

I have described saccharine and finer-grained quartzites in this relation. I have now to mention that at Rodos, sixty miles from the mouth of the Orange River, strata of limestone rest in extensive masses on the mountains, I was told, horizontally; while below, only a comparatively few beds of saccharine and other varieties of crystalline limestone were interstratified with the gneiss.

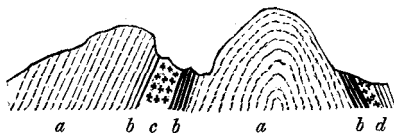


Fig. 3.—Section through Klein Poorden Poort.
(Pinchin and Rubidge.)

aa, quartzite; bbb, slate; c, porphyry (Bain);
d, porphyry.

I should hardly have thought it necessary to contest the igneous origin of marble at the present day, had I not seen in your Magazine the account of a recent experiment.

SOME ACCOUNT OF BARRETTIA, A NEW AND REMARKABLE FOSSIL SHELL FROM THE HIPPURITE LIMESTONE OF JAMAICA.

By S. P. WOODWARD, F.G.S.

The fossil represented in the accompanying figures is one of that kind whose discovery severely tests the faith of the naturalist in his previous conclusions, and may appear to raise a suspicion not only respecting the sufficiency of his data, but even as to the correctness of his method of investigation. Almost any person, at first sight of the specimen, would think he was looking at a coral, and it would seem like an attempt to impose on one's credulity to say it was a bivalve shell, like an oyster or a clam.*

Yet there is no doubt it is a kind of *Hippurite*, although the rays give it a novel and extraordinary character. The discoverer had quite satisfied himself on this point before he brought it to England and placed it in our hands. It was found last year (January, 1861), by Mr. Lucas Barrett, F.G.S., Director of the Geological Survey of the British West Indies, in the parish of Portland, in the north-east of

* This is not the only case of the sort. The genus *Goniophyllum*, one of the "*Zoantharia rugosa*," established by Milne-Edwards, is apparently identical with *Calceola*, the well-known bivalve fossil of the Eifel, placed by Lamarck with the "*Radistes*," and admitted as a Brachiopod, with a sign of doubt, by Mr. Davidson and myself. *Goniophyllum pyramidale* is a scarce fossil of the Upper Silurian at Dudley and Malvern, but not uncommon in the Baltic island of Gothland. It was described as a *Calceola* by Girard in 1842. Another species, which is so like *Calceola sandalina* that Murchison and Verneuil assumed the existence of Devonian strata in Gothland, on the strength of its occurrence, has small rootlets of attachment along the borders of its "hinge-area," and a vesicular interior, like *Cystiphyllum*. After carefully examining a series of examples belonging to M. Lindström, of Wisby, we can only say that they are probably neither Brachiopoda nor Zoantharia, although very like each in some respects.

Fig. 1.

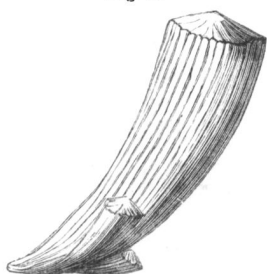


Fig. 3.

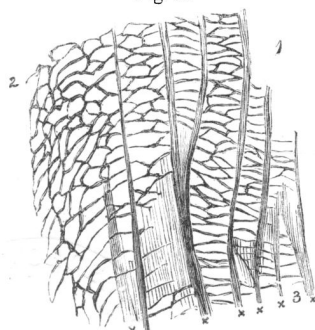


Fig. 2.

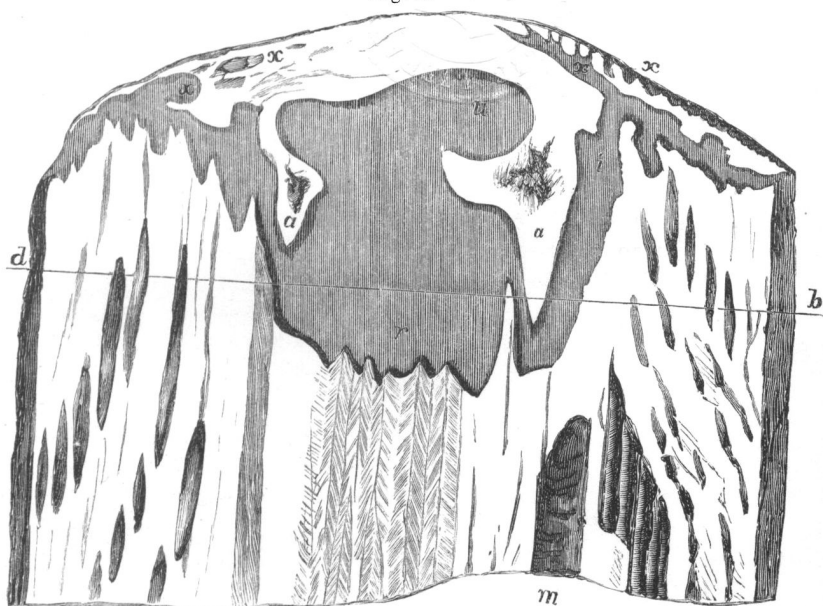
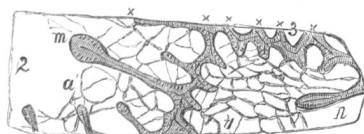


Fig. 4.

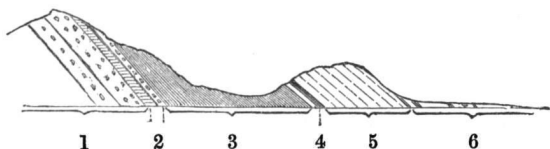


BARRETTIA MONILIFERA.

1. Reduced figure of a group of three individuals.
2. Longitudinal Section.
3. Tangential Section.
4. Transverse Section of Fig. 3.

Jamaica. This part of the island, lying to the north of the principal range of the Blue Mountains, which run east and west, is itself mountainous, rising to the height of 7000 feet. The hippurite limestone is well seen on the banks of the Back river, a tributary of the Rio Grande, at about fifteen miles from the coast. It is a hard, grey rock, occurring in bands of a few inches to a yard in thickness, subordinate to many hundreds of feet of shale which graduate upwards into other grey shales of the Eocene Tertiary, followed by white limestone of Miocene age.*

GENERAL SECTION OF THE TERTIARY AND SECONDARY STRATA, EAST JAMAICA.



1. Purple conglomerates. 2. Cretaceous limestone, with Hippurites. 3. Grey shales. 4. Orbitoidal limestone. 5. Miocene limestone. 6. Pliocene limestone and marls.

The appearance of the hippurite limestone of Jamaica is unlike that of any English cretaceous stratum. It abounds in small, oval bodies called *Orbitoides*, related to the Tertiary *Nummulites*, but mistaken by Sir Henry De la Beche for joints of the Encrinite (or *Entrochites*), and so leading him to compare this rock with the mountain limestone of England.† The other fossils of the limestone are *Radiolites*, *Inocerami*, a large *Nerinea*, and an *Actæonella* resembling *A. lævis*, D'Orb. The two last-mentioned shells are also found in the island of St. Thomas. The hippurites are plentiful, but embedded in the solid rock, and only to be procured by blasting with gunpowder. They often form groups of two or three; the smaller individuals having grown upon the sides of the larger. The example figured is five inches in diameter, and was probably eighteen inches or two feet in length. The fossil was at first broken across several inches lower down than the line of section represented (fig. 5), and when ground and polished it exhibited only a solid mass of nearly white, calcareous spar, the centre being filled up with a vesicular structure, as in the Silurian coral *Cystiphyllum*. The dark-coloured, moniliform rays, and traces of the dental apparatus agreed exactly in size, number, and position with those in the section afterwards taken at a higher level, but only halfway across, which shows a central cavity filled with dark limestone. There are 65 radii, alternately longer and shorter; the longest are from 1 inch to $1\frac{1}{2}$, and have 7 to 10 beads; the short rays have 5 or 6 beads, sometimes fewer. A third section, $3\frac{1}{2}$ inches in diameter, and only 3 inches from the conical fixed end of the fossil, presents fewer rays (about 46), and less distinctly beaded. In each section two radii are more important than the rest, and correspond with the two longitudinal ridges (*m n*) that

* Quarterly Journal of the Geol. Soc. xvi. p. 324.

† Trans. Geol. Soc., 2nd series, vol. ii. pt. ii. p. 143.

are always visible in European specimens of the hippurite, which have become hollow by the dissolution of their inner layer of shell,* (fig. 7). These ridges are formed by the folding in of the outer wall of the shell, and it is evident that the numerous rays of the Jamaica fossil are produced by a repetition of the same process. They seem intended to compensate the tenuity of the outer wall, and perhaps are the cause of its reduction. In a specimen of *Hippurites cornu-vaccinum*, of equal size, the outer layer of shell is an inch thick, whereas in the Jamaica fossil it measures only three lines, and in a transverse section (fig. 4) exhibiting the lateral union of three (probably small) individuals, the *double* boundary-wall is less than a line in thickness. In the sections represented (figs. 2, 5), the outer shell-wall has chiefly been removed by accident or destroyed by mining parasites, except where preserved by investing corals and small *Radiolites*.

The upper end of the fossil was slightly convex, retaining the opercular valve in a somewhat damaged condition. When split longitudinally through the centre, it showed the body cavity, and two shelly processes descending from the lid (as in figure 2, *a a'*). Of these the right-hand, or posterior, *apophysis* (*a'*) projects into a cavity, which is so close to the principal inflection (*m*) that part of it is shown in the same figure. The beads of the rays in the transverse section are strung together by almost invisible lines; but in this longitudinal fracture they are seen to be continuous plates, and are striated on the side by lines of growth. At the summit they must have formed a series of radiating ridges, with furrows between, bordering the interior of the valve. The bottom of the body-cavity was also more irregular than usual in shells. The upper valve is perforated by a few large radiating canals, with canaliculi conducting to the outer surface (*x x*).

After it came into my possession, a fresh section was made across that half of the cylinder which contained the dental apparatus, in order to show the exact form and position of the hinge-teeth. They are seen in the figure (5, *a a'*) filling their sockets exactly, with the exception of small defined spaces on their outer sides, which form the only trace, at this level, of the cavities occupied by the divided cartilage (*c c'*). The interval between the dental sockets (*l*) is occupied by a solid, rectangular portion of shell, representing the single dental process of the lower valve. There is no "ligamental inflection" of the outer shell, as in *H. cornu-vaccinum*, and many other species.

The existence of the ligamental plate in the typical division of the genus *Hippurites* is accompanied by such an amount of displacement of the hinge as to justify the subgeneric separation of those species

The inner layer of shells in the families *Pectinidae* and *Chamidae*, as well as the pearly lining of the *Aviculidae*, *Turbinidae*, etc., has the constitution of *Aragonite*, while the outer layer consists of *Calcite*, as stated by Gustav Rose, and confirmed by the observations of Mr. Sorby. The bi-axial character of mother-of-pearl may usually be detected with a tourmaline in any thin, translucent section, such as a counter or the edge of a pearl paper-knife.

in which the plate is wanting, and the cardinal apparatus lies close to the side of the shell instead of being at right angles to it.* We have already described and figured these peculiarities on former occasions, and it will be sufficient now to propose the name *Dorbignia* for *H. bi oculatus* and other hippurites (figs. 6, 7), which have no ligamental inflection, and a second subgeneric title, *Barrettia*, for the Jamaica fossil, which presents the further peculiarity of an indefinite number of pallial duplicatures extending all round the margin of the lower valve.

It still remains to speak of the shelly process from the upper valve (*a'*), seen in both our sections, descending into a pit between the posterior tooth (*t'*) and the principal duplicature (*m*). In the paper previously referred to we have described this process as the support of the posterior shell-muscle, having found characteristic indications of the muscular scar within the cavity which receives it. Since then, Professor Bayle, of the École des Mines at Paris, has published a description, with excellent figures, of some very complete examples of *Hippurites radiosus*. These specimens do not show any peculiarity unknown before, but they are far more perfect than the best we had ever seen, and exhibit in complete relief the extraordinary cardinal apparatus of the upper valve, of which our previous knowledge was chiefly obtained from sections. Owing to the condition of his specimens, M. Bayle has had the good fortune to procure, in a few weeks, better illustrations than we could obtain with much labour, continued at intervals for several years. Nevertheless, the very state of our materials has compelled a closer and longer examination, which we trust has not been thrown away! M. Bayle has quoted our views very fairly, and we hope he will yet see reason to adopt them. His memoir was accompanied by a critical notice from M. Deshayes containing the following passages:—

“Le travail de M. Woodward est le plus complet qui ait été publié sur l'ensemble des Rudistes. Cependant il reste bien des parties qui auraient demandé une discussion plus approfondie, des caractères qui, au point de vue zoologique, auraient pu être plus largement exposés et discutés.”

“Avec le travail de M. Woodward, on pouvait encore concevoir des doutes sur quelques parties, et notamment sur le nombre et la position des muscles. Ce naturaliste suppose l'existence d'un muscle adducteur des valves de chaque côté de la charnière, exactement comme dans les Sphérulites; ce second muscle se serait attaché dans la profondeur de l'une des cavités cardinales de la valve inférieure et au sommet de l'une des apophyses de la valve supérieure; mais les pièces préparées par M. Bayle ne laissent plus de doute à ce sujet; les deux impressions musculaires sont portées d'un même côté, par suite d'un renversement de l'animal, comparable à ce qui existe chez les Hippopes et les Tridacnes, ainsi que M. Bayle lui-même l'a parfaitement compris; tout l'appareil musculaire, se trouvant

* ‘Manual of the Mollusca,’ pt. ii. p. 279 (1854), and Quarterly Journal of the Geol. Soc., vol. xi. p. 40, 1855. (Read May 24, 1854.)

transporté sur le côté antérieur de l'animal, n'est plus en antagonisme direct avec le ligament, et nous comprenons très-bien les motifs de l'hésitation de M. Woodward à ce sujet. L'absence d'un muscle du côté postérieur de la coquille laisse à deviner l'usage des deux arêtes saillantes dans l'intérieur du même côté, et celui des oscules de la valve supérieure qui leur correspondent. J'accueillerais volontiers l'idée de M. Bayle, qui suppose aux oscules la fonction de laisser pénétrer l'eau dans la cavité du manteau, et ils correspondraient aux siphons de l'animal; c'est une vue théorique qui peut paraître plausible, mais qui n'a rien de prouvé."*

It must be regretted that M. Deshayes, whose notoriety as a conchologist was increased at the time by the circumstance of being President of the Geological Society of France, should have enunciated views which would be inexcusable in the veriest tyro in malacology. Their publication was the more surprising to me, because he had only just before examined my materials very fully and deliberately, and expressed his entire approval of my conclusions. If the author of the 'Mollusques Algériennes' would have taken the trouble to read my account of the *Tridacna*,† or, better still, if he had examined for himself one of the specimens brought home by Quoy and other celebrated voyagers, who have enriched the public museums of France, he would not have attributed to that bivalve a structure altogether incompatible with lamellibranchiate organization.

The readers of the 'Geologist' will pardon us for reminding them of such an elementary fact as that the bivalve shells like *Chama* are closed by two shell-muscles (*adductors*), one situated over or behind the mouth of the animal, the other in front of the posterior portion of the digestive canal. The whole body of the animal lies between them. The posterior adductor is developed first, and is invariably present. The anterior is usually smaller, and is wanting in the "monomyary" families, *Ostreidæ*, *Pectinidæ*, *Anomiadæ*, *Tridacnidae*, and most of the *Aviculidæ*. In *Mulleria* it is always lost by the breaking away of the front of the valves, and sometimes it is worn away in *Clavagella*. In *Pholas* the expansion and reflection of the front margin gives the anterior adductor a position which converts it into a cardinal muscle. In *Tridacna* the single shell-muscle is placed just as in the oyster; that which M. Deshayes has mistaken for a second adductor, is the *pedal* muscle, which is conspicuous in all bivalves spinning a byssus, or having a powerful foot.

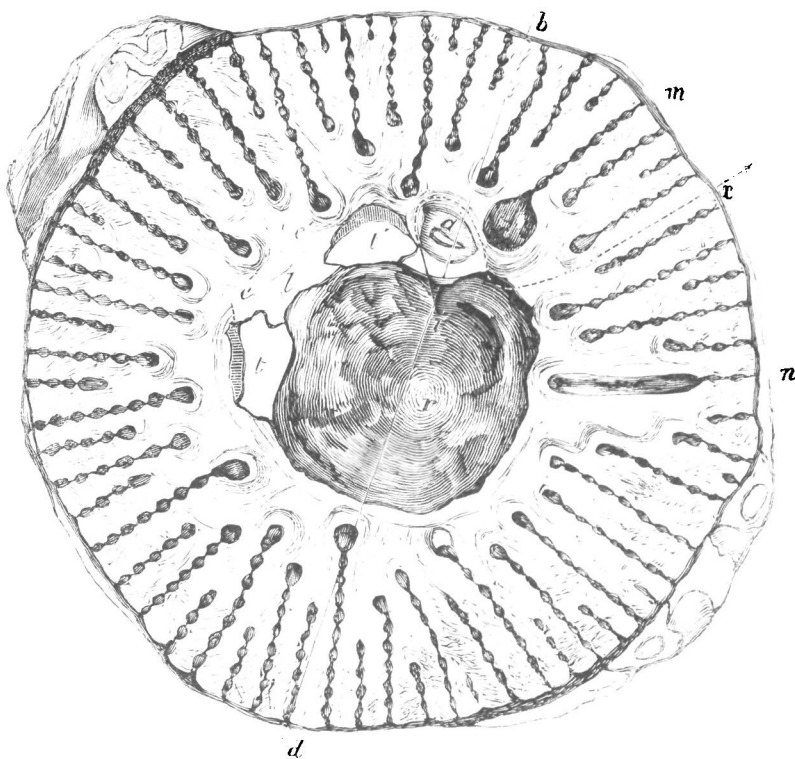
The posterior adductor of the Hippurite is situated exactly as in the Radiolite, but the supporting process projects vertically instead of expanding horizontally, and passes down into, but does not nearly fill, the deep pit between the hinge-teeth and the projecting ridge (*m*), which we have compared to the muscular plate of *Cucullæa* and other bivalves.‡ The position of this muscle is well represented by Goldfuss (at *c'*), in his small figure of the mould of *H. Lapeirousii*.

* Bull. Soc. Géol. France, séance du 21 mai 1855 (published March, 1856.)

† Ann. Nat. Hist., Feb. 1855, p. 100, and Supplement to 'Manual of Mollusca,' p. 469.

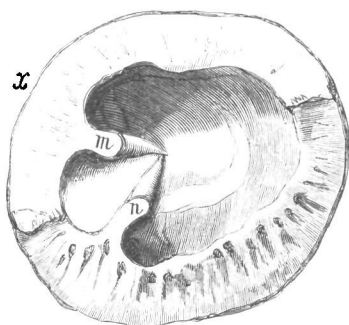
‡ Especially *Cardilia*, *Megalodon*, *Pachyrisma*, *Diceras*, and *Caprotina*.

Fig. 5.



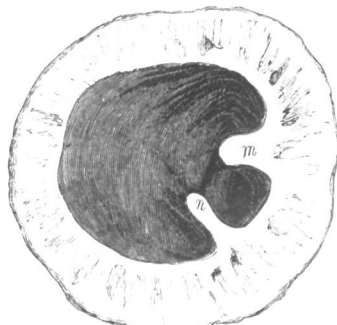
BARRETTIA MONILIFERA.
Hippurite Limestone, Jamaica.
(Reduced one-fifth.)

Fig. 6.



Upper Valve.

Fig. 7.



Lower Valve.

INTERIORS OF HIPPURITE, ANGOULEME.

(Petref. vol. ii. pl. 165, fig. 5, e). We have before pointed out that it is essential there should be space for the alimentary canal to pass between the hinge and posterior shell-muscle of a bivalve, and we have shown that such an opening is provided in the Hippurite and Radiolite by the undercutting of the muscular apophysis, which would otherwise close the whole interval (fig. 2, *i*). There is a hippurite in the British Museum which is hollow and empty, having been lined with only a thin film of spar. It is broken open at the side, and a wire has been passed round in the direction of the dotted line in fig. 5, *i x*, which is the course that must have been taken by the alimentary canal in the living animal. The nearest approximation to the hinge-structure of this genus is presented by the little *Caprotine*, found in soft yellow marls of Le Mans, in the Department of Sarthe, which may be cleared from the matrix without difficulty.

With respect to the other suggestion, that the two depressions in the lid of the Hippurite, (the *oculi* in *H. bioculatus*.) may be openings to facilitate the admission and escape of the branchial currents, it is only needful to observe that they have no existence *as orifices*, except in weathered specimens. These spots in the operculum correspond to the projecting columns in the lower valve, and fit down upon them closely. In the upper valve of *H. Loftusi*, figured in the 'Geological Journal' (pl. 3, fig. 4), portions of the columns remain adhering to the spots; and in the specimens now represented from Angoulême (figs. 6 and 7) the removal of the inner layer of shell has exposed the corresponding columns in each valve, while a portion broken from the lower valve is still attached to the upper, and shows the closeness of the contact at the place of the imaginary openings. The probable relation of the second column (*n*) to the respiratory currents of the animal was first suggested in our former descriptions.

EXPLANATION OF THE PLATES.

PLATE XX.

- Fig. 1.—*Barrettia monilifera*; group of three individuals, much reduced.
 Fig. 2.—Longitudinal section of the upper part of a large specimen, reduced one-fifth.
 Fig. 3.—Longitudinal section of a fragment, taken upon the line of union of three individuals.
 Fig. 4.—Transverse section of the same specimen.

PLATE XXI.

- Fig. 5.—Transverse section of the same specimen as Fig. 2: *b d*, line of section; *r*, body-cavity of lower valve; *u*, umbonal cavity; *l*, dental process of lower valve; *t t'*, dental process of upper valve; *a a'*, adductor processes; *c c'*, cartilage pits; *m*, muscular inflection; *n*, siphonal inflection; *i*, probable course of alimentary canal and exhalant current; *x*, canals and canaliculi of upper valve.
 Fig. 6.—Interior of upper valve of hippurite from Angoulême, with part of the wall of the lower valve adhering to it (marked *x*); the inner shell-layer wanting.
 Fig. 7.—Interior of a lower valve from the same place.