

those who do not confine their attention to one department alone, but seek to read the hieroglyphics of nature by the wonderful lights of science.

Ordinary Meeting, May 3rd, 1864.

E. Cresy, Esq., President, in the Chair.

The adjourned discussion on Mr. Mackie's paper was reopened by Mr. Mackie, who briefly recapitulated the chief points of his argument. A prolonged and interesting discussion ensued, in which many of the members joined. Remarks were also made by Professor Macdonald and other visitors.

Mr. E. Ray Lankester exhibited a fine specimen of *Pteraspis* discovered by him at Cradley, Hereford.

Ordinary Meeting, June 7th, 1864.

E. Cresy, Esq., President, in the Chair.

The following papers were read:—

No. 1.—“On the Excursion to Sevenoaks.” By Mr. C. Evans.

On Easter Tuesday, the 29th of March, the first excursion of the Association for this season was made to Sevenoaks, in Kent, for the purpose of examining the geology of the extensive railway-works now being carried on in the neighbourhood of that town by the South-Eastern Railway Company.

On arriving at the Sevenoaks Station of the London, Chatham, and Dover Railway, the party, consisting of 23 gentlemen, proceeded along the road, through the town to the escarpment of the hill at Riverhill, whence a very fine view of the valley of the Weald of Kent was obtained. The members, after descending the hill for a short distance, struck across some fields to the shafts at the south

end of the long tunnel just commenced. Advancing from this point in a north-westerly direction along the line of the railway-works, they examined in the first place the materials thrown out at the various shafts, and afterwards the open cutting at the northern end of the tunnel, some of the party extending their walk along the railway embankment and cuttings as far as Riverhead.

Having on a previous occasion given some description of these railway-works, I find that I have now very little to add with regard to the local geology of Sevenoaks to the account which I have given in my former paper. Under these circumstances I purpose on the present occasion to digress somewhat from the proper subject of this paper, and, while alluding to the principal facts which were noticed on the occasion of the excursion, to give you in addition *a general sketch* of the geology of the South-east of England derived principally from the various published works on the Cretaceous and Wealden beds, hoping thereby to excite in some of those now present sufficient interest in the subject to induce them either singly or in company again to visit this and other sections around the escarpment of the Weald, and to assist, as far as the time at their disposal will allow, in elucidating the many interesting questions with regard to these formations which yet remain unsolved.

The oldest strata that are met with at the surface of the country in the South-east of England consist of those remarkable fresh-water or fluvio-marine deposits, underlying the Cretaceous formation, which are known as the Wealden beds, since they are for the most part coextensive with, though not restricted to, the district known as the Weald of Kent, Sussex, and Surrey. The Wealden beds occupy a rudely elliptical area, a portion of which, separated from the rest by the British Channel, forms the surface of a small part of the North of France. The Wealden district is surrounded on every side by hills composed of the Cretaceous deposits. These Wealden beds are exposed at the surface of the country in consequence of a great fold or anticlinal axis, which extends through the middle of the district, by reason of which the various beds have been elevated into a curve of wide extent, and the upper members have subsequently been denuded from off the central portion of the area. A similar but smaller valley of elevation is seen in the

Isle of Wight, the central axis of which extends from Brook to Sandown Bay, and there also the Wealden beds are seen at the surface. On each side of these central axes the beds dip in opposite directions, those on the south side having an inclination to the south, and on the north side to the north. Sevenoaks being situated on the north side of the main anticlinal, the strata in that district in general dip to the north.

The Wealden beds have been subdivided into two groups. The lower of these groups, known as the Hastings Sands, consists for the most part of sand, calcareous grits, and clays, and forms the range of hills which extends in an east and west direction from Hastings to near Horsham. The upper group, the Weald Clay, consists of clays with occasional bands of limestone called Sussex, Petworth, or Bethersden Marble. It occupies the broad valley which intervenes between the central range of hills and the range composed of the Kentish Ragstone, one of the lowest members of the Cretaceous formation.

The Hastings Sand-beds are well seen in the fine cliffs in the neighbourhood of the town from which they take their name, and also in the various quarries along the inland range of the series now celebrated as having afforded to the late Dr. Mantell the remains of the *Iguanodon* and other reptiles of gigantic size.

The division of the Weald Clay is seldom well seen in Kent or Sussex, as no cliffs composed of it are met with on the coast. It forms, however, a considerable part of the cliffs in the Isle of Wight, between Atherfield and Compton Bay. This bed is the lowest worked through in the new railway-works at Sevenoaks, and the members have now a very favourable opportunity of examining the character and of collecting the fossils of this deposit.

Around the several shafts on the low ground at the foot of Riverhill the spoil-heaps show that the deposit consists of beds of blue and green clay, with a band of hard crystalline limestone, composed for the most part of the shells of freshwater univalves and bivalves (*Paludina* and *Cyrena*). The same shells are found in abundance on splitting the masses of clay, together with freshwater mussels (*Unio*), *Cyprides* in great numbers, and the scales of Fishes.

The Weald Clay is also seen around five of the shafts at the top of the hill, but in these upper beds the fossils do not appear to be so abundant. No trace is seen here of the band of marble, which has probably dipped below the level of the Tunnel. At some of these latter shafts blocks of an argillaceous limestone are brought up, some of which contain many small univalve and bivalve shells, while others show on their edges very thin bands, apparently containing many minute black grains. These black grains are the shells of a tuberculated species of *Cypris* in fine preservation, which stud the surfaces in great numbers; other species of *Cypris* are seen in the lower layers of the clay.

The Weald Clay is succeeded by the Lower Cretaceous deposits.

These latter beds, usually known as the Lower Greensand, consist of sandstones, limestones, and sands, either white, green, or ferruginous, and are succeeded by the thick bed of clay known as the Gault, which occupies the valley separating the Greensand hills from the high range of the Chalk downs. Of the Lower Greensand division of the Cretaceous formation we have three fine natural sections, namely, the one extending from Hythe to Folkestone, the one in Sandown Bay, from Redcliff to Shanklin, and the one at Atherfield and Compton Bay. Of these the one from Atherfield to Blackgang Chine is the most complete, since, on favourable occasions, the whole series of beds from the Weald Clay to the Gault may be seen in uninterrupted sequence. Dr. Fitton, our principal authority with regard to these beds, has in his admirable memoir on the strata between the Chalk and Oxford Oolite taken as his typical section the one from Hythe to Folkestone; and, having subdivided the Lower Greensand, as there seen, into three groups, he endeavoured to trace those subdivisions throughout the inland range of the series. His groups are as follows: 1st. An upper division, consisting for the most part of white, yellow, and ferruginous sands, with occasional concretions of limestone and chert. 2nd. A middle division containing more clayey beds, abounding in green matter, often of a marshy character, and containing comparatively little stone, and 3rd. A lower division containing the principal beds of building-stone or Kentish Rag, which in general forms a ridge of hills overlooking the Weald.

The section at Atherfield (subsequently described in detail by Dr. Fitton) differs from the one at Hythe, not only in the greater thickness of the whole series (800 feet), but also in the fact that there is no appearance at Atherfield of regular bands of stone in any part, the deposits consisting throughout of alternations of clays and sands, with occasional concretions. This section is also remarkable for the highly fossiliferous beds which rest immediately on the freshwater Wealden deposits. These beds, known as the Perna-bed and the Cracker-nodules, were at first considered as unrepresented elsewhere in England.

After the publication of Dr. Fitton's original memoir, Mr. Godwin-Austen described a section in the neighbourhood of Guildford, somewhat intermediate in character between those of Hythe and Atherfield. In this paper Mr. Austen also divided the Lower Greensand of Guildford into three groups, viz., an upper and ferruginous division, a middle division containing the Bargate Stone and Kentish Rag, and consisting of sands with subordinate bands of siliceous building-stone, and an argillaceous division, to which he applied the term "Neocomian," consisting of brown and yellow clays containing nodular concretions of great size and thickness abounding in corals and shells. The most remarkable features in the section at Guildford, as described by Mr. Austen, is the absence of any equivalent to the "middle division" of Dr. Fitton, and the presence there of the very fossiliferous Neocomian division, the equivalent apparently of the Perna-bed, and perhaps of the Crackers of Atherfield.

This Neocomian division—the junction-bed between the Wealden and the Lower Greensand—was subsequently recognised on the South-Eastern Railway at Red Hill, on the Maidstone branch of the same railway near Watlington, and in a shaft sunk through the Kentish Rag beds near Hythe. A similar bed was observed on the Portsmouth Railway, near Haslemere; and Mr. Bensted has described a marine fossiliferous clay as underlying the stone beds in his quarry at Maidstone, and resting on the Weald clay. At all these places it is found to contain fossils in abundance. This bed has not to my knowledge been observed in other localities, owing probably to the fact that it rests immediately on the Weald

Clay, resembles it closely in mineral character, and, like it, crops out in the low ground at the foot of the Greensand hills.

It is, therefore, very interesting to find that a similar bed was passed through at several of the shafts at the top of the hill at Sevenoaks. It was found to consist there of a dark-coloured sandy clay (with much water), abounding in specimens of *Arca*, *Corbula*, and many other fossils similar to those from the Neocomian bed of the other localities mentioned above. Some portions of the bed are concreted and contain the remains of a large *Perna*.

Unfortunately, at the time of the visit of the Association, the works at the shafts where the deposit was seen last autumn had been carried down to the Weald Clay, while the more northern shafts had not been sunk below the Kentish Rag, in consequence of which very little of this, the most fossiliferous bed at Sevenoaks, was to be seen on that occasion; sufficient however was exposed to enable several of the members to supply themselves with specimens of the deposit, and some of the more characteristic fossils.

The Neocomian bed is succeeded by the Kentish Rag series, the "lower division" of Dr. Fitton.

Throughout the greater portion of Kent this division forms a range of hills (broken, however, by the transverse river-valleys), which runs in a parallel direction to that of the Chalk Downs. This series is best seen in the quarries at Hythe, Maidstone, and other places, where it consists of alternations of bands of limestone more or less compact or crystalline, with layers of chert and a soft light-coloured sandstone full of grains of green earth, locally known as "hassock."

The calcareous matter of these stone beds appears to diminish in the western extension of the series; and in several places in Surrey, as, for instance, at Red Hill, the lowest beds consist of sands and soft sandstone, with occasional concretionary blocks of stone. In the western districts beds of stone occur in a position rather higher in the series, as, for instance, on the top of the hill at Nutfield, where a soft building stone is found associated with local beds of fullers' earth. In the neighbourhood of Guildford a building-stone, consisting of a conglomerate more or less compact, which is there known as Bargate Stone, occupies a similar position. The Bargate

Stone bands are associated with coarse pebbly sands. Traces of pebble-beds are to be seen at Dorking, Nutfield, and Folkestone, and probably elsewhere.

The absence in the Isle of Wight of regular bands of stone renders it difficult to identify the equivalent of the Kentish Rag series at Atherfield and Sandown Bay.

At Sevenoaks this part of the section presents the usual appearance of the Kentish Rag series in Kent, consisting of alternations of limestones, sandstones, and chert, blocks of which are seen around the more northern shafts of the tunnel; at the north end of the tunnel a very fine section of the lower beds of the series is well seen.

The most remarkable feature in this part of the section is a saddle or anticlinal axis, through the top of which the railway cutting has been formed for about half a mile, the beds on the one side dipping to the south-east, and on the other to the north-west. In the low cutting near the mouth of the tunnel a complete arch of the beds is seen. The beds are also much faulted at this spot.

Folds or minor anticlinal axes are described as occurring in the Lower Greensand beds at several other places. One is noticed by Dr. Fitton as exposed at Sundrish, a short distance to the west of the railway-section at Sevenoaks. Another is seen at Tilburstow Hill, south of Godstone; and another, passing across the district to the south of Guildford known as the Peasemars, has exposed the whole of the series from the ferruginous sands to the Weald Clay.

One of the commonest fossils in this group is the large *Gryphæa* or *Exogyra sinuata*, which I have met with at Hythe, Maidstone, and Sevenoaks; it is also very abundant in the central portion of the Lower Greensand at Atherfield and Shanklin.

Another common fossil is *Terebatula sella*, which at Atherfield occurs in bands associated with the "ranges" of *Gryphæa sinuata*. I have not as yet observed this shell in the Kentish Rag division at Sevenoaks, although it is there abundant in the Neocomian bed.

Two or three species of *Trigonia*, together with other bivalves, are found in some of the beds, but mostly in the form of casts. A small Belemnite also appears to be common in this part of the series.

One other shell I may mention, viz., the *Terebratula* or *Terebratella oblonga*, a brachiopodous shell characterised by several strong ribs or striations and other points of distinction. It has been found in the Kentish Rag series, and the same or a closely allied shell also occurs in the Cretaceous conglomerate and pebble-beds at Badbury Hill, near Farringdon. It is a rare shell in most localities.

I was much interested, therefore, on finding last autumn, near the shafts at Sevenoaks, several blocks of sandstone or Hassock, which I believe, from the position in which I found them, came from near the top of the Kentish Rag series, and which contained *Terebratella oblonga* in abundance, associated with a species of *Plicatula*.

The Kentish Rag division is succeeded at Sandgate by a remarkable bed, which, where seen in the undercliff between Sandgate and Folkestone, appears as a dark-coloured sandy clay, without any conspicuous bands of stone or concretions. It is between 70 and 100 feet thick, and was described by Dr. Fitton as the "middle division" of the Lower Greensand. In the inland sections of these beds Dr. Fitton describes this middle division as occupying flat and marshy ground, separating the hills composed of the upper division from those of the Kentish Rag. He also stated that this dark bed, though nearly 100 feet thick at Sandgate, thins out to the west.

Although I feel that I am setting my opinion against those of geologists who have given much more attention to the Lower Greensand than I have myself, I must observe that it appears to me, from several facts which I have noticed, doubtful whether this middle division of Dr. Fitton is entitled to rank as a natural group of equal value to the Kentish Rag or the Neocomian bed.

Although a valley is seen in many places to the north of the Kentish Rag hills, and separating them from the ferruginous sands of the Upper Division, such a valley does not appear to be continuous throughout the whole range of the formation around the Weald; and where one is present it does not always appear, as far as can be seen in our imperfect inland sections, to occupy precisely the same position in the series in different localities. Thus at Sevenoaks the line of railway, on emerging from the cutting before de-

scribed, passes by means of an embankment over low wet ground until it reaches the cutting through the ferruginous sands. But this valley is not continuous throughout the district, but appears to be only a small diagonal valley descending from the Ragstone hills, since an observer may advance along the road from the present railway-station on the ferruginous sands, up the hill through Sevenoaks, to the escarpment of the Kentish Rag, without the intervention of any valley.

The clearest inland section of this part of the series with which I am acquainted is the one seen in descending the hill on the south side of Saint Martha's chapel near Guildford. Here the ferruginous sands are only separated from the lower sands which rest on the Neocomian bed by bands of Bargate Stone and pebbly sands, and thin bands of fullers' earth.

It is, I believe, generally found that pebble-beds have a considerable horizontal range, and I have before observed that pebbly bands have been noticed in the Lower Greensand at several spots in the range of these beds from Guildford to Folkestone. Thus at Nutfield, Surrey, pebbly sands are seen below the fullers' earth and the associated beds of soft building stone (which by the way contains a small *Avicula* common also in the Bargate Stone), and certainly below any beds which, as represented in Dr. Fitton's section, intervene between the fullers' earth beds and the ferruginous sand, and occupy the low ground to the north of Nutfield.

Any pebble-beds which I have observed at Sevenoaks also occur at the top of the Kentish Rag cutting; while at Folkestone pebble-beds, also containing in abundance the *Avicula* of Nutfield and Guildford, are found *above* the dark clayey bed of Sandgate.

If we may assume that these pebble-beds are continuous throughout the district from Guildford to Folkestone, it results that the beds considered by Dr. Fitton as representing his middle division are not present at Guildford, are above the pebble-beds at Nutfield and Sevenoaks, while the typical bed at Sandgate is below them.

The upper division of the Lower Greensand consists for the most part of white, yellow, and ferruginous sands.

At Folkestone, where these beds are well seen in the cliffs, they differ somewhat from the equivalent beds elsewhere in containing

many bands of concretions of limestone and chert, and in being very slightly ferruginous.

At many places along the north side of the Weald, and also in the Isle of Wight, these beds consist of loose sands, occasionally ferruginous, and containing irregular veins of pebbly ironstone; and this is their condition in the neighbourhood of Sevenoaks. This division usually exhibits much cross-bedding.

The upper part of the Lower Greensand contains very few fossils, especially if we separate from it the Bargate Stone of Guildford and the beds associated with the pebbles at Sandgate. I have not found any trace of shells in the ferruginous sands at Sevenoaks.

Casts of shells occur in ferruginous sands at Shanklin; but they have been found in greatest abundance in concretions occupying a low position in the Upper Division at Parham Park, in Sussex.

The ferruginous sands pass under the thick clay bed of the Gault. The Gault passes into the Upper Greensand, and the latter into the Chalk-marl and Lower Chalk.

The Gault occupies the valley at the foot of the Downs, and presents the same mineral character throughout the whole of its range, and, where exposed, contains similar fossils to those so abundant in it at Eastware Bay, near Folkestone.

The Upper Greensand is thin, and seldom exposed in Kent; but in parts of Surrey and Sussex it contains beds of stone locally known as Firestone or Malm-rock. It increases in thickness in its progress westward; and in Dorsetshire, Devonshire, and Wiltshire it contains thick bands and concretions of chert. The Gault and Upper Greensand have not as yet been exposed in the railway-works at Sevenoaks.

I have entered so far into the details of the geology of the country around the Wealden escarpment, in the hope, as I before remarked, that others of the members will from time to time give some attention to an interesting group of deposits which, judging from the published papers on Geology, have not, during the last twenty years, received as much attention as several others of the Secondary formations. I will, therefore, conclude by alluding briefly to some of those points of interest to which the attention of members may be most profitably directed.

In the first place, the Weald Clay is one of those freshwater deposits formed of the spoils of adjacent land, in which we may search with the greatest chance of success for additional facts tending to throw light on the character of the old "country of the Iguanodon."

The Iguanodon is itself very imperfectly known, and still less is known of the various other animals, and of the plants which were its contemporaries. A few specimens picked up or obtained from the men for trifling sums might throw much light on doubtful points as to these subjects.

No Mammalia have hitherto been met with in the Wealden beds; and, although I am not prepared to state that they are to be found in the Weald Clay, yet it is quite possible that a continued examination of this deposit might result in the discovery of some of these most interesting remains, since several species of Mammalia have been discovered in the freshwater Purbeck beds below the Wealden.

The junction of the Lower Greensand and the Weald Clay is a subject also well worthy of further attention.

I have before stated that the deposit which I have termed the Neocomian bed has only been observed at a few places around the Weald; notices of any additional places where it may be seen would therefore be of great value.

As this is the most fossiliferous of the Lower Greensand beds at Sevenoaks and elsewhere, many additions to our lists of British fossils may, doubtless, be met with in it; thus enabling us to determine whether this junction-bed is truly the equivalent of the Neocomian beds of the Continent.

Although, in general, the fossils of the Kentish Rag are not well preserved, there are many points well worthy of attention with regard to this division of the series; and I may remind the members that the most instructive specimen of the Iguanodon at present known was obtained from Mr. Bensted's Ragstone quarry at Maidstone.

The exact equivalent at Atherfield of these beds has yet to be determined, for which purpose the change of mineral condition of the stone beds as they trend to the west, should be traced as far as possible.

I have already mentioned the doubtful character of the Middle Division of Dr. Fitton. For the purpose of solving this question, the dark Sandgate bed should be traced as far as possible inland, the material occupying any of the valleys intervening between the Kentish Rag and the ferruginous divisions should be noted wherever practicable, and endeavours should be made to determine whether the pebble-beds of Guildford, Nutfield, and Folkestone are continuous throughout the district. Diligent search should also be made in these pebble-beds for drifted fossils, as Mr. Meier has formed a very fine collection of drifted teeth, &c., from the pebble-beds of Guildford and Godalming.

Fossils of the upper beds of the Lower Greensand, being rare, should be carefully preserved and accurately determined (if possible), in order to ascertain whether the organic remains of this part of the series present a closer (per-centage) relation to those of the Gault and Upper Greensand than do those from the lower members of the formation.

Neither should the study of the Gault and Upper Greensand be overlooked, since on the knowledge of the various beds of the Middle and Lower Cretaceous rocks depends greatly the solution of questions with regard to the age of some interesting deposits in the North and West of England.

One of these outlying deposits is a clay bed, seen in the cliffs at Speeton, in Yorkshire, which is said to contain an admixture of forms elsewhere considered peculiar to the Oolite or the Greensand.

The Red bed at Hunstanton, in Norfolk, has already been described before the Association, but its age is still doubtful; by some it is considered as the equivalent of the Gault, while others look upon it as of Upper Greensand age.

Outlying deposits of pebble-beds and conglomerates occur in the neighbourhood of Farringdon, and are known as the Farringdon Sponge-gravels, as very beautiful Sponges are abundant in them. Although now very generally considered to be of the age of the Lower Greensand, the late Mr. Daniel Sharpe, a great authority, believed these Farringdon gravel-beds to be of more recent date than the Chalk itself, though still belonging to the Cretaceous period.

Another very interesting subject is the age of the Whetstone beds of the Blackdown Hills, in Devonshire, in which deposits fossils of the Lower Greensand, Gault, and Upper Greensand, beautifully preserved, although completely silicified, seem to be curiously intermixed in such a way as to make the age of the bed very doubtful. In our London museums these fossils are arranged as Upper Greensand. Mr. D. Sharpe considered them of the age of the Gault, and a few geologists have classed them as Lower Greensand.

Time will not permit me to enlarge at present on these questions, but I hope on some future occasion to bring this branch of my subject before you in greater detail, and in the meantime I trust that other members will come forward, and give us some local papers on the Middle and Lower Cretaceous formations.

No. 2. "Notes and Queries on Geological Subjects." By Mr. G. E. Roberts, F.G.S.

After the reading of the paper, it was proposed that "Notes and Queries" should be periodically published by the Association, and that the paper just read form the first number.*

Ordinary Meeting, July 5, 1864.

E. Cresy, Esq., President, in the Chair.

The following papers were read:—

No. 1. "On a Recent Marine Deposit at Boulogne." By Mr. C. B. Rose, F.G.S.

On returning from Paris in the spring of 1862 I slept one night at Boulogne, and on the following day I made a hurried examination of the harbour, piers, &c. In so doing I met with a hillock of sand and débris, enclosing *Cardia*, *Mytili*, and other shells, clearly such as inhabit the adjoining sea.

This circumstance haunted me on my return home so much as to

* Mr. Roberts's "Notes and Queries" have been printed and circulated amongst the members.