[*From the* QUARTERLY JOURNAL *of the* GEOLOGICAL SOCIETY *for May* 1881.]

On the Beds at HEADON HILL *and* COLWELL BAY *in the Isle of Wight.*

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[PLATE V.]

I. INTRODUCTION.

IN a recent communication laid before the Society* the opinion was expressed that a serious error had been made by almost all previous writers in regarding the marine beds at Colwell Bay and Headon Hill as on the same geological horizon; we read:—"We shall now demonstrate that the Colwell-Bay marine beds are not, as has been hitherto supposed, the equivalent of those of Headon Hill and Hordwell Cliff, but that they occupy a distinct and much higher horizon." Upon the correction of this supposed error a new classification and nomenclature for the Upper Eocene formation of Britain was proposed.

The author further, after a review of the palæontological evidence, arrived at the conclusion that, on the one hand, the fossils in the Headon Hill and Hordwell Cliffs were identical, while, in the second place, those of Colwell Bay, White Cliff, and Brockenhurst presented the closest agreement among themselves. Then, comparing the former two localities, taken together, with the latter three, taken together, he considered (1) that the fauna of the first group was largely estuarine, and that of the second group marine; (2) that less than half the forms found in the former occur in the latter; (3) that the fauna of the former approximated more to that of the Barton beds, having about *one third* in common with them, while not more than *one fifth* of those from the latter three localities occur at Barton; (4) that the fauna of the former two agreed with that of a series of beds on the Continent which underlay and were older than beds containing the fauna of the last three.

In the following communication the authors attempt to traverse these points in the paper above referred to, in succession. By reference to detail-sections they argue that the stratigraphical evidence is plainly demonstrative of the identity of the Colwell-Bay and Headon-Hill marine series, the beds being continuous through the cliffs and easily traceable.

Referring to the palæontological evidence, it is shown from collections, made with their own hands this year, (1) that the fauna of the Colwell-Bay and Headon-Hill beds are identical; (2) that this fauna differs considerably from that of the Brockenhurst bed, which occupies a lower horizon; (3) that the Colwell-Bay bed has less than one third of its species common to Barton beds, while the Brockenhurst fauna has nearly one half in common with Barton beds.

* "On the Oligocene Strata of the Hampshire Basin," by Prof. J. W. Judd, F.R.S., Sec. G.S., Quart. Journ. Geol. Soc. vol. xxxvi. p. 137.

We conclude therefore that no reason has been shown for upsetting the classification of the strata adopted by the Geological Survey, and which, for nearly a quarter of a century, has been received among geologists.

Certainly we wish to uphold in its integrity the work of the late E. Forbes *, and the classification of beds adopted by him when Palæontologist to the Geological Survey, and subsequently confirmed by Mr. H. W. Bristow, F.R.S., in the second Survey Memoir† on the Isle of Wight.

One of the authors, from his long residence in the district and his constant occupation with these beds, has been long satisfied that E. Forbes's account of the beds is true to nature, and his classification fully borne out by lithological identity of beds, as well as by distribution of the fossils. The present notes, then, are based on his part upon an aquaintance with the district, and the work of the Geological Survey there during its progress, supplemented by subsequent visits, and specially this summer by a joint examination by both, including measurement of beds and collection of fossils, which, however incomplete, was made bed by bed, and represents the prevailing fauna of each—a point on which we lay great stress.

We do not wish to delay over the history of previous opinion, which has been sufficiently treated in Forbes's and Prof. Judd's memoirs; but the latest criticism of Forbes's work (*op. cit.* p. 141) may be alluded to.

II. Totland and Colwell Bays.

The Survey Horizontal Section east of Headon Hill.—The first point at issue between Forbes supported by "nearly all observers," on the one hand, and Prof. Judd on the other, is whether certain marine beds known as the Middle Headon (including the "Venus-bed" of local collectors) in Colwell Bay are rightly associated with similar marine beds in Headon Hill. The Survey identify them, and correlate the freshwater beds immediately above and below as Upper and Lower Headon respectively in both localities. This succession, however, is stigmatized (*op. cit.* p. 142) as a "mistake" of which the "primary cause" is considered to be an "assumed" existence "of a great anticlinal fold of which the summit is supposed to be seen in Totland Bay. The manner in which this supposed anticlinal is regarded as having affected the strata is illustrated in Prof. E. Forbes's memoir, pl. vii. fig. 1, and also in Sheet 47 of the Horizontal Sections published by the Geological Survey. And yet further on we read (*op. cit.* p. 146), "at Totland Bay there is undoubted evidence of the presence of a slight anticlinal fold having its summit near Widdick Chine, to the westward of which the beds for a short distance have a slight dip to the south;" so that after all the only mistake the Survey could have made would have been to exaggerate the dip.

We are next told of the E. and W. flexure, which causes a slight

* On the Tertiary Fluvio-marine Formation of the Isle of Wight, by Prof. E. Forbes, F.R.S., 1856 [Memoirs of the Geological Survey of Great Britain].

† The Geology of the Isle of Wight, by H. W. Bristow [Sheet 10], 1862.

dip to the W. in Headon Hill; and it is implied that the Survey section is false, owing to the neglect of this consideration. We must point out, however, that this Section, Sheet 47, fig. 2, in which alone the anticlinal is shown, does not go through the summit of Headon Hill at all, and passes about a half mile inland at the latitude of Widdick Chine: in it the Upper Bagshot beds are made to appear a little above the sea-level at that spot; and we have great confidence that the calculations on which this is grounded are correct*; they would be brought up by the anticlinal of which the existence has just been acknowledged. So far then, we may observe, no reason has been shown why the Survey Section should not be received as correct.

Prof. Judd's Section (*op. cit.* pl. vii.).—We do not find any indications of the direction in which this section is drawn; but, from the names of chines which occur in it, we presume that it is intended to start from Alum Bay in a N.E. direction through Headon Hill, and after that to follow the coast-line; in this case it is not precisely comparable with the Survey Section, whose direction is indicated on the map as passing inland and crossing from sea to Solent. It will be seen at once why it does not correspond to nature, and agree with the views of other observers. It will be noticed that the Marine bed of the Headon Group (β of fig. 3, pl. vii.) is made to exist at the sea-level near Widdick Chine; and in the letterpress we read (*op. cit.* p. 147) "it is admitted on all hands that at the north-east angle of Headon Hill the marine band [Middle Headon beds] makes its appearence just above the sea-level." *On the contrary, we cannot imagine any one putting the bed in this position.* At the spot indicated the top of the Middle Headon is about 105 feet above the sea-level; so that the section, in our opinion, is erroneous: the dip thereby is exaggerated; and 105 feet of beds are intercalated which do not exist. We shall prove this presently by a detail-section at this point of the hill; at the present moment we wish to point out that, with the correction of this error of 105 feet, the argument against the accuracy of the Survey section entirely breaks down.

Thus, we are told that the height of the Bembridge Limestone above the sea-level at this point is 250 feet (*op. cit.* p. 147); then, the marine band being put at the sea-level, it follows that 250 feet of strata must intervene between that and the Bembridge Limestone; "but the Geological Survey [vertical] section shows less than one half of that thickness of beds, and in Colwell Bay the distance between the Bembridge Limestone and the marine band is 120 feet†. . . . . But 250 feet of strata is precisely the thickness required by my interpretation." Since we have to subtract 105 feet from

* The greater thickness of Upper Bagshot beds above the sea-level in the same line of section in the old edition of Sheet 47, and in the Plates of the Memoirs, seems due to the outline of the ground at the S. end being raised too high above Ordnance datum; probably the accurate height of the Beacon Hill was not obtainable till 1870, when the revised edition of Sheet 47 was published; otherwise the sections are practically identical.

† It would be 133 feet, according to Mr. Bristow's estimate (Forbes's Mem. p. 142), to the top of the Bembridge Limestone in Colwell Bay.

the estimate in the paper above referred to, we shall certainly have to abandon this section in favour of that of the Survey; for the thickness left, viz. 145 feet, more nearly corresponds with the thickness of the Bembridge, Upper Headon, and Osborne beds, which are stated by the Survey to exist at this spot, and whose thickness would be 144 feet *.

It would appear, therefore, that there is no necessity for supposing "that, in a distance of little more than one mile, a mass of beds 120 feet thick has expanded to 250 feet, and, further, that the beds have been entirely changed in their mineral character."

We do not understand the warning (*op. cit.* p. 146) against "trusting to the general impression which is produced by viewing these beds from a distance," nor the purport of the following statement:— "The strata of How Ledge and Warden Point are seen in such a true-scale section to be clearly continued in precisely similar beds appearing underneath the gravel of Headon Hill." The section offered to us is on rather too small a scale to show detail; but, in our opinion, the beds are inaccurately laid down in Warden Cliff, and no such bed as the Brockenhurst bed occurs at all in Headon Hill.

Before we commenced drawing our section, we traced the beds along the cliffs, measured their thickness, and obtained their height above the sea-level at various points, but found it possible only to show general results in the horizontal section; the details are embodied in the vertical sections.

Vertical Section at North-east Corner of Headon Hill (fig. 1, p. 91).—We may now proceed to a more detailed account of the beds. We will begin near the N.E. corner, where the Bembridge Limestone is seen, indicated on the section (*op. cit.* pl. vii. fig. 2) with an asterisk, and lettered 250 feet altitude. (The quarry there is not now at work; but it is the place at which one of us has obtained most of the finest specimens of *Palæotherium* which have been found in the Isle of Wight.) We take the thickness from the Survey Memoir as 25 feet.

Beneath this, in the section (fig. 3, pl. vii.), we notice a blank space with the legend "slopes covered by gravel and landslips." We think this scarcely a correct description. Landslips exist in that the clays and marls tumble and form taluses; but we saw no gravel covering the slopes between the Bembridge Limestone and Widdick Chine; nor indeed does it entirely conceal the beds between the Bembridge and Upper Headon Limestones all the way to Heatherwood Point in the other direction; at intervals tumbled gravel conceals a limited portion of them.

The gravel west of Widdick Chine is not accurately depicted: the thickness is exaggerated, while its horizontal extent is overestimated here †. It does not appear in the cliff certainly beyond 80 yards

* Taking the Bembridge Limestone at 25 feet, the Upper Headon and Osborne at 119 feet, as read off their vertical section by scale, after altering their lower boundary a few feet to correspond with our own.

† Mr. Bristow (Forbes's Mem. p. 105) gives the entire horizontal extension of the Lacustrine beds (Post-Tertiary) on both sides of the chine as 350 yards; the section under review makes the gravel extend about 720 yards.

from the chine on the west side (private grounds interfere with examination nearer the chine).

We should say, from our examination of the ground which intervenes between the escarpment of the thick Upper Headon Limestone and the Bembridge, that there is no difficulty in seeing what beds exist there. It is true they are sufficiently interrupted by local taluses to cause trouble in making a continuous measurement; but the tumbled portions are partial and affect only a few feet of beds at a time, so that by moving the observer's position laterally it is possible to see all the beds in turn. This we claim to have done; we do not pretend that our measurement of the beds is any thing but rough, though controlled by repetition, because we had no levelling-instruments with us, and in shifting horizontally from one spot to another there might be frequently a slight error in picking up the next bed to be measured. We might describe the beds immediately below the Bembridge Limestone, in descending order, as follows:—yellowish and ochry marls, red and grey mottled marls, marly clays with nodular bands, greenish-grey clays, pale greyish clays, grey and ochry clays, stiff pale or whitish clays with calcareous lenticular bands, red and green mottled marls, "cherry marl" with calcareous bands. These are the *Osborne beds* of the Survey; and they come in the precise position assigned to them in the Survey Memoirs. They are well characterized by the "cherry marl"—the mottled red and pale greenish marl which distinguishes the group from the Upper Headon; and we consider the subdivision a very useful one in the classification of beds. Their thickness here, by our comparatively rough way of measurement, is 70 feet. The vertical section of the Survey Sheet 25 gives 71 feet, reading off by scale down to the bed which we have taken as our boundary; their measurement seems to have been taken near Heatherwood Point, where this series contains a thick limestone of 18 feet; as noticed by previous observers, this limestone thins out to the east, and is only represented by nodular calcareous bands at the east end of the hill; its loss will probably be compensated by an increase in the clays. Our results are perhaps sufficiently near to those of the Survey to prove that the same series of beds has been examined in both cases. We should remark that from the lower red beds it is perfectly easy to draw a continuous vertical section to the beds below; and from here our measurements to the Lower Headon are uninterrupted in a vertical line. The Osborne beds yield few interesting fossils; *Limnæa* is abundant in the calcareous bands; but, as noticed by Forbes (Mem. p. 81), the shell-substance is not preserved. These beds are identical lithologically with the mottled red and pale green series at Cliff End.

The beds next below the red series are grey and ochry clays, very rich in *Potamomya gregaria* and *Paludina lenta* beautifully preserved: we place these in the Upper Headon; they are about 15 feet thick *.

* In the Survey Section no. 5, at Headon Hill (sheet 25, Vert. Sect.), these clays are included in the Osborne series; but in the Vert. Section. no. 4, at Colwell Bay, the boundary is so drawn that analogous clays are put into the Upper Headon.

This brings us to the vertical escarpment of the thick limestones, so conspicuous a band along Headon Hill cliffs that it is indicated on the Ordnance maps, both on the 25-inch and the 6-inch. We pause awhile to draw attention to the fact that we have accounted for about 110 feet of beds from the top of the Bembridge to the top of the great limestone (Upper Headon); and the Brockenhurst series does not exist here. *There is not a single marine fossil to be found in that interval; nor is there any bed with the faintest resemblance either lithologically or palæontologically to the Colwell-Bay* Venus-*bed.* This is in opposition to the view (*l. c.* p. 176 *et passim*) that the Colwell-Bay series exists here "entirely concealed" by some supposed gravel talus*; yet it is upon the existence of such a second marine series, thus supposed to be added above the Venus-bed that the presence of a Brockenhurst series at the west end of the island is inferred.

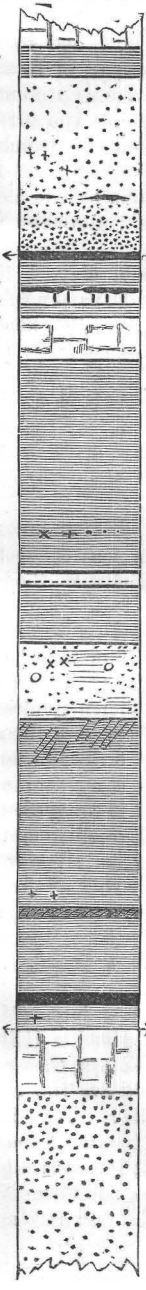
Next we turn to consider the thick limestone of the escarpment, the Limnæa-limestone of the Upper Headon. It is in several beds, of which details are given by the Survey; we measured it by suspending a tape, and found it 27 feet (fig. 1, p. 91).

The only difficulty in correlating the Headon-Hill beds with those of Colwell Bay is centred in this limestone: it might be a difficulty to those who would have expected *a priori* that the limestone would have maintained its thickness in direction of dip for a mile or two to the north; for we identify it with a limestone at Cliff End not above 1 foot 8 inches thick. It would be equally a difficulty according to the correlation which identifies it with the How-Ledge limestone (*op. cit.* p. 144); in this case the 27 feet has thinned to 3 feet at How Ledge, a distance of $1\frac{1}{6}$ mile in a straight line, while in Warden Cliff (only 926 yards distant from the Headon-Hill bed) it is about 5 feet; so that it must have thinned very rapidly at the first stage. The limestone in the Upper Headon at Cliff End, with which we identify it, is distant 1 mile 926 yards. In either case it thins out considerably to the north, as noticed by E. Forbes (Mem. p. 84). We shall be able to prove that it does not occupy the same position as the How-Ledge bed; for we have recognized that bed, which forms the summit of the Lower Headon, at a lower position in Headon Hill and in its natural position, viz. below the marine series (Middle Headon), as in Warden Cliff, where it was last seen. As a palæontological distinction between the Upper Headon limestone of Headon Hill and Cliff End † and the Lower Headon limestone

* With respect to the "inextricable difficulties and confusion" (*l. c.* p. 144) in which the Survey is supposed to be involved by their not allowing the Colwell Marine bed to come where the Osborne beds are placed, and which is supposed to be shown by 48 feet of strata being classified in the letterpress (Forbes's Mem. p. 81) as Osborne, while in the plate they are classed as Upper Headon, this is merely a question of classification and the drawing of a boundary-line, matters entirely subjective and not affecting the total thickness; their vertical section shows almost the same thickness of beds consistently, notwithstanding certain irregularities in the boundaries and classification.

† In the legend to the Survey Vertical Section, sheet 25, no. 4, this limestone in the Upper Headon is said to form How Ledge; this is plainly an oversight or clerical error, as is also the statement in Forbes's Memoir, p. 132, that the How-Ledge bed is faulted in Warden Cliff. The fourteen faults mentioned affect the Upper Headon limestone at Cliff End: their section is fairly correct; but there seems to have been some confusion between Warden Point and Cliff-End Point in the letterpress.

Fig. 1.—*Vertical Section of Beds at the North-east corner of Headon Hill.*
(Scale, 8 feet to the inch.)



BEMBRIDGE LIMESTONE ..... 25 feet.
OSBORNE BEDS..... 70 „
UPPER HEADON ..... 49 „ (total).

UPPER HEADON.

ft. in.
1 0 — Part of thick *Limnæa*-limestone. *Limnæa fusiformis*, &c.

Laminated greenish clay, with broken *Paludina*.

6½–8 0 — Whity-brown to buff sands, with layers of lignitic matter.

Greyer sands below. *Potamomya, Melania muricata, Unio, Paludina lenta.*

0 3 — Lignite.

9 in.–2 ft. — Greyish-green clays. *C. ventricosum*-bed with ..... } *Vicarya concava, Marginella vittata, Neritina concava, Melania muricata*, &c.

6 in. — ···*Limnæa*-limestone, soft and crumbling, with a thin lignite at top.

6 in. — ···Verdigris-green clay, with rootlets.

ft. in.
1 10 — *Limnæa*-limestone.

MIDDLE HEADON.

Stiff green clays with conchoidal fracture in drying.

Oyster-bed towards the base.

9 2 — Clay becoming greyer below. Fossils ..... { *Fusus labiatus, Mel. fasciata, M. muricata, Nerita aperta, Cer. variabile, C. pseudocinctum, Ostrea velata, Mytilus affinis, Corbicula obovata, Lucina colvellensis.*

3 0 — Alternating grey and ochry clays.

3 0 — "*Venus*-bed," richest portion, contains scattered flints, brown sandy clay becoming green clay and sand below. Fossils..... { *Cyth. incrassata, Mactra fastigiata, Mya angustata, Corbicula obovata, Nucula lissa, N. headonensis, Trig. deltoidea, Fusus labiatus, Cancell. elongata, Melanopsis fusiformis, Voluta spinosa, Vic. concava, Natica Studeri.*

Thin grey sandy clays, weathering brown.

8 0 — *Cytherea incrassata* &c. scattered throughout.

Mya angustata, especially near base.

2 6 — Chocolate-brown or blackish sands. { *Trig. deltoidea, Cer. pseudocinctum, Natica labellata, Melan. fusiformis.*

Trigonocælia-bed.

0 6 — Blackish-brown sands, *Neritina*-bed: *N. concava, M. fusiformis, C. obovata.*

1–1 3 — Very stiff tenacious clay.

LOWER HEADON.

2½–4 6 — *Limnæa*-limestone, "How-Ledge limestone:" *L. longiscata, fusiformis*, &c.

8 6 seen. — Whity-brown or yellow sands and sand-rock, with layers of *Paludina* and *Potamomya*.

[The base concealed by tumble and undercliff.]

of How Ledge, we may adduce that the former is very rich in *Planorbis*, while in the latter these shells are comparatively rare, the fossils being chiefly *Limnæa*.

As the Upper Headon limestone is the strongest bed in the section and forms an escarpment through the greater part of Headon Hill, in it we may obtain a datum line. We take as a point of reference the spot where the top of the escarpment cuts the surface of the ground or outline of the cliff; this is seen on the 6-inch or 25-inch map to be about halfway between the 100 feet and 200 feet contour-lines. From these points of known altitude, by the aid of the barometer, we obtain the height of our point of reference: it is about 140 feet above Ordnance datum.

The beds below the Limnæa-limestone are green clay, 1 foot, with broken *Paludina*, then pale buff or whitish sands, varying from 6½ to 8 feet, with occasional layers of lignitic matter, *Potamomya*, and *Melania muricata*; below, where it is sometimes grey, *Unio Solandri* and *Paludina lenta* may occur. We take this bed with the 3-inch lignite below as the base of the Upper Headon. The boundary chosen is, of course, arbitrary; but the fact of the next bed being decidedly brackish inclines us to draw the division from the Middle Headon here; the Survey vertical section, sheet 25, places it a few feet lower.

Our estimate for the Upper Headon at Headon Hill amounts to a thickness of 50 feet; the thickness on the Survey vertical section is given as 37 feet; but if we read off the distance between the beds which we have taken as boundaries, it becomes 48 feet. The combined thickness of Osborne and Upper Headon beds, according to the Survey section, is 119 feet, *i. e.* adopting the top of the *C. ventricosum* bed as the boundary; our estimate, taken at the north-east end of the hill, is 120 feet. The agreement is sufficiently close to render it probable that a thickness above the average of the calcareous portion is accompanied at the same spot by a diminution in the clays; so that the balance of average thickness is maintained at both ends of the hill. As we have said, we think it convenient to retain the name "Osborne Series" for the red and greenish mottled clays and marls and pale greenish-white limestones, since these physical characters distinguish them at once along this side of the Solent. We must decline to accept the statement (*op. cit.* p. 169) that "under this name beds lying below the Brockenhurst series, as at Headon Hill, have been confounded with others on a totally different horizon, above the Brockenhurst series."

We next come to the *Middle Headon*. E. Forbes relates (Mem. p. 85) that the uppermost and lower portions at Headon Hill are brackish-water beds abounding in *Cerithium ventricosum*, *C. pseudocinctum*, *C. concavum*, *Neritina concava*, and *Nematuræ*, the conditions being less purely marine than at Colwell Bay. This is, no doubt, true of the series as a whole; for below the *C. ventricosum* bed there are two freshwater Limnæa-limestones. But it appears to us that too much has been made of this; for instance, the lower Neritina-bed is identical in Headon Hill with the similar bed at Warden

Cliff, and again in Colwell Bay, both physically and as to its fossils; when we come to the portion of the series richest in *Cytherea incrassata* known as the "Venus-bed" proper, we find identically the same fossils as in Colwell Bay; we cannot detect any difference, so far as our researches go.

The uppermost bed is dark greenish clay, varying from 9 inches to 2 feet in thickness. When at its thickest the sands above are proportionally thinner. It is extraordinarily rich in fossils for the depth of one foot, chiefly *Neritina concava*, *Cerithium* (*Vicarya*) *concavum*, *C. ventricosum*, *Corbicula obovata*, *Marginella vittata*, *Melania muricata*, *Melanopsis fusiformis*. We may call it the *C. ventricosum* bed; for this fossil seems almost confined to this horizon, while the *Vicarya concava* is found here all through the Middle Headon, though especially plentiful in this bed; its underside is occupied by an impure lignite band, with freshwater shells (*Limnæa* and *Planorbis*), and rootlets, lying on a thin crumbly buff Limnæa-limestone. Both together are 4 to 6 inches. Below is verdigris-green clay, 6 inches; next a buff freshwater limestone with *Limnæa*, 1 foot 8 inches to 2 feet, the shells frequently blackish in colour. These beds betoken certainly a recurrence of freshwater conditions after the brackish bed above. Next follow truly marine beds—first stiff green and grey clay, about 9 feet, with a conchoidal fracture when dry. The abundance of oysters, *O. velata* (Wood), is the chief fossil feature; these and the other fossils occur mostly towards the base. Such fossils are *Fusus* (*Pisania*) *labiatus*, *Nerita aperta*, *Melania fasciata*, *M. muricata*, *Cerithium variabile*, *C. pseudocinctum*, *Mytilus affinis*, *Corbicula obovata*.

The fossils cited are merely the most common, such as may be found in a few minutes' search; but these being the most characteristic, seem to us precisely those required for the identification and correlation of beds.

Comparing the beds noticed so far with those at Colwell Bay, we observe practically identity of fossils; this last, which we may call the oyster-bed, is identical with the oyster-bed of Colwell Bay; in both localities *C. ventricosum* occurs above this bed, and there only, so far as we know.

Next below follow alternations of grey and ochry silts, 3 feet, in which we observed no fossils. Below are 11 feet of beds, brown sandy clay above becoming green clayey sands below, and then grey sandy clays: this is the "Venus-bed" of *collectors*; *Cytherea incrassata* occurs near the top and is scattered throughout the whole bed, but is most abundant for the space of one foot. The fossils obtained from the Venus-bed in a few minutes' search were *Cytherea incrassata*, *Mya angustata*, *Mactra fastigiata*, *Psammobia rudis*, *P. æstuarina* (Ed. MS.), *Nucula headonensis*, *N. nudata*, *Trigonocœlia deltoidea*, *Corbicula obovata*, *Vicarya concava*, *Ancillaria buccinoides*, *Fusus labiatus*, *Cancellaria elongata*, *Natica Studeri*, *N. labellata*, *Voluta spinosa*, *Melanopsis fusiformis*, *Nematura parvula*, *Limnæa longiscata*, *Planorbis obtusus*, crab-claw (*Callianassa*), coprolite.

Towards the base *Mya angustata* and *Corbicula obovata* were particularly abundant.

Next below the *Venus*-bed is the *Trigonocœlia*-bed, chocolate-brown sands, 3½ feet, with sometimes a blackish tint; we so call the bed from the principal fossil which occurs at precisely the same horizon in Warden Cliff and Colwell Bay; other fossils are *Cerithium pseudocinctum*, *Melanopsis fusiformis*, *Natica labellata*. Below are blackish-brown sands, 6 inches; at base is enough carbonaceous matter almost to amount to a lignite band; this may be called the *Neritina*-bed, the chief fossils are *Neritina concava*, *Melanopsis fusiformis*, *Corbicula obovata*, the latter in perfect condition, very large, and showing concentric colour-bands. The *Neritina*-bed occurs in the same position towards the base of the series in Warden Cliff and Colwell Bay. This can only be explained by admitting that the marine series in Totland Bay and Colwell Bay are identical; the *Ventricosum* bed at the top, and the *Neritina* and *Trigonocœlia* beds at the base, identical in physical and fossil characters, are strong presumptive proof of this.

Below is very stiff dark-grey clay, 1 foot to 1 foot 3 inches; fossils occur in patches, *Neritina concava*, *Cerithium pseudocinctum*, *Melania muricata*, *Limnæa*, *Corbicula obovata*. This is the lowest bed of the Middle Headon here. Summing up, we obtain a thickness of from 31 feet 9 inches to 33 feet for the Middle Headon of Headon Hill at the N.E. end. Reading off the Survey vertical section by scale, we obtain 35 feet for it between the boundaries adopted by us * for the thickness towards the west end.

The height of the base of the Middle Headon above the sea at this point, viz. about 120 yards in horizontal distance west of our reference-point, is by subtraction 72 feet. Direct barometric observations gave about 70 feet. We have already used these figures when alluding to the position assigned to this series.

The first bed of the *Lower Headon* is a Limnæa-limestone of the usual buff colour: it is 2 feet thick at this point; but a little further west we obtained a measure of 4 feet. This is in our opinion the well-known bed which forms *the top of the Lower Headon* in *Warden Cliff*, where it is quite a marked feature. It has there and in Colwell Bay precisely the same position in the series, supporting the Middle Headon—recognized by the *Neritina*-bed with all its characteristic features, the *Trigonocœlia*-bed, and so on. From Warden Cliff it is traceable uninterruptedly to How Ledge, where it disappears beneath the sea-level; we therefore speak of it as the "How-Ledge limestone." It is correctly drawn on the Survey vertical sections, sheet 25, nos. 4 and 5, where in the legend is a clerical error, to which we have already alluded. This bed is so distinctly lacustrine,

* Some irregularity in the boundaries of the Survey vertical section is to be noticed: viz. in the Headon-Hill Section, no. 5, the boundary is placed below the How-Ledge Limestone; in the Colwell-Bay section, no. 4, the boundary is placed at one bed above the How-Ledge Limestone; this seems an error of the engraver, and of course does not affect the thickness of the beds.

being almost made up of *Limnæa* shells and their débris, that it seems most convenient to include it in the Lower freshwater group; and it makes an especially good boundary.

The beds which follow next below the Limnæa-limestone at this spot are whity-brown or yellowish sands, and sand rock with *Paludina* and *Potamomya* in layers; $8\frac{1}{2}$ feet are seen; this is all that is exposed of the Lower Headon here. At this spot all the ground below is tumble or undercliff; and for a more complete section of the Lower Headon in the present state of the cliffs we shall do best to take the one exposed in Warden Cliff and under Totland Bay Hotel, where the fresh road-cuttings to the New Pier have been of service to us.

We consider that we have already sufficiently proved the identity of this lower limestone in Headon Hill with the How-Ledge bed of Warden Cliff; but if any objection be raised that its relations to certain specified bands in the (Middle Headon) Marine series being found identical in both localities is not conclusive—even though it has been shown that no other marine bed exists in Headon Hill—we have further means at our command. There are, however, only two beds in Headon Hill with which the How-Ledge bed could be continuous: viz. either it is the same as the thick Upper Headon limestone (which we consider impossible, as the beds both above and below would then just be reversed, viz. freshwater above and marine below, instead of *vice versâ*), or it must be identical with the one to which we assign it. It is possible, however, to settle the point by ocular demonstration *. Though the How-Ledge limestone is denuded from the top of the curve between Weston and Widdick Chines, some of the lower beds are traceable the whole way. Accordingly we can join on the section in Headon Hill to that in Warden Cliff. We account thus for a continuous section of beds from the lowest seen beds of the Lower Headon, through the Middle and Upper Headon of Colwell Bay, to the Bembridge Limestone on the north, and again from the same base of the Lower Headon, through the succeeding Lower Headon beds in the cliffs between Weston and Widdick Chines, to the sand below the How-Ledge limestone at the N.E. corner of Headon Hill, and thence up to the Bembridge limestone on the south; and we find that the section is identical in both cases. There is only one Marine (Middle Headon) series, lying between two freshwater series, the Lower and Upper Headon.

Of course, all this has been done before by the Geological Survey, and our work is nothing but a confirmation of results already sufficiently established by E. Forbes and Mr. Bristow.

On our horizontal section of the coast we have endeavoured to represent the position of the beds in the cliffs and the extent to which

* We are indebted to the Rev. O. Fisher, F.G.S., who specially visited Totland Bay this autumn, for the information that the Venus-bed is found in the Totland-Bay brickyard some little way above and behind the top of the cliff between the chines. He points out that since this is the only part where it is missing from the cliff, it is the link needed to prove that the bed is continuous all through.

they are traceable; but though the vertical scale is more than twice the horizontal, it is not possible to show the details; for these we must refer to the vertical sections.

Lower Headon Beds of the cliffs between Weston and Widdick Chines.—We left off with the Potamomya-sands, $8\frac{1}{2}$ feet below the How-Ledge limestone; these are easily traceable through the grass-slopes, exposures of a few feet occurring at intervals all the way to Widdick Chine, about 230 yards distant. There good sections are seen on each side of the roadway; here the sands have in the upper part more clay mixed with them, as in Warden Cliff. Whiter sands are below; above are alternating whity-brown sands with bluish silts. *Melania turritissima* occurs in the latter, a shell which occurs, indeed, in the Bembridge Marls at Hamstead, but which, in this district, we only know at one horizon, viz. the *Unio Solandri* bed, and one above that, at Warden Cliff and Colwell Bay; we remark its analogous position at Widdick Chine. Below the sands, again, is pale greenish clay, 3 inches; in descending order, soft buff Limnæa-limestone, 1 foot; brownish sands with *Potamomya* and reptile dermal ossifications: these occupy the position of the Crocodile-beds in the Lower Headon at Hordwell; they continue along the cliff as we walk northwards. Below is a carbonaceous band or impure lignite, 6 inches, then a repetition of clays with carbonaceous layers, followed by another Limnæa-limestone, 10 inches, Potamomya-clays, 4 feet, another Limnæa-limestone, 1 foot, greenish clays with *Paludina lenta*, *Potamomya plana*, *Melanopsis brevis*, *Limnæa* &c.; another Limnæa-limestone, 8 inches, full of *Gyrogonites*, below that clay with carbonaceous layers passing to drab sands, about 2 feet; then a lignite layer and impure Limnæa-limestone, soft and crumbling at the outcrop. The limestone full of *Gyrogonites* is noteworthy, as it occurs only low down in the Lower Headon, and serves to mark our position in the series at this spot. Now this Chara-limestone is exposed again at the back of the Reading Rooms, where there are the same five limestones seen as near Widdick Chine, the Chara-bed being the lowest but one; this is well seen behind the Reading Rooms, where there has been a cutting through the Lower Headon beds for a new pathway. It will be noticed that we have passed five thin Limnæa-limestones in the lower part of the Lower Headon in the cliffs immediately north of Widdick Chine, and again behind the Reading Rooms; we see them again as they rise from beneath the sea-level beyond the new pier under Warden Cliff; they are seen also in the recent scarping under Totland Bay Hotel. The continuity, then, of the section from the five lower limestones under Warden Cliff through Weston Chine to Widdick Chine is undoubted; and from there we continue through the sands above to the How-Ledge limestone in Headon Hill. The beds in the cliff here belong entirely to the Lower Headon *.

* The top of the cliff at the back of the Reading Rooms has a capping of about 7 feet of Post-tertiary sand; at the base of this is a layer of flints and derived marine fossils, *Cytherea incrassata*, *Ostrea velata*, &c., showing that the marine Middle Headon series existed here above this level. This Post-tertiary sand lies on the (Lower Headon) Warden sands.

Lower Headon of Warden Cliff.—The lowest beds seen are below the Totland Bay Hotel at Weston Chine. We therefore start from here in making a measure of the Lower Headon series, meeting higher beds as we go north towards Warden Point. The details of this measurement are given in the vertical section, fig. 2 (p. 98); we need here allude to only a few of the beds. The lowest bed seen in Totland Bay is a few yards south of the Coast-guard boathouse; here are visible, in ascending order, whity-brown sands, 1½ foot, a hard purple sandy ironstone, 6 inches, greenish clay, 4 feet.

In our vertical section, fig. 2, we have drawn an interruption in these clays, because we are not absolutely sure that they are identical with the similar clay in the road-cutting at the pier-head on the other side of the boathouse; there is little doubt of it, however. At the pier-head are seen 3 feet of clay in the road-cutting (after our section was drawn, on a later visit, a drain-opening showed 4¼ feet); and from this point the section is continuous without interruption. There is therefore only a possibility of error of a few feet.

Five thin Limnæa-limestones will be noticed. The two lowest contain *Chara*-seeds at the pier-head; on following them to their outcrop along the shore it is found that the fourth of them also has *Chara*-seeds at that point; the fifth, 1 foot 3 inches thick, is 50 feet below the top of the How-Ledge limestone, or top of the Lower Headon.

From the top of the cliffs these limestones may be seen at low water, forming five submarine ledges parallel to the great ledge at Warden Point; they strike N. 36° W.

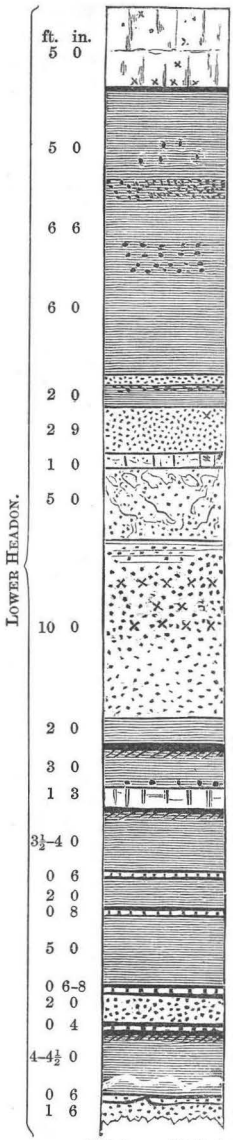
As there is great uniformity in these freshwater beds, and their fossils mostly occur in the Upper Headon also, we pass over many beds to notice the sand-rock bed, which is a conspicuous feature in Warden Cliff. This sandstone, somewhat calcareous at places and friable at others, forms Warden Ledge, and runs out at the top of the cliff close below the flagstaff of the coast-guard station.

About 11 feet above that comes the *Unio Solandri* bed* with *Melania turritissima*, a bed of which we have already noted a portion in the cliff at Widdick Chine; the *M. turritissima* occurs through a greater thickness of the 11½ feet of clays than does the *Unio*. Next comes the How-Ledge limestone, 5 feet, in two beds containing *Limnæa fusiformis*, with a carbonaceous or lignitic band at the base. The shells are more crowded at the base; and the lower surface of the blocks fallen from the cliff is a sight pleasing to the collector of fossils. The dip of this bed in Warden Cliff, calculated from its horizontal extension on the 25-inch map, between its position at How Ledge at sea-level and a point of known elevation near the flagstaff, is a slope of about 1 in 45. This How-Ledge bed crops out at the top of the cliff, a little north of the coast-guard flagstaff; it is

* The Unio-bed with *Melania turritissima* occupies an analogous position at Hordwell Cliff, being at about the same distance below the Lymnæa-limestone (which is a diminutive representative of the How-Ledge bed), where it has precisely the same lithological characters with the same abundance of black seeds (*Carpolithes*) as at Colwell Bay and Warden Cliff; it crops out again with the same fossils on the shore immediately south of Milford.

Fig. 2.—*Vertical Section of Lower-Headon (freshwater) Beds exposed between Weston Chine and Warden Cliff.*

(Scale, 12 feet to the inch.)



ft.	in.	
		Limnæa-limestone, in two beds, buff colour.
5	0	How-Ledge bed; extends from How Ledge to Coast-guard Station.—*L. fusiformis.*
		Lignitic or carbonaceous band.
		Pale grey clays, rather mottled. *Paludina* at intervals.
5	0	
		Alternating greenish and greyer clays, rather sandy below, but more so above. *Melania turritissima* and other fossils in layers at intervals.
6	6	
		Unio-bed.
		Laminated grey sandy clay, with *Unio Solandri*, *Mel. turritissima*.
6	0	Stiff clays, grey or brown in places,
		Sandy grey clay, more sandy above, with *Paludina lenta*, *Melanopsis brevis*, *Potamomya plana*, *Unio Solandri*.
2	0	
2	9	Pale whity-brown crumbling sand-rock, with strings of clay. } *Cyrena deperdita.*
1	0	Ferruginous sand-rock, variable in thickness, with *Limnæa*, &c.
5	0	Concretionary calcareous sand-rock, forms Warden Ledge. } *Limnæa*, *Potamomya*.
10	0	White and whity-brown sands, *Potamomya* in layers at intervals.
2	0	Stiff grey or sandy clay, with *Potamomya* crowded together.
		Lignitic band.
3	0	Greenish clay. *Potamomya gregaria.*
1	3	Buff-coloured limestone, with *Limnæa*.
		Lignitic or carbonaceous band.
3½–4	0	Greenish-grey clays.
0	6	Soft crumbling buff limestone, with *Limnæa longiscata*.
2	0	Grey marly clay.
0	8	Buff limestones, with *Limnæa*.
5	0	Greenish clay.
0	6–8	Buff compact limestone, with *Chara*-seeds (*Gyrogonites*) *Chara*-[bed.
2	0	Whity-brown sand-rock, with lignitic band below.
0	4	...Buff limestone, with a few *Chara*-seeds.
		···Carbonaceous layers.
4–4½	0	Green clay (behind wall at Pier-head).
0	6	...Green clay, a little south of Coast-guard boathouse.
1	6	···Nodular purple-red ironstone band.
		Pale yellowish or whity-brown sands.

LOWER HEADON.

Total..... 70–71 feet.

denuded away in the centre of Totland Bay. It cannot, however, have been many feet above the present cliffs near Widdick Chine, while a little south of that it exists in the cliff. At the N.E. corner of Headon Hill we noted it at a height of 70 feet above the sea; it is well seen also in the cliffs near Heatherwood Point, where it has a somewhat higher elevation.

There is evidence of an anticlinal in Totland Bay, as indicated in E. Forbes's sketchy diagram; the summit of the anticlinal we infer to be near the old wooden pier.

If we add up, we obtain a thickness for the Lower Headon exposed in Warden Cliff of 71½ feet (supposing no interruption at the point specified above). It remains to settle the relation of the lowest bed here seen to the Upper Bagshot Sands.

The junction of the Lower Headon with the Upper Bagshot is well seen north of Alum-Bay Chine; immediately above the Upper Bagshot sands come greenish-grey clays; then, in ascending order, alternation of clays and sands; next, pale greenish-grey sands; then a stiff marly clay: total 16 feet. Above is a purplish red clay-ironstone band; and succeeding that is the first thin Limnæa-limestone.

If we consider this red iron-band to be at the same horizon as that noticed under Weston Chine, as is extremely probable (though it is some 4 feet nearer to the lowest Limnæa-limestone), then we must add 12 or 16 feet to the 71 feet obtained for the Lower Headon in Warden Cliff, making a total of 83 or 87 feet before we reach the yellowish sand of the Upper Bagshot.

Knowing now the full thickness of the Lower Headon, we are able to test the argument as to the position of the Upper Bagshot, or Headon sands, as they were once called by E. Forbes (Mem. p. 34–6), in Totland Bay. It is stated (*op. cit.* p. 147) that the Survey actually represent these as occurring, in both the Vertical and Horizontal Sections, near the summit of the anticlinal in Totland Bay*.

There seems a little inconsistency in the Survey Vertical Sections concerning both boundaries of the Lower Headon; if we may classify these green clays in the Lower Headon, and then read off by scale from the top of the How-Ledge bed, the Survey Section would give a thickness of 85 ft. for the Lower Headon in Totland Bay.

It is urged "that the Headon-Hill sands do not occur in the position indicated by the Geological Survey;" and the crucial test of

* We pointed out above that the Survey Vertical Section [edition 1870] shows them only just above the sea-level at a point some way inland. The Vertical Section we are inclined to interpret in this way—that the beds denoted Upper Bagshot in Totland Bay are what we have classed in the Lower Headon; for the legend states, below the "clay-ironstone" are 6 inches sand in "Totland Bay," then "green clay with lenticular patches of sand" 15 feet, so that the description agrees fairly with our lowest beds at Heatherwood Point. The Survey Section does not state that these were exposed in the *centre* of Totland Bay; but as Heatherwood Point is the western point of the bay, we may assume that they may have been seen anywhere short of that point along the base of Headon Hill, where it is quite certain that they exist, and must have been open at that time at more points than one; for the white glass-house sands were then being actively worked in Headon Hill, and the yellower sands above them may still be seen about a mile from the N.E. corner of Headon Hill.

the excavations at the new Reading Rooms is supposed to prove "that beds are [there] found which have their exact counterpart in the Headon-Hill section, not at the base, but at a much higher part of the series." We can readily understand that the Upper Bagshot sands were not found in the excavation; we could even have predicted the fact beforehand; from a rough calculation, we estimate that the sands are above a dozen feet below the foundation. In favour of this view, we may add that, when the old wooden pier was being made, one of us heard from those engaged in the work, that the piles were driven with difficulty because of their piercing solid sand *.

But putting aside the question as to their exact depth here below the Reading Rooms, we are able to refute the notion that any thing higher than Lower Headon beds exist here. As mentioned above, we recognized immediately behind the Reading Rooms the five Lymnæa-limestones which come below the Potamomya-sand, both at Widdick Chine on the south, and Weston Chine on the north, between which places the sands may be traced almost continuously. The whole of the cliffs between Weston and Widdick Chines are occupied solely and throughout by Lower Headon beds (neglecting the cap of Post-tertiaries). All this part of the section (*op. cit.* pl. vii. f. 2) is inaccurate, in consequence of the Middle Headon being placed too low in Headon Hill.

Middle Headon of Warden Cliff.—Again, we cannot agree with that part of the section between Weston Chine and Warden Point. Here no marine bed is indicated; for in fig. 3, the section drawn to true scale, the Colwell bed is made to die out before the Warden battery is reached, which is occupied by an exaggerated thickness of gravel †.

There is no fact more patent to any observer than that the Colwell-Bay marine bed extends all through Warden Point and Cliff, where it is supported by the How-Ledge limestone. We made a measure in detail of the Colwell marine bed (Middle Headon) at a point about midway between Warden Battery and Weston Chine; it is here 34½ feet thick; we noticed there the Neritina-bed ‡ with its characteristic features and fossils below the Venus-bed as at Colwell Bay and Headon Hill. It would be wearisome to give all the details; but the Colwell bed here is easily recognizable as identical with the Middle Headon of Headon Hill, both physically and palæontologically. At Warden Battery, above the Middle Headon, comes some Upper Headon § besides the Post-tertiary cap.

In the section drawn to true scale (pl. vii. fig. 3) the Colwell-Bay marine bed has its horizontal extension curtailed by almost one

* The iron columns of the new pier are stated to pierce a bluish clay; we should interpret this to indicate the clays immediately above the Upper Bagshot Sands, and which are described as greenish in the Survey section.

† We cannot reconcile this with fig. 2 of the same plate, where the marine bed is more nearly correctly drawn.

‡ Previously noted as bed 16 by Dr. Wright, Proc. Cotsw. Club, i. p. 95, and Ann. & Mag. Nat. Hist. s. 2, vol. vii.

§ Described by Dr. Wright in 1850 as bed 5, Proc. Cotsw. Club, i. p. 90.

half; the result is that the dip is considerably exaggerated. Again, in Headon Hill an exaggeration of dip is produced by the error of 105 ft. in plotting the marine beds. The effect is that the identical bed (Middle Headon) is split into two beds separated by 120 ft. of beds. From our point of view this could only be done by counting more than 100 ft. of beds twice over. In the legend attached to the diagram section fig. 2, "new interpretation," the beds *g* are, in our opinion, the Lower Headon; *f* is the Middle Headon; *e* the Upper Headon; *d* and *c* are the Lower Headon; *b* is the Middle Headon again. According to the old view, which we certainly should prefer, this last 105 ft. has no existence in fact*.

Lower Headon of Colwell Bay.—The section in Colwell Bay is continuous with that of Warden Cliff; but in the bay, as we go north, a few lithological changes occur in the marine beds †, as noticed below, and which cause the marine beds at one part of Colwell Bay to differ far more from the same beds at the centre of the bay than the latter do from the marine beds of Headon Hill. On rounding Warden Point, beyond the sea-wall, is a small rifle-target; and from here the beds are fairly well exposed throughout the bay, though tumbled portions or a diminutive undercliff may conceal some of the beds in places, sufficiently to give considerable trouble in measuring the beds.

The Unio-Solandri bed with *Melania turritissima* has been frequently worked by one of us below the How-Ledge limestone here but this summer we could only find tumbled portions of it. The said limestone rises from beneath the sea-level at How Ledge ‡, whence its appellation, and crosses Colwell Chine; here and at the target it has the same lignitic band and clays beneath it as on the south side of Warden Cliff; it thins down to 3 ft. north of the chine. We mention these upper beds of the Lower Headon to show that the Colwell-Bay marine bed, as at Warden Cliff, reposes on the same succession of beds as in Headon Hill.

Middle Headon of Colwell Bay.—The lowest or Neritina-bed at the S.W. end of the bay, by the target, is now covered by tumbled matter, but is well seen a little further on about 50 yards short of Colwell Chine. Here, *i. e.* between the target and the chine in the

* The diagram in Forbes's posthumous work is so schematic that it omits the higher part of Headon Hill, and, perhaps for clearness sake, the effect of the anticlinal is exaggerated. It is rather severe to treat it as if it were drawn to scale, and, because the Upper Bagshot Sands were brought up too much in the centre of the roll, to say that E. Forbes was "mistaken in his interpretation" (*op. cit.* p. 176) of the beds. Forbes's diagram, in fact, with this qualification, represents the beds in their right position; thus the Lower Headon, no. 6, occupies the summit of the cliffs in the centre of Totland Bay, while no. 7, Middle Headon, is denuded from above it—all which is perfectly correct.

† Since Warden Battery has been built it is forbidden to search for fossils on the slopes at Warden Point. Many years ago one of the authors was in the habit of frequently exploiting the beds here for fossils, and many of them are incidentally described by Dr. Wright, Proc. Cotsw. Club, i. pp. 91, 92 (1850). The engineers, however, have not succeeded in grassing all the slopes, and fallen fossils may still be picked up at the base.

‡ Bed 18 of Dr. Wright, who describes it correctly in Warden Cliff, but appears to have mistaken its position in Headon Hill (*ib.* p. 95).

Marine series above the Neritina-bed, is some foxy-coloured sand-rock, while lenticular layers of white sand are seen thinning out in the grey clays, which also contain red-clay ironstone nodules, a different lithological condition from what occurs further north in the bay, or to the south of Warden Point. Above comes the richest part of the Venus-bed with abundant *Cytherea incrassata*; these fossils not only strew the tumbled clays, but with other fossils are commingled by the waves with recent shells on the strand. At this point of the bay *Ostrea velata* is very abundant above the part richest in *Cytherea*.

In the centre of the bay between Colwell and Bramble Chines this oyster is in extraordinary abundance; at one place it nearly crowds out most of the other fossils, and forms a massive oyster-bank about 21 ft. thick *, of which the lower 12 ft. is almost made up of these shells. The ordinary character of the Venus-bed is quite altered here, though its fossils occur mixed up with the oysters; we may notice as especially abundant *Murex sexdentatus, Pisania labiata, Natica labellata, Nerita aperta, Cerithium variabile, Ostrea velata, Nucula headonensis, Cytherea incrassata*, &c. On either side of this spot, near both How Ledge and Bramble Chine, the excess of oysters has disappeared, and they are chiefly abundant in a zone above the richest part of the Venus-bed, though they do occur sparingly throughout. *Cytherea incrassata* occurs through several feet, but the richest part of the Venus-bed consists of about 9 inches of bluish-green sand; in this the shells are found in the best state of preservation. Above the grey and greenish-grey sandy clays richest in marine forms are some pale bluish-green clayey sands, between Bramble and Linstone (or Lynchen) Chines; in these, at the level of about 5 feet from the base, is a band very rich in *Cerithium ventricosum, C. variabile, Melania muricata, Corbicula obovata*, with, occasionally, *Nerita*; this bed is seen just beyond the spring at Linstone Chine, it is only a few feet below the base of the Upper Headon. We wish to draw attention to the first-named fossil, as it occurs also near the top of the marine beds at Headon Hill, *i. e.* in quite an analogous position.

Upper Headon of Colwell Bay.—The slate-coloured grey clay with *Potamomya* † (immediately succeeding the bluish-green sands) we take as the base of the Upper Headon. A detail vertical section is given (fig. 3), in order to show the lithological differences existing between the series here and equivalent beds in Headon Hill. We do not, however, think them greater than the differences already noticed as occurring in the marine series in different parts of Colwell Bay, while the resemblances are sufficiently great to allow of their perfect correlation—not to mention their position between the Osborne beds above (so identical with the Osborne beds of Headon Hill) and the marine series below, which we have shown, on stratigraphical grounds, is most certainly identical with the Middle Headon of Headon Hill. The differences consist here in a greater development of sand and a reduction of limestone: the sands at the base

* Bed 12 of Dr. Wright (*ib.* p. 92), who, however, much underrates its thickness.
† Base of bed no. 5 of Dr. Wright (*ib.* p. 91).

Fig. 3.—*Vertical Section of Upper Headon Beds in Colwell Bay.*
(Scale, 8 feet to 1 inch.)

ft.	in.	
		Light-grey clays, with layers of shells. { *Paludina lenta, Potamomya gregaria,* &c.
15	0	Pale brownish-grey and light-brown clays in alternations.
0	6-9	Nodular band of ferruginous sand-rock. { *Corbicula obovata, Cyrena Wrightii.*
2	4	Whitish sand above, yellow and rusty sand below. { *Cyrena Wrightii, Paludina lenta, Corbicula obovata, Melanopsis fusiformis.*
1	4	Buff-coloured *Limnæa*-limestone, with carbonaceous layer below.
1	6	Pale greenish-grey clays.
		Zone of *Cerithium trizonatum.*
		Pale greenish clay.
4	0	Ferruginous sand layer.
		Paler sandy clays.
1	0	Stiff slate-coloured grey clay. { *Cyrena Wrightii, Corbicula obovata, Melanopsis fusiformis, Paludina lenta.*
5	6	Varying alternations of paler and darker grey clays.
		Pale buff-coloured sands, with lignitic or carbonaceous bands.
15	0	Greyer sands below. *Potamomya.*

UPPER HEADON.

Total..... 46½ feet.

are considerably thicker here than at Headon Hill; their character is very variable even in different parts of Colwell Bay. The Limnæa-limestone has here a much reduced thickness, as mentioned previously.

Among the other beds we may specially notice the horizon of *Cyrena Wrightii*; it occurs in the nodular ferruginous sand-rock with *Corbicula obovata*, also in the sand immediately above the Limnæa-limestone, and again in some of the clays below. Another fossil that we have only observed at one horizon is the *Cerithium trizonatum* (Morr.); it occurs in the pale greenish clays beneath the limestone, occupying only a narrow band in these clays. Equally characteristic is *Serpula tenuis* (Sow.), which occurs at the same horizon both here and at Headon Hill, viz. in the Upper Potamomya-clay just above the limestone.

The Paludina-clays at the top are identical with those of Headon Hill at the top of the thick limestones. Measurement by tape here gave 15 feet; total of the Upper Headon near Cliff End 46½ feet.

Osborne Beds of Cliff End.—The red and greenish mottled marls of the Osborne series follow. These beds show for a few yards only, and then become hidden under the grass which the engineers have grown on the artificial slopes below the battery. One of us well remembers the numerous little faults (14 are enumerated by the Survey, as cited above) which repeated the Limnæa-limestone. Beyond the battery the Osborne beds form the tumbled cliff; a measurement is no longer to be made with profit. Mr. Bristow gives 62 feet for the series here.

III. Palæontological Evidence.

The question now arises, Does the distribution of fossils bear out the separation of the Colwell-Bay and Headon-Hill marine beds and their reference to different horizons? and does it sanction the notion of the Brockenhurst bed being equivalent to the Colwell-Bay bed?

Two lists of fossils are laid before us, viz. one which mixes up the fossils from the Brockenhurst, Whitecliff Bay, and Colwell-Bay localities, and the other which gives those from the marine beds of Headon Hill and Hordwell Cliff; of the hundred forms (in round numbers) which occur in the latter list, it is said (*op. cit.* p. 150) "less than one half occur at the other three places."

We may urge at the commencement that it comes rather near to begging the question to mix up Colwell-Bay with Brockenhurst-series localities. We conceive one of the main points in dispute to be whether the Colwell-Bay bed has any more affinities with the Brockenhurst fauna than has the Headon-Hill bed; and to this subject we shall address ourselves after we have first compared the fauna of the Colwell-Bay and Headon-Hill marine beds.

The first thing to be done is to separate the faunas of all the localities which are to be compared together; this we have done in

the lists at the end of this communication. These have been drawn up from an inspection of the Edwards collection of Tertiary fossils in the British Museum †, while we have added many occurrences from our researches this summer, and we believe our list to be fairly correct.

We do not admit that the Edwards collection is sufficient for a full knowledge of the distribution of English Tertiary fossils: *e.g.* if a certain shell does not exist in the Edwards collection from Colwell Bay, it is no proof that it does not occur there, but simply that Mr. Edwards had better specimens of it from Headon Hill, which was considered, as, indeed, it is, an equivalent bed. The greater part of the Edwards collection was made by the hands of one of the authors; but we do not think it possible to establish from this collection that Colwell Bay contains so many marine forms which do not occur in Headon Hill, and therefore that the marine beds at these localities are not on the same horizon.

The following reasons induce us to say this:—It was the habit of the local collectors to exploit the Colwell-Bay bed far more than the Headon-Hill locality, because it was more accessible and showed a larger extent exposed; the fossils were better preserved, and in every respect it was easier to collect from. Again, some species which one of us supplied to Mr. Edwards from Headon Hill were not incorporated in this collection, probably owing to his having better ones from Colwell Bay; and doubtless they were exchanged with foreign correspondents or given away. These two considerations would serve to account for his Colwell-Bay collection being richer than his Headon-Hill one. Corroborative of this is the fact that in a few days' search this summer we have found several species in the marine bed at Headon Hill which do not exist in the Edwards collection from that locality.

Moreover we hold that the best test as to the contemporaneity of these beds is not to be obtained from the rarer forms, which may be evidenced only by a single example, but from a comparison of the commoner, which we should consider the more characteristic forms. Accordingly we add a list of the species obtained by us this summer from the Middle Headon of both localities: H indicates Headon Hill; C the equivalent bed at Colwell Bay.

List of all the Shells obtained *on the ground* by the authors for the purposes of this paper (Aug. 1880).

(Those with an asterisk pass up from Barton beds.)

*Lamna contortidens (*Ag.*) ... C, H.	*Borsonia sulcata (*Rou.*)..... C.
Marginella vittata (*Edw.*)..... H.	*Rimella rimosa (*Sol.*) ..... C, H.
*Voluta spinosa (*Lam.*) ..... C, H.	Murex sexdentatus (*Sow.*)..... C, H.
Pleurotoma headonensis (*Edw.*). C, H.	—— sp. ..... H.
*—— denticula (*Bast.*), var. odontella (*Ed.*) ..... C, H.	Pisania labiata (*Sow.*) ..... C, H.
	*Cominella flexuosa (*Ed. MS.*) C, H.

† We are greatly indebted to the Keeper of the Geological Department, Dr. H. Woodward, F.R.S., for his courtesy in allowing us access to the collection, even during the laborious process of packing up and moving the national collection to the new building at South Kensington.

List of Shells (*continued*).

*Ancillaria buccinoides (*Lam.*) C, H.
*Natica Studeri (*Bronn*)..... C, H.
*—— labellata (*Lam.*) ..... C, H.
Cancellaria muricata (*Wood*) C, H.
—— elongata (*Nyst*)..... C, H.
Odostomia gracilis (*Ed. MS.*) C.
Scalaria tessellata (*Ed. MS.*)... C.
*Cerithium variabile (*Desh.*) ... C, H.
*—— pseudocinctum (*d'Orb.*) C, H.
—— duplex (*Sow.*) ..... H.
—— ventricosum (*Sow.*) ..... C, H.
—— varians (*Ed. MS.*) ..... C, H.
—— (Vicarya) concavum (*Sow.*) ..... C, H.
Melania fasciata (*Sow.*)..... C, H.
—— muricata (*Sow.*) ..... C, H.
Hydrobia bulimoides (*Ed. MS.*) C, H.
Melanopsis subfusiformis (*Morr.*) ..... C, H.
—— fusiformis (*Sow.*) ..... C, H.
Actæon dactylinus (*Ed. MS.*). C.
Nematura parvula (*Desh.*) ... C, H.
Nerita aperta (*Sow.*) ..... C, H.
—— zonula (*Wood*) ..... C, H.
Neritina concava (*Sow.*) ..... C, H.
Bulla æstuarina (*Ed. MS.*) ... C, H.
Limnæa longiscata (*Sow.*)..... C, H.
Planorbis euomphalus (*Sow.*) C, H.
—— obtusus (*Sow.*) ..... C, H.
Paludina lenta (*Sow.*) ..... C, H.
Ostrea velata (*Wood*) ..... C, H.
*Mytilus affinis (*Sow.*) ..... C, H.
*Trigonocœlia deltoidea (*Lam.*). C, H.
Leda propinqua (*Wood*) ..... C, H.
Nucula headonensis (*Forbes*) C, H.
—— nudata (*Wood*)..... C, H.
Lucina (Strigilla) colvellensis (*Ed. MS.*)..... C, H.
Cytherea suborbicularis (*Ed. MS.*)..... C, H.
*—— incrassata (*Sow.*) ..... C, H.
Tellina headonensis (*Ed. MS.*) C, H.
[*]Psammobia compressa (*Sow.*), var. æstuarina (*Ed. MS.*)... C, H.
—— rudis (*Lam.*) .... C, H.
Mactra fastigiata (*Ed. MS.*)... C, H.
*Mya angustata (*Sow.*)=producta (*Ed. MS.*) ..... C, H.
*Corbula cuspidata (*Sow.*) ..... C, H.
Corbicula obovata (*Sow.*) ..... C, H.
Cyrena cycladiformis (*Desh.*). C, H.
*Balanus unguiformis (*Sow.*). C, H.
Callianassa Baylii (*Woodw.*). C, H.

Faunas of Middle Headon from Colwell Bay and Headon Hill compared.

The above list contains only the commoner forms, such as may be found in a few days' search. Out of a total of 58 species it will be observed that all but 7 were found by us in both localities *, and all but three are known to be common, or, again, a proportion of 94 per cent. of commoner Colwell-Bay forms occur at Headon Hill †. Surely from this we may presume a very close affinity if not identity of these beds. It is stated (*op. cit.* p. 150) that less than one half of the Headon-Hill and Hordwell species occur at Colwell Bay—a result, it seems to us, only obtained by mixing up fossils from Brockenhurst and Whitecliff Bay in the same list with the Colwell forms. We shall show below that the fossils cited from these two latter localities belong to a lower zone.

Next as to the statement that at Colwell Bay "the strata are of purely marine origin" while "the so-called Middle Marine beds of Headon Hill and Hordwell Cliff are of totally different character"

* Some of these do not exist from both localities in the Edwards collection, and have not found their way into the Headon-Hill and Hordwell list in the paper referred to, though previously cited by Dr. Wright from Hordwell (*ib.* p. 124).

† Comparing the whole known fauna from the Middle Headon of Colwell Bay and Headon Hill, we obtain the following result, viz. 74 per cent. of the Colwell-Bay marine forms have been found at Headon Hill. This is counting as separate species many names in the Edwards collection which are founded on imperfect and single specimens. As we have said, we think a surer guide in comparing faunas is to take only the characteristic and less rare species.

&c. (*l. c.* p. 148). Of the brackish-water genera which are supposed to be found in Headon Hill only, we may remark that we found *Cerithium*, *Cyrena*, *Hydrobia*, *Limnæa*, *Paludina*, *Planorbis*, *Melania*, and *Melanopsis* fully as plentiful in the marine series of Colwell Bay as at Headon Hill; *e. g.* in a quarter of an hour we turned out half a dozen specimens of *Limnæa longiscata* * from the richest nine inches of the Venus-bed, the best zone for *Voluta*, *Cancellaria*, *Murex*, *Cytherea*, &c. It has always been the opinion of one of us, who has worked these beds for so long, that these freshwater forms were either drifted down by flood-waters or were dead shells washed out of lacustrine or brackish deposits. They cannot have lived in the waters depositing the marine bed at Headon Hill any more than at Colwell Bay.

Another argument brought forward in opposition to the views of the Geological Survey is, that certain species of *Cerithium* are confined to Headon Hill and do not occur in Colwell Bay; and by this means have been "detected the serious errors which have crept into our classification and correlation of the strata we are now considering" (*op. cit.* p. 149). *Cerithium ventricosum* and *C. concavum* are said to be entirely confined to the Headon Hill and Hordwell localities. We cannot agree with the statement as to the distribution of *C. ventricosum* in the Headon-Hill beds and its "prodigious abundance." It is there, as far as we have observed, found only in one bed; moreover, it is equally abundant in a bed in a precisely similar position at Colwell Bay, viz. at the top of the Middle Headon. Its analogous position in these two localities we consider as fossil evidence confirmatory of the stratigraphical.

Nor do our observations confirm the statement of "prodigious abundance" of *C.* (*Vicarya*) *concavum* at Hordwell Cliff in the Middle Headon. One of the authors who worked that bed when a special excavation was made for the purpose †, considers that *V. concava* was extremely rare in the Hordwell bed; but, as is well known, it occurs abundantly in the Upper Bagshot sands further west at Long Mead End.

As to the supposed absence of *V. concava* from Colwell Bay, we remark that we had not been many minutes at work on the richest portion of the Venus-bed before we found a specimen, subsequently followed by a dozen more. It can scarcely be maintained, therefore, that the Colwell-Bay bed does not belong to the *C.-concavum* zone. This species is here, however, not so common as at Headon Hill ‡.

* Also noticed by Mr. Bristow, F.R.S. (Mem. 10*, p. 61), as well as by previous writers.

† The Middle marine or Middle Headon bed at Rook Cliff, Hordwell, has not been exposed for the last twenty-eight years; it is covered up by a great thickness of gravel, and its precise position is known but to few geologists. It was quite a thin bed, but rich in fossils, especially minute forms. Fossils in existing collections were all obtained about a quarter of a century ago.

‡ This species exists, however, in the Edwards collection, labelled as from Colwell Bay. The absence of a shell in the Edwards collection from Colwell Bay is no proof that it did not occur there; the local dealers might not have thought of picking up *V. concava* at Colwell Bay. For this species they went to Headon Hill, where it was more abundantly found and in better preserva-

Summary.—There is but one marine bed here, namely that in the Middle Headon; for the Colwell-Bay bed *can be traced stratigraphically* into the Headon-Hill Venus-bed, and the palæontological evidence is in harmony with the stratigraphical. The place of the Brockenhurst bed is at a lower horizon in the Middle Headon; but it does not appear anywhere in the west end of the island.

IV. Whitecliff Bay and New Forest.

Middle Headon of Whitecliff Bay.—We next have to raise a more serious objection to the way in which the Whitecliff Bay section has been interpreted. In mixing up all the beds in the marine series there together and calling them Brockenhurst series, it seems to us that the question has been obscured, if not begged. The statement is that the 100 feet of marine beds at Whitecliff Bay are the equivalents of the 25-feet of marine beds at Colwell Bay and of the beds in the New Forest with the Brockenhurst fauna (*op. cit.* p. 148). Hence the Colwell-Bay bed is placed in the Brockenhurst series, which is said to occupy a higher horizon than the Headon-Hill and Hordwell marine bed; and this view is indicated by dotted lines in the vertical sections on p. 170. Since the 100 feet of marine beds are classed together and called "Brockenhurst Series," we suppose that the Brockenhurst fauna is imagined to occur throughout them. As a matter of fact, that fauna is confined to one zone, and that the very base of the series.

Though we have worked over this part of the section bed by bed, we need not here give all the details, but will refer to the description of it on the Survey Vertical Section on Sheet 25. This series is there justly referred to the Middle Headon, since it lies between the freshwater Lower and Upper Headon, its total thickness read off by scale being 90 feet. At the top are clayey sands and yellow sands about 19 feet; then the "Venus-bed" clays &c., 15 feet; next, below, are compact sands with nodules about 42 feet, said to contain *Sanguinolaria Hollowaysii**; then come 14 feet of brown clays, the base "greenish and brownish clay, very fossiliferous." Now there is no doubt at all about the bed above and the Venus-bed here being any thing but the Colwell-Bay and Headon-Hill marine bed—its position and its fossils prove that; the characteristic Brockenhurst fossils are absent from it, and it is therefore certain that it differs entirely from the Brockenhurst beds.

The Sanguinolaria-sand differs lithogically from the lower part of the marine series, both at Colwell Bay and at Headon Hill. Such few fossils as we observed in it are distinctive, not of the Venus-

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tion. Moreover these collectors sought to obtain as many forms as possible, but were not concerned in finding the same species in both localities; and if they found only a few stray examples at one locality of a species of which they had a great number from the other, they were liable not to put a separate label for the odd few, but to mix them up with the larger parcel.

* A wrong determination; the shell is *Psammobia compressa*, var. *æstuarina*, Ed. MS. It occurs in the natural position of life, *i. e.* across the bedding.

bed, but of Brockenhurst beds; but though we have not sufficiently worked out this fauna, we may say that we are satisfied that they belong to a lower zone than any of the marine beds at Colwell Bay or Headon Hill, the Middle Headon being more fully developed at Whitecliff Bay than elsewhere.

Brockenhurst Zone at Whitecliff Bay.—The succeeding 14 feet are the equivalents of the Brockenhurst beds; the lowest two feet we shall call the Brockenhurst zone; the remainder of the thickness is not nearly so rich in species, and their grouping, as well as the lithological character, is more like that of the Roydon beds.

At the time the Survey section was made, the interesting bed at Brockenhurst had not been discovered nor its fauna described; hence such Brockenhurst fossils as were found in this zone here were not rightly determined (thus in the Survey section we must read *Cardita deltoidea*, Sow., for *C. acuticosta*), or specific names were withheld from them. Subsequent observers* have recognized the Brockenhurst fauna in this lowest bed. As we have obtained more fossils from it than previous observers, we have embodied our results in a separate column in the lists at the end of this essay; that column contains nothing except what we have collected with our own hands this summer from the lowest two feet †, lying on an eroded surface of the freshwater Lower Headon. Comparison of this list with the fauna from Brockenhurst itself will convince most, we think, of the perfect equivalence of the zone in the island and in the forest, while its position at Whitecliff Bay shows that it is at the base of the Middle Headon.

Brockenhurst Zone in the New Forest.—The greater part of the fossils from Brockenhurst were collected by the hands of one of the authors, and thence were dispersed into various public and private collections. They were obtained during the doubling of the line and widening of the cutting at Whitley Ridge, near Brockenhurst ‡, about twenty-three years ago. During this work he had the advantage of seeing more of the beds than any other geologist. He found the rich Brockenhurst zone (which varied from a few inches to nearly a foot) lying immediately upon the freshwater Lower Headon; while about half a mile up the line, near the bridge by Lady-Cross Lodge, the Middle Headon Venus-bed was seen, followed by the freshwater Upper Headon beds above, the beds having a very gentle dip up the line or easterly§. It is evident that the succession

* *Videlicet* Von Könen, Quart. Journ. Geol. Soc. vol. xx. p. 98; Rev. O. Fisher, Quart. Journ. Geol. Soc. vol. xviii. p. 67, footnote; Mr. T. Codrington, Quart. Journ. Geol. Soc. vol. xxiv. p. 519; Dr. Duncan, Pal. Soc., 'Fossil Corals,' i. p. 40 (1865).

† In the Edwards collection the label "Whitecliff Bay" includes many Venus-bed forms, indeed Lower and Upper Headon, or it may be any thing from the London Clay to the Bembridge Marls; there is therefore good reason for not allowing this collection to stand as evidence of what is found in the Brockenhurst zone at Whitecliff Bay.

‡ The railway-cutting at Brockenhurst (*op. cit.* p. 152) refers to the same spot as Whitley Ridge.

§ We visited the New-Forest localities together this summer, and found the Whitley-Ridge cutting entirely grassed over (the rich zone was below the level

here is, in ascending order, freshwater Lower Headon, Brockenhurst zone, Venus-bed, then freshwater Upper Headon, which agrees with the succession in Whitecliff Bay. Yet in the New-Forest section (*op. cit.* p. 170) we find the Brockenhurst bed placed above the marine band or Middle Headon of Totland Bay—in other words, the natural succession is inverted.

Again, in Headon Hill as we have seen, an imaginary Brockenhurst bed (of which the Colwell-Bay Middle Headon is stated to be the equivalent) is placed above the Upper Headon, in ground which is really occupied by the Osborne beds. If the Brockenhurst bed is at a higher horizon than the Middle Headon of Headon Hill, then where is the marine Middle Headon at Whitecliff Bay?

We can scarcely adopt a theory which makes the Colwell-Bay bed occupy a higher horizon than that of Headon Hill, because it is supposed to contain more Brockenhurst fossils, when the latter fauna is found below the zone with (Colwell-Bay or) marine Headon fossils both at Whitecliff Bay and near Brockenhurst. When once the position of the Brockenhurst fauna is recognized (and it has been correctly described by previous observers), the inconsistency of the theory is apparent.

Affinities of the Brockenhurst Fauna.—Seeing that the Brockenhurst fauna, if different in age from the Marine Headon, is older, instead of being younger, it would be rather anomalous to find that "while nearly *one third* of the Hordwell and Headon-Hill marine shells are Barton forms, not more than *one fifth* of those occurring at Brockenhurst, Colwell Bay, and Whitecliff are found at Barton." We have already mentioned one feature in the lists on which this statement is based by which the question is almost begged. We must next allude to what seem to us clerical errors, in order to justify the very different statistics which we have obtained by inspection of the Edwards collection, supplemented by our own researches.

In the Headon-Hill list we observe nine species * that are said to pass down into Barton beds, while in the Brockenhurst list this range is denied to them; and besides these nine, the range into Barton, as proved by the Edwards collection, is omitted in the Brockenhurst list in the case of twenty-two other species. Discrepancies of this sort must seriously detract from the value of any statistics based on such lists.

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of the rails, and will never be seen again here); the upper beds were yellowish clayey sands, poor in fossils. Sufficient characteristic Brockenhurst fossils may still be seen, however, on the old spoil-banks of the date of the making of the original single line, about forty-two years ago. By Lady-Cross Bridge the cutting is also grassed over; but evidence can still be found of the Venus-bed in the side drains and of the Upper Headon in the slopes above it.

* These species are—*Borsonia sulcata, Nematura parvula, Mytilus strigillatus, Cardium obliquum, Trigonocœlia deltoidea, Lucina obesa, L. concava, Panopœa subeffusa*, and *Scintilla angusta*. On the other hand, an error on the opposite side, omitting the range into Barton beds in the case of *Marginella simplex* and *Corbula cuspidata*, goes only one quarter of the way towards redressing the balance.

So far from the Brockenhurst zone having fewer forms common to the Barton than the Headon-Hill marine bed, we consider that it has rather more, as its position at the base of the Middle Headon at Whitecliff Bay would lead us to expect. Thus, if we take the whole Brockenhurst fauna (including the 15 corals which are mostly special to the zone), we obtain a total of 151 species, of which from 74 to 81 pass up from Barton, or a proportion of about one half. Summing up the Headon-Hill forms in the same way—out of a total of 79 species, 23 pass up from Barton beds, or a proportion of 29 per cent. But, instead of including the rarer forms, if we take only the more characteristic and abundant species of the Brockenhurst zone, it would be perhaps a preferable course.

The following list is a catalogue of the fossils in the Woodwardian Museum from the Brockenhurst zone, obtained by one of us many years ago at Whitley-Ridge railway-cutting, New Forest; and it may be taken to include the chief characteristic fossils of the zone. We have found all, except two, in the 2-feet bed at Whitecliff Bay this summer.

*Hippocrenes (Rostellaria) ampla.
*Rimella rimosa.
Murex hantoniensis (*Ed. MS.*).
*Typhis pungens.
*Strepsidura armata.
Cancellaria muricata.
Pisania (Fusus) labiata.
*Clavella (Fusus) longæva.
Leiostoma ovatum.
*Cassis ambigua.
*Ancillaria buccinoides.
Pleurotoma transversaria.
—— cymæa.
—— headonensis.
*—— denticula.
*—— pyrgota.
*Voluta decora (*Beyr.*) = maga (*Ed.*).
*—— spinosa.
—— suturalis.
—— geminata.
*Actæon simulatus.
Marginella æstuarina.
*Natica hantoniensis.
*—— Studeri.
*—— ——, var. grossiuscula (*Ed. MS.*).
*—— labellata.
Chenopus Margerini, var. speciosus.
*Infundibulum trochiforme = obliquum (*Sow.*).
Phorus cretifer (*Ed. MS.*).
Ostrea ventilabrum = prona (*S. Wood*).
*Anomia tenuistriata.
Pecten bellicostatus.
Modiola Nysti.
*Avicula media.
*Lucina bartonensis (*Ed. MS.*).
* Cardium porulosum.
Protocardium hantoniense (*Ed. MS.*).
Cardita deltoidea.
*Cytherea incrassata.
—— suborbicularis (*Ed. MS.*).
*—— Solandri.
Cyprina Nysti.
[*]Crassatella Sowerbyi, var. hantoniensis (*Ed. MS.*).
*Corbula ficus.
*—— cuspidata.
[*]Psammobia compressa, var. arcuata (*Ed. MS.*).
Panopæa sulculosa (*Ed. MS.*).
Madrepora anglica.
Dendrophyllia.
Lobopsammia cariosa.
Balanophyllia granulata.
Solenastræa cellulosa.

Of this shorter list a proportion of about 50 per cent. pass up from Barton or Bracklesham beds; so that, taking the whole fauna or the more characteristic members of it only, in either case nearly one half pass up from Barton beds—a very different thing from one

fifth, which was the proportion given in the paper referred to (*op. cit.* p. 150). If we compare with this the ratio of Barton forms in the list of commoner Headon-Hill given above (*supra*, p. 105), we find that 30 per cent. pass up from Barton beds (while in the complete list of the Headon-Hill fauna the porportion is also about 29 per cent.). Moreover, if we first eliminate the forms that occur also at Brockenhurst, so as to obtain what we may consider as specially Headon species, the proportion becomes even lower. On all hands the palæontological evidence seems perfectly in accord with the stratigraphical.

Relation of Colwell Marine to Brockenhurst Fauna.—In order to see whether the Colwell bed is more nearly related to the Brockenhurst than is the Headon-Hill bed, we will first take the proportion of Barton forms in it for comparison with similar treatment of the Headon-Hill catalogue. Examination of the list gives us a proportion of 29 per cent. of Barton forms in the Colwell-Bay bed; we saw above that, in the Brockenhurst bed, the ratio was about 50 per cent. and in the Headon marine bed 29 per cent. An inspection of the list of more characteristic Colwell and Headon marine fossils (*suprà*, p. 105) showed that these faunas are practically identical Now we see that their proportion of Barton forms is nearly equal, and far lower than in the Brockenhurst bed.

To complete the proof from fossils, if any such is needed, we may inquire whether there are more Brockenhurst forms peculiar to Colwell Bay than to Headon Hill. Examination of the lists shows that only the following Brockenhurst species occur at Colwell Bay and not at Headon Hill, viz. *Scalaria tessellata* and *Tellina affinis*, the latter passing up from Barton beds; while those occurring at Headon Hill and not at Colwell Bay are *Marginella æstuarina* and *Cardita paucicostata*—two only in each case, which amounts to perfect equality. If, on the other hand, we count those common to the Colwell and Headon marine beds, and not occurring at Brockenhurst, we find twenty-six species in this category. We are at a loss to understand how any one could imagine that the Brockenhurst fauna is identical with that of the Colwell-Bay bed and newer than that of Headon Hill.

That the Colwell-Bay bed is stratigraphically identical with the Headon Middle Marine we hope that we have sufficiently proved; and the fact is confirmed by fossil evidence. The same twofold proof has been brought forward to demonstrate that the Brockenhurst bed, where present, lies at the base of the marine Headon beds and immediately above the Lower Headon. This bed is absent at Colwell Bay and Headon Hill, but is seen at Whitecliff Bay, Brockenhurst, and Lyndhurst.

Since the Middle Headon includes every thing between the freshwater Upper and Lower Headon, it must be allowed to include the Brockenhurst beds, though that special fauna was not known when names were given to these groups of strata. It would cause the greatest inconvenience to abandon the term Middle Headon, as it

would entail the abandonment of the names Upper and Lower also. There is therefore no room for the term "Brockenhurst Series" in the sense proposed in the paper referred to (*op. cit.* p. 168)—a classification which would be in conflict with the best authorities, and founded, as we have endeavoured to show, on a defective appreciation of the beds. We may urge that no new facts have been discovered concerning the succession of the strata to make any correctionary classification or nomenclature in the main groups of the Upper Eocene at all necessary or desirable, and we should prefer to retain the local groupings which have been so long familiar to geologists. We may denote as the "Brockenhurst Beds" the lower part of the Middle Headon with the rich Brockenhurst fauna. It is not always developed; the absence of admixture of fresh water was evidently the necessary condition of its abundance of marine mollusca and of the existence of its corals.

It may perhaps be subdivided into the "Brockenhurst zone" and the "Roydon zone"*. The correlation of this fauna was justly made

* We found the Roydon brick-yard pit in a good state for examination this summer, and obtained from it twenty-eight species. They all came from the sandy clays with bands of iron-ore septaria; the lowest beds were below the level of the standing water. The section is as follows:—

Gravel, Post-Tertiary.

2–3 feet.	Bluish to yellow-grey clay.	
9 inches.	"Shell-bed;" clay very full of shells.	*Murex sexdentatus, Cardita oblonga* var. *transversa, Pisania labiata, Trigonocœlia deltoidea, Ostrea velata, Cytherea incrassata, Cyrena obovata* var. *subregularis* (Ed. MS.).
7½ feet.	Grey clay. Two nodule-bands of iron-ore septaria separated by grey sandy clay. Stiff bluish clay for the lower 2 feet.	*Voluta geminata, Voluta spinosa, Strepsidura armata, Pleurotoma transversaria, Pleurotoma hantoniensis, Natica epiglottina, Bulla Lamarckii, Protocardium hantoniense, Cytherea suborbicularis, Psammobia æstuarina, Corbula pisum*, &c.
7 feet.	Greenish-grey clayey sands.	

Reposing on Lower Headon fresh-water clays.

The shelly bed, we consider, represents part of the Venus-bed or Headon-Hill marine zone, since it contains the characteristic oyster and *Murex sexdentatus*, &c.

The clays and clayey sands below, of which we examined 7½ feet, while, according to the statement of the men employed, the remaining sandy beds below are another 7 feet, we propose provisionally to term the "Roydon zone." It is characterized palæontologically by the abundance of *Voluta geminata*, differing from the "Brockenhurst zone" by the absence or great rarity of *Voluta suturalis, Pleurotoma cymæa*, and *Cytherea Solandri*, for the latter shells are

by Von Könen in 1864, and by Dr. Duncan for the corals in 1866, whose work is not in any way affected by any thing in the present essay. We have merely striven to prevent the beds in the Isle of Wight and the New Forest being thrown again into confusion, and the accurate work of E. Forbes and the Geological Survey being rejected on such insufficient grounds as have been recently put forward.

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abundant in that rich zone, a few inches thick, in the Whitley-Ridge railway-cutting.

At the time of obtaining the Roydon fossils in the Edwards collection, one of the authors sank a pit to the base of these beds, and they were found lying immediately on the freshwater Lower Headon clays, the Brockenhurst zone being absent; the latter has apparently thinned out here, as the Roydon zone itself thins out a little further west.

Of the White-Cliff-Bay beds we are disposed to place in the Roydon zone all those between the "Venus-bed" clays of the Geological Survey Vertical Section and the lowest two feet of sandy clays lying immediately on the eroded surface of the freshwater Lower Headon, which said bed we have described above as the "Brockenhurst zone." The Roydon zone will thus include the 42 feet of yellow and green sands with ironstone-nodules, of which the chief fossil is *Psammobia æstuarina* (=*Sanguinolaria Hollowaysii* of the Geological Survey Section), also the remaining 12 feet of beds described in the legend as "brown clay," but which in their unweathered condition are slate-colour to greenish grey.

We had unfortunately not sufficient opportunity to work out the fauna completely; but such fossils as we found induce us to parallel these beds with those of the Roydon brick-pit. The lithological character of these lower beds, as seen below low-water mark at equinoctial tide, is singularly like the clayey sands of the Roydon brick-yard, while their chief fossils are the *Psammobia*, lying in the natural position of life, and *Cardita deltoidea*. At some future time we hope to work out the fauna more completely.

At Cutwalk hill, Lyndhurst, both the Brockenhurst and Roydon zones occur. In the pits which one of the authors sank in obtaining fossils for Mr. Edwards and others from this locality, the Brockenhurst zone was found lying, as usual, immediately on the freshwater clays of the Lower Headon.

Hence we may divide the Middle Headon into three zones, distinguishable easily by fossils (though, of course, many species are common to all three), viz. the Brockenhurst, the Roydon, and the Venus-bed or Headon-Hill zone. The percentage of Barton forms diminishes as we ascend in the series.

Fossils of the Middle Headon series, including the Brockenhurst beds †.

	Middle Headon.							Upper Bagshot.
				Brockenhurst beds.				
	Hordwell.	Headon Hill.	Colwell Bay.	Roydon.	Whitecliff Bay.	Lyndhurst.	Brockenhurst.	Long Mead End.
*Lamna contortidens (*Ag.*)	...	*	*	*	K.T.	...	K.T.	
Marginella simplex (*Edw.*)	...	...	*	...	...	...	...	*
—— æstuarina (*Edw.*)	...	*	...	*	...	*		
—— vittata (*Edw.*)	...	*						
Voluta geminata (*Sow.*)	...	...	...	*	K.T.	*		
—— —— var. tereticosta (*Ed. MS.*)	...	...	...	*	*			
*—— decora (*Beyr.*) = maga (*Ed.*)	...	...	...	...	K.T.	*	*	
—— suturalis (*Nyst*) = contabulata (*Ed.*)	...	...	...	*	K.T.	*	*	
*—— spinosa (*Lam.*)	*	K.T.	*	*	K.T.	*	*	
Mitra gracilenta (*Ed. MS.*)	...	...	...	*				
—— abbreviata (*Ed. MS.*)	...	...	...	...	K.T.	...	*	
—— polygyra (*Ed. MS.*)	...	...	...	...	...	...	*	
[*]Conorbis dormitor (*Sol.*), var. seminuda (*Ed.*)	...	...	...	...	...	*	*	
[*]——procerus (*Beyr.*) = alatus, var. hemilissa (*Ed.*)	...	...	...	*	K.T.	*	*	
Pleurotoma transversaria (*Lam.*)	...	...	...	*	K.T.	*	*	
—— cymæa (*Ed.*)	...	...	...	*	K.T.	...	*	
—— —— var. nana (*Ed.*)	...	...	?*					
*—— pyrgota (*Ed.*)	...	...	...	*	...	...	*	
—— bellula (*Phill.*)	...	...	...	...	...	...	*	
—— Woodi (*Ed.*)	...	*						
—— headonensis (*Edw.*)	*	*	*	K.T.	...	*	*	
*—— denticula (*Bast.*)	...	...	...	...	...	*		
*—— —— var. odontella (*Ed.*)	*	*	*	K.T.	K.T.	*		
—— læviuscula (*Ed.*)	...	...	...	...	...	...	*	
—— subdenticulata (*Goldf.*) = hantoniensis (*Ed.*)	...	...	...	*	K.T.	*	*	
* Borsonia sulcata (*Bou.*)	*	*	*	...	K.T.			
—— sp.	...	...	...	...	K.T.			
Chenopus Margerini (*de Kon.*), var. speciosa (*Schlot.*)	...	...	...	...	K.T.	...	*	
*Rimella rimosa (*Sol.*)	...	*	*	*	K.T.	*	*	
*Hippocrenes (Rostellaria) ampla (*Sow.*)	...	...	...	...	K.T.	*(?)	*	
Carried forward	4	9	8	15	17	14	18	1

† Those marked with an asterisk pass up from Barton or Bracklesham beds. The asterisk enclosed in brackets signifies that the type species exists in Barton beds, but not the special variety. The initials K.T. denote that the citation is the result of our own researches instead of being founded on the Edwards collection.

Fossils of Middle Headon series, &c. (continued).

	Middle Headon.							Upper Bagshot.
				Brockenhurst beds.				
	Hordwell.	Headon Hill.	Colwell Bay.	Roydon.	Whitecliff Bay.	Lyndhurst.	Brockenhurst.	Long Mead End.
Brought forward	4	9	8	15	17	14	18	1
Murex hantoniensis (*Ed. MS.*) ...	...	...	...	...	K.T.	*	*	
—— sexdentatus (*Sow.*)	*	*	*					
—— ——, var. cinctus (*Ed.*).....	...	...	?*					
*—— minax (*Sol.*)	...	...	...	...	K.T.	...	*	
*—— obtusus (*Desh.*)	...	...	...	...	...	...	*	
—— —— sp.	...	K.T.						
*Typhis pungens (*Sol.*)	...	...	...	...	K.T.	*	*	
Cantharus subcostatus (*Ed.*)	...	...	...	...	...	*		
Fasciolaria crebrilinea (*Ed. MS.*)	...	*						
Pisania (Fusus) labiata (*Sow.*) ...	...	*	*	*	K.T.	*	*	
——·——, var. concinna	...	...	*					
*—— nodicosta (*Ed. MS.*)	...	...	...	*				
*—— acuticosta (*Ed.*)	...	...	*					
Phos scalaroides (*Lam.*)	*							
*Clavella (Fusus) longæva (*Sol.*)...	...	...	...	*	K.T.	*	*	
Chrysodomus (Fusus) Sandbergeri (*Beyr.*)	...	...	...	...	...	...	*	
Leiostoma ovatum (*Beyr.*)	...	...	...	...	...	...	*	
*Strepsidura (Buccinum) armata (*Sow.*)	...	...	...	*	K.T.	*	*	
—— semicostata (*Ed. MS.*)	...	...	*					
*Cominella (Buccinum) deserta (*Sol.*).....	...	...	...	...	K.T.	...	*	
*—— flexuosa (*Ed. MS.*)	...	K.T.	*	...	K.T.	...	*	
—— ventricosa (*Ed. MS.*)	...	...	...	*				
*Ancillaria buccinoides (*Lam.*). ...	*	K.T.	*	*	K.T.	*	*	
*Cassis ambigua (*Sol.*)	...	...	...	*	K.T.	...	*	
*Natica hantoniensis (*Sow.*)	...	...	...	...	K.T.	...	*	
*—— obovata (*Sow.*).....	...	...	...	*				
—— conulus (*Ed. MS.*)	...	...	...	...	...	...	*	
*—— Studeri (*Bronn*)	...	*	*	...	...	*	*	*
*—— ——, var. grossiuscula (*Ed. MS.*)..	...	*	K.T.	...	...	...	*	*
*—— epiglottina (*Lam.*)	*	...	...	K.T.				
*—— labellata (*Lam.*)	*	*	*	*	K.T.	*	*	
—— ——, var. dubia (*Ed. MS.*)...	...	...	...	...	...	...	*	
Cancellaria muricata (*S. Wood*) =pyrgota (*Ed. MS.*)	*	K.T.	*	*	K.T.	*	*	
—— elongata (*Nyst*)	*	*	*	*	...	*	*	
*—— evulsa (*Sol.*).....	...	...	...	...	K.T.			
—— roydonensis (*Ed. MS.*)	...	...	...	*				
*Pyramidella (Turbonilla) obscura (*Ed. MS.*).....	...	...	...	*				
Turbonilla plicatella (*Ed. MS.*)...	...	...	...	*				
—— semilævis (*Ed. MS.*)	...	...	...	*				
*—— plicatilis (*Ed. MS.*).....	...	...	*					
Carried forward	11	20	22	31	31	25	39	3

Fossils of Middle Headon series, &c. (continued).

	Middle Headon.							Upper Bagshot.
				Brockenhurst beds.				
	Hordwell.	Headon Hill.	Colwell Bay.	Roydon.	Whitecliff Bay.	Lyndhurst.	Brockenhurst.	Long Mead End.
Brought forward	11	20	22	31	31	25	39	3
*Turbonilla obliquecostata (*Ed. MS.*)	...	*						
—— dubia (*Ed. MS.*)	...	*						
—— sorella (*Ed. MS.*)	...	*						
Odostomia loxodonta (*Ed. MS.*)...	...	*	*					
—— subumbilicata (*Ed. MS.*) ...	...	*	*					
—— geminata (*Ed. MS.*)	...	*	*					
—— multispirata (*Ed. MS.*)	...	*						
—— gracilis (*Ed. MS.*)	...	*	*					
*—— bordeola (*Lam.*)	*							
—— ——, var. angusta (*Ed. MS.*)	...	...	...	*				
Eulima gracillima (*Ed. MS.*).....	...	...	*					
*Cerithium variabile (*Desh.*)	...	*	*	...	...	...	*	*
[*]—— submarginatum (*Ed. MS.*), var. recentior (*d' Orb.*).....	*	...	*	...	...	...	...	*
*—— pseudocinctum (*d' Orb.*)	...	*	*	...	...	*	*	
—— duplex (*Sow.*)	*	*	*					
—— parvulum (*Ed. MS.*)	...	*						
—— pliciferum (*Ed. MS.*).....	...	...	*					
—— ventricosum (*Sow.*).....	*	*	*					
—— subconoideum (*Ed. MS.*) ...	...	...	*					
—— contiguum (*Desh.*)?	...	*						
—— multispiratum (*Desh.*)	...	*						
—— gyrostoma (*Ed. MS.*).....	...	*						
—— concavum (*Sow.*)	*	*	*	..	...	...	...	*
—— varians (*Ed. M.S.*).....	...	*	*					
Melania fasciata (*Sow.*)	...	*	*	...	...	...	...	*
—— muricata (*Sow.*).....	*	*	*					
*—— brevicula (*Ed. MS.*)	*							
*Hydrobia anceps (*Wood*)	*	...	*	...	...	...	...	*
—— Dubuissoni (*Bouillet*), var. rimata (*Ed. MS.*)	*							
—— bulimoides (*Ed. MS.*)	...	K.T.	*					
Melanopsis subfusiformis (*Morr.*)	*	*	*	...	...	...	*	*
—— fusiformis (*Sow.*)	*	K.T.	*	...	...	...	...	*
Scalaria lævis (*Morr.*).....	...	*	*					
—— tessellata (*Ed. MS.*)	...	...	*	*				
Nematura parvula (*Desh.*)	*	K.T.	*	...	...	...	...	*
—— pygmæa (*Forbes*)	...	...	*					
—— lubricella (*Braun*).....	*							
Cæcum Morrisii (*Ed. MS.*)	...	*						
Trochus pictus (*Ed. MS.*)	*							
*Trochita (Infundibulum) trochiformis (*Lam.*) =obliqua (*Sow.*)	...	...	...	*	K.T.	...	*	
Phorus cretifer (*Ed. MS.*)	...	...	...	...	K.T.	...	*	
Teinostoma minutissimum (*Ed. MS.*)	...	...	*					
Carried forward.....	25	46	47	34	33	26	44	11

Fossils of Middle Headon series, &c. (continued).

	Middle Headon.							Upper Bagshot.
				Brockenhurst beds.				
	Hordwell.	Headon Hill.	Colwell Bay.	Roydon.	Whitecliff Bay.	Lyndhurst.	Brockenhurst.	Long Mead End.
Brought forward	25	46	47	34	33	26	44	11
Teinostoma micans (*Ed. MS.*).....	...	...	*					
Nerita aperta (*Sow.*)	*	K.T.	*					
—— [æstuarina (*Ed. MS.*)]=N. zonula (*S. Wood*)	*	K.T.	*					
Neritina concava (*Sow.*)	*	K.T.	*	...	...	...	...	*
[*]Rissoa carinata (*Ed. MS.*), var. denticulata (*Ed. MS.*).....	...	*	*					
—— ditropis (*Ed. MS.*).....	*							
Tornatella limnæiformis (*Sandb.*).	*	...	...	*	K.T.			
—— altera (*Desh.*)	...	...	...	...	...	...	*	
—— dactylina (*Desh.*)	...	...	*					
*—— simulatum (*Sow.*)	...	...	...	...	K.T.	...	K.T.	
Adeorbis apertus (*Ed. MS.*)	*							
—— æstuarinus (*Ed. MS.*)	*							
*Orthostoma crenatum (*Sow.*).....	...	...	...	*				
—— retiarium (*Ed. MS.*)	...	...	...	...	K.T.	...	*	
*Ringicula parva (*Ed. MS.*).....	...	...	...	*				
Bulla æstuarina (*Ed. MS.*).....	*	*	*	...	...	*		
—— Lamarckii (*Desh.*)	...	...	...	*	...	...	...	*
—— curta (*Ed. MS.*)	...	...	...	...	...	*		
—— simillima (*Ed. MS.*) [*cf.* æstuarina]	...	...	...	...	...	*		
*—— attenuata (*Sow.*).....	...	...	...	...	K.T.			
—— navella (*Ed. MS.*)	...	...	*					
*—— Sowerbyi (*Nyst*)	...	...	...	...	K.T.			
—— tenuicula (*Ed. MS.*)	*							
*—— elliptica (*Sow.*)?	*							
Cylichna globulus (*Ed. MS.*).....	...	...	...	*				
—— ovalis (*Ed. MS.*).....	...	...	*					
Dentalium, sp.	...	...	...	...	K.T.			
*Anomia tenuistriata (*Desh.*)	*	...	...	...	K.T.	...	*	
Ostrea velata (*S. Wood*)	*	K.T.	*					
*—— flabellula (*Lam.*) = ventilabrum (*Goldf.*)	...	...	...	...	K.T.	...	*	
Pecten bellicostatus (*S. Wood*) ...	...	...	...	...	K.T.	...	*	
*Avicula media (*Sow.*).....	...	...	...	...	K.T.	...	*	
*Mytilus affinis (*Sow.*)	*	K.T.	*					
Modiola Nysti (*Kiehl, MS.*)	...	...	...	...	K.T.	...	*	
—— ignota (*Ed. MS.*)	...	...	...	...	...	...	*	
*Arca biangula (*Lam.*)	...	...	...	...	K.T.	...	*	
*—— appendiculata (*Sow.*)	...	...	..	...	...	...	*	
*—— lævigata (*Caill.*).....	*	*	*	...	...	*		
*—— duplicata (*Sow.*)=sulcicostata (*Nyst*)	...	...	...	...	...	...	*	
*Trigonocœlia deltoidea (*Lam.*) ...	*	*	*	...	...	*	*	*
Nucula headonensis (*Forbes*)	*	*	*					
Carried forward.....	41	56	61	39	45	31	57	14

Fossils of Middle Headon series, &c. (continued).

	Middle Headon.							Upper Bagshot.
				Brockenhurst beds.				
	Hordwell.	Headon Hill.	Colwell Bay.	Boydon.	Whitecliff Bay.	Lyndhurst.	Brockenhurst.	Long Mead End.
Brought forward	41	56	61	39	45	31	57	14
Nucula nudata (*Wood*)	...	*	*	*				
*—— similis (*Sow.*)	...	...	...	...	K.T.			
*—— lissa (*Wood*)	*	...	...	K.T.				
Leda propinqua (*Wood*)	...	K.T.	*	K.T.	K.T.			
*—— minima (*Sow.*)	...	...	...	...	...	...	*	
Cardita simplex (*Ed. MS.*)	...	...	...	*				
—— paucicostata (*Sandb.*)=nodicosta (*Edw.*)	...	*	...	*				
—— deltoidea (*Sow.*)	...	...	...	K.T.	K.T.	*	*	
—— orbicularis (*Goldf.*)	...	...	...	...	...	...	*	
[*]—— oblonga (*Sow.*), var. transversa (*Ed. MS.*)	...	*	K.T.	...	...	...	*	*
—— ——, var. serratina (*Ed. MS.*)	...	*						
[*]Crassatella Sowerbyi, var. hantoniensis (*Edw.*)	...	...	...	*	...	...	*	
*Lucina obesa (*Ed. MS.*)	...	*						
—— concava (*Defr.*)	*	*	*	K.T.	...	...	*	
—— pulvinata (*Ed. MS.*)	*	...	*					
*—— bartonensis (*Ed. MS.*)	...	...	...	...	K.T.	...	*	
*—— inflata (*Ed. MS.*)	*	*	...	...	...	...	...	*
Strigilla colvellensis (*Ed. MS.*)	*	K.T.	*	...	...	...	...	*
—— pulchella (*Ag.*)	...	*						
Diplodonta suborbicularis (*Ed. MS.*)	...	...	...	...	K.T.	...	*	
*—— obesa (*Ed. MS.*)	...	...	...	*				
—— planiuscula (*Ed. MS.*)	...	...	...	...	...	...	*	
*Cardium porulosum (*Lam.*)	...	...	...	*	K.T.	...	*	
*—— obliquum (*Lam.*)	*	...	...	*				
Protocardium hantoniense (*Ed. MS.*)	...	...	...	K.T.	K.T.	...	*	
*Cypricardia pectinifera (*Sow.*)	...	...	...	*	K.T.	...	*	
Isocardia transversa (*Nyst*)	...	...	...	...	...	...	*	
*Scintilla angusta (*S. Wood*)	*	...	*					
Lepton nitidulum (*S. Wood*)	*							
—— tumidum (*Ed. MS.*)	...	...	*					
Cyprina Nysti (*Heb.*)	...	...	...	...	K.T.	...	*	
*Cytherea incrassata (*Sow.*)	*	*	*	*	K.T.	*	*	
—— turgescens (*Ed. MS.*)	...	...	...	...	...	*	*	
—— tumida (*Ed. MS.*)	...	...	...	...	...	...	*	
—— suborbicularis (*Ed. MS.*)	*	*	K.T.	*	K.T.	...	*	
*—— subelliptica (*Ed. MS.*)	...	...	...	...	...	...	*	
—— hantoniensis (*Ed. MS.*)	...	...	...	...	...	...	*	
*—— Solandri (*Sow.*), var. attenuata (*Ed. MS.*)	...	...	...	...	K.T.	...	*	
[*]—— elegans (*Lam.*), var. *b*	...	...	...	...	...	...	*	
*—— Suessonensis (*Desh.*)	...	...	...	...	K.T.			
Carried forward	51	68	71	54	58	34	79	17

Fossils of Middle Headon series, &c. (continued).

	Middle Headon.							Upper Bagshot.
				Brockenhurst beds.				
	Hordwell.	Headon Hill.	Colwell Bay.	Roydon.	Whitecliff Bay.	Lyndhurst.	Brockenhurst.	Long Mead End.
Brought forward	51	68	71	54	58	34	79	17
[*]Psammobia compressa (*Sow.*), var. æstuarina (*Ed. MS.*), and var. arcuata (*Ed. MS.*)	*	*	*	*	K.T.	...	*	
—— rudis (*Lam.*)=solida (*Sow.*)	...	*	*	...	...	...	...	*
*Tellina affinis (*Ed. MS.*)	...	...	*	K.T.	K.T.			
—— headonensis (*Ed. MS.*)	...	*	*					
—— sphenoides (*Ed. MS.*)	...	...	*					
Syndosmya colvellensis (*Ed. MS.*)	...	...	*					
Mactra fastigiata (*Ed. MS.*)	*	K.T.	*	...	...	...	...	*
—— filosa (*Ed. MS.*)	...	...	*	...	...	...	...	*
*Mya angustata (*Sow.*)=M. producta (*Ed. MS.*)	*	*	*	K.T.	K.T.	...	...	*
*Corbula pisum (*Sow.*)	...	...	...	K.T.	K.T.	...	*	
*—— cuspidata (*Sow.*)	*	*	*	K.T.	K.T.	*		
—— nitida (*Sow.*)	*	...	...	*				
*Panopæa subeffusa (*Ed. MS.*)	...	*	*					
—— sulculosa (*Ed. MS.*)	...	...	...	*	...	...	*	
*Solen gracilis (*Sow.*)	...	...	...	...	...	...	*	
Corbicula obovata (*Sow.*)	...	*	*	...	...	*	*	
Cyrena cycladiformis (*Desh.*)	*	K.T.	K.T.	...	...	...	...	*
—— pisum (*Desh.*)	*							
*Clavagella coronata (*Desh.*)	...	...	...	...	...	...	*	
—— Goldfussi (*Phill.*)	...	...	...	...	...	...	*	
Fistularia Heyseana (*Phill.*)	...	...	...	...	...	...	*	
Saxicava, sp.	...	...	...	...	...	...	*	
Pholas, sp.	...	...	...	...	...	...	*	
Teredo, sp.	...	...	...	...	...	...	*	
Serpula, sp.	...	...	...	...	K.T.			
Pollicipes reflexus (*Sow.*)	...	...	*					
*Balanus unguiformis (*Sow.*)	...	K.T.	*	...	K.T.	...	*	
Callianassa Baylii (*Woodw.*)	...	K.T.	*	K.T.				
Solenastræa cellulosa (*Dunc.*)	...	...	...	...	K.T.	...	*	
—— Kœneni (*Dunc.*)	...	...	...	...	...	...	*	
—— Reussi (*Dunc.*)	...	...	...	...	...	...	*	
—— gemmans (*Dunc.*)	...	...	...	...	...	...	*	
—— Beyrichii (*Dunc.*)	...	...	...	...	...	...	*	
—— granulata (*Dunc.*)	...	...	...	...	...	...	*	
Balanophyllia granulata (*Dunc.*)	...	...	...	...	...	...	*	
Dendrophyllia	...	...	...	...	K.T.			
Lobopsammia granulata (*Dunc.*)	...	...	...	...	...	...	*	
Litharæa brockenhurstii (*Dunc.*)	...	...	...	...	K.T.	...	*	
Axopora Michelini (*Dunc.*)	...	...	...	...	...	...	*	
Madrepora Solandri (*Defr.*)	...	...	...	...	...	...	*	
—— Rœmeri (*Dunc.*)	...	...	...	...	...	...	*	
—— anglica (*Dunc.*)	...	...	...	...	K.T.	...	*	
Totals	58	79	87	62	69	36	104	22

Notes relating to Divergences from Prof. Judd's lists of Fossils, with Observations on the Edwards Collection of Middle-Headon Fossils.

Marginella simplex is not in the Edwards collection as from Barton; this and the following ten species, viz. *Mytilus strigillatus*, *Borsonia sulcata*, *Nematura parvula*, *Trigonocœlia deltoidea*, *Lucina obesa*, *L. concava*, *Cardita oblonga* var., *Cardium obliquum*, *Scintilla angusta*, and *Panopœa subeffusa*, are given in one list as occurring in Barton beds; and in the other list this range is denied to them.

The range into Barton or Bracklesham beds (as shown by the Edwards collection) has been overlooked in the case of many species (viz. twenty-two) in the lists of Colwell-Bay and Brockenhurst fossils (*op. cit.* pp. 153–156).

Voluta depauperata (Sow.) has been cited in error by Forbes from Colwell Bay; it occurs only in Barton or Bracklesham beds, and is therefore omitted from our list. *V. spinosa* (Lam.), type, occurs in Barton and Bracklesham beds; the form from Brockenhurst and Middle-Headon localities might be recognized as a distinct variety.

V. tereticosta (Ed. MS.) is plainly only a variety of *V. geminata* (Sow.) in which the costæ are a little less spiny; all intermediate degrees occur.

Clavella longæva, var. *egregia* (Beyr.). Von Könen mentions this from Brockenhurst; but we find the absence of ridges as rare as in Barton examples, and therefore omit the varietal name.

Hippocrenes ampla (Sow.) is not in Edw. coll. from Headon Hill or Hordwell; and we consider it does not occur there.

Murex sexdentatus, var. *cinctus* (Ed. MS.), is labelled in Edw. coll. as from Barton; but we suspect this to be in error; it appears to be from Colwell Bay, as in Prof. Judd's lists.

Natica obovata (Sow.) occurs at Bracklesham, as shown by the Edw. coll. *N. grossiuscula* (Ed. MS.) is probably only a variety of *N. Studeri*, as transitions exist between them. *N. dubia* (Ed. MS.) we consider only a large variety of *N. lamellata* (Lam.). *N. epiglottina* (Lam.) is in Edw. coll. labelled as from Hordwell; we found it at Roydon.

Cancellaria elongata (Nyst) is in Edw. coll. from Headon Hill and Hordwell, and *C. muricata* from Hordwell. *C. roydonensis* (Ed. MS.) seems a doubtful species.

Cerithium pyrgotum (Ed. MS.) we consider a Lower-Headon form, and omit it therefore. *C. varians* (Ed. MS.) is in Edw. coll. from Headon Hill. *C. cavatum* (Ed. MS.) may be only a variety of *C. concavum*; both it and *C. speculatum* (Ed. MS.) occur only at Long Mead End, and should be omitted from the list. *C. ventricosum* (Sow.) is in Edw. coll. from Colwell Bay; *C. subventricosum* (Ed. MS.) and *C. deperditum*? (Lam.) in Edw. coll. seem to be worn specimens of *C. ventricosum*; we agree with Prof. Judd in omitting them. *C. marginatum* (Ed. MS.), var. *recentius* (d'Orb.), occurs as in our list; its title to a distinct specific appellation seems doubtful. *C.* (*Vicarya*) *concavum* (Sow.) is in Edw. coll. labelled as from

Colwell Bay. *C. trizonatum* (Morr.) is in Edw. coll. from Hordwell &c.; it would therefore seem to be Lower Headon as well as Upper. *C. subconoideum* (Ed. MS.) seems doubtfully a distinct form. *C. æstuarinum* (Ed. MS.) as from Hordwell, in Edw. coll., is founded on a minute fragment, and we do not insert it. *C. headonense* (Ed. MS.) is in Edw. coll. from Headon Hill; but we do not insert it, as it may be Lower Headon only. *C. pulchrum* (Ed. MS.) is in Edw. coll. as from marine Headon beds of Hordwell. *C. pseudocinctum* (d'Orb.) is in Edw. coll. as from Barton.

Turbonilla plicatella (Ed. MS.) is in Edw. coll. from Roydon only; *T. plicatilis* (Ed. MS.) is there as from Colwell Bay and Barton.

Melania brevicula (Ed. MS.) is in Edw. coll. as from Hordwell and Barton; *M. Woodi* (Ed. MS.) from Hordwell seems a Lower-Headon shell, and is not inserted; the names *M. conica*, *M. polygyra*, *M. minima* (Sow.), we could not find represented in the Edw. coll., and omit them.

Rissoa carinata (Ed. MS.) occurs at Barton, but not the var. *denticulata*, according to the labels in Edw. coll.

Conorbis dormitor (Sol.) and *C. procerus* (Beyr.) occur at Barton, but not the special varieties to which MS. names are attached in the Edw. coll.

Hydrobia polita (Edw.) from Headon Hill is Upper Headon only, and therefore omitted; *H. anceps* (Wood) is in Edw. coll. as from Hordwell, Colwell Bay, Long Mead End, and Barton; *H. Dubuissoni*, var. *rimata* (Ed. MS.) is labelled as from Hordwell marine bed.

Trochus pictus (Ed. MS.) is in Edw. coll. from Hordwell; it is in the Woodwardian museum from near Setley Common, Lymington.

Melanopsis ancillaroides (Desh.) was in Edw. coll. subsequently labelled *M. subfusiformis* (Morr.); the former name may be omitted. *M. subulata* (Sow.) occurs twice in Prof. Judd's list, and with different ranges. *M. subcarinata* (Morr.) is in Edw. coll. as from Bembridge and Hordwell marine bed; at the latter locality it probably came from Lower Headon (freshwater) to judge from the aspect of the shell.

The species of *Adeorbis* in Edw. coll. are founded on single individuals; *A. æstuarina* (Ed. MS.) we could not find.

Orthostoma crenatum (Sow.) is in Edw. coll. from Brockenhurst and Barton.

Tornatella altera (Desh.) is determined from a single individual in bad preservation, and seems to us very doubtful. *T. hinnæformis* (Sandb.) [*sic*] of the Brockenhurst list is the same shell as *Actæon limnæiformis* (Sandb.) of the Headon-Hill list; it is in Edw. coll. as from those two localities. *A. simulatus* is inserted on the faith of our own researches. *A. dactylinus* (Desh.) is in Edw. coll. from Colwell Bay; we have found it there also.

Ringicula ringens (Lam.) occurs only in Barton or lower beds.

Trochita obliqua (Sow.) was described originally as "a small but perfect specimen from Brakenhurst [*sic*], in Sussex; the species is found much larger in the cliff at Barton;" the type was only $\frac{1}{8}$ inch long, and was recognized by Sowerby as occurring at Barton, while

at Brockenhurst it would have been found in Bracklesham beds probably; we consider it a young example of *T. infundibuliformis* (Lam.). We do not know why Edwards should have referred Brockenhurst forms to a different species from the common Barton species: we have compared numerous examples both from Brockenhurst and Whitecliff Bay, and consider them identical with Lamarck's species; we therefore rank *T. obliqua* as a synonym.

Nerita æstuarina (Ed. MS.) seems identical with *N. zonula* (S. Wood).

Neritina neritopsidea (Ed. MS.) is from the Upper Headon; we therefore omit it.

Ostrea flabellula (Lam.) is in Edw. coll. labelled as from "Colwell Bay *or* Headon Hill" [*sic*], but in error; the specimen has evidently come from the Barton Clay. *O. ventilabrum* is not in Edw. coll. from Colwell Bay, and it does not occur there; we are not sure that the distinctive differences given by Mr. Searles Wood between this species and *O. flabellula* are constant; we have compared examples of this oyster, so common in the Brockenhurst bed at Whitecliff Bay, with other examples from Barton beds; and some we consider perfectly identical with Barton and Bracklesham forms.

Avicula media (Sow.) is not in Edw. coll. as from Hordwell or Headon Hill, but from Long Mead End, *i. e.* probably from the Beacon Bunny (Barton) beds.

Dreissena Brardii (Fauj.) is in Edw. coll. from Hamstead and Hordwell (Long Mead End), ranging thus through all the fresh-water series. It occurs in social groups. We found a single derived specimen just above the Lower-Headon boundary at Whitecliff Bay.

Anomia tenuistriata (Desh.) is in Edw. coll. labelled as from Barton, Brockenhurst, and Hordwell; if the Brockenhurst example is to be identified with *A. Alcestiana* (Nyst), probably the Barton ones are so also. We follow Edwards in considering them all one species.

Mytilus strigillatus (Wood) in Edw. coll. is only from Barton beds; we therefore omit it. *M. affinis* is abundant at Colwell Bay, and ranges up from Barton beds.

Nucula similis (Sow.) is in Edw. coll. only from Barton beds; we found one imperfect specimen, however, at White Cliff Bay in the Brockenhurst bed. *N. lissa* (S. Wood) is said by Mr. Wood to occur at Brockenhurst; but it is not in Edw. coll. as from there; the Hordwell examples are possibly from the Upper Bagshot Sands.

Arca appendiculata (Sow.) and *A. lævigata* (Caill.) are in Edw. coll. as from Barton and Bracklesham beds.

Cardita deltoidea (Sow.) is not in Edw. coll. from Colwell Bay; and we doubt the fact of its occurring there.

Lucina Menardi (Desh.), as so determined, is not in Edw. coll. *L. gibbosula* (Lam.) and *L. pratensis* (Ed. MS.), in Edw. coll. as from Long Mead End, are not from Headon beds; we therefore omit them. *L. obesa* (Ed. MS.) and *L. inflata* (Ed. MS.) are in Edw. coll. as from Barton beds; the former is not distinguishable

from those labelled *L. concava*; indeed Edwards admitted it as doubtfully distinct.

Diplodonta obesa (Ed. MS.) exists in Edw. coll. from Barton and Bracklesham beds. *D. dilatata* (Sow.), determined as such, is not in Edw. coll.; Dixon cites it from Bracklesham.

Strigilla colvellensis (Ed. MS.) we found to be not unfrequent at Headon Hill. *S. pulchella* (Ag.) is in Edw. coll. determined from a single imperfect valve: it is impossible to say whether it is a second species; and we therefore omit it.

Cardium Edwardsi (Desh.) is not in Edw. coll. from Brockenhurst; it is a Bracklesham shell.

Cytherea suborbicularis (Ed. MS.) we found at Colwell Bay and also in the Brockenhurst zone at Whitecliff Bay. *C. suessonensis* (Desh.): under this name we find in Edw. coll. Barton and Lower-Eocene shells usually referred to *C. tenuistriata* (Sow.); we have it from the Brockenhurst zone in Whitecliff Bay. *C. partimsulcata* (Ed. MS.) is from Long Mead End only; we therefore omit it.

Cyprina scutellaria (Desh.) is solely from Lower-Eocene localities. *C. Nysti* (Héb.) is the only species from Brockenhurst in Edw. coll.; we have it from Whitecliff Bay.

Psammobia compressa (Sow.) is in Edw. coll. from Barton; the var. *arcuata* (MS.) is from Roydon and Brockenhurst; and var. *æstuarina* (MS.) is, according to the labels, from Hordwell, Colwell Bay, and Roydon. We have compared these examples, and cannot see any valid differences; we consider them all one species.

Sanguinolaria Hollowaysii (Sow.) is not in Edw. coll. from Lyndhurst, but is a Bracklesham shell. The Geological Survey cite it in error from Middle Headon beds of Whitecliff Bay.

Tellina corbuloides (Ed. MS.) in Edw. coll., from Colwell Bay, is a crushed specimen, undeterminable, but probably not the Hamstead species; we omit it. *T. ambigua* (Sow.) is in Edw. coll. labelled as from Hordwell, but is probably not from Middle Headon beds, although Forbes cites it from Colwell Bay. *T. reflexa* (Edw.) is a Bracklesham shell, and does not occur above the Upper Bagshot of Long Mead End. *T. headonensis* (Edw.) is in Edw. coll. from Headon Hill and Colwell Bay. *T. sphenoides* (Edw.) is from Colwell Bay. *T. affinis* (Ed. MS.) is in Edw. coll. from Brockenhurst and Barton; we found it also at Whitecliff Bay.

Syndosmya colvellensis (Ed. MS.) seems founded on a single minute valve.

Scintilla angusta (Ed. MS.) is from Colwell Bay, Hordwell, and Barton beds.

Mactra fastigiata (Ed. MS.) which occurs abundantly at Headon Hill, is from Hordwell in Edw. coll. *M. filosa* (Ed. MS.) from Colwell Bay and Long Mead End (Upper Bagshot) we are unable to consider a separate form, so rank it as a synonym.

Solen gracilis (Sow.) is in Edw. coll. from Brockenhurst and Barton beds.

Mya angustata (Sow.) was originally found by Prof. Sedgwick at Colwell Bay; Edwards has an apparently identical shell which he

at first identified with Sowerby's species, but subseqnently altered to *M. bartonensis* (Ed. MS.); we cannot, however, see any distinction between these and *M. producta* (Ed. MS.) from Colwell Bay; we consider them all one species. Mr. Searles Wood doubts the Hamstead form *M. minor*, Forbes, being a distinct species either.

Corbula pisum (Sow.) is not in Edw. coll. from Headon Hill or Hordwell; and we doubt its occurrence there; it is, however, fairly abundant in the Brockenhurst zone of Whitecliff Bay. *C. nitida* (Sow.) is in Edw. coll. from Roydon and Long Mead End; it was originally described from Prof. Sedgwick's specimens brought from Middle Headon beds. *C. fortisulcata* (Ed. MS.) we consider merely a variety of *C. pisum*; we omit it, since it comes from Long Mead End, probably from Barton beds. *C. ficus* was found at Brockenhurst by one of the authors, and is now in the Woodwardian Museum.

Panopœa corrugata (Sow.) is, according to the Edw. coll., only a Barton and Bracklesham shell; but quite possibly *P. subeffusa* (Ed. MS.) is not really separable from this species; in either case one of the names must be omitted.

Cyrena subregularis (Ed. MS.) seems to pass into *C. obovata* (Sow.). *C. deperdita* (Lam.) is in Edw. coll. from Headon Hill and Barton; it is probably from the Lower Headon. *C. arenaria* (Forbes) in Edw. coll. is scarcely separable from the preceding; it is from Headon Hill and Hordwell, but apparently from Lower Headon. Mr. Searles Wood figures a different form as Forbes's species. *C. gibbosula* (Morr.) is scarcely a distinct form. *C. æstuarina*, *C. altirupestris*, *C. obliquata*, MS. names in Edw. coll., are not inserted; they may probably be Lower-Headon shells.

Balanus unguiformis (Sow.) we found as frequent at Headon Hill as at Colwell Bay.

Pollicipes reflexus (Sow.) is cited by Forbes from Colwell Bay.

Callianassa Baylii (H. Woodw.) we have from all the zones of the Middle Headon.

EXPLANATION OF PLATE V.

The figure represents the coast-section from Headon Hill east of Heatherwood Point to Cliff End, Colwell Bay; it passes inland at Warden Point to avoid the projecting promontory. An attempt is made to represent where beds may be seen *in situ*, and where they are concealed by fallen material. Notwithstanding that the vertical scale is more than double the horizontal, it is impossible to show much detail; and for this reference is to be made to the accompanying vertical sections (pp. 91, 98, and 103).

The bends of the coast-line are approximately indicated by the compass-bearings given.

Discussion.

The President remarked that the paper was one of great importance. The question at issue was one sharply defined but difficult to come to a conclusion upon without visiting the sections.

Rev. O. Fisher said he had visited the locality with Mr. Tawney's paper and sections in manuscript, and that he agreed with the authors' conclusions. He thought the error on the part of Prof. Judd might have proceeded from the fact that at the N.E. corner of Headon Hill the Middle-Headon fossils were found by the sea-shore; these, however, were not truly *in situ*, but had been brought down by a slip; this he thought possibly the key to the erroneous interpretation. In confirmation of the view that the Colwell-Bay and Headon Venus-beds are one stratum, he had found it with its fossils in Totland brick-field, near the Hotel, exactly where it should occur to connect the disjoined portions. He had worked personally at the Brockenhurst locality at Whitley Ridge, and had identified the bed at the base of the Middle Headon in Whitecliff Bay. Consequently, if the Brockenhurst bed is to be called Oligocene, the Middle Headon can no longer be called Eocene.

Prof. Judd said that the paper rested largely on assumptions. His method of work in the field and in the museum had been made a matter of assumption. He had not hastily arrived at his conclusions, but for twenty years he had worked on these British beds, and for twelve years had studied their continental equivalents and collections of fossils made from them. The series of Eocene and Oligocene strata in Western Europe is perfectly clear; but when we come to Britain a difficulty has always existed. This confusion was removed by distinguishing the zone of *C. concavum* from the Brockenhurst series. The authors' sections were supposed to support those of the Survey; he thought on examination they would not do so. The mistake had really originated from using *Cytherea incrassata* to fix the so-called "Venus-bed" of fossil-collectors—the fact being that that shell has a wide range, and there is more than one "Venus-bed." In asserting that the different "Venus-beds" are upon the same horizon the authors begged the whole question. This autumn he again visited the island, and found that an excavation had been opened by the authors in a Venus-bed in Totland Bay, but in one quite different from that in Colwell Bay. Had the authors searched the Headon cliff they might have found other Venus-beds. The authors had confirmed his own conclusion that the Headon-Hill sands do not occur in Totland Bay; and this is fatal to their reading of the section. As regards the palæontological evidence, he thought that the method of comparison of most abundant fossils was often misleading, as might be shown in the case of the Cornbrash and Ragstone of the Lower Oolite. The authors say that the Brockenhurst bed is not above but below the Venus-bed. Now the former is the equivalent of the Tongrian beds of Belgium; and foreign geologists all regard the zone of *C. concavum* as the top of the Bartonian—that is, of the Eocene. Hence the result of their interpretation of the section was to place beds with an Upper-Eocene fauna *above* those containing a Lower-Oligocene fauna.

Mr. Starkie Gardner said he had always thought that in the particular section under discussion there was only one Venus-bed: the section of Headon Hill till last year had been fairly clear; and

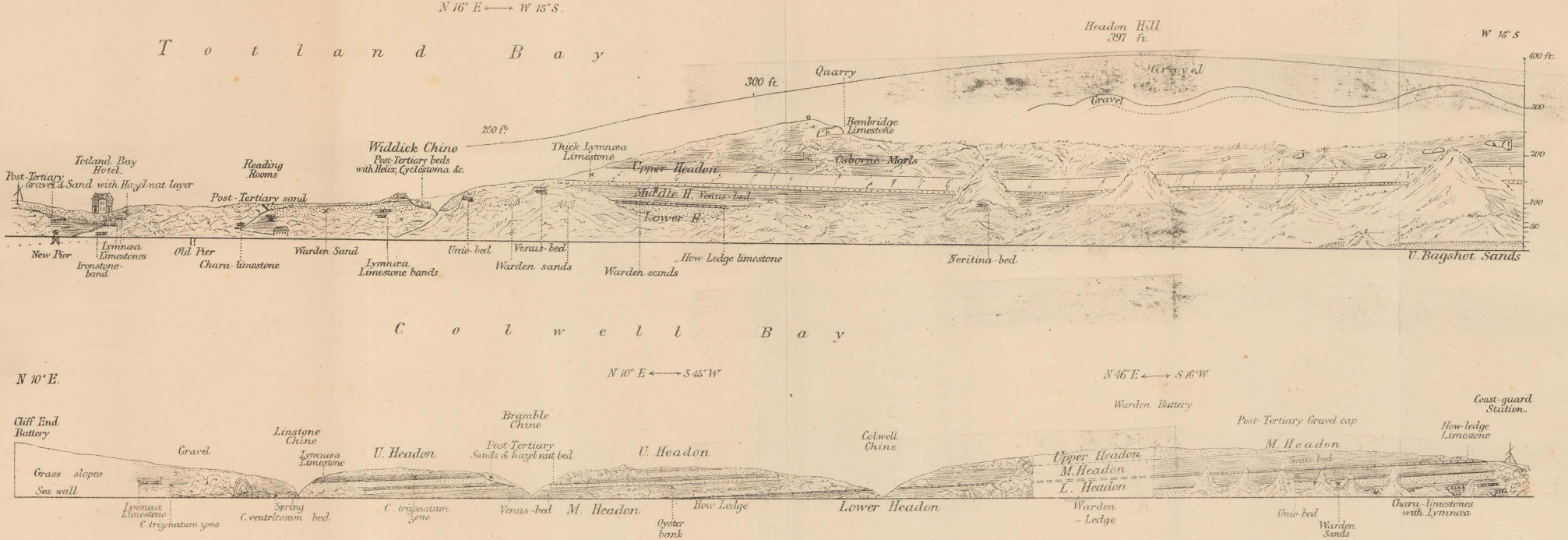
he had never seen more himself. He thought "Upper Eocene" and "Oligocene" equivalent terms, and the question, which should remain in use? one of priority.

Mr. WHITAKER said that cliff-sections in soft beds were apt to vary from time to time, so that observers who saw them under different conditions of exposure were likely to differ in interpreting them. The examination of other parts of the island, and especially the mapping of limestones or other well-marked beds, might partly help to settle the question in dispute. Perhaps the Geological Survey map had been constructed rather too much on theoretical grounds.

The PRESIDENT said that on the one hand we had the minute measurements of Messrs. Keeping and Tawney, and, on the other, the wider views of Prof. Judd. At any rate these views were now on both sides well laid before the Society; and the question, although a difficult one, as he had himself found in working over the ground 25 years since with Dr. Wright, would be now carefully examined by many others.

Mr. TAWNEY said that he thought Von Könen, in 1864, had rightly correlated the German and English beds. As for Mr. Whitaker's remarks, he thought a person who was puzzled by a cliff-section would make but little of a drift-covered country where no sections were to be seen. He still denied what Prof. Judd had said about there being more than one marine series. The *Cerithium concavum* zone of Prof. Hébert at Hordwell did not occupy the position attributed to this zone by Prof. Judd in Headon Hill. He maintained that there was but one Venus-bed. The 6-inch *Ostrea vectensis* bed in the Bembridge beds could not be confused with the Middle-Headon Venus-bed.

SECTION OF THE CLIFFS IN TOTLAND AND COLWELL BAYS, ISLE OF WIGHT.



Scale for Vertical Heights $\frac{1}{2500}$. Scale for Horizontal Distances $\frac{1}{5280}$, or 12 inches to the Mile (one inch to 146.6 yards.)

Fred. Dangerfield Lith. 22 Bedford St. Covent Garden