

PROCEEDINGS
OF
THE GEOLOGICAL SOCIETY.

POSTPONED PAPERS.

*On the AGE of some SANDS and IRON-SANDSTONES on the NORTH
DOWNS.* By JOSEPH PRESTWICH, Esq., F.R.S., Treas. G.S., &c.
With a Note on the FOSSILS; by S. V. WOOD, Esq., F.G.S.

[Read January 21, 1857*.]

THE lower and central tracts of the valley of the Thames, from Reading to the sea, consist of Eocene strata, with a limited covering of Crag on the sea-board of Essex and Suffolk. This mass of Tertiaries is skirted on the south of the Thames by a belt of chalk, which rises by a gradual and continuous slope, broken by numerous small transverse valleys, until it attains an average height of from 500 to 600 feet: it is then abruptly escarped, forming a cliff-like declivity stretching east and west, and at the base of which extend the Lower Cretaceous and Wealden series. This elevated chalk-tract is about ten miles broad at Dover and Canterbury, and ranges westward, with a variable width of six or eight miles, to Guildford, where it contracts to a narrow ridge not half a mile broad. These Downs form a distinct and marked division between the Tertiary strata of the synclinal Thames Valley, and the anticlinal dome-plain of the Weald: they exhibit throughout a chalk-surface, either quite bare or covered on the hill-tops by a thin capping of reddish clay, sand, and flints, with, here and there, an outlier of the Lower Tertiary strata rising above the general level of the chalk-plateau, and forming slightly detached and more conspicuous hills. These outliers are continued at a few places to the very edge of the chalk-escarpment.

Besides the more general drift, and the few local Tertiary outliers, there are, however, scattered commonly on the very summit of the North Downs, from Folkestone to Dorking, a few masses of sand, with subordinate gravel- and ironstone-bands, but generally so much disturbed and so mixed up with the drift, that they appear, and have

* For the other communications read at this Evening Meeting, see Quart. Journ. Geol. Soc. vol. xiii. p. 212.

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usually been taken, to form part of it*. They are to be seen on the Chalk Downs above Merstham; I had met with them on the chalk-escarpment near Otford in Kent, at Vigo Hill, again at places near Maidstone, and thence, in increasing importance, to the Downs above Folkestone. At the latter place, on the top of the hill on the Dover road, some of the best sections (small though they are) of these strata are exposed. I have not been able to trace the width of the deposit for more than a mile or two. It seems confined to the higher grounds.

It is the consideration of the age and geological position of these sands and iron-sandstones that forms the subject of the present inquiry. The sands are usually of a light buff-yellow or ochreous colour, though occasionally greenish, siliceous, but mixed with more or less clay commonly red, passing in places into small quartzose grits, and generally containing subordinate seams and bands of coarse iron-sandstone, ironstone-grit, and some flint-pebbles. The whole is very irregular in its mode of occurrence, reposing upon a much-worn surface of the chalk, ordinarily without any distinct stratification, or rather the stratification is obliterated, the seams of ironstone being almost invariably broken and fragmentary. There is, however, in all the larger outliers a certain amount of regularity, a certain uniformity of composition, and a distinctiveness of character, which, notwithstanding their rubby condition, led me to believe that they formed part of some sedimentary deposit *in situ*, and that they were not drift-beds. I was nevertheless unable, in the absence of superposition and of fossils, to come to any satisfactory conclusion with regard to their age; I had, however, satisfied myself that the ironstones at least were not drifted from the Lower Greensand, for on the chalk-hill above Merstham I had found a few blocks of this ironstone† full of *chalk-flint*-pebbles together with some unrolled flints, and again on the Folkestone chalk-cliffs. They are therefore newer than the Chalk. The question then arose, to which of the Tertiary strata these ironstones belonged; and as in East Kent there is found, under the London Clay, a bed of light-yellow siliceous sand, with a subordinate bed of

* It has even been a question whether the fragments of iron-sandstone belonging to these beds have not been drifted from the Lower Greensand of the Wealden area. Such ironstone-fragments, or "clinkers," as they are sometimes called, are often found in abundance in the drift-gravel of the transverse valleys of the Chalk Downs and in the Thames Valley. These I believe to be derived from the sands and ironstones of the North Downs, although in mineral character they are difficult to distinguish from the ironstones of the Lower Greensand. At the same time, I would by no means say that all the ironstone-fragments of the Thames-valley drift were derived from the North Downs. In the neighbourhood of Farnham they can in fact be distinctly traced from the Lower Greensand through the valley of the Wey into the Tertiary area; again through the gorge of the Stour, of the Medway, from the Wealden area to the lower levels of the Tertiary area. But I doubt whether the abundant flint- and ironstone-gravel of the deep lateral vales which do not traverse the downs, but commence at or near their summit-ridge, and open into the Tertiary area only, be not local and derived from the adjacent chalk and the superincumbent ferruginous sands, and that they are not transported from the Wealden area.

† There apparently mixed with the drift; but no section is exposed.

coarse and occasionally pebbly iron-sandstone, in some places fossiliferous, at other places without fossils, and often closely resembling in mineral character the ironstones on the Downs, it seemed at first sight most natural to suppose those blocks might be remnants of these beds mixed with the drift.

It might also be a question whether the loamy sands and ironstone were not portions of the Lower Tertiaries *in situ*, but modified in structure and character in consequence of their being nearer the shore of the Old Tertiary sea than the main mass between Faversham and Canterbury. But against this view I found that in all the outliers of Lower Tertiary strata, dotted at intervals over the North Downs even to the very edge of the escarpment, the sands and associated beds retain their clear, undisturbed, more uniform and fresh appearance, and general lighter colour, exhibiting in these isolated masses an exact counterpart in their structure and aspect to the same beds in the central Tertiary mass of the Thames Valley*. I further found that the loamy sands and ironstones formed outliers, often lower, or on a level with those of the Lower Tertiary strata, between which they seem to run as shown in the following section :—

Fig. 1.—General Section from the Valley of the Medway to the Valley of the Darent, parallel with and near to the edge of the Chalk Escarpment.

Shoreham.

Lower Halling.



a-f, Loamy yellow sands. *i*, Lower Tertiary sands and pebble-beds. *m*, Chalk.

Above Otford and at Vigo Hill†, the beds consist of fine argillaceous buff-yellow sand. There is a much better exhibition of them at the hamlet of Paddlesworth, about four miles W.N.W. from Folkestone, on the very summit of the Chalk Downs, and at a height of probably about 600 feet above the sea. They there form a slightly detached hill, and consist of 30 to 40 feet of ochreous and ferruginous sands, more or less argillaceous, with subordinate fine quartzose grits and broken beds and seams of iron-sandstone,—some of these forming blocks of 3 to 4 feet wide by 1 foot thick, or even more. These blocks, which are common in and about the hamlet, sometimes contain flint-pebbles and unrolled flints. The fields in the neighbourhood are strewn over with fragments of ironstone, and in a few of these I found on one occasion some pieces of fossil wood pierced by the *Teredo*, together with that which appeared to be the cast of a bivalve shell. Yet on the neighbouring shore at Folkestone, which is covered at

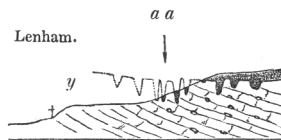
* The Tertiary sands also never present in Kent or Surrey the variable coarse quartzose grits and loamy sands prevailing in the Vigo and Folkestone-hill beds; whilst the flints found in the former are always much more worn.

† Ten years since, a good section of these sands was exposed here, but on a recent visit I found only one small opening preserved in a sand-pipe on the side of the lane descending the escarpment.

places with blocks fallen from the top of the cliff, and presenting therefore very favourable opportunities for examination, I have not found a single fossil.

The question was in this state, when, in the month of December 1854, Mr. Rupert Jones wrote to me from Charing (near Ashford in Kent), to communicate an interesting fact which he and Mr. Harris had noticed in that neighbourhood. He therein stated,—“The sand-pipes along these hills (from Harrietsham to Charing) abound with fragments of the ferruginous rock of the ‘basement-bed’ (of the London Clay). This is often a conglomerate, and I recognize the pebbles of this conglomerate as being frequent in the ‘pipes.’ I observe that it abounds with casts of *Pecten*, *Pectunculus*, *Calyptrea*, &c., but there are none of *Melania* and *Cerithium*. We find this iron-rock dispersed among the chalk-flints in the ‘pipes,’ and also sometimes in the sand-cores of the pipes. There are some large ironstone-fragments in which fossils are absent, but, as other pieces retain but faint traces sometimes, I think that all the pieces may be from the basement-bed.” This letter was followed by a considerable collection of the specimens alluded to. In some of the pieces of ironstone the fossils were extremely numerous, but they were all in the state of casts and impressions of species difficult to determine, and of genera common in great part to the Lower Tertiaries; and as they in fact looked a good deal like the fossiliferous ironstone of the sands under the London Clay at Boughton, near Faversham, my first impression was rather in favour of such a conclusion. Still there were some fossils which did not belong to that period—there were *Lunulites*, a large *Terebratula*, a species of *Emarginula*, and some peculiar spines of *Echini*, such as I had never met with in our Lower Tertiary strata; not being able, however, to form a decided opinion on the subject or to obtain one from any palæontologist to whom I showed the specimens, I put them on one side waiting further evidence. It was not until Nov. 1855 that I had an opportunity of visiting the spot, and I found Mr. Jones’s report quite correct as to these masses of ironstone being in detached blocks in sand-pipes, and mixed up with sandy gravel, clay, and flints. The following is a general section of the hill* :—

Fig. 2.—Section of Lenham Hill, Kent.



The dotted line, *y*, shows the probable extension of the fossiliferous beds, on the surface of the Chalk, over the hill, and their former extension in the direction of the Weald.

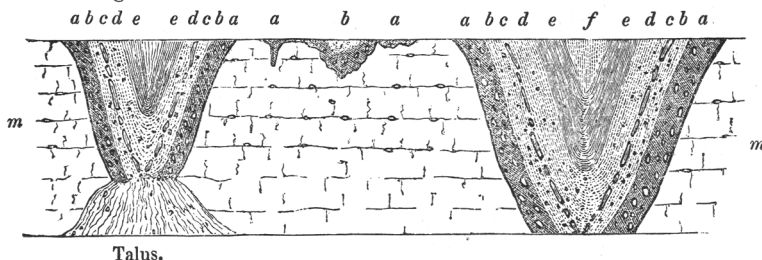
The blocks of ironstone are found irregularly mixed with sand and gravel in the core of the pipes *a, a*, the sides of which are lined

* This section is now much obscured.

with unrolled chalk-flints imbedded in a brown and ferruginous clay. To find similar fossiliferous blocks *in situ*, I re-examined the district between this ridge and the Thames, but without success. I found, however, at another chalk-pit between Lenham Hill and Harriets-ham Hill, and distant seven-eighths of a mile W.N.W. from the Lenham pit, some larger sand- and gravel-pipes, in which the more defined structure led me to conclude that the sand- and iron-stone of these pipes were not portions of drift, but were part of a deposit which once spread in regular beds over these hills, and a portion of which had been let down as it were into these pipes, by the gradual dissolution of the chalk at these spots, in the way I have described in a former paper*.

When a subsequent denudation removed the mass of the deposit from that area, these fragmentary portions of the sands and ironstones were protected by their position in the chalk, and remain as evidence of its former wider extension. The Harrietsham pit shows the following interesting section:—

Fig. 3.—Section on the Hill above Harrietsham, Kent.



f, e, Fine light-red and yellow sands, in parts very argillaceous.
d-b, Greenish sand, more or less argillaceous, with a subordinate bed or seam of ironstone concretions (*c*). In places *c* reposes directly on *a*.
a, Unrolled chalk-flints in brown and black clay. *m*, Chalk.

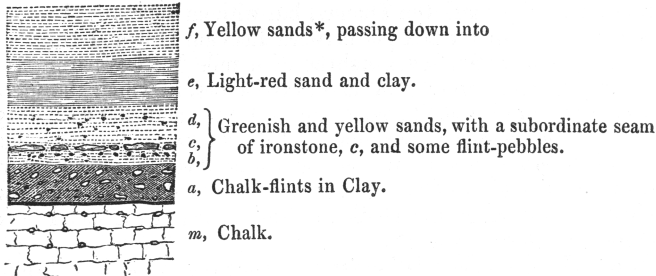
I found only a few traces of fossils† in this pit, except some doubtful vegetable or spongiform casts on the surface of the iron-stone, of the size of fingers, ramified and entirely covering some blocks. Flint-pebbles and a few very small quartz-pebbles occur in the beds *b-d*, and are often encased in the ironstone, which also sometimes contains unrolled flints, as in bed *a*. Now, as these pipes are cylindrical, and as each core of sand is symmetrical, with its several layers following a like order of succession, and retaining a nearly uniform thickness; and further, as the ironstone-band holds in each pipe the same relative position, its separate fragments pitching downwards with the curve assumed by the sand, it is to be inferred that these are let-down portions of strata, of which the original structure was horizontal and formed as in fig. 4.

* Quart. Journ. Geol. Soc. vol. xi. p. 64.

† The cast of a *Cardium* has since been found in the ironstone here.

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Fig. 4.—Diagram-section of the Ironsands in their original horizontal position.



Apart from the great scarcity of shell-impressions, the ironstones in this pit are precisely similar to those in the Lenham pit; and it is to be observed that there also only portions of the ironstone contain fossils. Amongst the fossils sent me by Mr. Jones was a specimen of a large *Terebratula*; and, when afterwards at Lenham, I was fortunate enough to discover another tolerably perfect cast, and it suddenly struck me, from this and other fossils, that it might be the large Crag species, both from its size and general appearance, and from the absence of any species of that magnitude in our Eocene series. On hastening to compare it with the figures in Mr. Davidson's Monograph, I found that it bore the closest resemblance in figure and size to the *T. grandis*. I again examined the other fossils, but, with the exception of the impression of a *Scalaria*, which resembled the *S. subulata*, I could obtain no satisfactory result. In the summer of 1856 I made another visit to Lenham, and found, in addition to former species, a large *Mya*-shaped shell†, also different to any of the Lower Tertiary fossils with which I was acquainted, and reminding me of a Crag species. On mentioning these facts to Mr. Searles Wood, he kindly undertook to examine the specimens, and has favoured me with the appended report (see p. 333).

I must confess to hold a stronger opinion on the subject than Mr. Wood, for there are collateral circumstances which greatly strengthen my belief of these beds belonging to the Crag, little as I was prepared to meet with the Crag at such an elevation and such a distance from the main mass. In the first place, I know of no Eocene strata in the London Tertiary area quite like this deposit in its lithological structure. Secondly, no London Clay or Lower Tertiary strata contain any *Terebratula* that can be compared to the *T. grandis*, or a *Lutreria* like the specimen from Lenham; whilst no *Echini* with club-shaped spines, nor *Emarginulæ*, *Maclæ*, nor *Nassæ* have hitherto been met with in the London Clay, or in the beds of sand beneath it; again, *Bryozoa*, which are common at Lenham, are

* These appear in other places to pass upwards into loamy yellow sands with subordinate seams of ironstone and some irregular beds of clay. Some slightly mottled clays above Otford appear to me to belong to this group, although much resembling the mottled clay of the Reading series. It is a question also whether a few sandstone-blocks are not occasionally concreted in these sands.

† Probably the *Lutreria elliptica*.

exceedingly scarce in the London Tertiaries. Thirdly, the structure of the Lower Tertiary sands is much more regular and uniform, and they are not, like these beds, broken up and disturbed in a way which seems to have arisen from the irregularity of the bed of the underlying chalk, both prior to their formation and by an increase in that irregularity at a subsequent period by the action of water wearing pipes. And fourthly, because I find similar beds on the chalk-downs on the opposite side of the Channel, between Calais and Boulogne; and thence, passing across the plain of French Flanders, we again meet with analogous strata,—though more important and with more ironstone,—on the top of Cassell Hill, 515 feet above the sea, and *overlying the Calcaire grossier series*. No fossils are found there; but M. Dumont and Sir C. Lyell refer those beds to the Diestian Sands, which they class with our Crag; for M. Dumont had found near Louvain these same sands overlying the Limburg and Bolderburg strata and containing impressions of shells, of which the following species are mentioned by Sir C. Lyell:—*Terebratula grandis*, *Solen Ensis*, and *Syndosmya prismatica*; and 13 genera, of which the species could not be determined, are enumerated*.

From the apparent identity of the more important outliers of yellow sands, loams, and iron-sandstones at various places on the North Downs, with the small isolated fragmentary beds at Lenham and Harrietsham, and from the circumstance that, when even such outliers† are wanting, it is common, nevertheless, to find portions of similar sands and pebbles in the core of the pipes dotted over the high chalk-surface, thus showing the former wide extension of the beds, I conclude that they all belong to the same series, and also that they extended formerly for some distance beyond the summit of the Chalk Downs, and that they are all of the same Pliocene age. Hitherto no trace of any Crag has been found south of the Thames‡; the occurrence, therefore, of these beds in Kent, not only so far from the main mass, but also at altitudes so far exceeding any which it attains in Suffolk and Essex, is a matter of considerable interest,—an interest further increased by the circumstance that it gives us a still nearer date whereby to limit the denudation of the Weald; whilst, from this rise in their level, and the fact of their stretching thus far inland, it is probable that they may formerly have ranged over the Wealden area, and even have been connected with the beds of that age in Normandy and Brittany§.

* Quart. Journ. Geol. Soc. vol. viii. p. 295.

† The ironstones which form a marked feature in Belgium and East Kent seem further westward to be of merely local occurrence.

‡ My friend Mr. John Brown, of Stanway, considers some sands at Chislet, between Canterbury and the Reculvers, to belong to the Crag. I cannot agree with him, as I believe them to be identical with the beds *beneath the London Clay* at Herne Bay; but I mention the fact in order to direct the attention of others to the point in dispute, and to state that, in case Mr. Brown's view should prove correct, his observations at Chislet should have the priority over mine at Paddlesworth and Lenham. Amongst the fossils which he has collected in that locality there are some which he considers to be Crag species, whilst others are distinctly Eocene, such as the *Cyprina Morrisii*, and others.

§ It furnishes us also with an important clue to the age of some of the drift-beds on the south of the Thames.

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From the greater prevalence of some of the more abundant Coralline Crag forms, I should feel inclined to place these beds in that group rather than in the Red Crag. Thus the *Scalaria subulata*, *Astarte pygmæa*, and *Mactra triangulata*, as also the genera *Pyrula* and *Avicula*, are peculiar to the Coralline Crag; the *Terebratula grandis*, *Astarte Omalii*, and *Tellina donacina* are also more particularly abundant in this portion of the Crag, the former shell attaining a larger size than in the Red Crag; and of the genera *Lucina*, *Kellia*, and *Lepton* there are a considerably greater number of species in the Coralline than in the Red Crag. On the other hand, the *Leda myalis* and *Astarte compressa* are said to occur only in the latter division; but the former is a very doubtful specimen. The remaining species and genera are of about equal value with regard to either division. Still the number of species at all recognizable are so few, that the palæontological argument must be received with reserve.

There are, however, some other points which tend to confirm in some measure this synchronism,—points of physical structure and geographical distribution. Thus, with regard to the latter point, one main feature of the Coralline Crag contrasting with the Red Crag is, that the former contains a considerably larger proportion of species of southern, and the latter of northern affinities*. So in these Lenham beds, the geographical distribution of the 11 recent and 5 extinct species in Mr. Wood's list (p. 334) shows a certain preponderance of southern forms. The following Table exhibits this distribution:—

	Coralline Crag.	Red Crag.	Faluns of Touraine.	Subapennine fossils.	Recent, Mediterranean.	Recent, British Seas.	Recent, Northern Seas.
1. <i>Dentalium costatum</i> .....	*	*	...	...	*?
2. <i>Emarginula reticulata</i> .....	*	*	*	...	...	*
3. <i>Nassa prismatica</i>	*	*	*	...	*		
4. <i>Scalaria subulata</i>	*						
5. <i>Arca lactea</i>	*	*	*?	*	*	*	
6. <i>Astarte digitaria</i> .....	*	*	...	...	...
7. — <i>compressa</i> .....	...	*	...	...	...	*	*
8. — <i>Omalii</i>	*	*					
9. — <i>pygmæa</i>	*	...	*?				
10. <i>Cytherea rudis</i> .....	*	*	...	...	*
11. <i>Leda myalis</i> .....	...	*	...	...	...	...	*
12. <i>Modiola modiolus</i> .....	*	*	...	...	*	*	*
13. <i>Mactra triangulata</i>	*						
14. <i>Nucula nucleus</i>	*	*	...	*	*	*	*
15. <i>Tellina donacina</i> .....	*	...	...	*	*	*	*
16. <i>Terebratula grandis</i>	*	*	*				
	14	12	5	3	8	6	5

* See Mr. S. Wood's Monograph, published by the Palæontographical Society, for much valuable information on this subject.

It thus seems that, with the exception of three extinct species (4, 8, and 13) which are local, and two (7 and 11) recent northern species, the remaining eleven have or have had a southern range,—three as far as Central France, and eight as far as the Mediterranean. The other genera also as a group exhibit more southern than northern affinities.

The connection, before suggested, of an extension of this older Crag eastward and southward over our chalk-downs would account for the introduction of the several more southern forms of Molluscs*. There are even circumstances connected with this inquiry which render it possible that these Lenham beds may be a stage older than the Coralline Crag; for a considerable number of the fossils, so far as such imperfect specimens will allow us to judge, do not apparently belong to either the Coralline or the Red Crag; and are either new species or may be found to agree with some of the older Pliocene, or Upper Miocene, species of France. This can only be determined when we are in possession of better and more specimens, or discover some fresh fossiliferous localities.

I have shown on a former occasion, that the axis of the Weald was probably one of elevation at the commencement of the Cretaceous period,—further, that at the commencement of the Tertiary period the chalk had been so planed down around the Weald, that there could be little doubt that in the centre of the then Wealden area, the Upper and Lower Greensands were exposed, and that their *débris* contributed towards the formation of the Lower London Tertiary beds. Now, again, at this early Crag period it would appear that these Lower Tertiaries, together with the London Clay, which had during a period of subsidence partly, if not entirely, covered up the old Wealden island, were also largely denuded, and that the Crag was deposited in depressions between the remaining outliers of the Tertiary strata, resting in places upon the again bared surface of the Chalk. At the same time it is evident, from the lithological structure of these presumed Crag beds, that they must have derived their origin, not only from the *débris* of the Tertiary strata, but more from that of the Lower Greensand and adjacent strata, for the chief materials of the Lenham and Paddlesworth beds are yellow and ochreous sands more or less mixed with yellow and red clay, quartzose grits, small quartz-pebbles, and green sand—all common and prevailing constituent parts of the Lower Cretaceous series of Kent. Added to this, the prevalence of iron, derived probably from the Lower Greensand, and again concreting a portion of the Crag sands derived from the same older strata†—and giving therefore to this newer iron-sandstone a like appearance to the older,—and of flints derived from the chalk, leads me to believe that another island existed in the Wealden area at the commencement of the Crag period, and that the

* Not that that communication was uninterrupted; it was broken by an old Wealden island.

† Still from the Tertiary strata in part, as the Crag sands often contain the common Lower Tertiary flint-pebbles,—generally scattered, but sometimes in thin seams, and in masses,—together with certain white flint-pebbles.

surface of that island was formed of a larger tract of Lower Greensand and Chalk (with Tertiary cappings) than was exposed in the former island, and that the detritus from this island, worn down by coast- and river-action, contributed the chief supply in forming the encircling deposit of Crag*.

The great denudation of the Weald is thus brought to a still more recent date than this period, these Crag beds extending to the very edge of the chalk-escarpment and having been truncated by the same action that wore down that escarpment. I have previously shown that this operation had taken place at a comparatively recent period, as some beds of drift were cut off in the same way; but I was unable then to assign a date to that drift, some of which now appears however to be older than this Crag. We may conclude, therefore, that the final denudation of the Weald took place subsequently to the Crag period. At the same time, as, in the Suffolk area, a great break takes place between the Coralline and Red Crag, the lower one being a deposit formed in tranquil waters, whereas the Red Crag contains *débris* worn and broken from other beds, and reposes upon a strongly abraded and indented surface of the Coralline Crag, it seems not improbable that another elevation of the Wealden area took place between the Coralline Crag and Red Crag periods, whereby the boundaries of the island† before referred to were so extended as to form a continuous barrier between the French and English Crag areas at or soon after the Red Crag period. This would be in harmony with the fact so often noticed, that at the period of the Red Crag we first find northern shells prevailing to an extent that leads us to believe that the sea of that Crag period was open to and connected with the northern seas, and would show how the communication which at the period of the Coralline Crag existed with more southern seas was then cut off and ceased.

Note.—Since the above paper was read I have again visited all the localities named therein, but without finding any better sections. It is evident that it is on the chalk-downs between Folkestone and Wye that these beds are best developed, and I would especially direct attention to Paddlesworth and to the neighbourhood of Kingmill Down, as well as to the hills above Otford and thence to Vigo Hill. A considerable number of fresh specimens have been obtained from

* On the chalk-hills between Upper Gatton and Great Shabden, and about a mile and a quarter in a direct line N.N.W. from Merstham, there is an outlier of light yellow sand, a small section of which may be seen in a pit in the fir-wood on the east of the road. This sand differs in several respects from the Lower Tertiary sands, and yet is not like any of the presumed Crag beds we have described. Its base is not shown, and only a patch of gravel overlies it, nor could I find any fossils. I am nevertheless inclined to place it with the Lenham group, for it is coarser and not so worn as the Lower Tertiary sands; it contains also a few thin flakes of ironstone, some flint-pebbles (white and not so well worn as the Eocene pebbles), bits of unrolled flints, also some patches of quartzose grit, and a few rare and small fragments apparently of the chert and ragstone of the Lower Greensand. A deeper excavation might possibly expose some of the ironstone-bands and conglomerates, blocks of which are so common at Aldersted Farm on the other side of the valley along which the Brighton road passes.

† Bringing that island into connexion with the continental area.

Lenham, some of which (as well as the beds themselves) have been considered to have a very Eocene look; but I see no cause to alter my opinion, although I admit that it will be very desirable to have that opinion strengthened by better and more positive specimens. I can, however, now add (with doubt) to my former list, *Lutraria elliptica*, *Tapes perovalis*, *Pectunculus glycimieris*, *Leda lanceolata*, *Cardium edule*, *Cytherea rudis*, *Pecten Brueri*, *Nucula depressa*, Nyst, *Crassatella concentrica*, Duj. (?), *Balanus bisulcatus*, and species of *Phorus*, *Donax*, *Venus*, *Ostrea*, and *Thracia*. I must however mention that Mr. Harris has found on the hills above Charing some blocks of ironstone, which, amongst several undetermined fossils, contain a *Ditrupe* much like the *D. plana* of the London Clay. These may possibly be really blocks from the Lower Tertiary sands which we know often extend in outliers to the edges of the escarpment, and which blocks may have remained when the sands were removed; or they may have been drifted here. The Crag sands are generally so thin, have been so extensively denuded, and are so mixed up in most places with the ordinary drift, which extends so widely over the Chalk Downs, that it is often most difficult to define their extent or even constantly to determine their presence.

Mr. Harris has also been indefatigably at work in tracing the extent of these sands and ironstones above Charing; and we are indebted to him for having had in November last a trench made at Down Wood to a depth of 29 feet, but without, I regret to say, throwing any fresh light on the position of the fossiliferous ironstone. The section was filled up when I was there in February, but from Mr. Harris's description I should infer that it consisted chiefly, if not entirely, of drift. No fossils were found. The following section has been kindly furnished by Mr. Harris:—

Trench in Down Wood, on Charing Hill, about 1½ mile N.E. of Charing, Kent; 15 feet long, 4 feet wide, and 28 feet deep.

	ft.	in.
1. Surface-earth*, small fragments of flint	1	6
2. Reddish sandy loam, sometimes dark-brown, occasionally yellowish, with very few flints and an occasional pebble in its upper half, and with some few flints in its lower portion...	25	6
2a. Traversing the loam, No. 2, from north to south, is a "run" of whitish loam, with a sectional area of 8 feet square, containing towards its base a few large chalk-flints and some irregularly dispersed masses of unworn flints cemented together with sand and iron matter.		
3. Brownish clay and large chalk-flints, some of them greenish..	2	0
4. Chalk-flints, with white coating, supposed to be lying on the chalk†.		

At a distance of a quarter of a mile west of the section above described, another smaller trench was subsequently opened under Mr. Harris's direction; and at the depth of six feet was "found a con-

* The surface of this "grubbed" or displanted woodland is strewed with slags and fragments of ironstone both with and without fossils.

† From the wells or holes dug for getting at the chalk in the vicinity, it is seen that the surface of the chalk is very irregular.

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tinuous stratum of fossiliferous iron-sandstone reposing on a bed of very large chalk-flints, externally stained with iron, and a few pieces of iron-sandstone. The sandstone was from 4 to 6 inches in thickness." Mr. Harris considers, that, owing to the rise of the surface from the first to the second section, the sandstone of the latter, if continued eastward, would come out at the surface where the first trench was dug. The beds in the second section, which seem to me to be more like beds *in situ*, would, I think, be cut off before reaching the first section, if I am right in considering the beds there to be drift-beds.

In a chalk-hole in the field west of Warren Street, and now just filled up, I found this small section remaining, of strata which are *in situ* :—

	ft.	in.
Yellow sand	1	0
Mixed red clay and yellow sand.....	3	0
Seam of compact ironstone, with traces of fossils.....	0	2
Layer of small flint-pebbles	0	6
Brown sand and clay	1	0

Mr. S. V. Wood's *Remarks on the Fossils from Lenham*.—"Mr. Prestwich has submitted to my examination a series of fossils, on account of their bearing a general aspect to those of the Crag. They consist of casts of shells in sandstone, &c., displaying sometimes the sculpture of the exterior, though oftener the shape only of the interior of the shell; and the majority of the specimens belong to the bivalve division of the Mollusca.

"The cast of a shell is at all times a very unsatisfactory dependence for specific identification; and, unless the same species be exhibited in a bivalve, for example, with the sculpture of the exterior well displayed, while another specimen will equally show the characters of the interior with hinge or dental apparatus, no safe reliance can be placed for a perfect identity with any species; neither is a univalve, if the aperture (upon which the generic character is sometimes dependent) be not also in a perfect condition. In the present case, I am afraid the most that can be said is, that there is a stronger resemblance in these fossils to the shells of the Crag than to those of any other formation, and what may also perhaps assist in the assignment is the apparent absence of any *decided* species exclusively belonging to the Older Tertiaries. There are, however, amongst them two or three forms somewhat resembling species belonging to the Paris Basin, though in these instances there is by no means an identification with any Older Tertiary shell known to me; still, if it be asked whether a perfect reliance can be placed upon any specimens as truly characteristic of the Crag period, I fear an answer must be given in the negative, although the general aspect of the fossils is certainly favourable to the assumption that they belonged to the Upper rather than to the Lower Tertiaries; and, as the locality whence they were obtained is very remote, it is possible the two or three strangers may have existed at the same time with our long- and well-known Crag species; and, if they cannot be identified with any of the Older Tertiaries, which I

am unable to do, they will not materially interfere with our determination, and their lithological character will remove all doubt as to the possibility of their being derivative fossils.

"The accompanying list contains the names of those species to which they bear a very close resemblance. I give them as approximations only; and, although there is not one which without a doubt could be satisfactorily determined, I still think that, taken collectively, they are such as to justify a probable assignment to one of the Crag periods, and they appear to have been inhabitants principally of the Coralline zone. In reviewing this list it will be observed that there is a large preponderance of bivalves, and many of the individual specimens belong to the genera *Nucula*, *Leda*, and *Arca*, with a hinge characterized by a linear series of teeth or denticulations, and of a magnitude approaching what may be called an Arctic Fauna, accompanied with several species of *Astarte*, &c., generally considered also of a Boreal character; and these might perhaps incline us to assign the deposit to the age of the Red Crag:—

Cliona.	Astarte Omalii ?
Lunulites. Coronula (?). Balanus(?).	— compressa ?
Diadema ? (species of).	Cythera rudis ?
Terebratula grandis ?	Venus ?
Pecten avicula ?	Tellina donacina ? or Donax.
Modiola modiolus ?	Mactra triangulata ?
Arca lactea ?	Anatina.
Leda myalis ?	Panopæa ?
Nucula nucleus ?	Dentalium costatum ?
Cardium (with spines).	Emarginula reticulata ?
Cardita.	Trochus.
Lucina or Diplodonta.	Natica.
Kellia or Lepton.	Rissoa ?
Isocardia.	Scalaria subulata ?
Astarte digitaria ?	Nassa prismatica ?
— pygmæa ?	Pyrula;

with a few others I have not been able to determine*.

"There is, however, in the Coralline Crag somewhat of an anomalous collection of shells, many of which are peculiar to the Arctic seas of the present day, while some of their associates are found only in the Mediterranean or the South of Britain; and, although there are amongst Mr. Prestwich's fossils many which resemble Red Crag species, there is not one, with the exception of *Leda myalis* (and this is but a doubtful identification, as I have not been able to see the exterior), that might not also be considered as belonging to the Coralline Crag. I believe they may with more propriety be considered as the equivalent of the Older Crag, more especially as there is one specimen which has every appearance of being the cast of a true *Pyrula*; and, although this genus has also been procured from the Red Crag, I believe the specimens so found to be derivative fossils, and not to have belonged to that period. In looking at the list of genera, it will not, I fear, afford much assistance in the determination, as the

* Mr. Searles Wood has since added, with a doubt, a *Phorus*, which he thinks may be related to *Trochus cumularis*, Brongn., and *Pectunculus glycimeris*, although the latter, he says, might be the Vicentin variety of *P. pulvinatus*. See also p. 332.

whole of them have been obtained from the Lower as well as the Upper Tertiaries; and unless any dependence could be placed upon the genus *Astarte* as somewhat characteristic of the Crag, there is not another but has yielded several species throughout the whole of the Tertiary period. There are amongst these fossils several impressions of what appear to have been the spines of a species of *Diadema*; and, although I have never met with this genus, Mr. Woodward tells me he has seen a fragment of a spine from the Coralline Crag, and it is an animal whose presence might be expected in that formation. The shell (or rather the internal cast of it) which most resembles an Eocene or Older Tertiary species is a *Nucula* with a divergent hinge much like *N. deltoidea*, and this at first sight certainly created considerable doubt as to its correct assignment; but our fossil is considerably larger than any specimen or any figure belonging to that species that I have seen, though at the same time it is very different from any Crag species.

"Should these fossils be really the remains of a Crag period, I think their resemblance is greater to the Older portion of the Upper Tertiaries than to the Red Crag; and as we have always been in the habit of considering the Red Crag a deposit formed in a sea open to the northward, with land on the south of it, the presence of the Coralline Crag Formation thus elevated into land, whence these fossils were procured, would not militate against such a supposition.

"In the above list there are 4 species, viz. *Dentalium costatum*, *Nassa prismatica*, *Astarte Omalii*, and *Terebratula grandis*, which, although found in the Red Crag, did not, I think, belong to that period, but were probably introduced into the deposit from destroyed portions of the older bed. This would give to the Coralline Crag a preponderance in number of what I have considered as identifications (or at least strong resemblances), making 14 for that formation, and only 10 for the Red Crag."

On the PALÆOZOIC BASIN of the STATE of NEW YORK.

Part I. *A Synoptical View of the Mineralogical and Fossil Characters of the Palæozoic Strata of the State of New York.* By J. J. BIGSBY, M.D., F.G.S., Late British Secretary to the Canadian Boundary Commission.

[Read November 18th, 1857.]

Introduction.—It having appeared to others as well as myself that a *résumé*, such as is contemplated by the above heading, is desirable, I have attempted the task in the following pages.

The characteristic geological points have been distributed under a few heads, and then treated with brevity or fulness according to the demands of the occasion;—the heads being those of "mineral character," "mode of transition" (among groups), "place," "position or dip," "thickness," "fossils," in general (typical), "fossils occurrent in Europe," "recurrent in New York."

My hope and intention has been to form a standard of reference