

## III.—THE PURBECK BEDS OF THE VALE OF WARDOUR.

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THE paper written by the Rev. W. R. Andrews and myself, published in 1894, gave a more complete account of these beds than had previously been attempted; we showed that they were divisible into Lower, Middle, and Upper groups, comparable with those established by Professor E. Forbes in the Purbecks of Dorset, and characterized by the same species of Cyprides. This paper was based on the joint examination of exposures visible in 1890, though one of us, being then resident at Teffont, had observed and collected from these exposures for many years.

In the following year (1895) Mr. H. B. Woodward's memoir on the "Middle and Upper Oolitic Rocks" was published, and his account differed from ours in several particulars, notably as regards the thickness of beds referable to the three several divisions, as to the interpretation of the section near Dinton Station, and as to the total thickness of the formation. We refrained from comment at the time, partly because we were prepared to accept such corrections as were based on the freshly cut exposure near Dinton, and partly because the mapping of the district had not then been completed, and we were content to wait till this was done, in the expectation that Mr. Woodward would then reconsider some of the points on which we were not in agreement with him.

The mapping of the area was completed in 1900 by Mr. C. Reid, and this year (1903) the map (Sheet 298, new series), together with an explanatory memoir prepared by Mr. Reid, have been published. I am sorry to find, however, that the account of the Purbeck Beds in this explanation is merely a reprint of that given by Mr. Woodward in 1895, without any alteration, and with only some small additions by Mr. Reid. As the Geological Survey has failed to take advantage of this opportunity for revision, and as silence on our part might be understood as an admission that no such revision was necessary, I think it desirable to discuss some of the points in which our account differs from that given by Mr. Woodward. On some of these questions Mr. Andrews and I are disposed to modify the opinions expressed in 1894, but on others we continue to think that our views and observations are correct. We regret that it has not been possible for all concerned to meet on the ground, for we think that if this could have been arranged we should have come to an agreement on most, if not on all, the points of difference.

1. *The Section at Wockley.*—Mr. Woodward's account of this section is so different from ours that it is not easy to correlate the one with the other; but one point is clear, that he does not take the same plane of division between the Portland and Purbeck Series as we did. In this matter I am obliged to maintain that our account of the succession is not only fuller but more accurate than Mr. Woodward's, for he has not sufficiently distinguished between

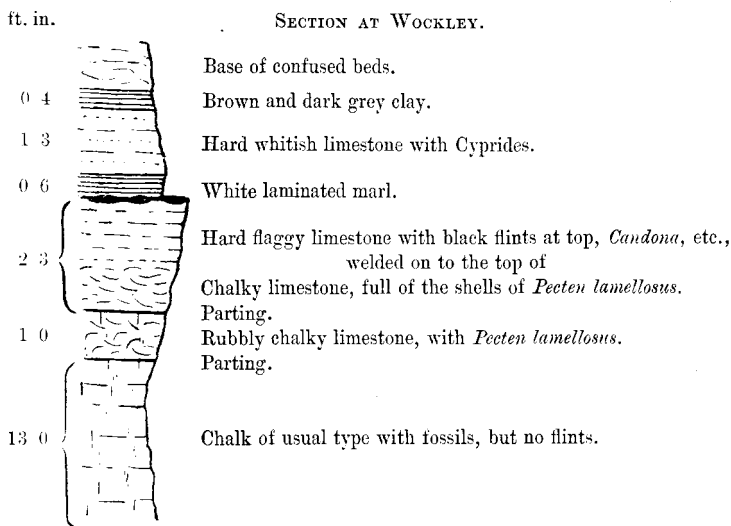
the several beds at and near the junction of the two formations. That this is so will be apparent when the two descriptions are placed side by side (as below), but in order to indicate the correlative beds more clearly I have taken the details of the Portlandian part of the section from my notebook, in which the separation of the beds composing this series was fully noted.

Our account.		Mr. Woodward's account.	
	ft. in.		
6. Laminated brown and grey clay, with patches of black clay ...	0 4	Dark shaly clay, much squeezed up in places.	
5. Hard whitish chalky limestone with Cyprids, and a layer of cherty stone with small lenticles of flint at the top	1 3	Compact limestones, 2 feet.	
4. Soft grey and white laminated marl ...	0 6		
3. Hard flaggy limestone with black flints at the top, passing down into chalky and shelly limestone ...	2 3	Bed of Roach, with lenticular mass of chert at top.	
2. Rubbly chalky limestone full of large Pecten, with marked planes at top and at base ...	1 0		
1. Chalky limestone with Portland fossils	13 0	Chalky limestones, obliquely bedded, with Portland fossils.	10 to 15 feet.

Bed No. 3 of the above succession is made up of two parts: the lower foot is a fairly compact, white chalky limestone, crowded with the shells of *Pecten lamellosus*; the upper part is a flaggy limestone without marine shells, but containing the Cyprides *Candona ansata* and *C. bononiensis*, which are marine and estuarine species: these two beds are closely welded together, they project beyond the others and usually break away in one block. Mr. Woodward follows Fitton and others (who considered the flaggy stone to be a fresh-water bed), and takes the plane along which they can be separated as the line of division between the Portland and Purbeck Series. We, having Professor Rupert Jones' assistance in determining the Cyprides, recognized the flaggy bed as of estuarine origin, and finding a marked plane at its summit, preferred to regard it as the topmost bed of the Portland Series.

I am quite prepared to admit that the beds which are welded together do contrast strongly in lithological character, and if this same kind of junction prevailed throughout the district, it would be a matter of small importance whether the one plane or the other were taken as the division between the two formations. It is well known, however, that in the Chilmark quarries (only two miles distant) there is a completely different development of beds at this horizon; at that place there are 16 feet of oolitic limestones between the top of the chalky limestone and the bed which is taken as the base of the Purbeck Series. I have suggested that the flaggy part of the 'junction bed' at Wockley is a reduced representative of these oolitic limestones, for if it is not so, then it is certain that these limestones can have nothing to represent them at Wockley, and in that case one would have expected to find a very well-marked plane of division between the Portland 'chalk' and the base of the Purbeck Beds.

In all such cases where difference of opinion can arise, unless the main facts and features of the exposure are fully described, and unless the thickness of each separate bed is given, with a record of such fossils as come to hand, students who cannot visit the locality themselves are unable to form anything like a correct picture of the section. With this object we give in the Figure a diagrammatic representation of that portion of the quarry-face which includes the beds above mentioned.



2. *Division of Lower and Middle Purbecks.*—The best exposure of this junction is in the quarry at Teffont, and of this section a full account was given by Mr. Andrews and myself, for he had watched it for many years and had obtained many fossils from the different beds therein exposed. We found *Cypridea fasciculata* (var. of *granulosa*) abundant in the 'flagstone bed' and in the shale above that bed, while in the clay below it was less abundant and was associated with *C. purbeckensis*. This clay-bed may therefore be taken as the junction of the two groups, and it would not matter whether it were included in the one or the other. Mr. Woodward, however, includes the flagstone and some of the overlying beds in the Lower Purbeck, putting the plane of division at the base of the calcareous shale or shaly limestone, which is full of a small *Modiola*.

Mr. Woodward gives no reason for his grouping of the beds; he does not dispute our record of *C. fasciculata*, though he does not quote it, and here, therefore, the question of consistency certainly does arise, for the accepted divisions of the Purbeck Series are based on the successive appearance and prevalence of the three species of *Cypridea*, *C. purbeckensis*, *C. granulosa*, and *C. punctata*, and any writer who accepts this basis of classification should be consistent and should not group beds as Lower Purbeck when their prevalent Cyprid is *C. granulosa*.

If Mr. Woodward preferred to adopt some other criterion he might have explained his reason for abandoning that of the Cyprides; it may be only a coincidence that his Lower Purbecks include all the so-called 'Lias beds,' but it is conceivable that he preferred to group together beds of similar lithological character rather than be fettered by the range of a single small Crustacean. In that case, however, "to be consistent" he should have made a similar alteration in the grouping of the Lower and Middle Purbecks of Dorset; it is not satisfactory to have one method of classification for Dorset and another for Wiltshire.

I see no reason for any departure from Forbes' convenient method, and consequently I maintain that the Middle Purbeck group in the Vale of Wardour is much thicker than Mr. Woodward makes it. In his table on p. 267 he gives the thickness of Middle Purbeck Beds as only 12 feet, but he has apparently based this estimate on his section of the railway-cuttings west of Dinton given on p. 274. In this section he has referred the lowest beds exposed to the Lower Purbeck, but I believe he is quite mistaken in such a correlation. His 'brown sandy limestone' No. 1 represents the 'shaly limestone,' which he takes as the base of the Middle Purbeck in Teffont quarry, and the whitish limestones above are the equivalent of the 'White Bed' in that quarry. I write confidently of this because there are similar beds in the next cutting on the railway (south of Teffont), and their combined thickness there (4 feet) is rather more than the beds on the same horizon west of Dinton (where Mr. Woodward's measurement makes them 3 feet 9 inches).

With the above correction, Mr. Woodward's restricted Middle Purbeck would be about 15 feet thick, but when the group is carried down to the base of the shale below the 'flagstone' in the Teffont quarry, as I consider it ought to be, its total thickness is a little over 22 feet.<sup>1</sup>

3. *The Upper Purbeck Group*.—The existence of this group in the Vale of Wardour was denied until the publication of our paper in 1894, though the Dinton cutting, in which the lower part of the group is exposed, had been open for many years, and if anyone had taken the trouble to collect Cyprides from the beds and to submit them to an expert like Professor Rupert Jones, he would have

<sup>1</sup> I admit an error in our computations of thickness on p. 66 of *Quart. Journ. Geol. Soc.*, vol. L, due to our having counted in twice beds which we now recognize to be the same.

learnt that they contain plenty of *Cypridea punctata* without any *C. granulosa*.

In 1890 this cutting was partially grassed over, and the relations of the beds seen in it to those in the next cutting were not clear. The publication of our account induced Mr. Woodward to visit the place again, and he was fortunate enough to find that the cutting had been freshly widened so that the succession could be clearly seen; further, by digging below the level of the rails, he carried his measurements down to the *Archæoniscus* bed. Some of these beds were admitted by Mr. Woodward to be of Upper Purbeck age, but the greater part of what we had regarded as Upper Purbeck was referred by him to the Wealden.

With respect to the beds seen in the cutting, I accept the fresh evidence obtained by him: I agree with him as to the plane of division between the Middle and Upper Purbeck groups, and admit that there is no necessity for the hypothetical faults which we had introduced. I have no reason to doubt his measurements of the beds in the middle of the anticline, but think that the sand and clay at the base of the Upper Purbecks must thicken to the westward. Some of the sand which I saw at the eastern end of the second cutting may have been rearranged, but I do not think there was less than 6 feet of it *in situ*, or less than 4 feet of the clay below. This view is confirmed by the section in the deep cutting south of Teffont (not described by Mr. Woodward); we gave a complete account of the beds therein exposed, and it is now quite clear that they include the base of the Upper Purbeck. The highest beds seen are as follows:—

	ft.	in.
Wet grey and yellow sand ... ..	3 or 4	0
Light-grey sticky clay ... ..	1	8
Soft marly clays with thin brown iron-stained layers ... ..	2	0
Light buff-coloured marl ... ..	0	4
Hard whitish grey-hearted silty limestone ... ..	1	0

The limestone is clearly the same as that taken at the top of the Middle Purbeck in the Dinton cutting, and there is here 4 feet of marl and clay above it, succeeded by more than that thickness of sand. Mr. Andrews and I also saw the same limestone in the next cutting (south-east of Chicks Grove Farm), overlain by grey and yellow clay, brown sand and sandstone, and a gravelly soil, but these upper beds were confused by slipping; they are clearly a remnant of the outlier of Upper Purbeck subsequently mapped by Mr. Reid north-west of the Farm.

The basal part of the Upper Purbeck group being now established, there remains the question of its upper limit, and this we admit to be difficult of settlement. Mr. Woodward draws the line between Purbeck and Wealden, quite arbitrarily, at a thin layer of sand seen in the cutting about 10 feet below the surface of the ground. Of the beds thus referred to the Wealden Mr. Reid remarks, "In the Dinton cutting only some ten feet of the lower part of the Wealden Beds can be examined, and the exact age of these deposits is perhaps not quite satisfactorily made out." He thus admits that their age

is a matter of opinion, and I can understand that as he and Mr. Woodward were obliged to draw a line somewhere for delineation on the map of the Geological Survey they gave the Wealden the benefit of the doubt.

Mr. Andrews and I considered these beds as a continuation of the Upper Purbeck, and we obtained fossils from the material thrown out of a well sunk at the cottages near Dinton Station; it is true that most of the species found range from Purbeck to Wealden, but they included *Cypridea punctata*, which has not yet been recorded from Wealden. The well is 40 feet deep, and the fossils probably came from less than 30 feet down. How much of this thickness is Purbeck and how much Wealden is evidently a matter of opinion and extremely uncertain. The following may be given as a summary of the beds which lie between the Lower Greensand and the Middle Purbeck, near Dinton, with estimated thicknesses:—

	feet.
4. Yellow and grey silty clays by Dallwood Farm ...	15-20
3. Grey silty marl (in the well) ...	10-12
2. Stiff grey and yellow clays (in the well and cutting)...	25
1. Marls, shales, and grits (in the cutting) ...	12

No. 1 is Upper Purbeck; No. 2 may be either Purbeck or Wealden; Nos. 3 and 4 are probably Wealden.

4. *Purbeck and Wealden at Teffont*.—When in 1890 Mr. Andrews and I endeavoured to trace the Upper Purbeck and Wealden clays towards Teffont we found that their thickness became very much less, and that the space occupied by their outcrop north of Teffont Rectory was very narrow. We found there exposures of the following beds in descending order:—

- D. Black clay.
- C. Greenish-black glauconitic sand.
- B. Mottled clay, white, yellow, and claret-coloured, like the 'cat's-brain' clay of Kentish Wealden.
- A. Yellow silty clays.

The upper two members of this succession we regarded as Lower Greensand (Vectian), the lower two as Wealden, believing A to be part of the Dallwood Farm beds, No. 4 of the series near Dinton. We saw nothing between this and the Middle Purbecks, and there did not seem room for the Upper Purbecks (Nos. 1 and 2) to come in, so that we concluded the Wealden had here overlapped the Upper Purbeck Beds.

From the newly issued 1 inch map I find that Mr. Reid does not carry the Wealden clays so far west as the point where we saw the above succession, but has coloured all the beds north of the Rectory between the Middle Purbeck and the Vectian Sands as Upper Purbeck. It is clear, therefore, that Mr. Reid agrees with us in thinking there is not room enough here for the whole thickness of Upper Purbeck and Wealden, but differs from us in regarding the beds which do occur as Purbeck instead of Wealden. In the explanation of the map (Sheet 298) he does not describe any exposure of these beds north of Teffont, either under the head of Purbeck or Wealden, but quotes our description of them in his

chapter on the Lower Greensand, and then remarks that he doubts our correlation of the clays at Dinton and Teffont.

Here, again, therefore, it is a matter of opinion, and those responsible for the published mapping of this bit of ground do not seem able to give very good reasons for their beliefs. We suppose Mr. Reid correlates the yellow silty clay of Teffont with the yellow grey and white clays at the top of the Dinton cutting, but in the latter place there is nothing like the peculiar 'cat's-brain' clay, and until some one can find that kind of clay in the Upper Purbeck of the Vale of Wardour I shall continue to regard it as belonging to the Wealden, and to believe that Mr. Reid has not carried the Wealden far enough to the westward along the northern side of the Vale.

When describing the Purbeck Beds in 1894 we incidentally remarked that there was a complete discordance between the Purbeck Beds and the Lower Cretaceous Series, "including the Wealden." This was carelessly expressed: the great unconformity is undoubtedly at the base of the Lower Greensand, but we certainly did think that the Wealden overlapped the Upper Purbeck. Whether it really does so depends on the correct separation of the Wealden from the Purbeck. The bare idea of a break at the base of the Wealden fluttered the dovescotes of Jermyn Street to such an extent that the question seems to have assumed proportions of paramount importance in the minds of Messrs. Woodward and Reid. Others, however, may deem it of equal importance that the divisions of the Purbeck Series should be established on logical grounds, that the thickness of each group should be carefully estimated, and that the outcrop of the Wealden Beds should be carefully discriminated from that of the Upper Purbecks.

Finally, Mr. Reid's reference to *Endogenites erosa* adds nothing to the strength of his position. He admits that "it is too doubtful a form to be of much value for correlation," but immediately adds, "though its presence supports the view that the strata containing it truly belong to the Wealden period, and are not, as supposed by Messrs. Jukes-Browne and Andrews, of Purbeck age." He quite ignores the fact that we found a large piece of similar endogenous wood in the Upper Purbeck sand of the Dinton cutting. It is also a fact that pieces of *Endogenites erosa* have been found close to the spots where outliers of the Upper Purbeck are shown on the map, and when it is remembered that the fossil wood has never been found in the beds referred by Messrs. Woodward and Reid to the Wealden, it will be apparent that the facts are much more in accord with our view than with Mr. Reid's.

In conclusion, I may place on record that I have submitted one of the surface fragments to Mr. A. C. Seward, and he kindly informs me that he believes it to be the true *Endogenites erosa*, now known as *Tempskya Schimperii*, and in reality the stem of a tree-fern. Unfortunately, I could not send him a piece of the wood found in the sand at Dinton, and cannot therefore affirm that it was also *Tempskya*, but it was so similar that I took it to be the same.



I append a revised estimate of the total thickness of the Purbeck Beds in the Vale of Wardour, if the Upper group is to be restricted within the limits indicated by Mr. Woodward.

	ft. in.		
Mean thickness from top of No. 30 to base of limestone with <i>Unio</i> (part of 21) ... ..	12	0	Upper Purbeck, 22 feet.
Yellow sands with <i>Endogenites</i> ... ..	6	0	
Grey clays and marl ... ..	4	0	
Thickness from top of No. 19 to top of the <i>Archæoniscus</i> bed (No. 13) ... ..	7	0	Middle Purbeck, 22½ feet.
From top of No. 19 to top of cinder bed (south of Telford) ... ..	4	3	
From top of cinder bed to base of the 'scale' below the flagstone at Telford ... ..	11	0	
From base of 'scale' to marl-band below the 5th Lias Section in Ridge quarry from marl below 'Lias' to bottom of quarry ... ..	19	10	Lower Purbeck, 64½ feet.
Allowance for gap between quarries ... ..	7	0	
Section at Wockley from surface to base of Purbeck Beds	22	0	
Total ... ..	108	10	

#### IV.—THE DISAPPEARANCE OF LIMESTONES IN HIGH TEESDALE.<sup>1</sup>

By C. T. CLOUGH, M.A., F.G.S., of H.M. Geol. Survey.

IN High Teesdale, on certain hillsides, the structure of which in most respects clear, the observer is struck by the disappearance of some, generally constant, limestone which ought naturally to occur. The limestone most usually missing is the Great Limestone, which, with the exception of the Melmerby Scar Limestone, is the thickest of all in the dale. Though the ground is almost free from peat and drift, and plainly shows the banks formed by the Four Fathom Limestone and Firestone,<sup>2</sup> there is yet perhaps neither bank nor 'shake-hole' (swallow-hole) to represent the Great Limestone. In the cases referred to the difficulty cannot be accounted for by supposing that the limestone along its outcrop is thrown out by a fault, for the outcrops of the beds above and below can be followed round the hill without interruption.

Where the limestone disappears many masses of sandstone are usually found, most of which seem somewhat disturbed; and, in the small streams, thin irregular bands of soft, rather siliceous, clay and iron ochre occur. The clay and ochre represent the limestone, which, in the language of the dalesmen, has been 'eaten away' along the outcrop and replaced by 'famp.'

<sup>1</sup> The substance of this communication was written 25 years ago. Since then Mr. F. Rutley has written "On the Dwindling and Disappearance of Limestones" (Q.J.G.S., 1893, vol. xlix, p. 372), but he makes no mention of their special liability to dwindle in the neighbourhood of faults and veins, and gives no instances of their disappearance on a large scale. Mr. J. R. Dakyns has written a short paper "On 'Flots'" (Report Brit. Assoc., 1881, p. 634), and the material in many 'flots' seems of much the same nature as 'famp.' The writer has recently seen an instance of famping, differing somewhat from the examples in Teesdale, in one of the limestones (the Skateraw Middle Limestone), which has been quarried at Catteraig, near Dunbar, and this has recalled the subject to him.

<sup>2</sup> The Four Fathom Limestone is a little below the Great, and the Firestone is a sandstone a little above the Great Limestone.