yellow, granular centre. False branches free, and usually divergent at the base.

Habitat.—In chalk marshes, moistened by water with a salinity of 1·25 parts per thousand, or less.

Locality.—Lake Forsyth, Stafford Lake, and near the Fresh Creek Lakes, in Northern Andros Island, Bahamas.

Remarks.—This species falls into the division *Petalonema* of Bornet and Flahaut, but differs from other ocreate species of similar dimensions and structure in its intense green colour. It differs further from most of the species in this group, such as *S. densum*, *S. velutinum*, and *S. alatum*, by its characteristic heterocysts; from *S. crustaceum*, which it resembles in size and shape of heterocysts, it differs strongly in the lack of any trace of cohesion between the false branches.

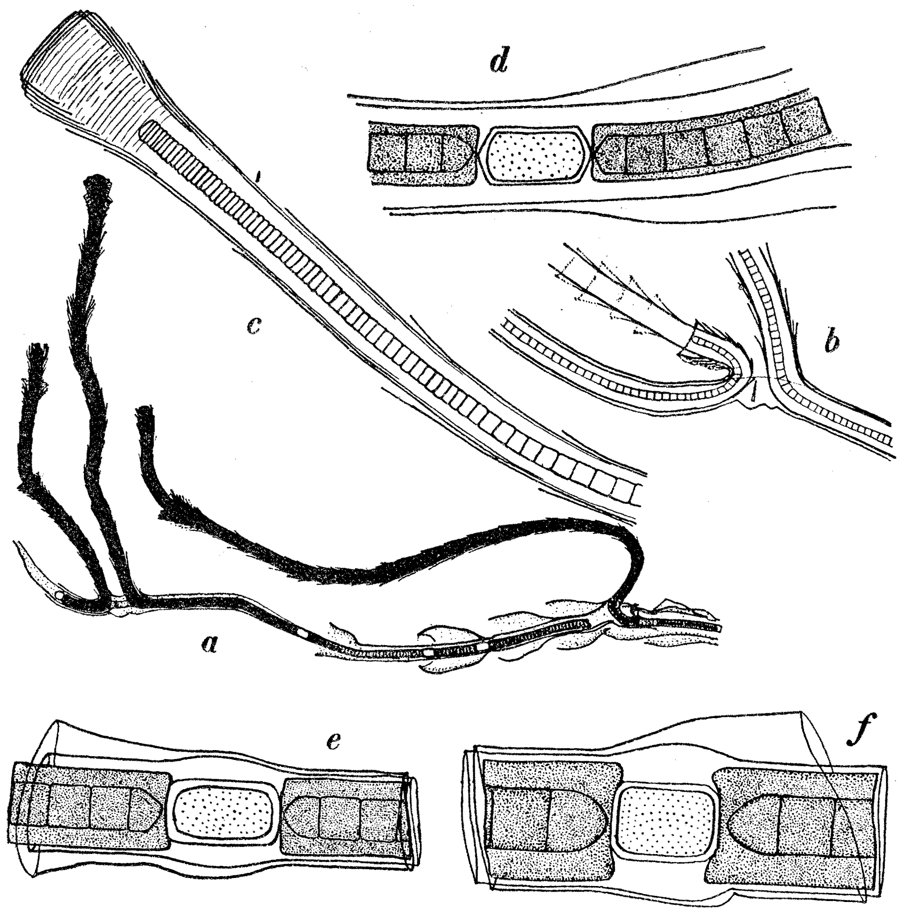

FIG. 14.—*Scytonema androsense* sp. nov., Lake Forsyth. (*a*) Part of the plant to show the spreading habit of the ocreae. × 120. (*b*) Method of branching. × 240. (*c*) Characteristic growing apex of a filament. × 480. (*d*) Part of a filament to show the deeply pigmented inner sheath broken at a heterocyst. × 800. (*e*) and (*f*) Typical heterocysts. × 800.

Scytonema crustaceum AGARDH, figs. 15 and 16.—Associated with *S. androsense* in the interior of Andros Island, is another species of *Scytonema*, which approaches *S. crustaceum* var. *incrustans* in many of its characteristics, but differs in the behaviour of its false branches. Unlike the typical *S. crustaceum*, and its variety *incrustans*, which give rise to branches in pairs, this form most commonly produces its false branches singly, and a paired arrangement is less frequently seen. Where the false branches do arise in pairs, they are usually immediately ascending, and are free for their entire length, fig. 16a. False branches arising singly, however, frequently pierce only the innermost sheath of the parent filament, and run within the outer sheaths for some distance before they break free, fig. 16b. Where the false branches entirely fail to break through the sheaths of the parent filament, fig. 16c, a peculiar disorganization of the trichome is sometimes observed to take place, fig. 16d; the filament produces a bulbous swelling, within which the trichome develops into a tangled mass of *Nostoc*-like chains, or may even break down into separate spherical cells.

In view of these peculiarities, this plant is best regarded as a variety of *S. crustaceum*, for which the name *catenula* is proposed.

S. crustaceum Agardh. var. *catenula* nov.—Plants forming matted strata and woolly tufts, dark grey to deep green in colour. Filaments 20–45 microns in diameter, often with an irregular outer edge. Sheaths of strongly divergent lamellæ, olive-brown in colour. Spreading ocreæ absent. Trichome 5·0–12·5 microns in breadth, with spherical

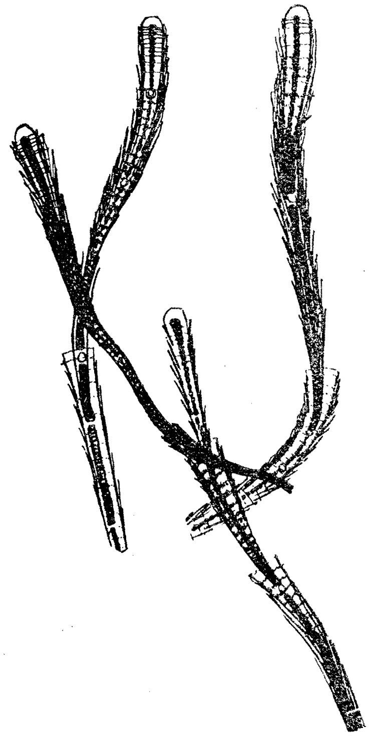

Fig. 15.—*Scytonema crustaceum* var. *catenula*, Lake Forsyth. Part of plant to show the divergent sheaths. × 150.

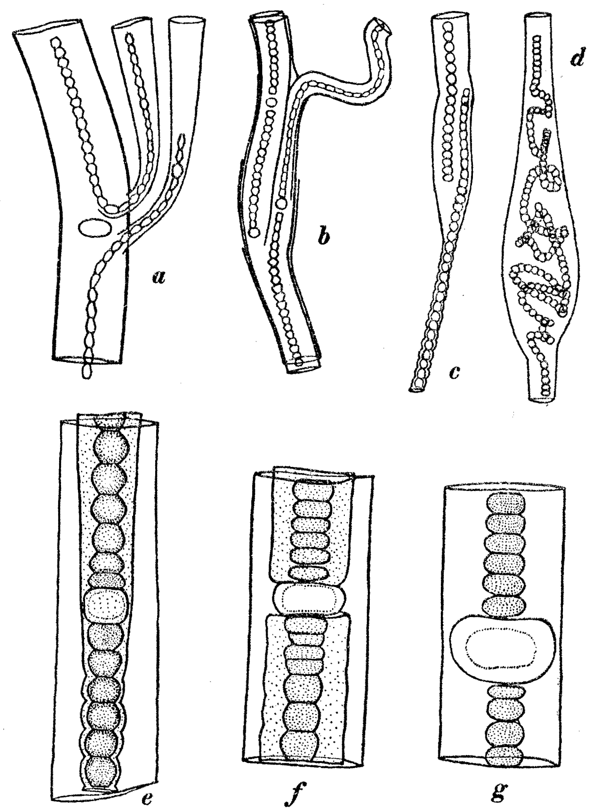

Fig. 16.—*Scytonema crustaceum* var. *catenula*. (*a*) Normal method of branching. × 200. (*b*)–(*d*) Branches with only partial rupture or non-rupture of the sheaths. × 150. (*e*)–(*g*) Typical heterocysts. × 500.

or compressed barrel-shaped cells; cell contents pale blue-green. Heterocysts compressed, wider than the trichome, and broader than their own length, colourless or olive-green, homogeneous. False branches usually arising singly, less commonly in pairs; solitary false branches frequently failing to pierce one or more of the outer sheaths, so that the branch runs within the parent filament, between two of the sheaths, or produces a bulbous swelling, within which the trichome becomes loosely aggregated or even disorganized into separate spherical cells.

Habitat.—In chalk marshes, associated with *S. androsense*.

Locality.—Marshes round the head of Lake Forsyth, Stafford Lake, and the Fresh Creek Lakes, Andros Island, Bahamas.

VIII.—Summary.

(1) Algal deposits, with characteristic structures, in some respects resembling certain Palæozoic stromatolites, are developing over a considerable area in Northern Andros Island.

(2) Several geographical belts can be recognized in the island, and the algal deposits in each belt possess a growth form distinct from that shown by algal deposits growing in other belts.

(3) The calcium carbonate which goes to make up these deposits is not necessarily precipitated by the algæ responsible for the structures, but consists of essentially mechanically entrapped sediment.

(4) The algal deposits are entirely unlithified, and do not require a solid substratum upon which to grow. They originate normally as a surface modification of unconsolidated sediments, and well-developed algal sediments are found to pass laterally and also downwards, into ordinarily bedded sediments.

(5) Generally the characteristic structure is produced, not by a single species, but by a community of organisms ; this is especially true of the structures with a dominantly concentric arrangement, as opposed to a radial one.

(6) Any particular species of alga may enter into, and help to build up, more than one type of rock structure.

(7) Although this kind of structure is best developed in regions of low salinity, it is also found in localities where the salinity is essentially that of the open ocean.

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EXPLANATION OF PLATES.

Plate 21.

Fig. 17.—Mangrove flats on the North shore of the Wide Opening, seen at ebb tide. These flats are colonized by algal heads of Type B.

Fig. 18.—Algal heads of Type B at Twelve O'clock Cay. The photograph was taken looking down through a few inches of water, gently flooding the algal beds with the rising tide.

Fig. 19.—Algal heads of Type C, near the North Eastern shore of Lake Forsyth.

Fig. 20.—Surface view of the algal flats near the headwaters of Lake Forsyth. The individual discs are 4 or 5 inches in diameter.

Plate 22.

Fig. 21.—Type A. Section in Reflected Light, showing the surface and uppermost laminæ. × 10.

Fig. 22.—Type A. Slab etched with acid to show the relative thicknesses of organic layers (dark) and sedimentary layers (light). The individual filaments of *Symploca* and *Phormidium* cannot be distinguished at this magnification, and the algal material appears as rather ill-defined layers of jelly. Filaments of *Scytonema* may be distinguished in the lower part of the figure. Reflected light. × 10.

Fig. 23.—Type A. Thin section showing the relation between the algal filaments and the grains of sediment at the surface. Transmitted light. × 100.

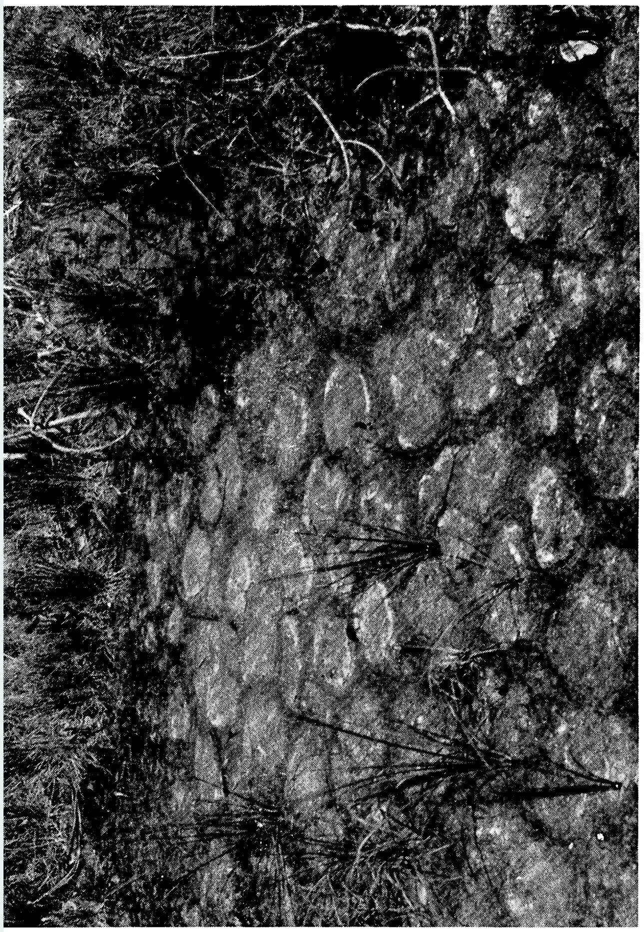
Fig. 24.—Type B. An algal layer, consisting mainly of deeply pigmented *Gloeocapsa magma* and *G. viridis*, runs across the centre of the figure. The normal texture of the sediment in this locality is seen in the lower half of the figure. Near the top of the section is a band of much finer grained sediment, enmeshed between filaments of *Symploca*. Reflected light. × 10.

Fig. 25.—Type C. Part of a mature algal head, sectioned in artificial resin. The dark layers consist of compressed algal filaments, mainly belonging to species of *Scytonema*. Reflected light. × 10.

Fig. 26.—Type C. Thin section, showing sections of algal tubes (*Scytonema*, spp.). Transmitted light. × 100.

Fig. 27.—Type D. Thin section, showing the large proportion of organic matter (dark), and the extremely fine grain of the sediment. Transmitted light. × 100.

Fig. 28.—Radial algal head, from Stafford Lake. The open, porous structure is in strong contrast with the compact forms shown in the other figures of this plate. Reflected light. × 2.3.



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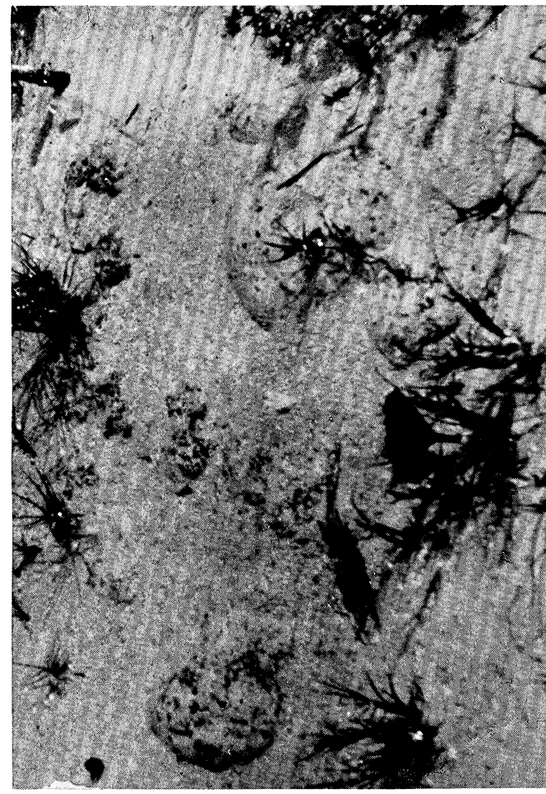

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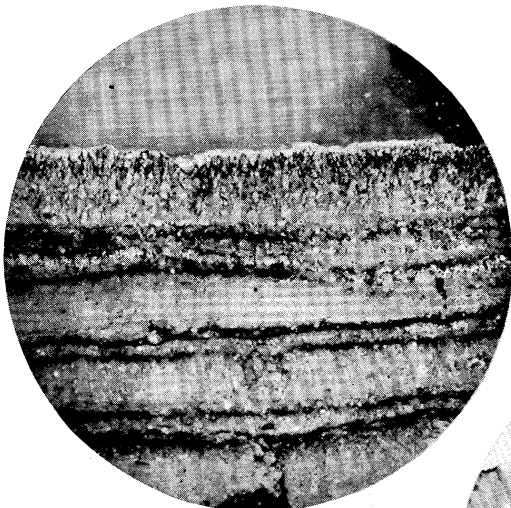

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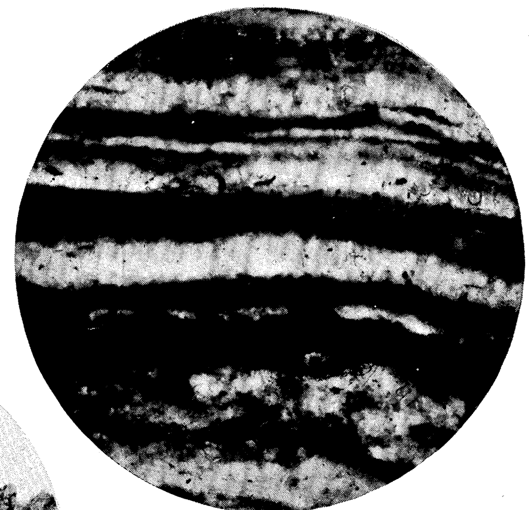

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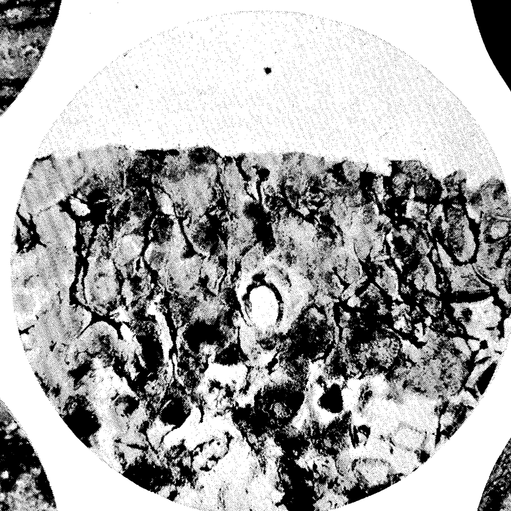

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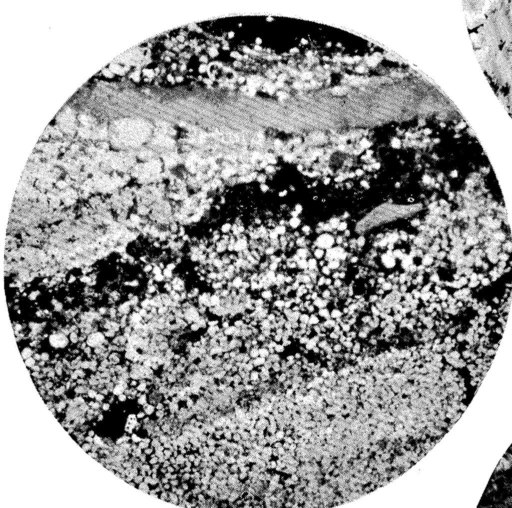

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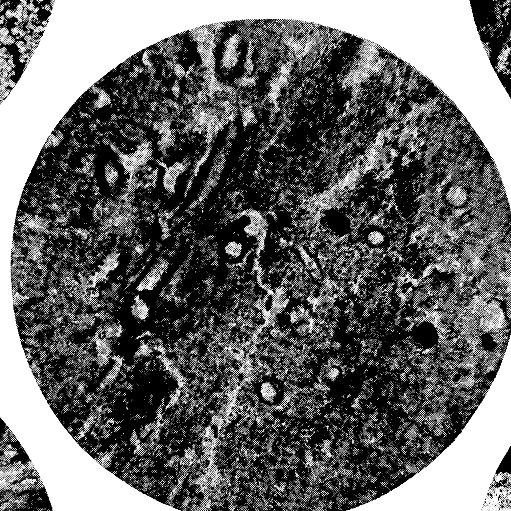

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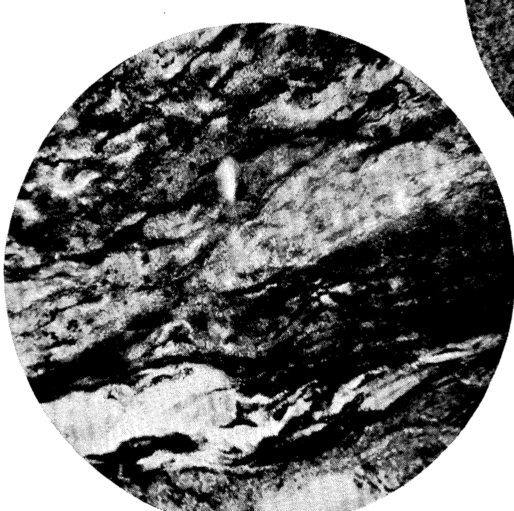

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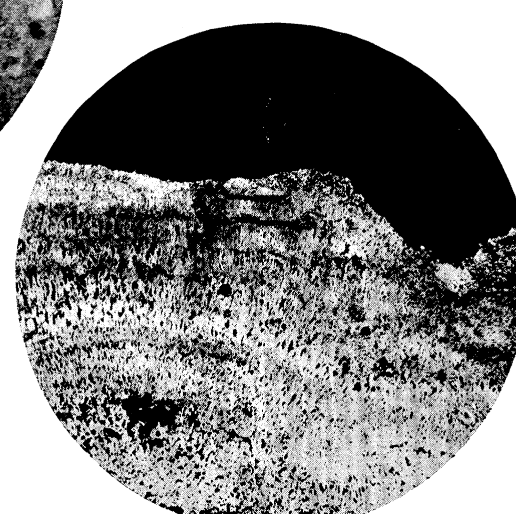

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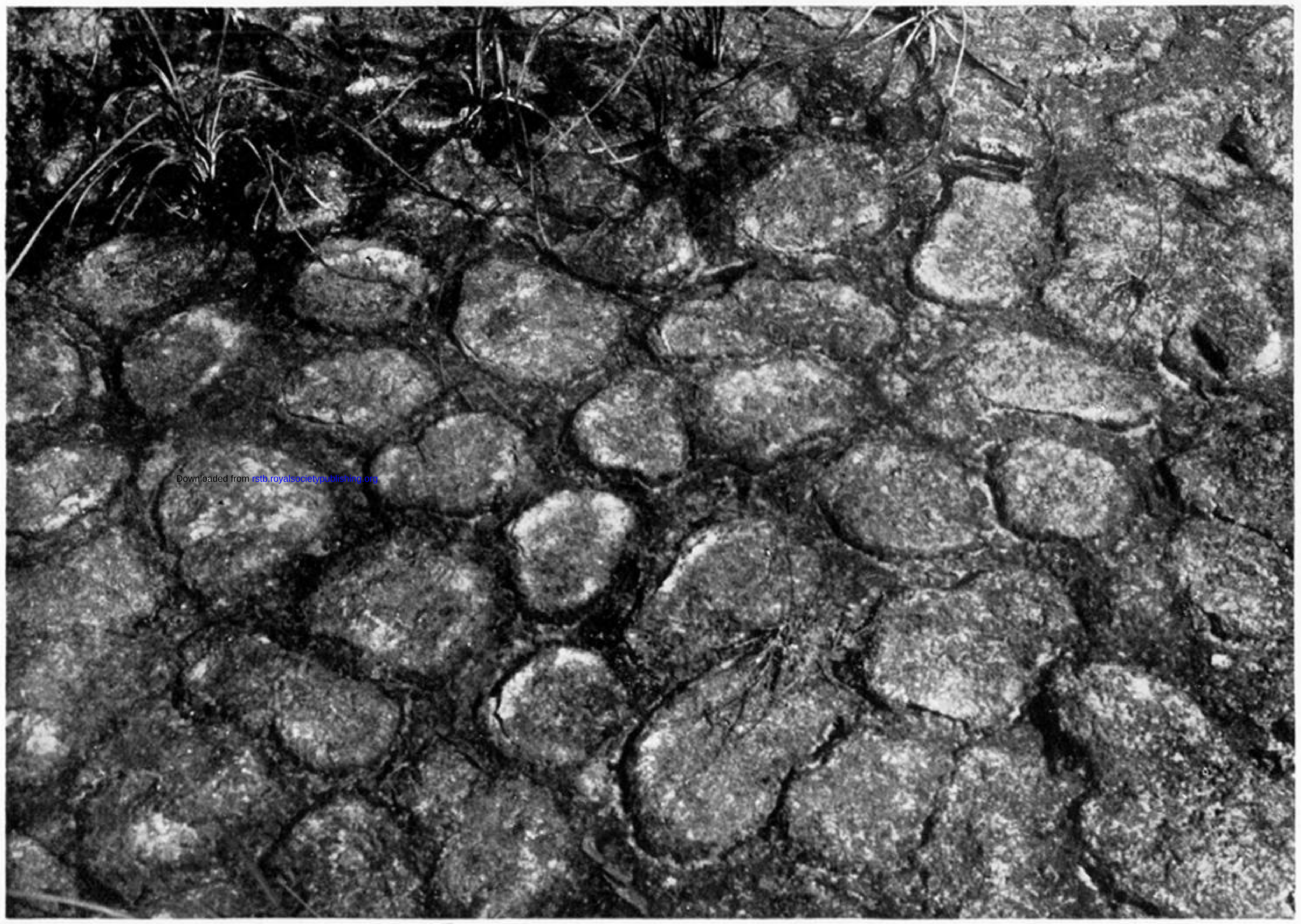

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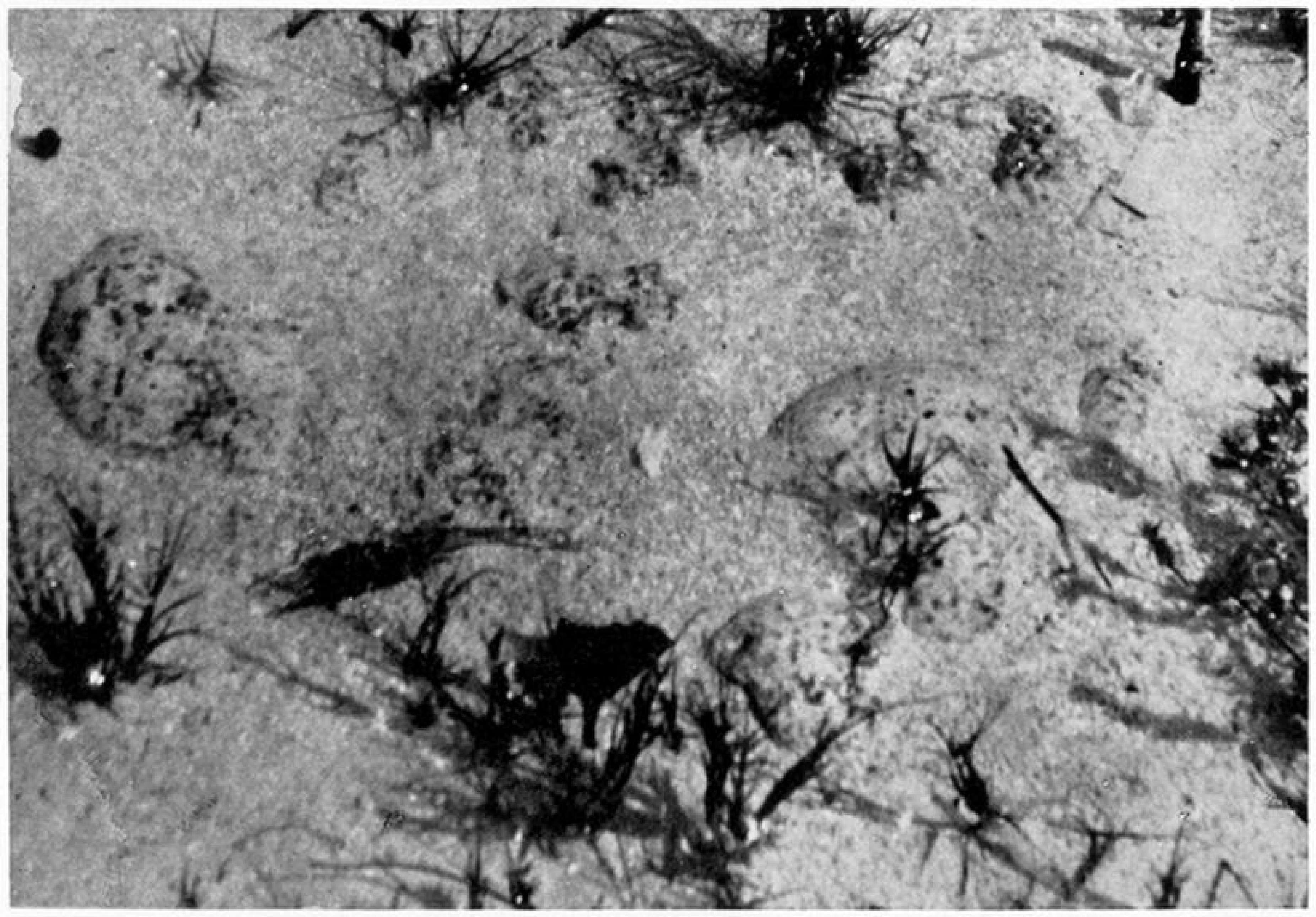

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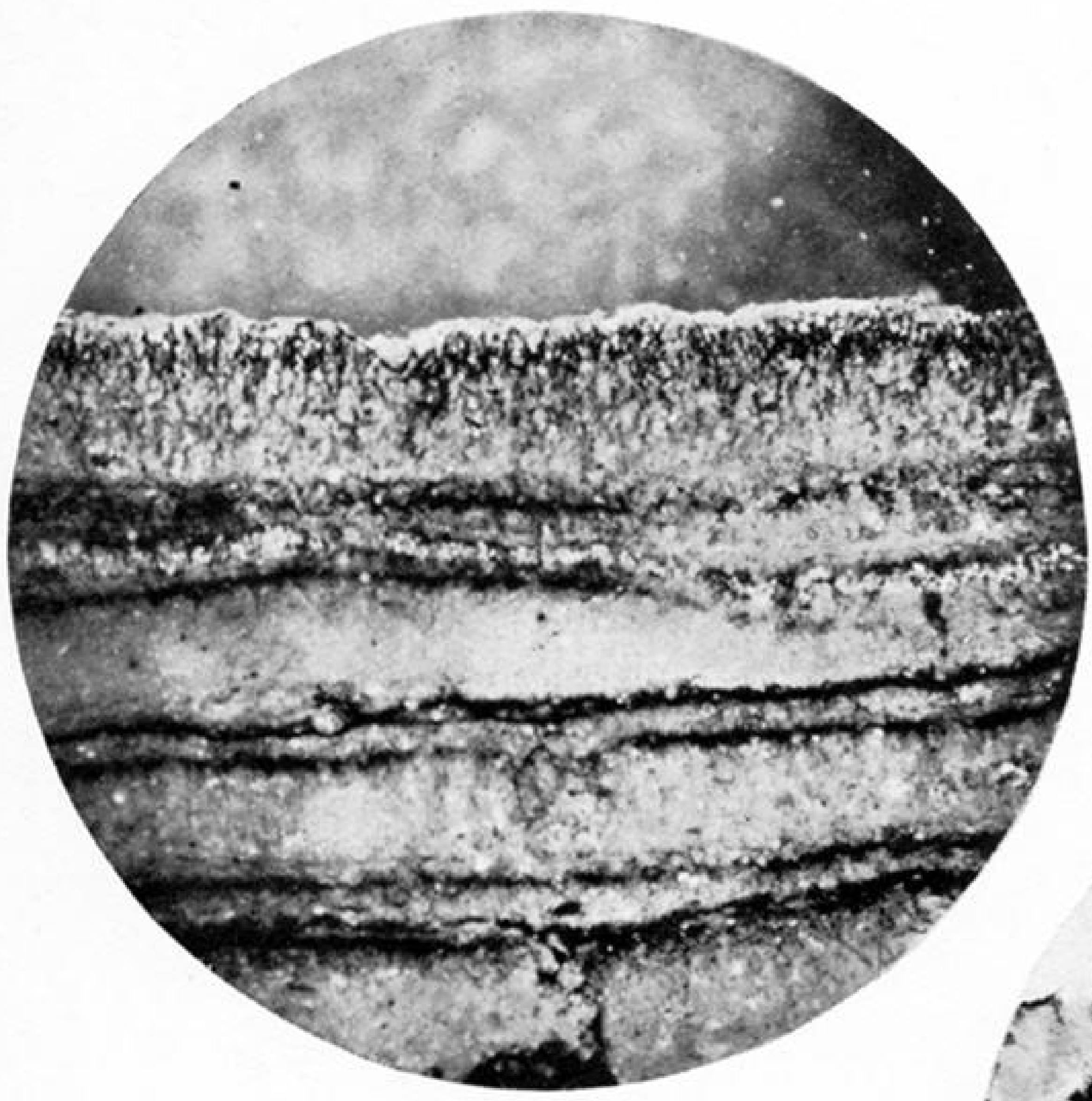

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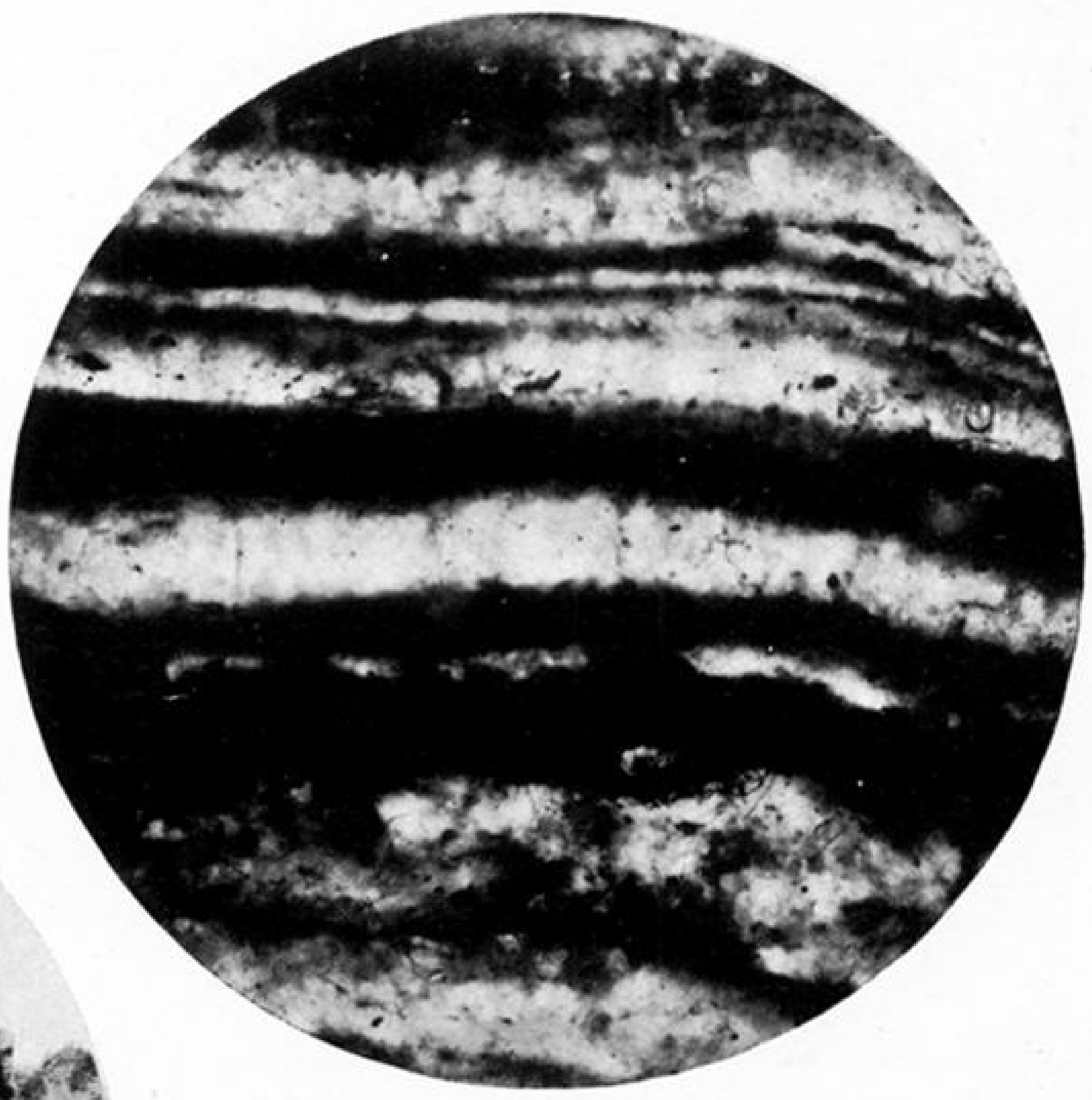

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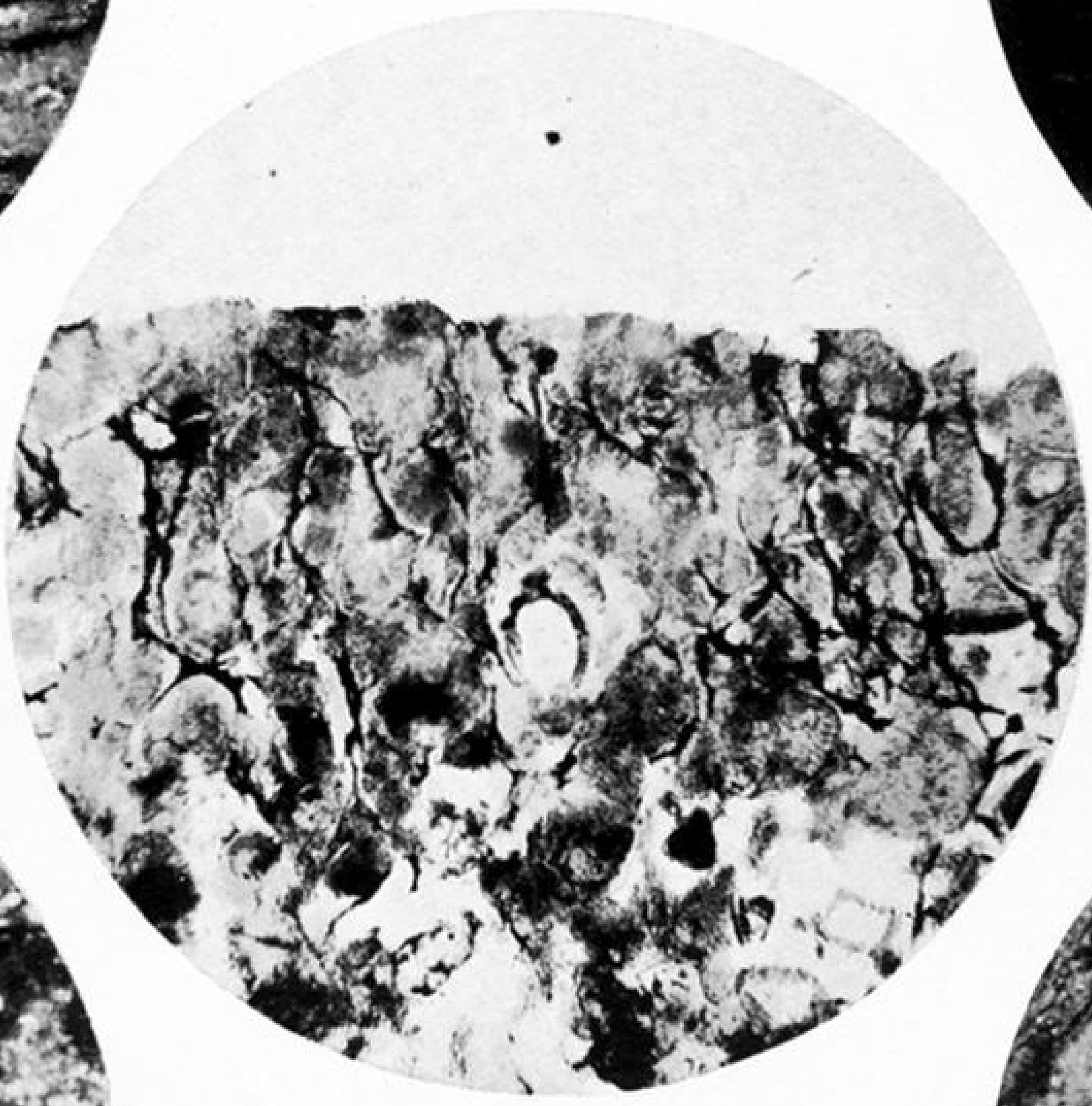

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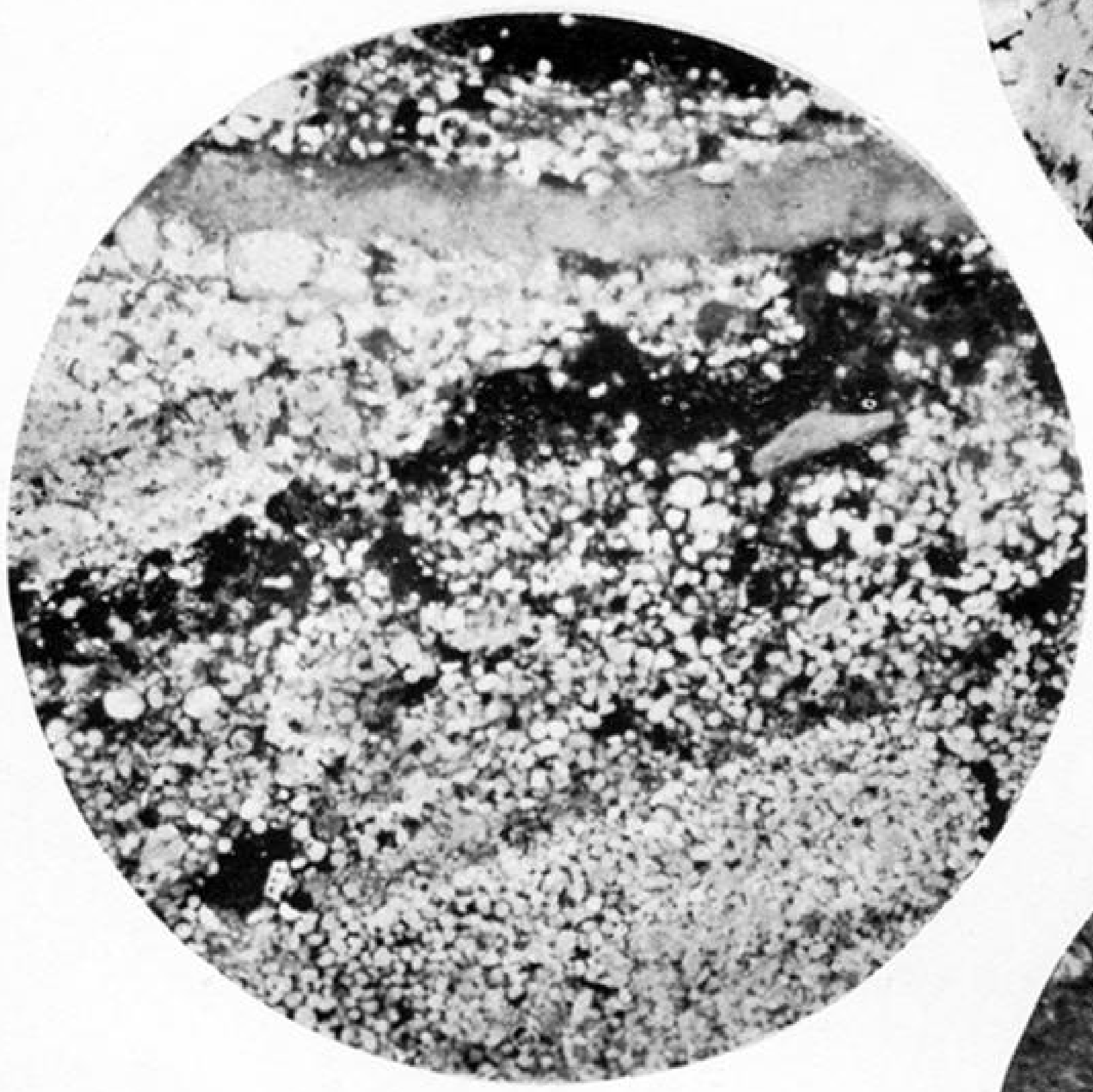

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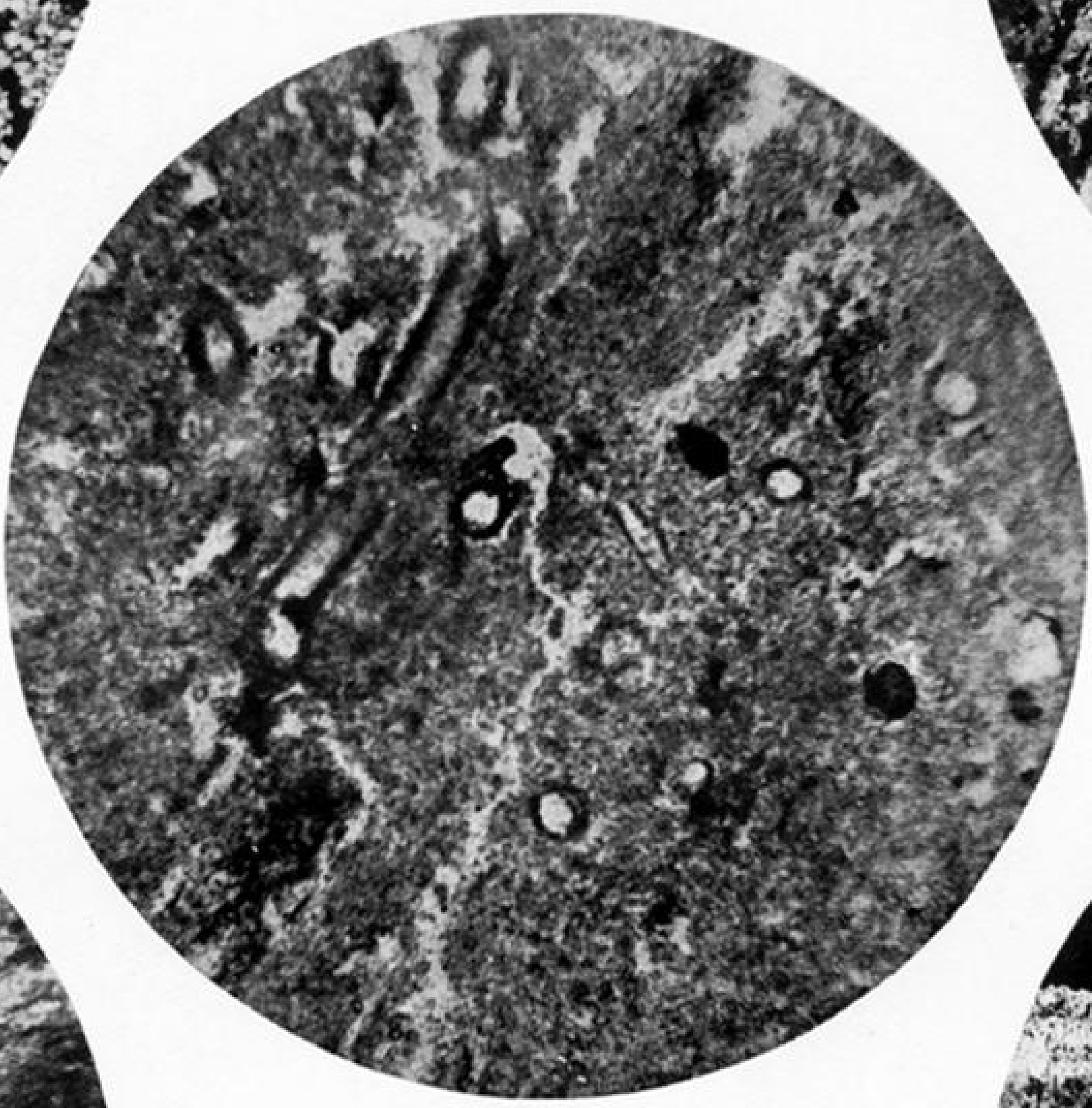

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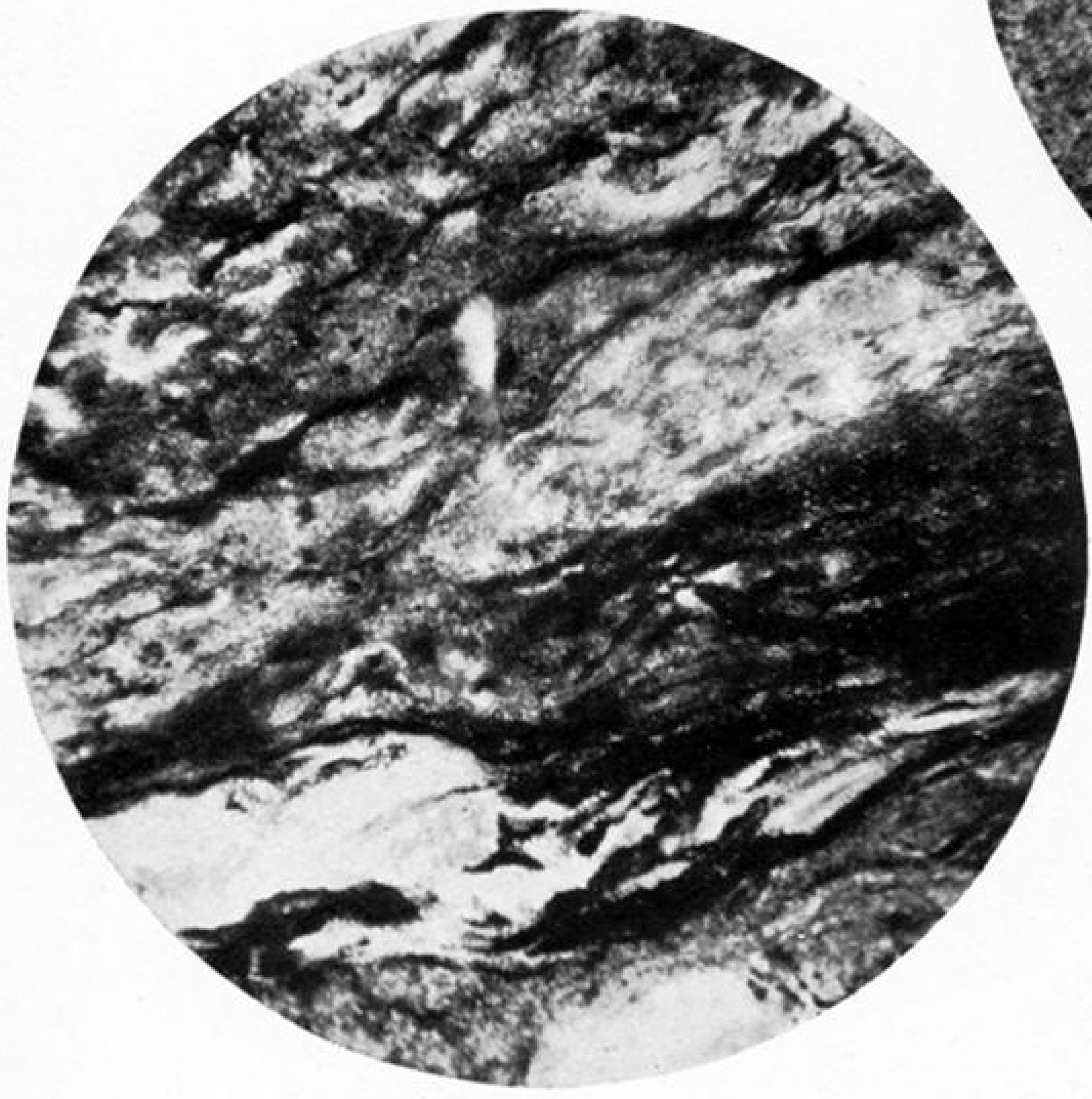

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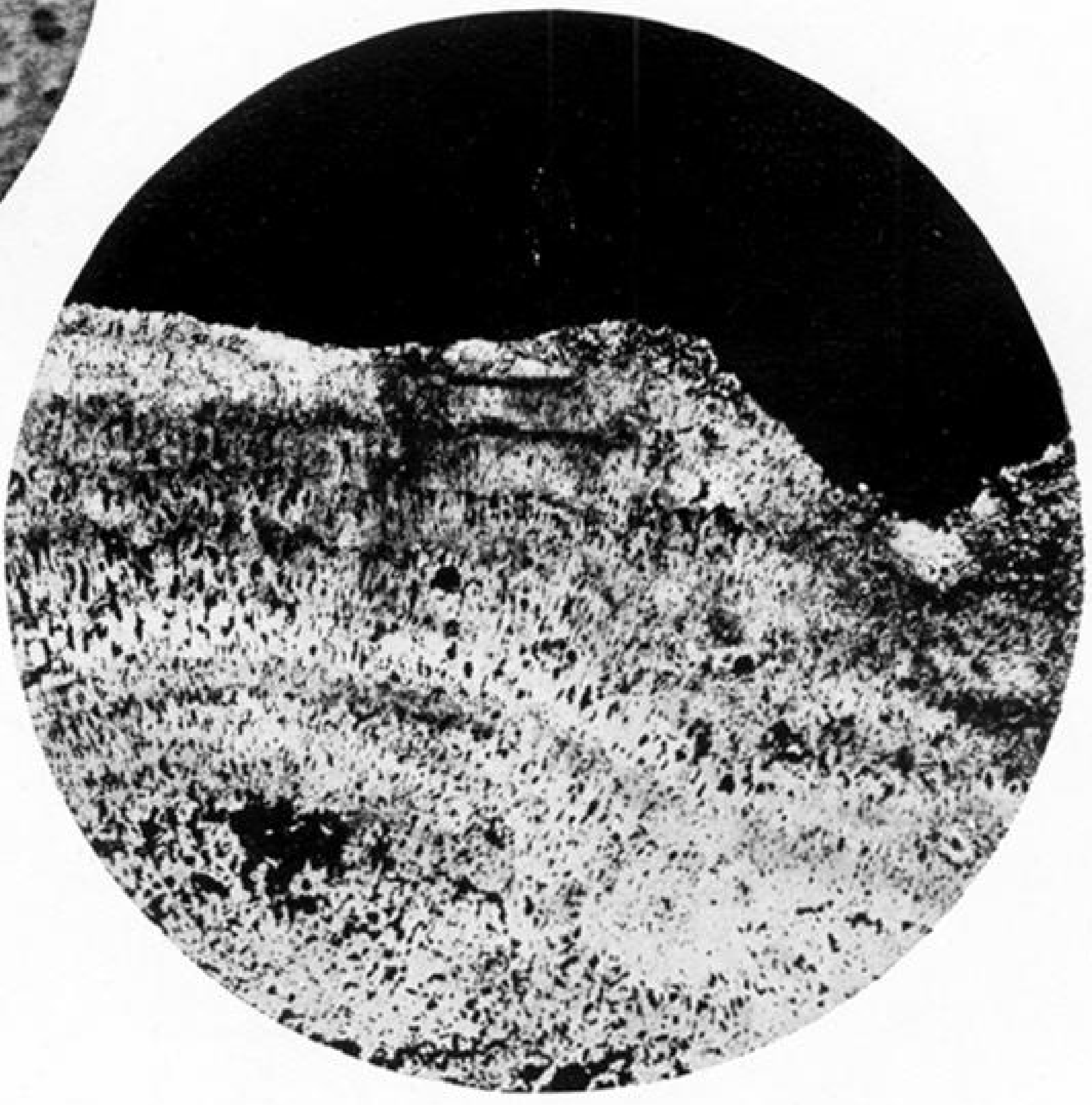

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PLATE 22.

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