not described as having any red tint. It does not colour the fields red, when free from drift, but pale yellow fragments lie thick upon the soil. The marls above form red soil, and the upper limestone which "contains little or no magnesia" "has often a red tint." If both these beds contain iron in the same form, why is the upper one peroxidized and the lower one not so? Were Mr. Ward's explanation the true one, the lower limestone ought certainly, at least here and there, to be reddish; but, as before stated, neither this bed, nor the grits on which it is seen to rest in clean section, are at all red, where I have seen them, except in the one case where a bed of red marl lay between the grit and limestone.

III.—Notes on Fossil Sponges.

By Harvey B. Holl, M.D., F.G.S.

(PART II.)

(*Continued from page* 315.)

III. Pictet converted D'Orbigny's families into tribes, and introduced some additional genera created by Giebel, King, etc.; and, except in the description of new genera and species by Reuss, Roemer, Salter, Eichwald and others, the subject remained very much where D'Orbigny left it until M. de Fromentelle proposed a new arrangement, based upon what he terms the "organs which serve for the nutrition of the sponge,"—viz., the tubule, oscules, pores, etc. Like D'Orbigny, he divides the sponges into two orders: 1st, the Spongiaria, which comprises only recent genera; and, 2nd, the Spongitaria, which contains all the fossil genera, with the exception of the doubtful group, the Clionidæ. The second order is further divided into three sub-orders: 1, those sponges which have one or more tubules (the *Spongitaria tubulosa*); 2, those that have oscules, but no tubule (*Spongitaria osculata*); and 3, those that have neither tubule nor oscules (*Spongitaria porosa*). Each of these sub-orders is further divided thus: the tubular sponges into those in which the tubule is solitary, and those in which it is grouped, and also into those with oscules and those without oscules. The oscular sponges are similarly subdivided, according to form, disposition of the oscules, and presence or absence of an epitheca. Lastly, the porous sponges are divided into those that are more or less regularly cup-shaped, and those that assume some other form.

In this arrangement no importance is attached to the nature of the sponge-tissue as a character. In fact, M. de Fromentelle states that he considers it to have "a value altogether secondary, for it is not the form or composition of the skeleton which determines the functions, but the functions themselves which give to the animal the particular form which characterizes it."[1] It is not necessary, however, here to discuss this question, further than to observe, that the power which the sponge has to secrete a siliceous spicular framework in one case, or a fibrous rete in another, implies

[1] *l. c.*, p. 17.

an inherent difference in the nature of the animal, however much they may resemble one another in external character. It will be desirable, therefore, to consider the value of these organs for a moment before proceeding further, and in so doing it will be well to turn to the living sponges for aid.

1. *Form.*—As already observed, form, taken alone, is of little value even as a specific character, for whether it be cup-shaped, tubular, or polymorphous, it is not distinctive, inasmuch as it is common to sponges widely differing in all other characters, and indeed, as remarked by Dr. Bowerbank, trusting too implicitly to outward configuration has led to the placing of spicular and fibrous sponges side by side in the same genus. Moreover, the form varies greatly at different periods in the growth of the same individual; and even in the cup-shaped sponges, commonly the most constant as regards this character, there is a wide difference in the figure of the old and young individuals of the same species. Hence it is that we know so little of the young condition of many of the fossil sponges, which are not recognized as such, but are regarded, for the most part, as distinct species.

A circumstance which illustrates how the form of the sponge is liable to be governed by accident is mentioned by Dr. Bowerbank in speaking of their reproduction, and is so suggestive that I quote his own words: "On a fragment of a bivalve-shell 20 or 30 sponge-gemmules had located themselves, the largest of which did not exceed $\frac{1}{300}$ of an inch in diameter, and their distance apart is about equal to their diameter. In their present state," says Dr. Bowerbank, "it is evident that they are separate developments; and it is equally evident that a slightly further amount of extension would have caused them to merge into one comparatively large flat surface of sponge. We see, by this instance, that a sponge is not always developed from a single ovum or gemmule, but, on the contrary, that many ova or gemmules are often concerned in the production of one large individual; and this fact may probably account for the comparatively very few small sponges that are found."[1] Thus the form of the sponge may be modified, in some instances, by the number of gemmules or ova that may happen to be grouped together, for it is well known that sponges of the same species readily unite when in contact.

It is necessary to bear these facts in view, for in most of the higher groups of life, whether living or extinct, variation in form is restricted to within very narrow limits, and therefore it is one of the most important characters we possess in the determination of the species. Nevertheless, even in the sponges it is not without a value, for in certain fossil genera the more matured individuals appear to be tolerably constant in this respect, as for instance the *Ventriculites, Ischadites, Guettardia,* etc., but at the same time the young condition of these genera are unknown to us, or if so have been regarded probably as altogether distinct; the youngest indi-

[1] *l. c.*, p. 146.

viduals which are recognizable with certainty having already attained, comparatively speaking, considerable dimensions.

2. *The Cloaca.*—The cloaca or tubule may be either isolated or grouped. It may extend nearly the entire length of the sponge or only a part of the way, as in *Siphonia.* It is distinguished from the oscules by its larger size, the evenness of its walls and often by the orifices of the excurrent canals, or oscules, opening into it. The cloaca is essentially an ejaculatory passage, and in those fistulous sponges having oscules on the outer surface, these latter are the orifices of incurrent, not of excurrent canals, and in the living sponges are sometimes protected by a diaphragm formed of long simple slightly curved (acerate) spicula, but which would necessarily be lost in the fossil.

In the young sponge the cloaca is sometimes absent, as is often the case in the earlier period in the growth of *Siphonia pyriformis,* in which the place of the cloaca is occasionally found occupied by a group of small tubules, which ultimately either becomes converted into one large fistulous opening by the breaking down of the intervening tissue, or is surmounted by the true tubule. In its earlier condition, therefore, it presents the characters of *Jerea,* and only becomes converted into a veritable *Siphonia* as it approaches maturity.[1] On the other hand, in old fistulous sponges the margins of the cloaca sometimes break down and become fissured, and at length converted into an irregular cavity, in which it is difficult to recognize the characters of the original tubule.

3. *The Oscules.*—The oscules are the orifices of the incurrent and excurrent canals. By all authors who have written on the fossil sponges, however, they have been regarded solely in the light of ejaculatory openings, but the study of the recent species has enabled Dr. Bowerbank to ascertain that this is not the case, and that in the tubular and cyathiform sponges, those only which open into the cavities appertain to efferent canals; while those situated on the exterior lead into the canals which are destined to give passage to the incurrent streams of nutritive fluid. In all the tubular and cup-shaped sponges, therefore, their office may be inferred by their position. In the amorphous sponges they are scattered over the surface either singly or in groups, sometimes on mammillary elevations or ridges, sometimes in pits or depressions, and are probably ejaculatory orifices, imbibition taking place through the pores and interstices of the sponge skeleton. They are permanent organs, and vary greatly in size, proximity, and regularity in their distribution. Occasionally several grooves radiate from the margin of the oscule, and in other species there is no distinct orifice, but the grooves terminate internally in three or four small pores, which then supply the place of the single oscule; but even these are sometimes scarcely perceptible, as in the Silurian *Stromatopora* (*Stellispongia*) *constellata* (Hall). These stellate grooves or "*Sillons*" are not, however, physiologically distinct from the oscules; and the smaller grouped

[1] The *Jerea pyriformis* (Lamouroux) is perhaps a distinct species.

tubules, as for instance those in *Jerea* (*Polypothecia*) *dichotoma* (Benett), and *J. pyriformis* (Lamour.), etc., do not differ from oscules except in their greater length.

4. *The Pores.*—Besides the oscules, palæontological writers are in the habit of speaking of the pores. It must be understood, however, that by this term they designate not the temporary openings in the sarcode of the animal during imbibition, to which it is properly applied, but merely the interstices in the tissue of the skeleton in the dead sponge; for in the living state these interstices are more or less completely filled with the sarcode. In some sponges there are no orifices either of incurrent or excurrent canals that are distinguishable either by form, size, or position from the ordinary interstices of the sponge-tissue, the whole being formed of a nearly uniform rete; and in these cases the pores or interstices must supply the place of the larger orifices, although closed by the sarcode during the intervals of active inhalation and exhalation; moreover, in those sponges possessing well-marked incurrent orifices, it is still probable that the whole of the external surface is more or less an inhalent one, through the interspaces of the rete, according to the exigencies of the animal.

5. *The Epitheca.*—Among the fossil sponges some portion of the surface, especially externally towards the base, is frequently observed to be either without pores, or they are so minute as to be invisible, and the sponge then appears as though covered by a more or less smooth or slightly wrinkled membrane, which has been regarded by D'Orbigny, De Fromentelle, F. A. Roemer and others, as analogous to the epitheca of the *Zoantharia*; and the occurrence of this epitheca has been held to be an additional evidence of the stony nature of the sponge skeleton. When examined microscopically, by means of thin sections, however, it appears that this epitheca is due to the filling up of the interstices of the superficial parts of the sponge, which, in the situations in which it exists, is finer and more condensed than elsewhere.[1] This greater density at the surface may be seen in many recent sponges, the superficial portions of the tissues being closer and finer than that of the interior, which was formed during an earlier and more active period in the growth of the sponge. But either from having arrived at maturity, or at a period when the growth was temporarily arrested, for in some sponges the growth is intermittent, or, as appears sometimes to be the case, from some local cause, the tissue at the surface assumes a closer arrangement. Thus in the common *Halichondria panicea*, the surface over greater or lesser portions frequently presents a condensed appearance with scarcely any visible interspaces, the outer superficial portion being

[1] It is to this closer superficial portion of the tissue that M. Etallon has applied the name of périenchyma. "Dans certains cas," he observes, "lorsque le spongiaire parait avoir acquis tout son développement, le tissue devient plus fin, plus serré, recouvre toute la surface d'une couche plus ou moins épaisse et adhérente et donne au squelette un aspect différent de celui qu'il avait a l'époque de la croissance et qu'on peut toujours retrouver par des coupes ou par l'usure."—*Rayonné's du Corallien* (*Haut Jura*), p. 139; also *Sur la Classification des Spongiaires du Haut Jura*, p. 137.

made up of a densely matted layer of spicula placed for the most part parallel to the surface; and the same is true of many fibrous sponges, as shown by Dr. Bowerbank. In some of the fossil sponges a similar modification of the tissue at the surface appears to have obtained, especially in certain cup-shaped and cylindrical sponges, and in the calcareous fossils in which this has been the case, the interstices, from their extreme minuteness, are more or less filled with carbonate of lime. Thus a species of *Cupulospongia*, common in the gravel-pits of Farringdon, frequently presents on its interior a smooth surface, described by the late Daniel Sharp as a membrane.[1] But if a number of individuals of this species be examined, it will be observed that although it sometimes completely lines the interior of the cup, it more often occurs only in patches; and that, while some of the interstices are blocked up, there are others that remain open, and this not as the consequence of friction or weathering, but as the result of fossilization. It is, however, in some of the sponges of the Oolite that we see this infilling of the interstices most distinctly, in some of the cylindrical forms especially, the whole of the sponge, except its summit, appearing as though invested by a sheath, but which, were it really of the nature of a true epitheca, as in the *Zoantharia*, it would be difficult to comprehend how the functions of the animal were carried on.[2] It is more than probable that this structure is nothing more than the cast of the impression or mould of the outer surface of the sarcode of the sponge, perhaps slightly thickened, but it is not constantly present even in the same species. For example, there is a small cylindrical sponge, not unfrequent in the Coral Rag, at Bullington Green, near Oxford, in which more or less of this so-called epitheca is met with in some individuals, while the greater number show nothing of the kind. It appears, therefore, that the epitheca is sometimes only a result of

[1] Quart. Journ. Geol. Soc., vol. x., p. 196.

[2] It is not here necessary to discuss the question of a "dermal membrane," as this would of course perish with the sarcode, and about which, moreover, some difference of opinion appears to exist, the facility with which the pores open and close to admit or check the incurrent streams of water, and the readiness with which the sarcodal mass is repaired after injury, and unites on contact with that of another individual of the same species, are facts which have been held to militate against the possession of such a structure. That the supporting tissue, in certain recent species, becomes closer and is otherwise modified at the surface, is clearly ascertained (see Bowerbank. *Ecronemia acervous*, Bowerb., MSS., *l.c.*, p. 173, pl. 28, f. 355; also pp. 107, 108, pl. 20, f. 309 and 310; *Halichondria panicea*, Johnston, pl. 19, f. 303), and in some species there is a crusticular layer of embedded ovaries abounding in minute spicula (Bowerbank, *l.c.*, *Pachymatisma Johnstonia*, Bowerb., p. 172, pl. 27, f. 353; *Geodia Barretti*, Bowerb., MS., p. 169, pl. 28, f. 354) beneath the surface of the sarcode. There is likewise a sponge common on the coast at Tenby, in which, in some individuals, the base and for a little distance above it does appear, in the dried condition, to be invested by something like a membrane, which terminates upwards in a well-defined and thickened or slightly wrinkled margin; the kerato-spicular tissue of the sponge immediately beneath it is more densely reticulated than in other parts of the animal; but I was unable to satisfy myself that it constituted a true membrane as distinct from the sarcode. That this soft structure may, under favourable circumstances, so impress the mould of the fossil as to produce the appearance described as an epitheca, may be possible; but this is altogether different from the sclerotic sheath which invests the exterior in the *Zoantharia*.

fossilization, and is sometimes probably the cast of the outer surface of the sarcode which has left its impress on the mould; that it is absent in the earlier and growing stages of the sponge, and is not constantly present in the matured individuals of those species in which it occurs; and, moreover, that it sometimes results from the contact of foreign bodies, in consequence of the increased density of tissue which such bodies are apt to produce. Its value, therefore, even as a specific character, is not great.

Simple as De Fromentelle's arrangement may at first sight appear, it is open to the objection that it is based upon characters that are not always very constant or very well defined, and are liable to graduate from one into another. Moreover it unites in one genus or species individuals which, having a very close similarity in external appearance, are totally different in the organization of the skeleton, and, on the other hand, it separates others which, though differing in outward characters, are closely allied in their structural details; for, however great may be the similarity in form or disposition of the oscules, etc., the power to secrete a framework composed of spicula in one case, or entirely fibrous in another, appears to indicate a difference in the nature of the sarcodal mass of higer importance than mere outward configuration, which we know from the study of recent species is frequently subject to considerable variation, either from age, local peculiarities, or other circumstances. Thus, Dr. Bowerbank, in illustration of the amount of variation observable in the recent sponges, refers to our common British *Halichondria panicea*, which, when of small size, has the oscules "situated on the surface of the sponge, and are scarcely, if at all, elevated above the dermal surface; while in large specimens of the same species we find them collected in the inside of elongated tubular projections or common cloaca which vary from a few lines only in height and diameter to tubular projections several inches in height, with an internal diameter of half or three-quarters of an inch. When they attain such dimensions, their parieties are often of considerable thickness, and their external surface becomes an inhalent one, like the body of the sponge." [1]

IV.—About the same time that M. de Fromentelle's Memoir appeared in the Transactions of the Linnæan Society of Normandy, M. Etallon communicated to the Société Jurassienne some papers on the sponges of the Upper Jurassic rocks, in which he proposed a new arrangement of the species and genera, based on the structural details of the skeleton. As he treats only on those fossil sponges which belong to the Upper Jura, his classification is necessarily incomplete; but it is nevertheless sufficiently so to foreshadow his views on the subject generally. Like D'Orbigny, he regards the *Clionidæ* as horny sponges, and forms them into an order by themselves; while the testaceous sponges included in the *Petrospongidæ* of M. Pictet, he divides into two orders—1st, the *Dictyonocœlidæ* or spicule-bearing

[1] *l. c.*, p. 113. Here we have an example of an oscule passing into a cloaca as age advanced, and an amorphous sponge becoming a fistulous one.

sponges, and 2nd, the *Spongiaires vermiculés*, or true *Petrospongidæ.*[1]

With respect to the first of these groups, M. Etallon observes:—"There are among the testaceous sponges which do not enter into the family of *Petrospongidæ*, some that have their skeleton made up of little needle-shaped spicula, which are merely held together by the parenchyma or sarcode of the animal, and of which, in certain formations, we find the scattered remains; but in other species these needle-shaped spicula are always anastomosed so as to form little stars united together by the extremities of their rays." It is to this group that he gives the name of *Dictyonocælidæ*, and he describes these stellate spicula as being formed by the enlargement of the two extremities of a slender cylindrical spicula, which thereby become cone-shaped at the end, and unite, by the circumference of their base, with neighbouring cones, to form a six-rayed spicula with a central nœud; and, in the centre of this knot or nœud, M. Etallon believes that there exists a cubic space which is subdivided by vertical and horizontal laminæ placed in the axis of the rays into eight chambers. There results from this arrangement a frame work composed of horizontal, vertical, and radiating rods, having a knot at their point of intersection, and this eight-chambered nœud may be regarded as standing in the place of the octohedral structure of Mr. Toulmin Smith.

While agreeing with M. Etallon that there are certain sponges constructed on a general plan of intersecting horizontal, vertical, and radiating rods, a plan, indeed, which still obtains at the present day, the writer is far from admitting that this is the ordinary plan on which the spicular sponges are organized, and he has entirely failed to detect any trace of that subdivision of the cavity of the nœud into the eight cubic chambers described by M. Etallon.[2] Moreover, the manner in which it is suggested that the skeleton is made up—for as its development cannot be traced in the fossil it can be nothing more than a suggestion—is altogether opposed to what we know of the growth of spicula in general; and the study of the recent siliceous and calcareous sponges gives no countenance to the supposition that radiating spicula are formed by the union of the rays. On the contrary, as observed by Dr. Bowerbank, "However closely the spicula may be brought into contact with each other, or with siliceous fibre, they do not appear to unite or anastomose, while fibre, whether siliceous or horny, always anastomoses when it comes into contact with parts of its own body, or of those of its own species."[3] The growth of the sponge-tissue is outwards, not interstitial, and the parts once formed and fully developed undergo no further change. Judging from analogy, the development of the spiculum always

[1] The *Clionidæ* are, however, only the accidental occupants of the cavities in which they are found, having located themselves in the excavations formed by Annelida and the terebrating mollusks. For the most part they are spicular sponges.

[2] In some stellate spicula, probably in all, at the point where the central canals of the rays unite in the nœud, there is an hexagonal space, as noticed by this author, but the appearance of vertical and horizontal laminæ are referable to an optical effect of light.

[3] *l. c.*, p. 5.

proceeds from the centre, and growth takes place by additions to the thickness of the rays and at the points, and the occurrence of radiate spicula in the same individual sponge of all sizes, from the matured condition down to extreme smallness, always preserving the radiate form, is entirely against the view of M. Etallon. If union ever takes place, it is probably the result of fossilization, in cases where the points of the rays are in contact, and it is then brought about probably either by adventitious deposit, or in the replacement of the original structure the mineral which has infilled the mould has run together.

Nevertheless the labours of M. Etallon are a move in the right direction, and it appears probable from his research that by a careful investigation of the structural details of the fossil sponges, it may be possible ultimately to arrive at results which may lead to an arrangement of the species and genera more suited to the requirements of the day than the artificial systems of D'Orbigny and De Fromentelle. The time, however, is probably not yet come for this to be attempted, the more especially as the arrangement of the recent species is far from being settled.[1]

V.—Two conclusions are suggested by the foregoing remarks:—1st, that the present state of the fossil sponges affords no certain indication of their condition during life; and 2nd, that in the differentiation of the genera and species, the same principles must be kept in view in the fossil as in the recent sponge. Some of the oldest fossil sponges were as highly organized apparently (if the term is admissible to these humble forms of life) as those of the present day, as for instance the *Protospongiæ* of the Lingula Flags and Ludlow Rocks,[2] the Silurian *Ischadites*, and the Devonian *Sphærospongia tesserata*. The *Protospongiæ*, in fact, belong to that general type of cyathiform sponges, formed of elongated vertical and

[1] These "Notes" were written in the year 1866.

[2] Two undescribed species of this genus occur in the Lower Ludlow rocks of Leintwardine, for one of which I propose the name of *P. Ludense*, and for the other *P. maculæformis*. In *P. Ludense* the sponge has the figure of a horn slightly curved, and attains a height of 10 or 12 inches, and a transverse diameter (in its compressed state) of 4 or 5 inches. It consists of vertical and transverse fibres, which intersect each other obliquely at the base, but become more or less horizontal as the sponge enlarges; it is not evident, however, whether these fibres were united at the points of intersection, or simply apposed. The fibres which emanate from the base ascend to the summit, but as the sponge enlarged other fibres became intercalated, and scattered stellate (four-rayed?) spicula occur in the interspaces. In all the specimens hitherto met with the sponge is completely flattened, but its original cup-shaped figure is shown in a specimen in the Ludlow Museum, in which a thin plate of compressed sediment which filled the cavity exhibits the fibres on either side; and in the *P. fenestralis* of the Lingula Flags, the same can be ascertained by making transverse sections, when the cut ends of the rods are shown ranged in parallel rows on either side of a lamina of the matrix which occupied the cavity, reduced to a mere plate by compression. The other species, *P. maculæformis*, occurs as semi-circular or semi-oval stains on the surface of the Lower Ludlow shales, about 1½ inches in height and an inch in transverse diameter. As in the former species, it consists of extremely delicate vertical and transverse fibres, with a few stellate spicula in the interspaces. So thin is the fossil that it might readily be mistaken for mere vegetable stains, unless the fibres are especially sought for with a magnifying glass, and its cup-shaped form is inferred only from the type to which the sponge evidently belongs.

horizontal rods or fibres, which become more abundant in the Oolitic and Cretaceous rocks, and have their representatives even in the present day. The *Amorphospongidæ* first make their appearance in the Silurian rocks, and occur more or less abundantly in the calcareous marine deposits of all the succeeding epochs; and species are still living in our present seas, for which, as far as external appearances are concerned, at any rate, it is difficult to find good distinctive characters. The cup-shaped and cylindrical forms of this group commence in the Devonian and Carboniferous Limestones, and in the *Mortiera vertebralis* (De Koninck),[1] we have a depressed form of the latter, which, in the Mountain Limestone (?) of India attained greater vertical development. There are recent forms which, to all appearance, are undistinguishable either in figure or in the texture of the rete, and the only appreciable difference that can exist must be in the structure of the fibre. *Siphonia pyriformis* is apparently a still living species, well-preserved specimens from Blackdown presenting no external character to distinguish them from the recent form, nor with certainty do its structural details. The Warminster specimens are seldom well preserved; but in the flints of the Chalk thin sections sometimes show the spicular structure of the cords, of which the skeleton of this sponge is chiefly composed.

All the fossil sponges, exclusive of those masses of scattered spicula found in the Mountain Limestone Chert of the Great Orme's Head, the Lias of Glamorganshire, or the flints of the Chalk, etc., appear to be capable of being arranged in four groups having a common character—viz. 1st, those in which the skeleton is built up mainly of fibres or elongated spicula, which cross each other more or less at right angles, but which, in the cylindrical forms of this group, assume in part a radiating arrangement; 2nd, those in which it is constituted of variously formed spicula, heterogeneously arranged; 3rd, those in which the skeleton consists of a rete, the cords of which are formed of spicula; and, 4th, those formed of a rete of fibres in which spicula, if present, were only accessory, and which, judging from the general structure of the fabric, were probably keratose or horny sponges. No doubt the first two groups trench upon each other, in so far that the rectangular structure is frequently accompanied by accessory stellate and other spicula; and the last two may be often difficult to differentiate, in consequence of the structure not being sufficiently well preserved. These, however, are difficulties which the palæontologist has to contend with constantly, and which it is his object, with time and opportunities, to remove. Many a fossil conchifer has been moved from genus to genus, until the structure of its hinge was ascertained; many a mollusk is still uncertain as regards its affinities to existing genera. But on their relation to existing genera and species, which can be arrived at only by patient inquiry into structural details microscopically, by means

[1] Placed doubtfully among the *Zoantharia*, by M. Edwards and Haime, but specimens of this fossil from the Great Orme's Head, better preserved than De Koninck's types, now in the British Museum, enable the author to assign them a place among the sponges.

of thin sections or otherwise, can the differentiation of the fossil Spongiadæ be satisfactorily made. Occasionally the structure, especially in the silicified sponges, is so admirably preserved as to render this not difficult; but until their true affinities to recent species have been studied from a *strictly zoological* point of view, our knowledge concerning them must be wanting in scientific precision. The result of such inquiries will probably be to reduce many genera to the lower grade of species, and many species to mere varieties or conditions of growth. In common with other forms equally low in the scale of organization, the sponges appear to have endured through a long range of time, subject only to modifications, which scarcely amount to specific distinctions.

IV.—Further Remarks on Mr. James Geikie's Correlation of Glacial Deposits.

By S. V. Wood, Jun.

In a republication of the papers by him which appeared in successive numbers of this Magazine, Mr. James Geikie has replied to the objections which I offered to his views, and also to the views of sequence which I myself advance, by asserting that the seaward ends of glaciers never float; and that my view that "wherever the ice-sheet rested there no deposit occurred, the material produced by its action incessantly travelling outwards to the ice-edge," is a misconception.

The question whether this flotation does or does not occur is one of the things yet to be solved, and it is difficult to imagine that the continuous Antarctic ice-wall followed without soundings for hundreds of miles by Sir James Ross does not float.[1] Perhaps in thinking that it did, I too readily adopted the view of Mr. Archibald Geikie, the Director of the Scotch Survey; but the question is one wholly beside the main issue, which is—

1st. Is unstratified clay or Till deposited under the sea?

2nd. Whence does the material of such Till come unless it be a product of land-ice shed out from the sea extremity of that ice?

3rd. How, if so shed out, can it be denied that the material is constantly travelling outwards?

4th. If so travelling outwards, how can the material shed out under the sea at the commencement of a period be synchronous with the material that was under the sheet at the close of the period.

The Scotch geologists have mostly insisted on a negative to the first of these propositions; and Mr. Croll, in arguing that the unstratified clay of the Holderness cliffs—a clay identical so far as its physical structure is concerned with the Scotch Till—was due to a

[1] In supposing that, so soon as it has a tendency to float, the glacier breaks off into bergs from the rise and fall of the tide, Mr. Geikie seems to me to have overlooked the fact that in such deep water and open sea as that in which the Antarctic ice terminates, the vertical movement of the tide is altogether insignificant. It is to the Antarctic, rather than the Arctic regions, that we must turn to find the ice conditions of our Glacial period.