

## EXCURSION TO THE EAST COAST OF YORKSHIRE.

MONDAY, AUGUST 3RD TO SATURDAY, AUGUST 8TH, 1891.

*Directors:* The PRESIDENT, G. W. LAMPLUGH and Rev. E. M. COLE.

(*Report by* THE DIRECTORS.)

*Monday, August 3.*—The Members who took part in this Excursion were on the first day divided into two parties—some having gone down to Yorkshire previously, and others starting by the advertised train from London or joining the Excursion on the road.

Those who had already arrived in Yorkshire started in good time in the morning to make the tour of Flamborough Head, under the direction of Mr. Lamplugh. After encountering a hailstorm, they reached the North Sea Landing in grateful sunshine. The lowness of the tide enabled them to explore Robin Lythe's Hole, probably the largest sea-cave on the Yorkshire coast. The cave is drilled through the compact hard limestone, known as Chalk-with-flints, but a very different rock from the soft flinty Chalk in the South of England. The interior of the cave is so much higher than its seaward entrance, that the higher parts of the dome cannot have been excavated by the direct action of the waves; but the ordinary atmospheric disintegration may have been aided by the alternate compression and rarefaction of the air when great waves have entered and closed up the narrow entrance. From this spot to the lighthouse at the end of the promontory, the precipices everywhere revealed excellent sections of the flinty Chalk, capped with a variable thickness of Glacial deposits, consisting in this part of the area chiefly of Boulder Clay. Striking illustrations of the wave-power on the coast were pointed out in the isolated King and Queen rocks, and in the deep narrow inlets which gash the cliffs.

In Selwick's Bay (misspelt "Silex" on the old ordnance map, a mistake suggesting an abnormal knowledge amongst the old Yorkshire folk of the composition of flint), was seen a considerable fault, bringing down the flintless Chalk against the flinty on the south. The actual line of fault is marked by contortions and veins of calcite. Another kind of contortion was seen near Common Hole, a few hundred yards away, in this case on the surface only, and doubtless produced by the presence of moving ice.

The Drifts in this locality were peculiarly interesting, the lowest Boulder Clay consisting very largely of transported masses of Speeton Clay from which many of the characteristic fossils were collected. Another remarkable result is due to the proximity to

the cliff line of a deep ravine in the Chalk now filled and obliterated by the Glacial deposits. Two of the sea-worn caves have perforated the Chalk and have reached the buried ravine, and as the Drift infilling has rapidly been scooped out by the waves, two deep pit-like "creux" or blow-holes have been formed near the edge of the cliff.

On the south side of the lighthouse, a descent was made to the shore, for the examination of the large erratics, which are here strewn about after being washed out of the neighbouring Drift. A large variety of rocks was noticed, including granite, mica-schists, gneisses, Carboniferous Limestone and sandstone, basalt, &c., but the Secondary rocks were very feebly represented. The cliffs on this side of the headland, beneath which the party walked to South Sea Landing, are not nearly so bold and picturesque as those on the northern side. They consist of the higher flintless Chalk in which fossils are rare, with a thick capping of gravelly Drift.

The party which left London by the 8.45 train arrived punctually at Driffeld, and, after settling at the Bell Hotel, went immediately to Mr. Mortimer's Museum, which is well-known to be remarkably rich in the fossils of the Chalk and in pre-historic remains from the Wolds within twenty miles of the town. The Chalk fossils would not bear comparison with what may be obtained in the richer beds of the South of England; but, considering the barrenness of the Yorkshire Chalk, the number and variety of the fossils here displayed is remarkable. Amongst them is a large ammonite 4 ft. 9 in. in diameter, to which is assigned the MS. name of *wharramiensis*, from the locality where it was found. The characters exhibited, either by this specimen, or by the small ones, which obviously belong to the same species, are scarcely sufficient for diagnosis, and the general shape is that of *A. lewesiensis*. Other fossils are large perfect *Inocerami*, including *I. digitatus*, *I. barroisi*, &c., and numerous sponges, echinoderms and pelecypods. The pre-historic remains derived from the surface of the Wolds are placed in the table-cases of the gallery. They consist of thousands of Neolithic flint-implements, including arrows, knives, scrapers, burnishers, grinders, &c. Some of the lanceolate knives are marvels of execution, being chipped with the greatest regularity, although so thin as to be translucent. There is no Flint-Jack living who could make their like. The wall-cases contain the contents of 280 tumuli which have been opened in the district.

After duly inspecting this interesting museum, and thanking Mr. Mortimer for being present to explain its contents and for permission to visit it, the party took train to Flamborough, where the various Members of the Excursion united to form a single body, who placed themselves under the direction of Mr. Lamplugh. Carriages were taken to South Sea Landing, where the party

descended to the shore. Here is seen an ancient valley carved out of the Chalk, with its base descending below the sea-level. It is now filled at the bottom with very coarse chalk rubble, above which is a considerable thickness of sand and gravel, more or less underlying or passing into the Boulder Clay. At a certain spot on the east side of the little bay, about half-way up the cliff, the Director pointed out the spot where the band of marine shells described by him ("Geol. Mag," Dec 3, vol. vii, p. 61) had been met with. Some of the members expressing a wish to examine the band *in situ*, Mr. Lamplugh led the somewhat difficult way, pointing out on the way up the cliff a stratified horizon in the midst of clay which indicates the separation of the Upper and Lower Clays, since it is at this level that the Middle Sand and Gravels, when present, make their appearance. The patch containing shells was seen to consist of sand of marine origin, irregularly stratified and highly contorted, clean, ferruginous, and often showing an "iron-pan" at the base. The boundaries are so irregular that it could not have been deposited in the ordinary way from water. Some fragmentary shells were met with, including *Astarte borealis* and *Cyprina islandica*.

Leaving the South Sea Landing, the Members divided their attention between the Chalk below, and the Drifts above, as they walked along the coast towards Bridlington. The Chalk here is the flintless Chalk throughout, belonging to the zone of *Marsupites*, plates of that crinoid being pretty easily obtained. The strike of the beds is not very far removed from the shore-line, so that higher beds come on slowly in the westerly direction. One band was noted as full of fragments of *Inoceramus*, and others at higher levels were rich in sponges, including various species of *Ventriculites*. The Chalk is subjected to many small faults whose aggregate throw may be considerable. The surface of junction between the minor beds is in places very jagged or tooth-like, with an intervening band of dark-green earth, so that in weathering the line resembles the sutures in the bones of the skull.

The Drifts were chiefly remarkable for the great variety they shewed within short distances. In one place they were entirely clay; in another almost entirely sand and gravel, and in one or two places there was a gradual passage from one form into the other. Sometimes chalk-rubble was seen at the base, and sometimes it was absent. The valleys in which these deposits lie thickest are, of course, of Pre-Glacial origin, one being very well seen at Danes Dyke, where, as in other cases, the modern water-course has partially re-excavated the hollow.

At Sewerby a halt was made to examine the celebrated buried cliff. This section was unfortunately rather obscure; but there was no difficulty in making out that the Chalk ended abruptly in a steep cliff about forty feet high, at the foot of which lay an ancient beach of rolled and *Pholas*-bored chalk pebbles.

This beach was covered by a land-wash of marly material and fallen chalk, containing small snail shells, and above this a thick mass of loose blown sand was seen, forming part of an old dune, under which the cliff had been buried and preserved. In these beds excavations were carried on two years ago under the auspices of the British Association and of the Yorkshire Geological and Polytechnic Society, and bones and teeth of numerous mammals were obtained, along with remains of fish and birds. Among the species represented were *Elephas antiquus*, *Rhinoceros leptorhinus*, *Hippopotamus amphibius*, *Bos* or *Bison*, *Cervus*, *Hyæna*, *Arvicola*, &c. The upper part of the blown-sand is cut off by the Basement Boulder Clay, which is seen to descend from the crest of the old cliff, overlapping the ancient land and marine beds, until it reaches the shore-line. Other Glacial and Post-Glacial deposits, such as the Sewerby Gravel, succeed, completely masking this bold Pre-Glacial feature. The base of this buried cliff is not far from the sea-level of to-day and a similar cliff has been proved by well-sinkings round the eastern edge of the Wolds, showing that in Pre-Glacial times the sea reached the Chalk hills over all the district of the Holderness. It was driven out by the Glacial deposits, but is fast regaining its former dominion.

It was almost dark ere the party reached the Alexandra Hotel ; but their day's work was not yet finished, for after tea they accepted the kind invitation of Mr. Thomas Boynton to examine at his house his most interesting collection of antiquities and animal remains from the lake-dwelling which he had excavated at Ulrome, pictures of which, as seen when freshly exposed, adorned the walls. He also invited any of the Members to be present during some further excavations which he contemplated in the course of the summer. Adequate time could not be given to do justice to the collection, for the Members had to gain seats in the last train from a popular watering-place on Bank Holiday !

*Tuesday, August 4.*—The object of this day's Excursion was to examine as much as possible of the coast from Speeton to Scarborough. With this intent a start was made by the 8.52 a.m. train from Driffield, which the railway company were good enough to allow to stop at Speeton. Here the full force of the party assembled and started merrily towards the cliffs. At the station they noticed a chalk-pit where there was scarcely any covering of Drift to be seen ; but between here and the sea was observed a long conspicuous ridge from 40 to 80 feet above the general level, running in a south-easterly direction, and capped by a windmill. This ridge is a portion of the great terminal moraine of the great northern ice-sheet, which was traced across England by the late Professor Carvill Lewis, who visited and took sketches of this spot. The Drift, in fact, which is so abundantly developed on the northern side of this ridge, is here piled up on the highest ground

in a chain-like series of steep mounds, but beyond this line dies rapidly away to westward.

On reaching the summit of the escarpment a magnificent bird's-eye view is seen, whereby the structure of the country may be well made out. Here, the Director (Mr. G. W. Lamplugh) pointed out, was the termination of the Chalk formation, while in the triangle of low ground between the foot of the ridge and the sea, were found the Lower Cretaceous and Jurassic clays emerging from beneath it, though most of the minor surface features were due to the covering of the Drift, and far away in the northern distance might be seen the rising crags of the Middle Jurassics. At this spot the Director took occasion to remark on the passage in the President's account of this area in the pamphlet which had been issued to Members\* where the Portlandian or Neocomian age of certain portions of the Speeton Clay was discussed. He pointed out that the 50 feet of "strong" clays below the coprolite bed, referred to by Mr. Leckenby, had not been unnoticed by him, as was stated, but that he did not differentiate them from the rest of the Kimmeridge beds, all being equally shaly. He considered the *remanié* character of the fossil *Lucina portlandica* which occurred at the base of the *Belemnites lateralis* beds as by no means proved. *Belemnites lateralis* was said to be typically Neocomian on evidence which stood in great need of revision. The opinions of palæontologists differed regarding the forms called *Ammonites gravesianus*; but in a forthcoming work on these fossils, by a well known Russian specialist, they were regarded as referable to continental species. He thought that the oyster called *Exogyra sinuata* differed from the ordinary Neocomian form, and that this and other species resembled Portlandian forms. The President in reply admitted that these details required much careful work before they could be considered settled, but stated that the general facies bore no resemblance to that of the Portlandian of this country or of France, and pointed out that the view of Mr. Lamplugh involved the Jurassic age of the Lincolnshire oolitic ironstone beds, which was a sweeping change in general views, the correctness of which was a large matter to prove.

After availing themselves of the forethought of one of the local collectors of fossils who had prepared himself for their coming, and obtaining some of the characteristic fossils with the silver hammer, the party betook themselves to the shore, passing over the obscure drift-covered outcrops of the Flinty Chalk and Lower Chalk. At the foot of the cliff, the Red Chalk was seen in huge slipped masses and some of its fossils were collected. The attention of the party, however, was attracted, by the exposures of Speeton Clay, away from the better section of the Red Chalk and underlying clays in Speeton Gap, which was left unvisited, though the clays were pointed out in the slips.

\* Vide pp. 138-140, *supra*.

By a chance, rare at this season of the year, a portion of the Speeton Clay was seen uncovered on the shore, and, as the tide was rising, Members hurried on to avail themselves of the unusual opportunity of seeing the beds *in situ*. Only a passing notice was therefore taken of the black clays with bands of cement nodules which peep from beneath the slips in the cliff—and which constitute the upper division of the Speeton Clay. They contain the characteristic belemnite, now known to be *Belemnites brunsvicensis* von Strombeck (= *B. semicanaliculatus*? of Judd), with a fauna which is taken to prove them to be of Aptian or Lower Greensand age. The beds exposed on the Scar were found to belong to the two zones of *B. jaculum* and *B. lateralis* which succeed the above in descending order. The junction between these two zones was marked by a band of curious agglomerated phosphatic nodules, which the Director pointed to as his “Compound Nodular Band.” These nodules appeared to lie all upon one horizon forming an irregular and discontinuous seam. The lithological character of the clays showed no very marked change; but the fauna of the beds above this line of nodules was seen to be different from that below. *Belemnites jaculum* and *Ammonites noricus*, in particular, were easily found above the band, but not at all below; and the belemnites characteristic of the zones were not found to be intermingled. The Director stated that the ammonites which were long ago found in the Speeton Clay, and were recognised as characteristic Portlandian forms, could be shown to have come from the zone of *Belemnites lateralis*. Moreover, these clays rested directly and without unconformity upon bituminous shales of undoubted Upper Kimeridge age, and for these reasons he regarded that zone as probably equivalent to the highest Jurassic beds of the South of England. The President on the contrary could not recognise any English Portlandian forms amongst the ammonites, and considered that there was an unconformity marked by change of lithological character and by a coprolite bed at the base of the zone.

A search was made in the cliff for this coprolite bed, which was formerly well exposed, but without success. Not a sign of it, of any kind, was to be seen. The whole of the beds were seen to be bituminous shales with impressions of Kimeridgian fossils, and the top was covered by slips or by the estuarine shell beds at the base of the Drift.

Having come so far on the road the party decided to continue along the shore to Filey, though nothing was to be seen but Drift. One mass of this, however, attracted attention from afar; for from a distance—ay, and close at hand also—it looked like rock *in situ*, and bore considerable resemblance to Middle Kimeridge Clay. After a careful scrutiny, however, of the fossils obtainable from it, including *Belemnites araris*, there could be no doubt that the mass must be, in spite of all appearances, a transported block

of the *jamesoni* beds of the Lias, of unusually large dimensions. This, at least then, is not an exposure of Middle Kimeridge, which, as it is presumably lying below, might at any spot be found *in situ*, if the Drift were removed.

On reaching Filey the Members dispersed awhile for lunch, but made a rendezvous below the Life-Boat House at half-past two. The tide was now fast rising and cutting off access to Filey Brig; but the party walked along the shore in that direction till the first rock was visible beneath the Drift, where the trend of the coast changes. The surface of this rock was pointed out by Mr. Lamplugh as showing glacial striæ, and their direction was verified by compass as trending from N. 20° E. Soon after this point, boats had to be taken to reach the Brig. Here the President, who now assumed the direction, pointed out the fossiliferous limestone on the southern side, from beneath which as the Brig was crossed came out the various calcareous grits, the most conspicuous being the uppermost, called by Mr. Hudleston the Filey Brig Calc-grit. Owing to the state of the tide the lowest beds were not visible; but the section was verified as far as the principal dogger beds forming the bay near the Spa.

Few fossils could be obtained beyond the ordinary oysters; but the *Rhaxella* sponge was particularly sought for, and several masses of sponge of some sort were obtained.

Clambering up the cliff, the Members who had been in the van rejoined the rear guard, who had ascended the gentle slopes, and a united company sat down in prospect of a splendid panorama. On the south near their feet lay the vale of Pickering based on Kimeridge Clay, and beyond were traceable the wolds of Chalk stretching from Flamborough Head to Knapton, where they turned towards the south. From this spot the great moraine could also be well traced, descending from the heights above Speeton to the lower elevations in front of the Chalk to the east. On the north was seen the succession of the Oolitic series; the Oxfordian and Estuarine Clays, forming the valley between here and Scarborough, the hills to the west showing the capping of Corallian rocks, while to the north-west rose the moorlands of the Inferior Oolite rocks of the Peak, and in the far distance could be seen the Middle Lias of North Cheek jutting out beyond Robin Hood's Bay. The Director also drew attention to the contrast presented by the rounded outlines of the Wolds of Chalk when compared with the flat-topped hills of the Oolites which formed the Moors. On this the Rev. E. M. Cole pointed out that the term "Moors" was used in a much more restricted sense than this in Yorkshire, and that the flat-topped hills which had served as illustrations of the Director's remarks were called the "Tabular Hills," while only the Inferior Oolite of the Peak produced the "Moors."

From this spot the walk was continued along the cliff top, the

shore being inaccessible, and the gradual rising of the lowest beds of the Lower Calcareous Grit, Oxford Clay, and Kellaway Rock was traced from various points of view. On reaching Gristhorpe Bay the descent to the shore was found to be very muddy and precarious, notwithstanding the reply of the old fishwife as to whether it were fit for a lady, "Ooay, I've come oop mysell," so that only a portion of the company followed the Director. Those who did, saw, at the base, the low cliffs of the Upper Estuarine beds, the Middle Oolites and Cornbrash being half way up the cliff. At the promontory a more calcareous band with a rather nodular structure was seen to represent the Scarborough Limestone. Beneath this the sea-worn rocks and shelving ledges and scars showed numerous lignitic patches, but it is not in these that the far-famed leaves have been obtained. All about were seen lenticular hollows in the ledges, the edges of which showed the tips of dark leaves in the yellow sandstone. These are the spots whence the flora has been already extracted, but other patches were seen which had not been touched, from being more deeply embedded. Doubtless a dynamite cartridge or two would soon restore the prolificness of the locality.

A walk along the shore to below Redcliff led the now straggling Members to the fault in the great gully, which some explored on the spot, while others were content to view from below the sudden termination of the Calcareous Grit and Oxford Clay on the north against the Estuarine Series whose rise they had been tracing on the south. Beyond the fault a new band of rock was seen to rise from below the Oxford Clay, in which some Callovian fossils were seen, and close on the shore a low scar of the curious purplish rubbly Cornbrash was hammered with success.

Here the day's work ended, and, mounting to the road, the tired Members sought the expected carriages; but one had broken down, and half the party had to walk. They came up smiling at the end before the remaining carriage, having walked the whole distance from Speeton station to Scarborough, along the coast, geologizing all the way.

*Wednesday, August 5.*—This was a day of comparative rest for some. By the kindness of Mr. J. W. Woodall arrangements had been made for conveying the party in his own steam yacht and in the harbour tug, on a coasting voyage to Filey Brig on the one hand, and to Robin Hood's Bay on the other. The stormy and threatening character of the weather on the day before, however, led to only a small number of Members putting down their names to avail themselves of the opportunity, and for them the yacht alone sufficed. The morning itself proved as blustery as had been feared, and more so; but the little craft, in spite of the weather, kept close in shore as far as Filey Brig, and the party were able to verify the section drawn in the programme in all its details. Their



attention was also drawn to huge tufts of white flowers growing in the wildest spots on the cliffs, and, a couple of the men having volunteered to get some, they turned out to be the maritime variety of *Matricaria inodora*. Returning to Scarborough, the yacht put round the Castle Rock, and Members were able to trace the Kellaway Rock at the Harbour, descending to the sea, the Oxford Clay above it, almost covered by the fallen blocks from the cliffs above, and, on the summit, the crags of Calcareous Grit, capped by the Lower Limestones. At the north end of the Castle Rock they had a splendid view of the great slip that had taken place the previous winter, when a great mass had slipped over the clay into the sea with a noise that was heard all over the town, and, according to the evidence of one of the yachtsmen, who had been an eye-witness, dashing the spray above the level of the cliff. As rain was now added to wind, it was determined to forego the northern voyage, and the party, after having heartily thanked Mr. Woodall, who met them on their return, landed once more on terra firma.

The afternoon somewhat brightening, an attempt was made to examine the northern side of the Castle slopes. A few Members accompanied the Director to the archway on the road to the Castle grounds, beneath which the evidence of the fault here occurring, viz., the want of correspondence of the Kellaway Rock and lower part of the Oxford Clay, on one side, with the base of the Lower Calcareous Grit, on the other, was pointed out. Between the two cliffs some masses of Estuarine beds cropping out showed that there was here a double fault as shown in the section. The rain now returning, the numbers were still further reduced and only two or three continued on the eastern slopes to examine the curious concretions in the sandy beds of the Lower Calcareous Grit, with outstanding *Serpula* and other fossils, or to climb by the narrow defile along the face of the Lower Limestones with their *Gervillia* and *Echinobrissi*. Even these few were prevented by the signals of the rifle practice from venturing down to see the Oxford Clay. On the other side, however, they were able to examine the yellow sandstone blocks of the Kellaway Rock, with their *Gryphaea dilatata* and *Myacites recurvus*; and, though the slopes were for the most part covered, some blocks of Cornbrash which had defied removal were seen in their proper position and yielded *Pecten fibrosus* and *Rhynchonella varians*.

The other and larger half of the party, excluding those who dared not face the weather, placed themselves under the direction of the Rev. E. M. Cole, who led them away to Pickering. On arriving there the Director took the party to the quarries on the right hand just below the Castle. Here the beds below the Coralline Oolite were examined, and large masses of *Trigonia* found; the most interesting feature, however, being the presence of pisolite. Many good specimens were obtained, some in

section, showing the concentric structure. A good example of the *Chemnitzia* Limestone was obtained for inspection, as also of the Coral Rag; but the time was too limited to allow of their adequate examination, while the Supra-Coralline beds could only be pointed out from the train. Further up the valley the Kellaway Rock was seen forming rounded knolls on the hill-slopes.

On reaching Levisham a start was made for Saltersgate on the road to Whitby. A somewhat tough pull landed the party on the Kellaway platform, which extends for miles with a gentle slope upwards to the north. On this platform the Middle Oolites are built and present a fine escarpment facing north, the Lower Calcareous Grit above the Oxford Clay throwing out spurs here and there in the form of "nabs" or "nesses." The view, from the summit of this platform, of the dale in which the railway runs, was extremely fine, calling to mind in miniature the pictures of the Colorado Cañon.

On reaching Saltersgate, four miles distant, the rampart, for it can scarcely be called anything else, was scaled and the Hole of Horcum came in view. This is a grand inlier with a floor of Kellaway Rock, and sides of Middle Oolites. On the north the rim is so narrow that it must eventually be worn away by ordinary denudation, when the Hole will cease to be an inlier, but will become connected with the platform beyond. From the summit of Winny Nab, 950 ft. high, a magnificent view may be obtained on a clear day, extending from the cliffs of Bempton on the south-east to Helmsley Moor and the Black Hambletons on the west. The unfavourable weather prevented the enjoyment of this and rendered hopeless an intended visit to Blakey Topping; so the party set out for a mournful and rapid trudge in pouring rain down the valley to Pickering.

On arriving there they interested themselves in matters to which rain was no obstacle by visiting the church under guidance of the Vicar, the Rev. G. H. Lightfoot, who kindly explained the recently restored fifteenth-century frescoes which adorn the walls of the nave.

*Thursday, August 6.*—In brighter weather the party started by the early train for Peak, and here again they divided. There was much to be done in the three hours at their disposal, to descend to the shore, to tramp along the scars and re-ascend, so the less active preferred to remain at the top and watch their brethren of the hammer at their work. The vigorous Members went down by a precipitous path over the Estuarine Beds, where the Director pointed out the position of the Millepore Bed forming an outstanding craggy band and also of the Eller Beck Bed, which was far more obscure, and they landed at last on the very spot where the uppermost bed of the Dogger kept the shore. Here hammers were soon vigorously at work extracting the *Nerinea cingenda*, *Astarte*

*elegans* and *Trigonia spinulosa* with which the rock abounds. The peculiar purple and oolitic appearance of the bed was also noted. In the massive rocks beneath, the two lines of dark nodules were easily seen in place, rising off the shore into the cliff, and below them numerous specimens of the large casts of *Terebratula trilineata* were obtained. It was noted that a more marked stratigraphical break occurred above the *Terebratula* bed than at any horizon below it, and this break was pointed out as having been taken as the summit of the Blea Wyke Beds, so that stratigraphically there was much to be said for the inclusion of these latter in the Lias. The Members were called upon to notice specially for future reference the considerable thickness of deposits which here intervened between the nodule beds and the undoubted Lias shale. Considerable time was spent along the scar, where, the water being low, the rocks were seen to perfection, whilst from the little rocky prominences, many examples of the little nests of *Serpula deflexa* were obtained, and, from the dark rocks below, specimens of *Ammonites aalensis*, one Member also securing the carapace of a *Glyphea*. A considerable hunt was necessary before one of the nodules with *Lingula beani* was discovered, as they lie at rather a low level and the beach stones were pretty numerous, but when the right line was struck several were found, and all who wished carried away admirable examples of that fossil and its constant companion, *Discina reflexa*. No one was able to draw the line where these beds ended and the true Lias began, so gradual was the change. Nowhere, however, on this side of the little Bay could the shaly beds proper be seen. On the other side, where the rocks are bared again, they are very characteristic; and, though no ammonites were met with, beautiful double valves of *Trigonia litterata* were found in some abundance, together with nests of *Monotis substriata*. The collectors by this time had done well in the time at their disposal, and nothing was now left but to hurry up to catch the train. The path taken lay under the shelving talus that forms beneath the Dogger from the *striatulus* shales, in the nodules of which *Ammonites striatulus* is best obtained; but, though several suitable nodules were examined, no one was fortunate enough to light on one with the ammonites, and all had to be content with knowing that any of the other nodules might be expected to yield them. At the summit of the hill they met the rest of the party, who had been employing themselves in examining the fault and the beds on the two sides of it.

The whole party then returned by train to Haiburn Wyke, where lunch was in waiting, after which some delay was caused by the non-arrival of the carriages, by which they were to be taken to Cloughton. It was found in consequence impossible to examine both sides of Cloughton Wyke, and the Scarborough Limestone of Hundale Scar could only be pointed out as forming a low promontory and rising in a well-marked band along the

southern cliff. The northern side, on the contrary, was well examined, and a walk over the huge blocks which strew the shore brought the Members to the little promontory where the dark ferruginous Millepore Bed juts out, and also forms the scars. Numerous examples of the characteristic *Cricopora straminea*, which forms in places a great part of the rock, were obtained. *Pinna cuneata*, *Ceromya bajociana* and one specimen of *Gonioseris angulata* were also obtained. The overlying Middle Estuarine Beds, where the road reaches the shore, showed in a recent fall some thin seams of coal, and black impressions of Cycad fronds were obtained from the adjacent shales.

From this point a drive was taken towards Suffield, mounting on the low banks which are formed by the Kellaway Rock, the precipitous escarpment of the Lower Calcareous Grit towering above the road on the right. This also had to be surmounted on its lower, more southern portion, quarries being seen on the summit of the rise. On arriving at Suffield the Members alighted, and made their way by the upper road to the quarries in the Lower Limestone, where the Lower Coral Rag is seen. Here *Gervillia aviculoides* was found in characteristic abundance, with spines of *Cidaris smithi* and *Echinobrissus scutatus*. The corals, however, did not make much of a show, only some obscure masses of *Isastræa* being obtainable, and Members rather grumbled at the name of Coral Rag being given to this bed. In fact, the party was not particularly fortunate in this respect, as occasionally many more corals are obtained with better specimens of gastropods and *Terebratulæ*, but time was limited on this occasion. From here a descent by a narrow path was made to the valley, and the carriages were taken to Hackness.

On arriving there only part of the company decided on accompanying the Director to the Bell Heads quarry, the remainder continuing their drive round by Ayton to Scarborough, but, owing to the miserable character of the conveyances, not reaching there much sooner than the others. The richness of the Bell Heads quarry somewhat atoned for the poorness of the Suffield one, since several varieties of corals—*Thamnastræa*, *Isastræa*, and *Rhabdophyllia*—completely made up the higher layers, and a cart-load might have been carried away; while perfect specimens of *Phasianella striata* were showered down by Mr. Cole from the surface of the ground above as fast as he could pick them up. On the rough road down to Hackness, now deserted, the Middle Calcareous Grit was noted crossing the surface, and, at a lower level, limestone again. A sharp walk brought the Members to the inn where the carriages were re-mounted, and Scarborough was reached a little after eight o'clock.

*Friday, August 7th.*—A start was made at the same hour and to the same place as on the previous morning, the work on this

occasion lying in the district beyond. The party were met at Peak station by Mr. Marshall, of Peak Hall, who obligingly conducted them to his great alum-shale quarry, now unworked. From the top of this quarry there is an excellent view of the general arrangement of the strata in Robin Hood's Bay, and as the spot is nearly six hundred feet above sea-level, an idea of the thickness of the Upper and Middle Lias together is obtained, the topmost beds of the Lower Lias being on the shore beneath. The bulk of the rock which caps the quarry was seen to be of the Estuarine Series, with plant-remains, but the true relations were best seen from below. The representative of the Dogger was found at the base of the massive rock, not being many inches in thickness. It was found to be full of pebbles, and amongst them numerous examples of *Terebratula trilineata*, as at Blea Wyke; but the peculiar purple bed at the top could not be distinguished. To call attention to the difference of development here and on the eastern side of the fault, the Director placed himself on the Lias shales, and with his hammer extracted some of the carbonaceous patches in the Estuarine beds, thus covering all the intervening beds by less than his body's height. He then called to the remembrance of Members the eighty feet of rock from which they had collected fossils on the day before. The possible causes of this great difference were discussed in the paper that had been prepared in explanation of the Excursion.\* He then called upon Dr. Maybury, as the chemist of the party, to explain the process of alum extraction. The shales, the doctor explained, were sulphurous from the presence of disseminated pyrites, and, on their exposure to the atmosphere, this became oxidized and entered into combination with the alumina of the clay. In order to produce alum, a soluble salt of potash was added to the lixiviated mass, and this caused a double decomposition to take place, producing a sulphate of alumina and potash. The crystallization took place in large vats into which the liquor was drained.

It was impossible to descend directly to the shore, as the cliff had foundered, and the pathway had not been kept up since the manufacture of alum had ceased, and was at best a muddy one, so a return was made to the path which leads down by the fault. Half-way down a halt was made, and the evidence of the fault in the crag of Dogger and Estuarine beds on the east, ending abruptly, was pointed out, the continuation of the line being in beds below the jet rock. The locality of the scar, called the Peak Steel, where the zones of *Ammonites margaritatus* and *A. spinatus* are seen, was also shown, with the Jet Rock shortly following them in the fork into which the fault divides. Thus from this point almost every part of the Lias may be seen in one view. Facing the sea the *jurensis* beds and alum-shales formed the slopes on the left; the Jet Rock and Grey Shales down to the *margaritatus*

\* Vide pp. 124-6 *supra*.

beds are on the scar in front ; the *capricornus* and *jamesoni* beds, on the steep cliff on the left ; and the *oxynotus* and *bucklandi* beds, on the scars beyond.

As the tide was nearly at its lowest and the seaward scars uncovered, it was decided to hurry on to examine them on such a favourable opportunity, without stopping to work in the Middle Lias beds. The dividing line of the *oxynotus* and *bucklandi* beds having been pointed out, the Members scattered themselves about and found their way gradually to Bay Town, picking up fossils all the way. Many broken examples of *Ammonites sagittarius* were found in the *oxynotus* beds, with *Pentacrinus tuberculatus*, and the oblique variety of *Gryphæa incurva* ; but too little time was allowed for searching for *Ammonites gagateus* in the cliff nearer Bay Town. Only two or three accompanied the Director in a dash, *pedibus nudis*, to the outermost reef of all, cut off, even at the lowest tide, by an inlet of the sea, whence he brought back examples of the true *Ammonites bucklandi*, *A. conybeari*, and *Lucina limbata*. The greater number contented themselves with the *Ammonites semicostatus* of the higher and nearer bands ; but *Gryphæa incurva* and *Hippopodium ponderosum* were found pretty uniformly dispersed over the scars.

Lunch being not quite ready, the time, both before and after, was spent in examining the basal beds of the Middle Lias—the zone of *Ammonites armatus*, to the north of the village. Quite close to the town the band of *A. tardecrescens* showed itself by several well-marked, though imperfect, examples ; and large specimens of *A. armatus* were seen imbedded in the scar a little further on. Only those, however, who reached the bend of the cliffs came upon the richly fossiliferous pyritous band, whence they brought back *Spirifer walcotti*, *Waldheimia sarthacensis*, *Unicardium cardioides*, *Plicatula spinosa*, *Limea acuticosta*, *Gryphæa maccullochi*, and *Belemnites araris* ; while a little further on they saw, but did not extract, *Ammonites polymorphus*. One of the Members hurried on the Director to see a “magnificent head of an Ichthyosaurus,” which he had discovered embedded in the shale, but could not extract. Half-way there, he mentioned that he had been able to extract some enormous teeth ; but, on exhibition, these turned out to be *Pinna folium*, so the expedition retreated. The mistake may be pardoned, for it is said that a geological surveyor sent up one of these huge shells, with a mass of pyrites at the larger end, to Jermyn Street, as the snout of an Ichthyosaurus ; but this no doubt is a libel.

In the afternoon the train was taken to Hawsker ; but on arriving there, owing to the station not being marked on the six-inch map, and to several of the Members rushing off in the wrong direction, as if they knew the way, the Director was himself misled, which caused a delay of nearly half-an hour, so that, when the path down to Hawsker Bottom was reached, an hour only

remained in which to explore it. The path leads down under overhanging crags of the Estuarine sandstones, and here several Members halted and found examples of the ferns and other plants which are tolerably abundant. Very little of the Dogger can here be seen, and the rest of the path is on the crumbling shales of the Lias. Those at the base yielded plenty of the common Ammonites—*A. communis* and *A. holandrei*—and further on, the good exposure of Jet Rock claimed chief attention, as it had nowhere else been seen. The bituminous smell of the shales and the liquid filling of the interior of some ammonites were noticed, and good examples obtained of *Ammonites elegans* and *Inoceramus dubius*; but the time was too short to do much, and forbade even attempting the examination of the Grey Shales. These and the *spinatus* beds were therefore left unvisited, and the party returned by train to Scarborough.

*Saturday, August 8th.*—The final day was one of ease and separation, about half the party proceeding to Whitby by train. Strolling through the old town, they purchased *Ammonites* at the shops, and a fine specimen of a *Zamia* lately procured, and then mounted the 199 steps to look at the Abbey, the history of which was expounded by Mr. Parker. The superior weathering power of the Moor Grit over the other stones of which it is built, was noticed. A visit was also paid to the parish church, with its high old baizelined pews, its double gallery, its three-decker pulpit, its seat for the bishop in a gallery running across the chancel arch, and its numerous exits for those who are wearied or late. Descending again, a jet working shop was visited, and polished mementoes of the visit, manufactured “while you wait,” were procured; and then at last the geology began by the Members descending to the now uncovered scars. These are in the Alum-shale, and are surmounted by the thin Dogger with the massive Estuarine Beds above. The party was soon dispersed, looking for the numerous *Ammonites*, *Belemnites*, and *Ledæ*; but most were interested in the sagacity of a local collector, Stephen Palmer by name, who knew, by the shape of the surface of the scar, where an ammonite would be found in a nodule beneath, picking out and developing several from spots where the Members could see no signs of a fossil. Others pushed on to Saltwick Nab to see the Jet Rock on its outer side, and found evidence of it in the presence of *Ammonites elegans*, *Belemnites tubularis*, and *Inoceramus dubius*. Mr. Starkie Gardner devoted his attention to the Estuarine sandstones, where they come down in a low synclinal to the shore line, and discovered in a loose block an immense assemblage of *Zamia* and ferns in a good state of preservation, but requiring some work to extract.

The rain which now came on prevented many Members paying a visit to the Museum, and the party finally dissolved at

the station, after carrying out to the end almost every item of a rather formidable programme.

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