

The Forest-bed Cervidæ taken as a whole, although composed of a remarkable and peculiar assemblage of forms, show us, as has been pointed out by Mr. Boyd Dawkins in the valuable paper above mentioned, that the Forest-bed itself is rather of Pleistocene than Pliocene age; and as we know that *Elephas primigenius*, *E. antiquus*, and *Bison priscus*, all Pleistocene forms, are numbered amongst its fauna, we are justly entitled to consider that the data are such as warrant the above conclusion.

II.—On the Affinities of the Genus *Stromatopora*, with Descriptions of two new Species. By H. ALLEYNE NICHOLSON, M.D., D.Sc., M.A., F.R.S.E., Professor of Natural History in University College, Toronto.

In the 'Annals' for August 1873 I described four species of *Stromatopora* (one from the Upper Silurian, and three from the Devonian rocks of Canada), all of which exhibited certain relationships with the Spongida. As regards two of the species described in the paper alluded to, I have now obtained some further material, by which certain interesting points of structure are brought out, and the reference of these fossils to the Spongida is still more clearly established. I have also to describe for the first time two new and exceedingly interesting species of the genus—one from the Corniferous Limestone (Devonian), and the other from the Niagara Limestone (Upper Silurian). In the first place, however, it may be as well to discuss briefly the systematic position of the genus *Stromatopora*.

The genus *Stromatopora* of De Blainville includes a number of fossils of doubtful affinities, which have the common character of forming amorphous masses or irregular expansions, composed of delicate calcareous laminae, arranged in successive strata one above the other, and separated from one another by minute vertical props, pillars, or dissepiments. Very often the successive laminae are disposed round an imaginary centre or centres in a concentric manner, giving rise to spherical, hemispherical, or irregularly massive forms. In other cases the mass * is extended so as to form an expanded cup or irregular

* I would suggest that the term "sarcodeme" (Gr. *sarx*, flesh; *demos*, people) might advantageously be employed to designate the entire organism or colony amongst the compound Foraminifera and the Sponges. Some such term is certainly needed in treating of such problematical organisms as *Stromatopora*, of which the exact systematic position is doubtful.

sheet, made up, like the preceding, of successively superimposed laminae.

The main element, therefore, in the structure of *Stromatopora*, and the only one about which all observers are tolerably agreed, is a system of parallel calcareous laminae, generally of great tenuity, not in actual contact, but separated from one another by narrow interspaces. The successive laminae are kept apart by a vertical system of calcareous pillars, which divide the interspaces between the laminae into minute, usually quadrangular compartments, and thus render the whole mass more or less minutely vesicular.

So far, the structure of *Stromatopora* would be compatible with a reference of the genus either to the Foraminifera or the Spongida; but there are unfortunately many differences of opinion as to the further structure of these fossils, and these have led to equally wide differences of opinion as to the affinities and systematic position of the genus.

According to M'Coy (Pal. Foss. p. 12) the vesicular tissue of *Stromatopora* is composed of "minute, curved, calcareous plates," which he compares to the coenenchyma of *Palaeopora* and *Fistulipora*. He also states that the upper surface is occasionally marked "with extremely obscure, distant, quincuncially arranged, small pits," which he appears to think may represent the corallites in the above-mentioned or other allied genera.

Prof. Hall agrees with M'Coy in referring *Stromatopora* to the Coelenterata, and in placing it in the neighbourhood of *Tubipora* (Pal. N. Y. vol. ii. p. 135). He considers that the fossils of this genus are composed of "minute cylindrical tubes with considerable space between, and that the laminated structure arises from thin layers of calcareous matter, deposited and filling the spaces between, and enclosing the tubes."

My own investigations of a very extensive series of specimens from the Lower and Upper Silurian rocks and from the Devonian Formation have led me to the conclusion that the genus *Stromatopora* is clearly referable to the Spongida, and that it should be placed amongst the Calcispongiae, a group represented by many and varied forms both in past time and at the present day. The reasons for this belief may be shortly summed up as follows:—

a. The fundamental structure of *Stromatopora* is by no means inconsistent with the belief that it belongs to the calcareous sponges. It does not consist of reticulated calcareous spicula, as in the more typical members of the group; but neither does it consist of a vesicular tissue composed of "minute curved calcareous plates" (M'Coy), which could be in any way

compared to the vesicular coenenchyma of many tabulate corals. On the contrary, it consists of successive calcareous layers which may be regarded as composed of an amalgamated system of horizontal spicules, separated by interspaces, and kept apart by a vertical system of delicate calcareous rods, giving rise to a system of more or less quadrangular cells. The horizontal laminae are upon the whole continuous; but they sometimes subdivide and inosculate; and the vertical pillars are decidedly irregular, being sometimes inclined at various angles, and not being placed at uniform distances apart even in all portions of a single specimen. Some of the vertical rods appear to pass continuously through several laminae and across the interspaces between them; but the greater number are confined entirely to the interval between two successive laminae, not being continuous or corresponding with those in the interspace immediately above or below. There is no ground, so far as I am aware, for believing that these vertical pillars or rods are perforated, or could possibly be of the nature of tubes inhabited by the separate zooids of a colony; on the contrary, in all the forms which have come under my notice, there is the strongest possible proof that they are solid and imperforate. There is thus nothing in the fundamental tissue or groundwork of *Stromatopora*, as above described, which would necessarily preclude us from referring the genus to the Spongida; nor can any stress be laid upon Prof. M'Coy's argument that these organisms cannot be sponges on account of their possessing a rigid and inflexible skeleton, since similar reasoning would compel us to remove from the Spongida a vast number of forms the zoological position of which is beyond doubt. At the same time, if *Stromatopora* consisted wholly of the laminated and reticulated tissue above described, and possessed none of those openings which are so characteristic of the Sponges, then indeed the genus might be more properly referred to the Foraminifera, the near allies of the Sponges in some respects, but destitute of the canal-system which is present in the latter.

b. Such openings, however, can be shown to exist in certain forms of *Stromatopora*; and there is strong reason for believing that they will ultimately be found to be present in all. Thus in *S. striatella*, D'Orb., and *S. concentrica*, Goldf., both typical examples of the genus, Prof. M'Coy long since described the existence of vermicular tubes opening on the surface by small apertures, and passing more or less vertically through the component layers of the mass (Pal. Foss. pp. 14 & 15). There is some ambiguity in the language used by this eminent palæontologist in describing these tubes and their

openings in *S. concentrica*; and the evidence is not at present sufficient to warrant any positive statement of opinion as to whether they may correspond with the "pores" or the "oscula" of an ordinary sponge. It is probable, however, that they should be regarded as representing the "pores," and that the "oscula" will yet be discovered by a more extended and complete examination. Again, in *S. ostiolata*, Nich., a species from the Guelph formation of Canada, the upper surface of the mass exhibits small but regularly arranged openings, which, from their remoteness and general form, can hardly be regarded as other than "oscula" ('Annals,' Aug. 1873, pl. iv. fig. 1). In *S. tuberculata*, Nich., again, I have now discovered a system of comparatively large and remote openings, which communicate with canals traversing the organism, and which appear to fulfil beyond all question the function of exhalant apertures. In *S. granulata*, Nich., no openings are ordinarily to be detected, probably on account of the manner in which specimens are generally preserved; but I have one example showing both small and large openings, which must be considered as being inhalant and exhalant. In *S. perforata*, Nich., now described for the first time, the entire mass, or "sarcodeme," is traversed by numerous and close-set canals of considerable size, which open at the surface in rounded apertures generally placed on conical or chimney-like eminences. These must represent exhalant canals and apertures. Lastly, in *S. Hindei*, also now described for the first time, there is a series of small close-set apertures which must represent "pores," and another series of larger, more remote, and more irregularly disposed openings which can only be regarded as oscula. With the exception, however, of the last-named species and of the single specimen of *S. granulata* above alluded to, I am acquainted with no species of *Stromatopora* which has hitherto been shown with certainty to possess two sets of openings—one small and inhalant, the other large and exhalant. It must be remembered in this connexion that the difficulties in the way of observation are in this case extremely great, since the condition of mineralization in which these fossils occur is generally such that the cavities of the mass are filled up with foreign material, whilst the reticulated tissue itself is often silicified. Hence it would be easy for such minute surface-apertures as the "pores" of a sponge to be irretrievably filled up and obliterated or to escape detection.

c. The shape of the various species of *Stromatopora* is such as would accord perfectly well with the belief that the genus is referable to the Spongida. Some species are in the form of rounded or irregularly hemispheric or conical masses. Others

are somewhat cup-shaped; and others, again, have the form of irregular and extended crusts, apparently attached at one point to some solid body, from which they spread laterally in every direction, or seem to form incrusting sheets.

Upon the whole, I think the evidence is very decidedly in favour of the view that the genus *Stromatopora* is referable to the Calcispongiæ. In accordance with this view, I retain in this genus the forms which I have named *S. tuberculata*, *S. granulata*, *S. perforata*, and *S. Hindei*, since these are undoubted sponges, and would upon any other view of the affinities of *Stromatopora* require to have a new genus formed for their reception.

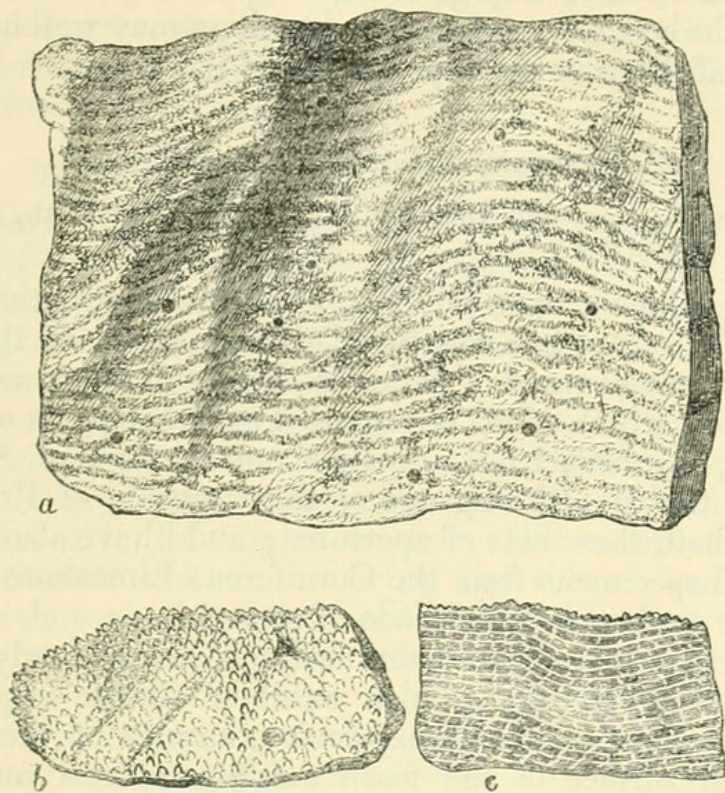
1. *Stromatopora tuberculata*, Nicholson.

Stromatopora tuberculata, Nicholson, Ann. & Mag. Nat. Hist., Aug. 1873, pl. iv. figs. 2, 2 a.

Having now obtained a considerable number of additional specimens of this species, I have to add two observations of importance to my original description. In the first place, I have now obtained specimens showing that the under surface of the expansions of *S. tuberculata* is covered by a thin calcareous basement-layer, which is thrown into very numerous concentrically arranged undulating wrinkles. This surface thus presents somewhat the appearance of the epitheca of a *Favosites*; but it is much thinner and rougher, and is pierced by apertures. In the second place, both the upper and the lower surface exhibit at irregular intervals rounded apertures which are placed at distances apart of from two lines to half an inch, and have a diameter of from half a line to two-thirds of a line. These apertures are wanting in some specimens, which, however, are but fragmentary, whilst they can readily be detected in others. They are the openings of canals which penetrate the mass in a more or less vertical direction; and I noticed their occurrence in my original description of the species, though I did not at that time fully recognize their nature. The case was thus stated by me:—"Many examples exhibit rounded openings or tubes, from half a line to a line in diameter, descending at right angles to the mass, and placed at varying intervals. These openings are not elevated above the general surface. They are not constant in their occurrence, though very generally present; and I have not been able to satisfy myself that they are not truly extraneous to the fossil. They may, perhaps, be annelidous in their nature; or they may be due to the fact that the organism has enveloped a colony of *Syringopora*, which has subsequently been dis-

solved away" (*loc. cit.* p. 93). The materials now in my hands, however, are quite sufficient to prove conclusively that

Fig. 1.



a, part of the under surface of a large example of *Stromatopora tuberculata*, showing the concentrically wrinkled basement-layer and the openings of the oscula, natural size. *b*, a portion of the upper surface, natural size; *c*, a vertical section of a fragment of the same, magnified to show the internal structure.

these canals and apertures are truly parts of the fossil. They are mostly to be detected upon the upper surface of the mass; but in one large specimen, which seems to have grown from a broad base of attachment and then to have spread out laterally in an irregularly cup-shaped form, they are plentifully developed on the lower surface. It can hardly be that they can be any thing else than openings corresponding to the "oscula" of sponges. The "pores" I have not yet made out with absolute certainty; but I believe that the surface-tubercles are truly of this nature, some of them showing almost conclusive proofs of having been perforated by minute openings at their apices.

There would thus appear to be every reason for concluding that *S. tuberculata* is truly a calcareous sponge; and the chief question remaining is whether it can with propriety be re-

tained in the genus *Stromatopora*. My own opinion is decidedly against forming a new genus for its reception, since it has the essential structure of *Stromatopora*; and the difficulty which I experienced at first in detecting the oscula, even in the examination of a large series of specimens, has convinced me that the occurrence of similar openings may well have been overlooked, even in the type species of the genus.

2. *Stromatopora granulata*, Nicholson.

Stromatopora granulata, Nicholson, Ann. & Mag. Nat. Hist., Aug. 1873, pl. iv. figs. 3, 3 a.

The specimens upon which my original description of this species (*loc. cit.* p. 94) was founded were all from the Corniferous Limestone; and I failed to detect in them any traces of apertures which could be regarded as either pores or oscula. Recently, however, I have obtained an example of *S. granulata* from the Hamilton group of the township of Bosanquet, showing both these sets of apertures; and I have also obtained additional specimens from the Corniferous Limestone showing the under surface and the mode of growth.

The first of the above-mentioned specimens is only a fragment; and its greater portion exhibits all the appearances which characterize the Corniferous examples of the species. The upper surface of the fossil exhibits several rounded or conical elevations, one of which is perforated by a large sub-circular aperture leading down into the interior, and evidently of the nature of an osculum. Whether the other elevations were similarly perforated or not does not clearly appear. The pores are only shown over a small portion of the fossil, and have the form of minute close-set perforations in a delicate calcareous membrane or surface-layer. Beneath this layer, and over all parts of the specimen whence it has been denuded, is seen the ordinary granulated surface from which the name of the species was originally derived. There is thus a probability established that all the specimens from the Corniferous Limestone which exhibit simply this granulated surface are imperfect, and that there has been removed from them an exterior and very delicate membrane in which the pores were pierced. The granulated layer which appears to form the surface in so many specimens would seem on this view to have served the purpose of distributing the water received through the external poriferous layer, the granules with which it is studded being more or less confluent, and giving rise to a complicated system of sinuous or vermicular horizontal channels.

The under surface of *S. granulata* is covered by a thin, con-

centrically wrinkled calcareous membrane, precisely similar to the epitheca of a *Favosites* or *Fistulipora*. Usually the species forms extensive crusts of no great thickness; but I have one specimen in which the organism is attached by a broad base to a large *Heliophyllum*, from which it spreads out laterally in all directions as a horizontal expansion, the under surface being covered with a wrinkled "epitheca," and having been obviously free.

3. *Stromatopora perforata*, Nicholson.

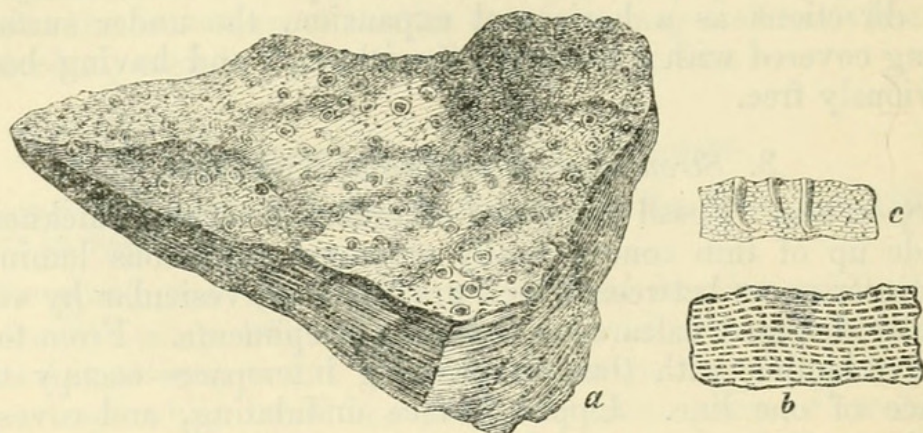
Spec. char. Fossil composed of crusts of varying thickness, made up of thin concentrically arranged calcareous laminae, the interspaces between which are rendered vesicular by vertically disposed calcareous rods or dissepiments. From four to five laminae with their intervening interspaces occupy the space of one line. Upper surface undulating, and covered with very numerous rounded apertures, which vary in width from two thirds of a line to one line, and are situated at distances apart of a line, more or less. These apertures are usually placed at the summit or on one side of conical eminences; or they are elevated above the general surface, the margin of the opening on one side being in general higher than on the other. These apertures are the orifices of vertical or somewhat oblique canals, which penetrate the vesicular tissue of the fossil, and are lined with a delicate calcareous membrane, marked with faint encircling striae. For a certain distance (two or three lines) each canal descends in a straight line, and then is curved so as to become nearly parallel to the lower surface of the mass, at the same time contracting in its diameter (fig. 2, c). Between the oscula, as just described, the surface is covered with a fine miliary granulation, composed of minute pustules placed close together and arranged in irregular vermicular or sinuous lines.

Stromatopora perforata is perhaps the most remarkable species of the genus which has been yet described; and it cannot be doubted that it is a genuine member of the Calcispongiae, though in some respects an abnormal one. In its internal structure it agrees altogether with *S. tuberculata*, *S. granulata*, and *S. mammillata*; and with the two former of these it agrees further in the possession of a series of apertures which cannot be any thing but "oscula." No "pores," however, have been detected, unless some of the surface-tubercles should in reality be perforated, which is likely enough.

S. perforata is readily distinguished from *S. tuberculata* by the much greater number and closer arrangement of the oscula, by the elevation of these apertures above the general surface,

and by the finer and more minute character of the surface-granulation. The number and closeness of the oscula also

Fig. 2.



Stromatopora perforata: *a*, a fragment, showing the osculiferous upper surface, natural size; *b*, a fragment magnified, to show the internal structure; *c*, vertical section of a fragment, showing the form and course of the canals, natural size.

separate this form from *S. granulata*, in which the oscula are remote, and often cannot be detected at all, though in other respects the surface-characters of the two are very similar or even identical. The under surface of *S. perforata* is still unknown; but the fossil forms thinner or thicker crusts, often covering pretty extensive surfaces, the thicker expansions being composed of a succession of crusts superimposed one upon the other.

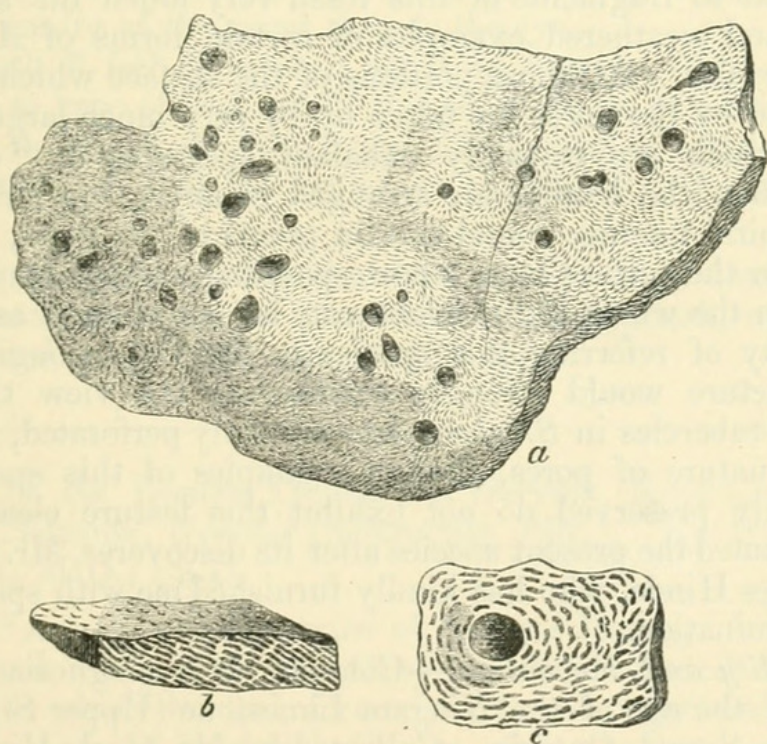
Locality and Formation.—Rare in the Corniferous Limestone of Port Colborne. Collected by the author.

4. *Stromatopora Hindei*, Nicholson.

Fossil forming thin crusts or subhemispheric masses composed of successive concentrically disposed strata, each stratum made up of parallel calcareous laminæ separated by interspaces. Sometimes the component laminæ of each stratum are parallel with the upper and lower surfaces of the stratum or nearly so; but more commonly they are oblique to these surfaces. The result of this is that the interspaces between the laminæ open on the surfaces of each stratum as so many elongated and oblique apertures, which have usually the form of fissure-like sinuous slits, but sometimes present the appearance seen in weathered specimens of *Alveolites*. The laminæ of each stra-

tum are sometimes connected by transverse pillars, but more commonly they are so bent and curved as to inosculate with one another at points closely approximated, thus giving the whole mass a vesicular structure. Well preserved specimens show about eight laminae in the space of one line. The upper surface of the fossil exhibits not only the linear and vermicular openings above spoken of as produced by the interlaminar spaces, but also a series of large rounded or oval openings, which are more or less irregularly disposed, and which are the orifices of so many canals which penetrate the mass vertically or obliquely. The size of these oscular apertures varies; but most of them have a diameter of from a line to a line and a half. They also vary greatly in their number in a given space, some fragments exhibiting many of them placed close together, whilst others only show a few, and these remote. The walls of the canals leading away from these openings are not lined by a continuous calcareous membrane (as in *S. perforata*), but are perforated like a sieve by the elongated slits

Fig. 3.



Stromatopora Hindei, Nich.: *a*, upper surface of a fragment, natural size, showing the pores and oscula; *b*, vertical section of a fragment, enlarged, showing the obliquely arranged laminae and interlaminar spaces; *c*, upper surface of a fragment, enlarged.

produced by their intersection with the interlaminar spaces. Lastly, the general surface is undulating, and the oscula are not elevated upon eminences or papillæ.

This remarkable species departs in some important respects from the structure of the typical species of *Stromatopora*; but it presents at the same time such a close resemblance to forms like *S. tuberculata* that it does not seem necessary to form a new genus for its reception. The chief peculiarity of the present form depends upon the fact that the component laminae of the mass are not arranged concentrically as regards the entire mass; but the fossil is composed of concentric layers, each of which is composed of parallel or subparallel laminae disposed obliquely to the surfaces of the stratum. Hence the interlaminar spaces, instead of being parallel with the surface of the mass (as in *S. tuberculata* and *S. granulata*), open upon the surface in the form of oblique, sinuous, or vermicular openings, sometimes rounded or subtriangular, but more commonly linear and having a transverse diameter of about one hundredth of an inch. It can hardly be doubted that these minute openings, which cover the greater part of the entire surface, are of the nature of inhalant apertures or "pores;" and they communicate to fragments of this fossil very much the aspect of worn and weathered examples of certain forms of *Alveolites* and *Cœnites*. All those portions of the surface which are not occupied by the pores are taken up by very much larger openings, which are certainly exhalant apertures or "oscula." Very often the laminae are arranged in any given stratum in a subspiral manner round certain points of the mass, and the pores on the surface have a corresponding arrangement.

Upon the whole, little doubt can be entertained as to the propriety of referring this species to the *Calcispongiæ*; and its structure would strongly corroborate the view that the surface-tubercles in *S. tuberculata* are truly perforated, and are of the nature of pores, though examples of this species as ordinarily preserved do not exhibit this feature clearly. I have named the present species after its discoverer, Mr. George Jennings Hinde, who has kindly furnished me with specimens for examination.

Locality and Formation.—Common in a magnesian limestone of the age of the Niagara Limestone (Upper Silurian), at Owen Sound, Ontario. Collected by Mr. G. J. Hinde.



Nicholson, Henry Alleyne. 1874. "II.—On the affinities of the genus *Stromatopora*, with descriptions of two new species." *The Annals and magazine of natural history; zoology, botany, and geology* 13, 4–14.
<https://doi.org/10.1080/00222937408562422>.

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