REMARKS ON THE UPPER CHALK OF SURREY.

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THE Upper Chalk of Surrey has recently acquired special interest because of the discovery that it includes a large part of the zone of *Marsupites*. When I prepared the chapter on the Upper Chalk of this county for the Geological Survey memoir on "The Cretaceous Rocks of Britain," published in 1904, not a single plate of *Marsupites* or *Uintacrinus* had been found, either in Surrey or in the adjoining part of Kent. I began that chapter by stating that "no systematic exploration of the Upper Chalk of Surrey has yet been made," and I could not even be certain that the zone of *Marsupites* came into the western part of the county. As regards the Eastern part of the county, I expressed my belief that this zone was not present in that area and that the Chalk there had suffered greatly from erosion before the deposition of the lowest Eocene beds.

My reason for this opinion was that the thickness of the Upper Chalk in that area, as proved in the boring at Streatham, was less than it is known to be either to the east, north, or west, and, consequently, that, if the zones of the Chalk maintained anything like the thicknesses which they severally possess in Kent, it was not likely that a total thickness of only 623 ft. could bring in the zone of *Marsupites* below Streatham.

Nothing pointed to any great variation in thickness of the zones in these south-eastern counties, so that the inference was a reasonable one, but, nevertheless, it has turned out to be wrong. Not only does the zone of *Marsupites* exist in Surrey, but the systematic exploration of the Upper Chalk which was a desideratum in 1903 has now been ably carried out by Mr. G. W. Young,* who has shown that the *Marsupites* chalk occurs not only in outliers at a distance from the border of the Eocene, but also at so many points along that border that we are warranted in supposing it to have a continuous outcrop from Addington on the east to Ashted and Epsom on the west. The probability of its further continuance through western Surrey is very great, for its existence there was surmised by Prof. Barrois in 1876,† and his description of the highest Chalk seen near Guildford was quoted in the memoir on Cretaceous Rocks.

It appears, therefore, to be demonstrated that the zone of

* *Proc. Geol. Assoc.*, vol. xix, p. 188 (1905).

† *Recherches sur le Terr. Cret.*, *Mém. Soc. Geol. Nord.* 1 (1876), p. 139.

Marsupites does form an integral part of the Upper Chalk of Surrey, and we are at once confronted by the question—how can this be made to accord with the supposed small thickness of that division of the Chalk in East Surrey? I can imagine three possible answers to this question: (1.) The record of the Streatham boring may not be correct and the thickness of the Chalk at the outcrop may be greater than was supposed; (2.) The record of the boring may be correct and the thickness below Streatham may be exceptionally small from local pre-Tertiary erosion; (3.) Some of the Upper Chalk zones may be much thinner than they are in the neighbouring counties.

Mr. Young does not seem to have realised this difficulty, for his discussion of the supposed small thickness of Chalk in East Surrey does not touch the question. He quotes part of a passage from my "Building of the British Isles," but seems to have misunderstood it, for he says that I mentioned no boring south of London between Chatham and East Horsley, whereas I expressly said that the Chalk was thinnest at Streatham, and suggested that a pre-Tertiary uplift "had produced a broad low dome which had its centre on the Surrey side of the Thames."*

Mr. Young argues for a continuous and rapid thinning of the Chalk south of London and for the existence of a local north and south anticline in Tertiary times, but the evidence to which he refers is merely that of the overlap of the Blackheath Beds, which was probably a general southward overlap and overstep along a wide tract or front caused by a contemporary uplift of the Chalk over the Wealden area. I do not desire to discuss this point, but shall keep to that which seems of special interest, namely, the pre-Tertiary thickness of the Chalk, and how it comes to pass that the zone of *Marsupites* is present in Surrey. I propose, therefore, to consider all the evidence that is now available on this point.

To begin with the Streatham boring, there is no good reason to doubt the accuracy of the record and, fortunately, samples of Chalk from successive horizons were examined by Mr. W. Hill. I am inclined to think, however, that the base of the Upper Chalk may be somewhat lower down than the plane taken by Messrs. Hill and Whitaker in 1889.† It is stated (p. 228) that a specimen from 460 ft. showed "the peculiar structure of Chalk Rock," but Mr. Hill informs me that by this he meant to say it showed the characters of the Rocky Chalk which occurs in the zone of *Holaster planus* in the south-eastern counties, and the structure of which is similar to that of the Chalk Rock of more western counties.

The next sample examined was from 485 ft., and this is described as "probably the top of the zone of *Terebratulina*

* *Building of the British Isles*, Ed. i', p. 291. (1892.)

† See *Geology of London (Mem. Geol. Survey)*, vol. ii, p. 225.

gracilis in the beginning of the passage to the Chalk Rock." Mr. Hill has kindly re-examined his slide of this Chalk and tells me that it is probably from the very highest part of Middle Chalk, and possibly only just below the base of the *Holaster planus*-zone as defined by us on pp. 138 and 139 of the "Memoir on Cretaceous Rocks." Hence the base of the Upper Chalk may be as low as 480 ft., and as the top of it was found at $241\frac{1}{2}$ ft. the thickness of this division may be $238\frac{1}{2}$ ft. Even so, however, it remains very thin if we are to suppose that it includes even a small part of the *Marsupites*-zone.

In this connection it is noteworthy that the highest $8\frac{1}{2}$ ft. are described as consisting of "flints with little chalk," below which are 11 ft. of "soft white chalk without flints," and then chalk with frequent layers of flints. It seems to me very likely that the highest $8\frac{1}{2}$ ft. really consisted of soft chalk with a few flints, the chalk being so soft and rotten from the water percolating into it from the overlying sands that it went to pieces under the boring tool, which only brought up the flints. It is possible, therefore, that this $8\frac{1}{2}$ ft. represents much more than that thickness of chalk, and that the boring traversed 28 to 30 ft. of the *Urtacrinus* band before entering the zone of *M. cor-anguinum*, but if so the latter cannot have more than half its usual development, for the zones of *Holaster planus* and *M. cor-testudinarius* combined are not likely to be less than 100 ft. thick, and this will leave only 119 ft. for the zone of *M. cor-anguinum*. If, however, the *Marsupites*-zone does not come in under Streatham there will be at least a thickness of 138 ft. assignable to that zone.

Let us next consider the boring at Purley for the East Surrey Waterworks, as recorded by Mr. Whitaker,* and the estimate of thickness which Mr. Young has attempted to make therefrom. Unfortunately Mr. Young's particulars of the boring are not quite correct, and his total is too small. The account published by Mr. Whitaker puts the base of the Chalk at 479 ft. from the surface, and gives the surface level at 215 above O.D. The highest point of Russell Hill to the N.N.W. is 361 ft., so that the difference is 146 ft., which, added to the depth at Purley, makes a total of 625 ft. But there is a distance of half-a-mile between the site of the boring and the top of Russell Hill, and a certain thickness of Chalk must be brought in here by the northerly dip. If we take the dip as only 1 deg. this will bring in 17 ft. in 1,000, and consequently about 44 ft. in half-a-mile. This, added to the 625, gives 669 ft., and even this does not take us to the very top of the Chalk, for Russell Hill is not capped by Thanet Beds, though its summit is probably very few feet below the plane of their base.

* "Some Surrey Wells" (fourth paper), *Croydon Nat. Hist. and Sci. Soc. Trans.*, p. 71 (1905).

We can hardly be far wrong, however, in taking the full thickness of Chalk below Russell Hill as about 670 ft., and as this is more than the total at Streatham or than the average thickness under London, this evidence favours the view that the thickness along the outcrop of the Chalk is greater than it is under the Eocene to the north. The difference however is not sufficient to explain the presence of the *Marsupites*-zone; allowing 380 ft. for the Lower and Middle Chalk the thickness left for the Upper Chalk will be 290 ft., but of this 40 or 50 ft. must belong to the *Marsupites*-zone and if 100 ft. is assigned to the lower zones, there is left only from 140 to 150 ft. for that of *M. cor-anguinum*.

There might of course be a fault between Russell Hill and the Purley boring with a down-throw to the north of about 100 ft., but this would be making a great assumption, without any evidence to support it. It seems much more probable that some part of the Upper Chalk is unusually thin in Surrey, and since both of the zones of *Holaster planus* and *M. cor-testudinarium* seem to be well developed, it must be the zone of *M. cor-anguinum* which is here so much thinner than usual.

A thickness of 150 ft. is small when compared with the known thickness of this zone elsewhere. Thus on the Kentish coast it is estimated to be 250 ft. thick; in Sussex it has been measured and found to be 242 ft.; near Chatham it must be at least 200 ft., and in South Wilts it is estimated at 240 ft. Moreover at East Horsley, in the very centre of Surrey, a boring made in 1886 proved no less than 817 ft. of chalk,* which seems to give room for a normal thickness of the *M. cor-anguinum*-zone.

Unfortunately the record of the boring at East Horsley does not give sufficient details of the Chalk to enable us to fix the thickness of the Upper and Middle divisions from the account given, for the passage from the one division to the other must occur somewhere in a thickness of 159 ft. which is lumped together as "very hard Chalk." It seems clear, however, that the thickness of the Lower Chalk is 174 ft., and we shall not be far wrong if we put the thickness of the Middle Chalk at 200 ft., and in this way we get a remainder of 443 ft. for the Upper Chalk. Now if we assign (as before) 100 ft. of this to the zones of *Holaster planus* and *M. cor-testudinarium*, and allow 100 ft. at the top for the zone of *Marsupites*, there is 243 ft. left for the zone of *M. cor-anguinum*.

It seems, therefore, nearly certain that whatever may be the cause of the small thickness of Upper Chalk in Eastern Surrey it has ceased to prevail at East Horsley. If, therefore, the real thickness of the zone of *M. cor-anguinum* is only about 150 ft. at Croydon and Purley it has thickened again to its normal amount at Horsley. In other words the tract over which it becomes so

* See "Some Surrey Wells," by W. Whitaker, *Trans. Croydon Micr. and Sci. Soc.* (1894), p. 137.

thin lies between Horsley and Dartford, a distance of about 30 miles. Any further information about the thickness of the *M. cor-anguinum* Chalk within this area will be useful and interesting, especially with regard to the plane of division between it and the zone of *Marsupites*. There may have been some contemporaneous erosion, such as seems to have occurred at Taplow.

In conclusion it must be clearly understood that the view which is advocated above is merely a surmise, put forward to explain the presence of the zone of *Marsupites*, and adopted solely because it accounts for all the facts without introducing any other difficulty or assumption into the problem.